PROJECT MANUAL DELIVERABLE #7

coLlab

HFT Stuttgart | 202115 | 27.07.2022

SYNOPSIS

This document is part of the competition “Solar Decathlon Europe 2021/ 2022 …goes urban!” by the University of Applied Sciences Stuttgart (HFT Stuttgart). This manual delivers the reports of the project coLLab.

Hochschule für Technik Stuttgart

energy endeavour FOUNDATION

solar decathlon europe 21 WUPPERTAL GERMANY …goes urban!

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

BERGISCHE UNIVERSITÄT WUPPERTAL

TABLE OF CONTENT

coLlab

Table Of Content **2**
1 Summary of Changes **7**
2 Rules Checklist **12**
3 Contest Support Documents **18**
3.1 Architecture 19
3.2 Engineering and construction 25
3.3 Affordability & Viability 29
3.4 CESA 31
3.5 Sustainability 35
3.6 Urban Mobility 39
4 Architecture Design Report **42**
4.1 General Architectural Concept 43
4.2 Site Integration 43
4.3 Structural Design 67
4.4 Solar System Integration 69
4.5 Reconfigurable Features 74
5 Engineering & Construction Report **76**
5.1 Location Analysis 77
5.2 Final Energy Concept Summary 81
5.3 Reduction of Energy Demand 84
5.4 Measures to Decarbonize Energy Supply 93
5.5 Housing Demonstration Unit (HDU) 99
5.6 Life Cycle Carbon Footprint 105
6 Affordability & Viability Report **109**
6.1 Analysis of the Context 110
6.2 Targets & Objectives of Concept 115
6.3 Concepts 117
7 CESA Report **124**
7.1 Responsibility for Public Relations 125
7.2 Overall Communication Project 125
7.3 Communication Sub-Report 126
7.4 Education Sub-Report 133
7.5 Social Awareness Sub-Report 141
8 Sustainability report **145**
8.1 Circularity 146
8.2 Sufficiency, Flexibility & Environmental Performance 150
9 Urban Mobility Report **168**
9.1 Analysis 169
9.2 Survey of Mobility 175

9.3 Conception 179
9.4 Demand of Energy by Mobility 187
9.5 Part of the mobility Concept shown on HDU 188
10 Dinner Party Menu 190
11 Contest Week Task's Planning 195
12 Cost Estimation and Project Financial Summary 199
12.1 Fund-raising plan 200
12.2 Comments on the Price-Cost-Proposal. 201
13 Site Operations Plan 202
13.1 General data 203
13.2 Site Operations Coordinators 203
13.3 Logistic outside of SDE21 Solar Campus 203
13.4 Logistic on SDE21 Solar Campus 205
13.5 Assembly/ Disassembly schedules 207
13.6 Equipment Requirement Chart 209
13.7 Assembly & Disassembly Chart 210
13.8 Site Operations Chart 211
14 HS Report and Documentation 213
14.1 Health & Safety Checklist 214
14.2 General Data of the Project 214
14.3 Health and Safety Plan Objectives 216
14.4 Instruction Concept Including Contents 217
14.5 Conditions of the site where construction will take place and interesting data related to the prevention of risks during the construction process: 218
14.6 Activities for Risks Prevention 228
14.7 Critical work phases for risks prevention 230
14.8 Risks identification and efficacy evaluation of the adopted protections 232
14.9 Collective protections to use 235
14.10 Individual protection resources to use 236
14.11 Safe working procedures of every Team member 239
14.12 Machinery and auxiliary resources 239
14.13 Planned Measures in case of accident 240
14.14 Risks identification for works on construction-site 243
14.15 Useful plans and information for works 243
14.16 Adopted system for the level of health and safety control during works 243
14.17 Formation and information about health and safety 244
14.18 Emergency evacuation plan during the assembly and disassembly periods 244
15 Detailed Water Budget 246
16 Electrical & PV Design System 249

16.1 Electric System Design Checklist 255
16.2 Photovoltaic Checklist 259
16.3 Electrical Storage System Checklist 264
17 Project Specifications 265
18 Structural Calculations 270
19 Bibliography 272
20 Appendix 276
20.1 Engineering & Construction 277
Appendix A – Reduction of Energy Demand 277
Appendix B – Final Energy Concept 281
Appendix C – Measures to Decarbonize Energy supply 284
Appendix D – HDU Simulation assumptions 288
20.2 Affordability and viability 290
Appendix A – Calculation of rent 290
Appendix B – Calculation of property value 293
Appendix C – Profitability calculation 297
Appendix D – Calculation of federal funding 303
Appendix E – Calculation of cash flow analysis 304
Appendix F – Calculation of capitalized value 305
20.3 CESA 307
Appendix A: List of participating subjects 307
Appendix B: Visual Identity Manual 315
Appendix C: Sponsorship Manual 323
Appendix D: Public Tour Description 327
20.4 Sustainability 332
Appendix A – Materials 332
Appendix B – Construction 337
Appendix C – Maintenance 338
Appendix D - Circularity concept 339
Appendix E – Carbon footprint of the construction 340
Appendix F – Biodiversity 342
Appendix G – Society 344
Appendix H – Climate 347
Appendix J – Building Material 353
20.5 Cost Estimate and Financial Summery 362
20.6 Health and Safety 365
Appendix A - Technical Specification of the Safety Equipment List 365
Appendix B - Time and construction schedule of work units 367
Appendix C - Operating instructions 370

20.7 Structural Calculations 387
Appendix A – Foundation 387
Appendix B – Timber construction 388
Appendix C – OPV façade 389
Appendix D – Ramp construction and handrail 390

1 SUMMARY OF CHANGES

coLlab

Chapter	Heading	Notes	Date
Rules Checklist		New Chapter	**DEL#6**
Contest Support		Updated	**DEL#6**
Architecture Design	4.1 General Architectural Concept	Overview added	DEL#4
	4.2.2 Site Concept	Occupation added	DEL#4
	4.2.3 The whole building – Utilisation concept	Concept added	DEL#5
	4.2.6 Housing Demonstration Unit – Architectural Concept	Justification of two-storey unit added Further description added	DEL#4
	4.2.7 BIM	New Chapter	DEL#5
	4.2.8 Interior design	Concept updated	**DEL#6**
	4.2.9 Lighting Design	Information added	**DEL#6**
	4.2.10 Lighting Quality	Information added	**DEL#6**
	4.3.2 Structural design - HDU	Updates	DEL#5
	4.4 Solar system integration	Updates	DEL#4
	4.4.1 The Whole Building	Updates	DEL#5
	4.4.2 HDU	Content added	DEL#4
	4.4.3 Constructive Solution	Details further explained	DEL#4
	4.4.4 Additional Properties	Detailed comment on the carrier plate of the OPV-cells	DEL#4
	4.4.5 Maintenance	Climatic influencing factors and processes added	DEL#4
	4.4.6 Economy of Installation	Information added	DEL#4
	4.5 Reconfigurable Features	Updates	DEL#5
Engineering and Construction	All chapters	Whole report completely revised	**DEL#6**
	5.2 System Design	Description of new energy concept added	DEL#4

	5.3 Reduction of Energy Demand	"c. HDU" section added at the end Dynamic performance analysis of HDU added	DEL#4
	5.5 Life Cycle Carbon Footprint	Completely revised	DEL#5
Affordability and Viability	6.1 Analysis of Context	Removed outdated phrases, information on investment risk added	**DEL#6**
	6.2 Target & Objectives of concept	Removed outdated phrases, description of the target group's values ideas added	**DEL#6**
	6.3 Concepts	Removed outdated phrases	DEL#4
	6.3.1 Concept for affordability and economic viability	Removed outdated phrases, added more detail and new aspects	**DEL#6**
	6.3.2 Concept for Social Viability	Added more detail and new aspects	DEL#4
	Appendix	Information added	**DEL#6**
CESA	7.2 Overall Communication Project	Chapter added	DEL#4
	7.3.1 Analysis	SWOT Analysis revised, External Media added	DEL#4
	7.3.3 Operative Planning	Information added	**DEL#6**
	7.3.4 Implementation	Update	**DEL#6**
	7.3.5 Assessment/Controlling	Update	**DEL#6**
	7.4.2 Strategic Planning	Workshops added	DEL#5
	7.4.4	Information added	**DEL#6**
	7.5 Social Awareness Sub-Report	Added	DEL#4
	7.5.2 Strategic Planning	Online Strategy revsed	**DEL#6**
	7.5.3 Operative Planing	Totally revised	**DEL#6**
	7.5.4 Implementation	Totally revised	**DEL#6**
	Appendix C Visual Identity Manual	Update	**DEL#6**
	Appendix D Sponsorship Manual	Update	**DEL#6**
	Appendix E Public Tour Description	Update	**DEL#6**

	Appendix F Implementation List	Update	DEL#6
Sustainability	8.1 Circularity	Update	DEL#6
	8.1.1 Materials	Update the Building parts catalogue	DEL#6
	8.1.2 Construction	Update to the current plans	DEL#6
	8.1.4 Circularity Concept	Update of the UMI calculation	DEL#6
	8.1.5 Carbon footprint of the construction	Update/ Addition of service system and evaluation of different building parts	DEL#6
	8.2 Sufficiency, Flexibility & Environmental Performance	Update the Urban-Loop-Design list	DEL#6
	8.2.1 Biodiversity	Update	DEL#6
	8.2.2 Society	Update	DEL#6
	8.2.3 Climate	Update	DEL#6
	8.2.4 Durability	Update	DEL#6
	8.2.5 Building Material	Update	DEL#6
Urban Mobility	9.1 Analysis	Updates	DEL#6
	9.3 Concept	Information added	DEL#6
	9.4 Concept	Started to create concept of sharing offer	DEL#4
	9.5 HDU	Information added	DEL#6
Dinner Party Menu		Completely revised	DEL#6
Contest Week Tasks' Planning		New Chapter	DEL#5
Cost Estimation and Project Financial Summary		Completely revised	DEL#6
Site Operations		Completely revised	DEL#6
Health & Safety		Completely revised	DEL#6
Detailed Water Budget		Completely revised	DEL#6
Electrical & PV Design		Completely revised	DEL#6
Project Specification		Information added	DEL#6

Structural Calculations + Appendix		Updated	**DEL#6**

2 RULES CHECKLIST

coLlab

Rule Description	Content requirement(s)	Drawing(s)/ Report(s)
3.2 Team Officers & Contact Information	Team officer's contact information completely fulfilled in Table 2 (SDE21 WAT).	HFT_CON#6_2022_03_23.xls
4.3 Lot Conditions & attribution	Drawing(s) showing the storage and unloading areas and corresponding load's.	SO-0102
4.3 Lot Conditions	Calculations showing that the structural design remains compliant even if there is a level difference, and drawing(s) showing shimming methods and materials to be used if needed.	Appendix Structural Design
4.4 Footings	Drawing(s) showing the locations and depths of all ground penetrations on the Competition site.	ST-1001
4.4 Footings	Drawing(s) showing the location, contact area and soil-bearing pressure of every component resting directly on the ground.	ST-1001
4.7 Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the Competition site and specifications for heavy machinery.	SO-1001, SO-2001, SO-3001
5.1 Solar Envelope Dimensions	Drawing(s) showing the location of all unit and site components relative to the solar envelope.	AR-4001, AR-4002, AR-4003
6.1 Structural Design Approval	Structural drawings and calculations signed and stamped by a qualified licensed professional.	HFT_DAP#6_2022_03_23
6.1 Electrical & Photovoltaic Design Approval	Electrical and Photovoltaic drawings and calculations signed and stamped by a qualified licensed professional.	HFT_DAP#6_2022_03_23
6.1 Codes Design Compliance	List of the country of origin codes complied, properly signed by the faculty advisor.	HFT_DAP#6_2022_03_23
6.2 Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to digitally measure the architectural footprint.	AR-4301

6.2 Architectural Footprint	Drawing(s) showing all the reconfigurable features that may increase the footprint if operated during Contest week.	AR-4501; AR-4502; AR-4503; AR-4504
6.3 Measurable Area	Drawing(s) showing the Measurable Area.	AR-4101, AR-4102
6.4 Entrance & Exit Routes	Drawing(s) showing the accessible public tour route, specifying the entrance and exit from the unit to the main street of SDE21 Solar Campus.	AR-10 01, PT- 00 01 to PT-00 02, PT-10 01 to 03
7.3 PV Technology Limitations	Specifications and contractor price quote for photovoltaic components.	HFT_PS#6_2022_03_23
7.4 Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices and corresponding specifications.	EL-3001, PV-3001, HFT_PS#6_2022_03_23
7.6 Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components and corresponding specifications.	PL-1001, SW-0001, SW-2001
8.1 Containers locations	Drawing(s) showing the location of all the water tanks.	PL-3001
8.2 Water Delivery	Drawing(s) showing the fill location(s), quantity of water requested at each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s).	PL-1001, PM Water Budget, HFT_WATER#6_2022_03_23
8.3 Water Removal	Drawing(s) showing the quantity of water to be removed from each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s).	PL-3001, PL-3002, PL-3003, PM Water Budget, HFT_WATER#6_2022_03_23
8.5 Greywater reuse	Specifications for greywater reuse systems.	PM Water Budget, PL-5201
8.6 Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems.	PL-3001
8.8 Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems and corresponding specifications	ME-2021, ME-2002
8.9 Greywater Heat Recovery	Specifications for greywater heat recovery systems.	SW_0001, HFT_PB_heatex_Warmduscher.pdf

9.1 Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system.	AR-2000, AR-21-01, AR-22 02, AR-23 02, AR-23 03, AR-24 01, AR-24 05
9.2 Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems.	PM Water budget, PL-5101
10.2 SDE21 Sensors' Location & wire routing	Drawing(s) showing the location of bi-directional meters, metering box, sensors, cables and feed-through to pass the instrumentation wires from the interior to the exterior of the unit.	ID-1001, ID-1002, ID-2001, ID-3001
11.2 Use of the SDE21 Logo	Artwork, and content of all communications materials, including signage (please refer to the SDE21 Graphic Chart & Brand Manual).	Appendix CESA – B Visual Identity Manual
11.3 Teams' sponsors & Supporting Institutions	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage (please refer to the SDE21 Graphic Chart & Brand Manual).	Appendix CESA - Sponsorship Manual
11.4 Team Uniforms	Drawing(s) showing the artwork, content and design of the Team uniform (please refer to the SDE21 Graphic Chart & Brand Manual).	Appendix CESA – B Visual Identity Manual
12.4 Public Tour	Drawing(s) showing the public tour route, indicating the dimensions of any difficult point, complying with the accessibility requirements.	PT- 00 01 to PT-00 02
23.0 Contest 5: Drying Method	Drawing(s) showing the clothes drying method and the place where the clothes will be dried.	ME-2301
23.0 Contest 5: House Functioning	Appliances and corresponding technical specifications (Appliances and Home Electronic Equipment specifications and user manuals).	ID-5001, EL-3001; HFT_PS#6_2022_03_23, HFT_FACT#6_2022_03_23.xlsm
36.5 Photovoltaic systems design	Specifications of PV generators, inverters, wiring, cables, protections, earthing systems, interface with the electricity distribution network turned on.	PM Electrical & PV Design System, PV-0001, PV-3001, HFT_PS#6_2022_03_23

36.5 Photovoltaic systems design	Inverters' certificates.	HFT_PS#6_2022_03_23
36.5 Photovoltaic systems design	Maintenance plan for PV generators, supporting structure, inverters, wiring, cables, protections, circuit breakers in case of fire and earthing system. Fire protection systems for PV DC wiring.	Architecture Report, PV-2001 to PV-2016
36.5 Photovoltaic systems design	The corresponding table 'design summary' must be completed.	HFT_ELEC#6_2022_03_23
51.3 Fire Safety	Specifications for fire reaction of constructive elements, extinguishers and fire resistance of the unit's structure.	EL-4001, EL-4002
51.3 Fire Safety	Drawings showing compliance with the evacuation of occupants' requirements and fire extinguishers location.	FP-0001; FP-0002
51.4 Safety against falls	Specifications of compliance with the slipperiness degree classes of floors included in House Tour.	AR-2101; AR-2102
51.4 Safety against falls	Drawing(s) showing compliance with conditions for uneven flooring, floors with different level, Restricted Areas stairs, Public Areas Staircases, Restricted Areas Ramps and Public Areas Ramps.	AR-20 01, AR-20 02, AR-24 01 to 06
51.4 Safety for impact risk & avoiding trapping	Drawing(s) showing compliance with conditions for avoiding impact risk and trapping.	HFT_HS#6_2022_03_23.xlsx, HS-10 01 to 06, AR-24 05
51.4 Safety against the risk of inadequate lighting	Specifications for level of illumination of House Tour areas light fittings.	EL-4001, EL4002
51.5 Accessibility for People with Disabilities and Special Needs	Interior and exterior plans showing the entire accessible tour route.	AR-24 05, PT-00 01-02
51.6 Structural Safety	Specifications for the use of dead loads, live loads, safety factors and load combinations in the structural calculations.	Structural Calculations Appendix
51.7 Electrical and PV Systems	Complete the 'Electrical System Design PV Chart and Checklist'	HFT_ELEC#6_2022_03_23

51.7 Electrical and PV Systems	Specifications of the wiring, channels, panels and protections of the electrical installation.	PV-2001 to PV-2016, PV-3001, EL-1001, EL-5001
51.7 Electrical and PV Systems	One-line electrical diagram and drawings showing the grounding, execution and paths.	EL-1001, EL-5001, PV-4001

3 CONTEST SUPPORT DOCUMENTS

coLlab

Disclaimer

The project “coLLab” at HFT Stuttgart is mainly supported and coordinated by students from the so-called core team. They take care of the contents and are in close contact with the responsible professors. The students are supported by permanent employees, who take over the construction management as well as administrative tasks and keep the project together. Professors supervise various projects in which students work temporarily through a project at SDE.

3.1 **Architecture**

3.1.1 **Site integration**

“CoLLab” means collaborative laboratory, which wants to offer new forms of living collectively in urban situations on small surfaces. Furthermore, coLLab describes an extension that enters into a symbiosis with the existing building and adapts to existing structures. Moreover, the project should not only have a positive effect on the environment, but implicitly take up the human as its scale and focus on the importance of common space and social networks. The coLLab team at the Stuttgart University of Applied Sciences has decided to work on the addition of storey and renovation of an existing building on the university's campus, called “Building 5”.

The HFT campus can be described as an arrangement of different buildings, some of which create qualitative urban planning situations, while others are separated from each other by oversized streets and car parks. At the moment, the use of Building 5 is limited to teaching and research. In the course of the renovation of the existing Building 5, opportunities for a variety of uses are to be seized.

In the future, the building will not only be a place for applied science, but also a house full of innovation, a place to exchange and a place for social interaction. The addition of storey will also create new incentives: Living and studying on campus. An exciting interface between teaching and leisure, it will initially offer students affordable living space. The vision of long-term use is a functioning community and the emergence of an intercultural village on the roofs of Stuttgart. On the top floor, pensioners, refugees, single parents with children, visiting professors, families and people in need are to be offered a home. Through social mixing, we expect valuable social interactions and a growing house community. The campus with its transformation into a car-free zone, as well as the transformation of Building 5, should become a social meeting place for residents and visitors and create a social togetherness.

In order to realize this vision, various construction measures will be taken on the campus and in front of Building 5. On the one hand, measures that will be implemented in the short term and in the near future, and on the other hand, measures that require a major redesign of the campus.

To mention just one measure for redesigning the campus, self-built furniture was developed and assembled from old panels by students. The campus furniture offers additional seating areas where students can spread out, study or exchange ideas. In addition, planting opportunities are provided to grow either crops or flowers typically used for architecture models. The realisation of the campus furniture is still ongoing and already provides new opportunities for social interaction.

As part of a mobility concept, the public space is to be given more quality. The rejuvenation of large streets and improved public transport connections will create a pedestrian and cyclist-friendly district that is well connected to the neighboring residential areas and the city center.

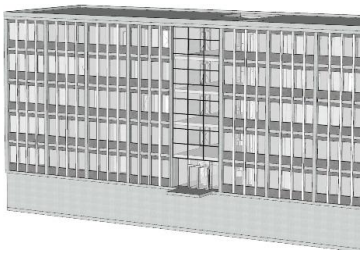
3.1.2 **Building Design**

The chosen building for the renovation and addition of story – Building 5 - was constructed between 1956 and 1959. Reinforced concrete was chosen as the construction, which is executed as exposed concrete. The facade is very strongly vertically structured. The exposed concrete facade columns alternate with non-load-bearing artificial stone columns. The corridor walls are bricked and loadbearing. The ceilings are ribbed concrete ceilings or solid flat concrete ceilings. An analysis for the solar potential of the buildings resulted in an annual yield of 1,200 kWh/m^2*a. Due to its structure, the existing building is considered a typical representative of its time and offers great potential to develop transferable solutions that can be used throughout Europe.

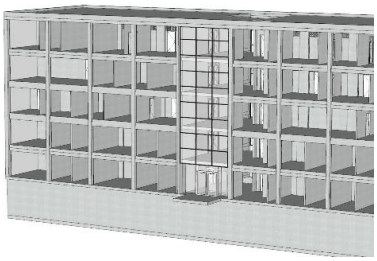
Renovation

The existing Building will be renovated mainly to reduce energy consumption, but also to improve the quality of the rooms. One measure is the modification of the façade. The vertical pillars and horizontal ceilings give this building a unique character, which are to be preserved by the renovation measures.

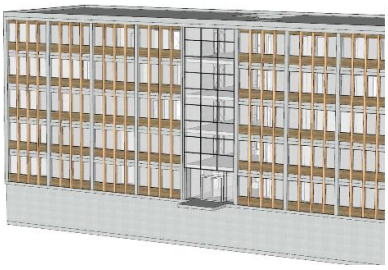
The possible solution for this building is unconventional, but very innovative. First the non-weight-bearing concrete pillars, old windows and balustrades will be removed. The grey pillars and ceilings remain, so that new, prefabricated elements can be used. This new element is manufactured in wood, so its lightly and has a good insulation. With this measure, the weight of the whole building is reduced, so there are more possibilities for the two extra storeys, which will be added.



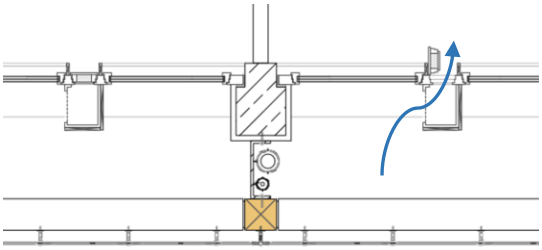
1. Existing Building



2. Removal of non-structural parts



3. Installation of wooden elements and plastering of main pillars with ceilings

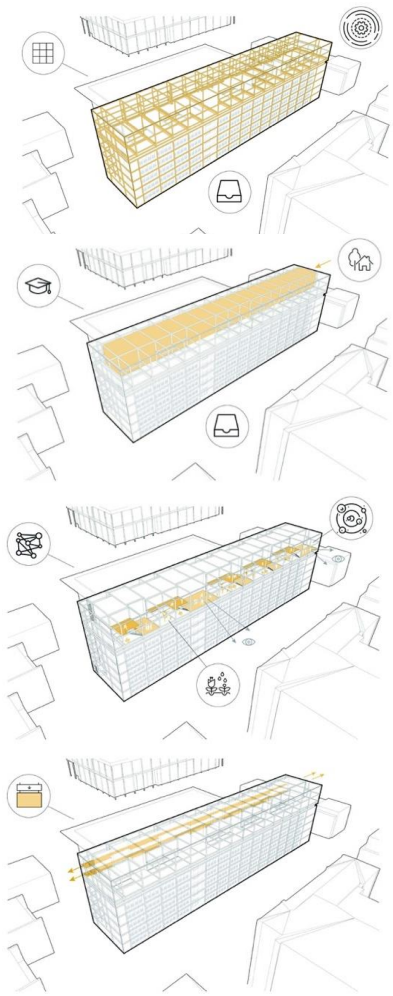


To keep the appearance of the vertical pillars, the new wooden elements will have the same grid size, as the old façade. The new wooden columns are not only responsible for maintaining the external appearance of the building, but also for ventilating the rooms. Solar chimneys in front of the staircases draw fresh air into the rooms through a physical effect via the ventilation flaps.

Addition of storey

The special feature of the design is that the extension not only works on the chosen Building 5, but can also be placed on similar existing structures. In order for the concept to be not only future-proof and innovative but also to be able to survive on the market, a transferable solution is sought. From these requirements, an architectural basic construction is developed, based on the existing building, the so-

called grid. It is a constructive skeleton, which is adaptable in size depending on the existing building and its load bearing structure. The innovation of the design is to develop a flexible and adaptable system that creates high-quality living space in a minimal area and stands in symbiosis with its surroundings.



The existing structure forms the basis of the grid, which can be scaled and adapted according to requirements. Thus, the design can react to similar existing structures and guarantee the transferability of the concept. The Grid fulfills other functions in addition to the transferability of the design:

It includes the Living Block: wall panels are placed and lined up to create two- or one-story living modules for one to three people. In order to create variety and to break up the block, the individual modules are shifted in the grid to each other. In addition, this creates zoning and private addressing.

Green and open spaces are also oriented along the structure of the grid. They are located in front of the residential units, oriented to the south and offer view relationships to the campus and the adjacent urban garden. The green and open spaces consist of terraces that provide privacy at different levels and at the same time places for communication and interaction. This creates interweaving between the two levels, quality and varied public places for community use.

The circulation is located north of the residential units and is also connected to the grid. The staircases of the existing building are extended towards the north and lead directly to the arcades on the north side. The access also serves as an escape route, which is why the southern part functions without the creation of different fire compartments and can therefore provide maximum flexibility.

The grid significantly determines the appearance of the exterior and the facade. Pipes of the extension can run behind the grid. In front of the grid, the façade is fixed, a net structure with OPV modules. This very light looking and translucent façade - grid together with net - is also put over the existing façade.

3.1.3 **Interior & Lighting Design**

Residential units that will be inserted into the Grid offer space for individual design and creative freedom within the inhabitant's own four walls. These units are formed by the juxtaposition of functional walls. A living module consists of two intelligent walls in a row and the outer facade on the north and south sides. Within these functional walls, intelligent furniture and technology components are placed and optimally arranged. Between the functional walls, an open space is formed that can be adapted to the

needs of the occupants. While the functional walls within the living modules are always the same, the residents can individually design and appropriate the space between the walls. This guarantees transferability to existing buildings with different constructive raster and roof areas.

A kitchen module and the bathroom module are integrated into one side of the apartment. The opposite wall consists of individual cabinet elements that can be rotated, the so-called rotating corps. These corps stand out from the room envelope due to their floating mounting on a ball-bearing swivel rod. This creates a light, loose spatial structure and gives room to breathe. Joints between the corps reinforce the effect and make it possible to perceive the room in its full depth. The cabinet modules are not the elements that define the space (as in a built-in cabinet) but the walls themselves. The rotating corps are not standard furniture elements, but are specially designed for the project. Each corpus contains its own function and is specially designed for its function. One corpus is used to store clothes, another can be folded out to form a table for working, and in another one books and personal items can be stored. Thus, many different spatial situations can be represented in one room.

The occupant is to be given an individualistic way of living. The fact that the resident can turn the modules according to the time of day and the situation in which they are used allow an independent individual configuration. In addition, it is possible to calm the room completely by turning all the rotating corps with the closed side towards the centre.

Surface-mounted wiring and lighting rethought

When implementing the lighting concept, it is important to note that all cables are laid on the surface in order to save material and space for the installation level on the one hand, to react flexibly to new room uses or requirements and to simplify maintenance work and destruction process on the other.

In order to allow easy and flexible installation of lights even for laymen, the DCTAPE system was developed for the project. This new type of surface-mounted installation consists of a thin zinc conductor strip that can be taped to ceilings and walls. Lights (and in future also USB sockets) then can be flexibly plugged into the DCTAPE by the user. Thus, the lighting can be adjusted individually to his needs. This results in a graphic image of surface mounted tapes on the ceilings and walls.

The lighting concept of the kitchen and the bathroom consists of creating light based on the user's daily routine. There, the ceiling light can be used to create a “light shower” that vitalizes the body in the morning hours and supports the release of melatonin in the evening by changing the color temperature and illuminance, thus helping the user to fall asleep (Human Centric Lighting).

3.1.4 **Solar System Integration**

The solar systems are also a major aspect of the architectural concept, that rather than hidden away, they determine the building's aesthetic while also having several technical functions.

Innovative organic photovoltaic (OPV) technology is being used on the façade and roof with individual, diamond-shaped OPV cells. These are set into the steel cable mesh attached on the outside of the Grid structure which surrounds the whole building. The cable mesh has large diamond shaped openings, about 95.3cm in height and 55cm in width, with a 60° angle at the top/ bottom.

A simulation is used to determine the optimal placement of the OPV cells on the facade. The criteria for the placement of the shading elements for Building 5 in Stuttgart are optimal shading of the windows in summer and at the same time allowing radiation to pass through for solar heat gains in winter.

The result shows the optimal placement of the OPV cells on the façade and roof, taking the criteria into account. The simulation and the resulting shading matrix are constantly updated as changes are made to the design or other parameters. One of the biggest advantages of this simulation tool is its transferability: with the right inputs, a customized, optimized shading model can be created for each site and project.

3.1.5 **Housing Demonstration Unit**

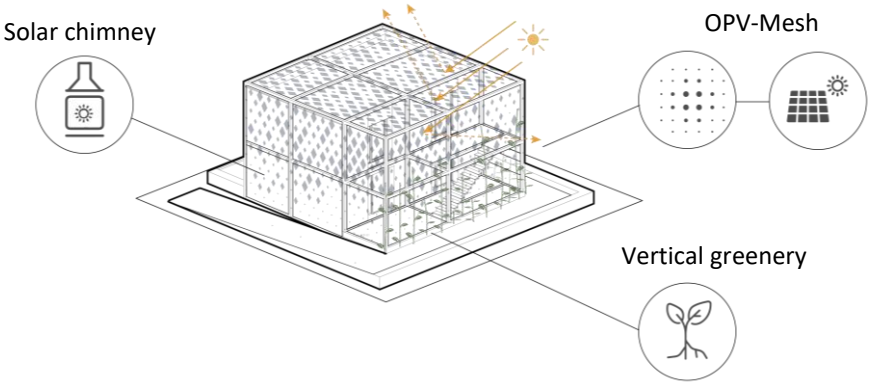


Fig. 3.1 Façade of the Housing Demonstration Unit

The Demonstration Unit represents a segment of the Building Design in which two individual residential units are stacked on top of each other. This underlines the need for denser urban redensification. Moreover, these residential units, which are inserted into the grid, offer space for individual design and creativity. The interior is characterised by functional walls on both sides, into which smart furniture and technical components are built. Next to it is a two-storey unit placed, that

will be converted into an arrival and exhibition space to inform visitors about the projects aim and to engage with the project content.

In the interests of the construction process and manufacture, the front edges of the units are aligned with each other. The grid, which provides the infrastructure for everything to come, is also essential to the assembly of the façade and spatial boundary of the two-storey open space to the south. The communal area is obligatory for a functioning common well-being and strengthens relationships and exciting exchange among each other. The mesh façade with integrated solar system supports the open space character within the HDU and the relation between inside and outside. It is important to think of the HDU in the fifth view as well. Accordingly, it was decided to draw the mesh over the roof area - unlike the overall design. The potential and concept of the mesh is reinforced in its function and declination as an uncompromising solar system providing energy for the HDU. Although the ground-level vertical façade greening is not used on the extension, it is nevertheless intended to demonstrate the architectural appeal of how the two structures are interwoven in the HDU.

Fig. 3.2 Visualisation of the Housing Demonstration Unit

3.2 Engineering and construction

3.2.1 Energy Concept

Overview – Active and Passive

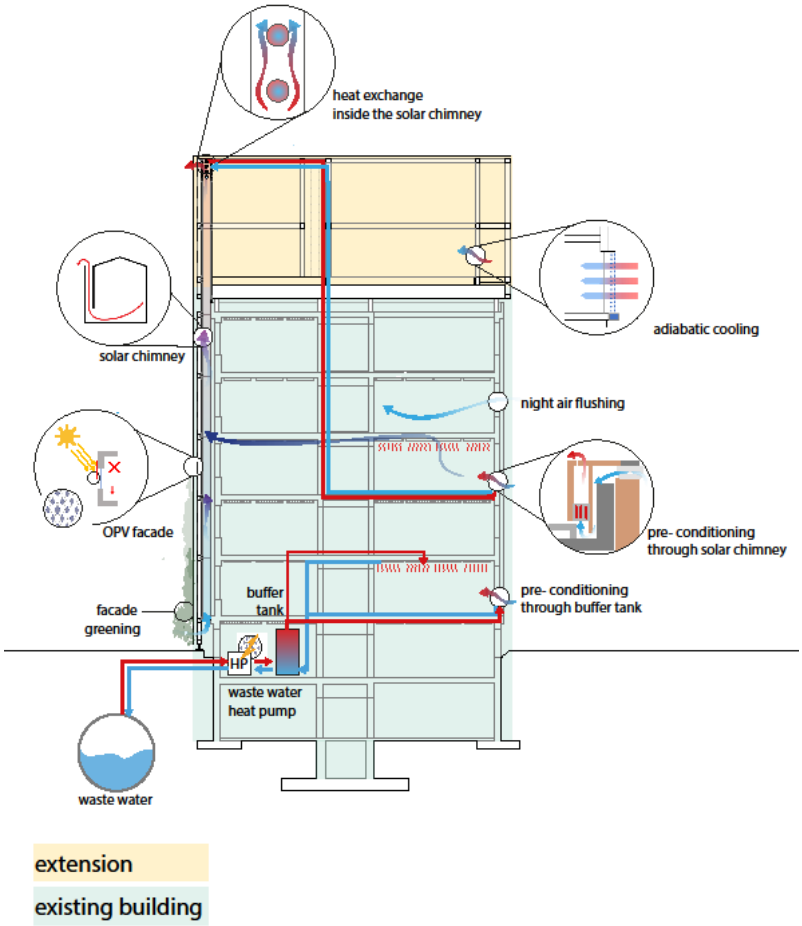


Fig.3.6:Energy concept

Ventilation Concept

The low-tech ventilation system for the renovation part of the coLLab project consists of decentralized trickle vents to ensure a hygienic air change rate year-round. These trickle vents are intelligently combined with a heating element to pre-heat the supply air in winter ("pre-condition through buffer tank" and "pre-condition through solar chimney"). A solar chimney is used to naturally exhaust air out of the building through thermal buoyancy. At the top of the solar chimney an air to water heat exchanger is placed and connected to the supply air heating element via a run-around coil heat recovery system to pre-condition the supply air in selected rooms. In the rest of the rooms, the pre-conditioning element is supplied with warm water from the buffer tank. During shoulder seasons and in summer the heat exchanger in the solar chimney is bypassed and natural ventilation is boosted. The non-load-bearing pillars of the façade of the existing building are replaced by vertical ventilation flaps that allow for nighttime flushing without endangering the safety of the building.

The residential modules of the extension feature cross-ventilation from the operable windows and are not connected to the solar chimney. In summer the supply air is adiabatically cooled with a water feature in front of the window.

Space Heating and Domestic Hot Water

The main sewer near building 5 serves as the environmental heat source for a heat pump. The heat is distributed in the building via radiant ceilings panels. To cover the domestic hot water demand in the building, decentralized fresh-water stations are placed in the residential modules.

OPV Façade – Shading and Renewable Energy

The GRID is the basic architectural construction and is based on the existing building. It is a constructive skeleton, which is adaptable in size depending on the existing building and its load bearing structure. The spaces between the wooden structure of the GRID are filled with organic PV collectors (OPV), which function as shading elements and generate electricity renewably. They are automatically scaled and distributed based on simulation results in accordance with the greatest benefit for indoor comfort. On the roof of the residential modules, monocrystalline PV collectors are placed (refer to innovation report).

System Design - Active

The main part of the heating and DHW demand is covered by two 40 kW cascading brine/water heat pumps in bivalent-parallel operation with wastewater as the environmental heat source. The peak loads are covered by the existing district heat. The PV System generates electricity for self-consumption. To improve the self-consumption rate, a battery storage is included.

PV System and Battery

The PV System consists of organic photovoltaic modules and monocrystalline silicon-based photovoltaic modules. If there is electric yield, the priority is to directly cover the existing building demand. If there is surplus afterwards, it is fed into the battery for later use. When the battery is full, the electricity is fed into the grid. An increased self-consumption rate of solar power reduces the decentralized feed in energy into the grid during peak hours. Hereby, the control complexity to maintain the target frequency in the grid is reduced. If the building demand cannot be met by means of the battery or direct use, electricity is extracted from the grid.

Heating

Even without the power needed for the heat pump, the electricity demand of the building significantly surpasses the yield generated by the PV-system. Therefore, the heat pumps are operated heating demand driven, eliminating the need for a large puffer tank. The heat pumps operate parallel since the temperature of the wastewater is constant year-round (12°C). A COP of around 7 is maintained, even on cold days with high loads. For smaller loads, only one heat pump, and for higher loads two heat pumps are running. Peak loads are covered by the existing district heat.

DHW and legionella protection

If there is solar power excess, and all other building electricity demand has been met, the heat pump is operated, regardless of heating demand. This mainly happens during shoulder seasons and in summer. The generated hot water is stored in the puffer tank and used for domestic hot water production in the residential modules that make up most of the domestic hot water demand. The hot water from the buffer tank is used to supply decentralized fresh water stations in each module. The energy is passed to the incoming fresh water via a heat exchanger. If the desired temperature level is not met, the DHW is further heated electrically. Since the DHW water volume after the fresh water station is less than 3 liters and only heated according to demand, no further legionella protection is required. In the existing building, there are only a few taps (café, tea kitchen) that require domestic hot water. Therefore, electrical decentralized instantaneous water heaters are installed here.

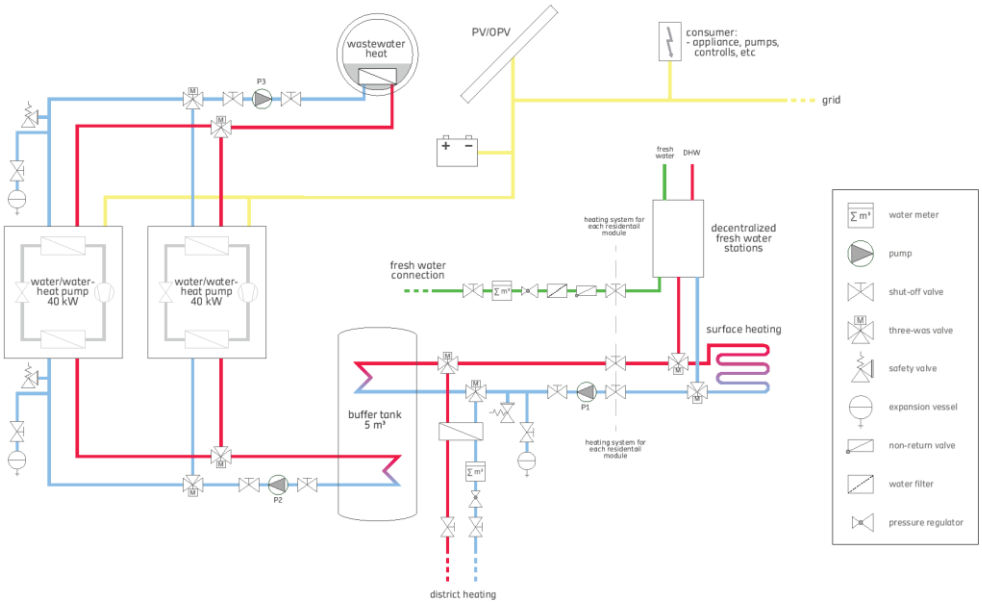


Fig. 3.7: Energy system with DHW for the extension

3.2.2 Performance Analysis

A parametric study, with varying heat pump capacity and battery storage capacity was conducted and the results were compared in terms of Co2 emissions over the life cycle and in operation. The optimum sizes fir the systems are 2 cascading 40kW heat pumps and a 50 kWh battery storage (refer to engineering and construction report).

The following figures show how the required energy is provided to cover the electrical and thermal demand. The left bars in the diagrams show the demand and the right bars how this demand is met. Both the existing building and the addition are considered. The coverage rates are obtained from the simulation described in the previous chapter.

The figure below shows the coverage of the thermal energy demand (DHW and heating). The thermal heating energy marked in dark yellow is provided by the heat pump. This amount of energy is divided into the electrical and thermal parts of the heat pump. The light-yellow marked part is covered by electric reheating and makes up the lowest coverage, since this only happens with the electric reheating of the DHW in residential modules. The remaining heat demand of 13.9 % is covered by district heating.

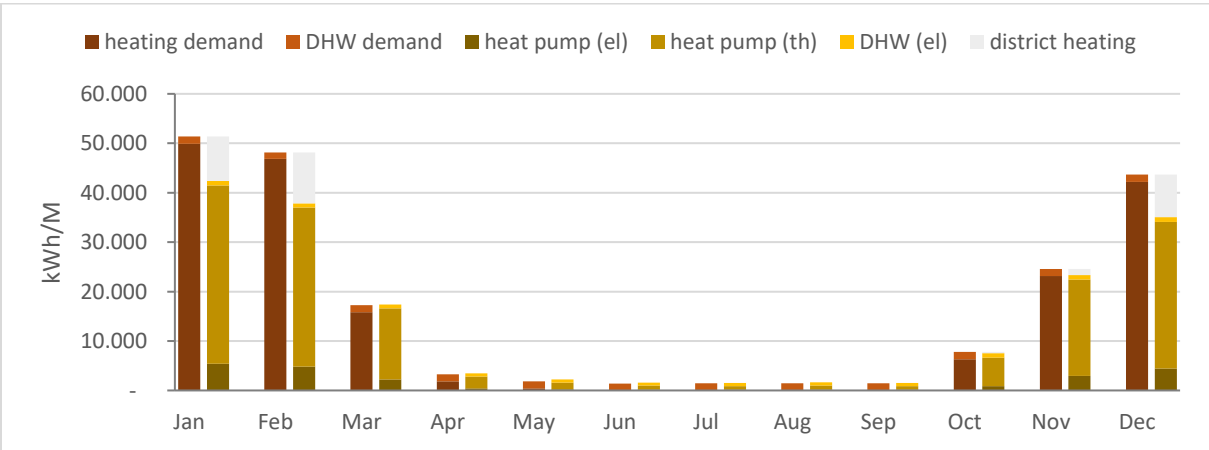


Fig. 3.8:Thermal energy demand and supply

The electricity demand in the figure below is composed of the demand of household appliances (appliances, lights, etc.), the electric domestic hot water reheating, the demand of the heat pump and the other pumps. This demand can be covered to 35.3 % by the solar direct use and to 4.2 % by the solar electricity stored in battery. In total, 39.5 % is covered by solar energy. The remaining demand is covered by the grid.

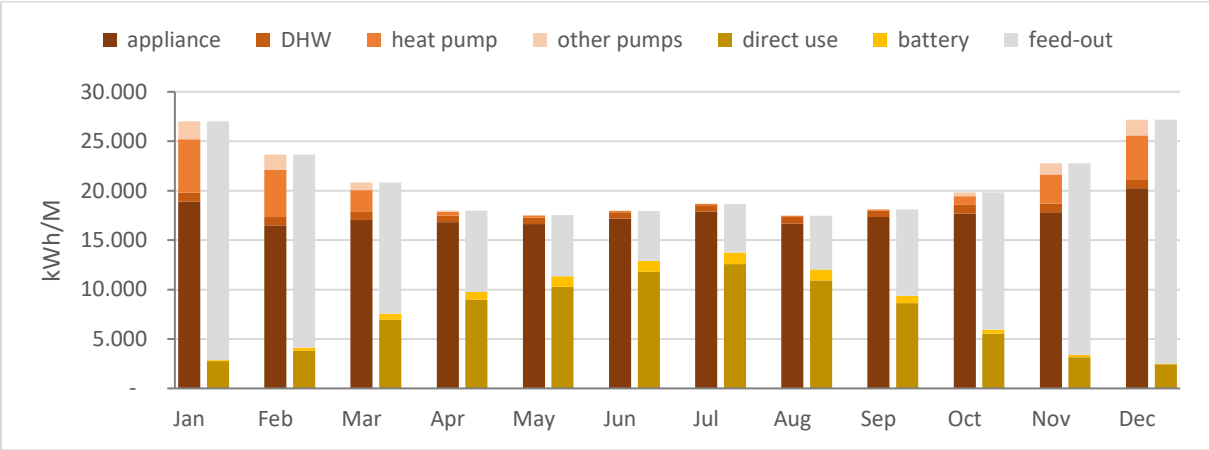


Fig. 3.9: Electrical energy demand and supply

68.4% of the generated electricity is consumed directly. The battery increases the consumption rate to 74.4%. In total, only about a quarter of the generated energy is not used and fed into the grid.

3.2.3 **LifeCycle Carbon Footprint**

The OPV Façade, Solar chimney and adiabatic cooling elements described in "Overview" are transferred to the HDU.

There is no active heating of the HDU in the competition period. However, since the LCA is to be conducted for a period of 50 years, active heating is simulated in SimRoom.
The thermal heating demand for the HDU is **34.30 kWh/m²** and **46.16 kWh/m²** for DHW. These values are calculated based on a residential profile. It is assumed that to cover the electricity required to meet the thermal energy demand, a brine/water heat pump with a COP of 3.5 is used.

The CO_2 equivalencies from the other life-cycle phases were determined as a part of the sustainability contest (UMI Tool) and are seen in the diagram below. With all the assumption made the total Carbon Footprint of the building is **45281 kg CO_2e/50a**.

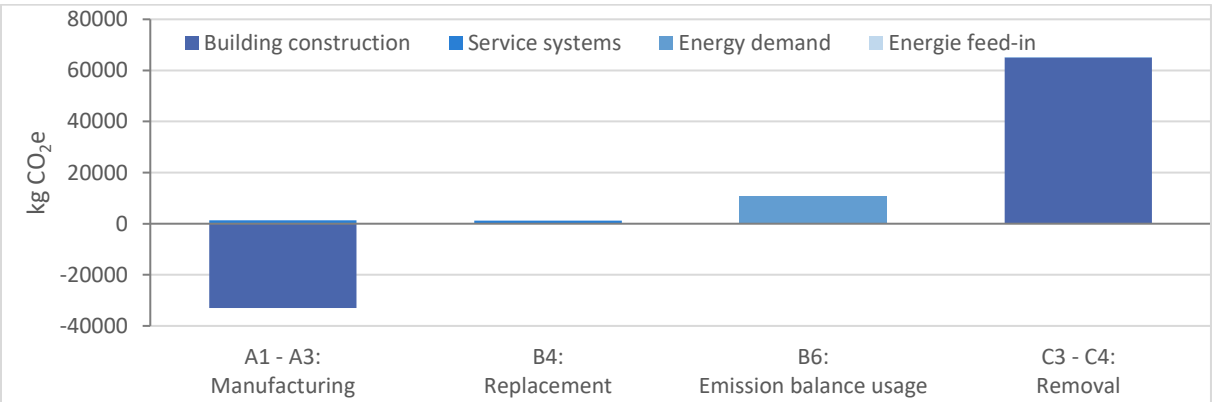


Fig.3.10:: Life cycle analysis

3.3 Affordability & Viability

3.3.1 Introduction

The Affordability and Viability Report is seen as a crucial document regarding the purpose and the strategy of the SDE21. Social, economic and urban issues are tackled. The background as well as the strategy and the developed solutions of the collab contribution are described and illustrated.

3.3.2 Analysis

Stuttgart is surrounded by hills and therefore located in a “Kessellage” or “Boiler Location”. An expansion of the city is consequential limited. Lacking land to build on leads to the question how the urgently needed residential demand shall be supplied.

The chosen location, the HFT Stuttgart campus, is placed directly in downtown Stuttgart. Therefore, the described situation is perfectly suitable for our project. Stuttgart (and the campus) indicates a lack of free building land and a high potential to use existing constructions to be renovated and extended. Because of the limited building land and apartments, the offer cannot meet the demand. The scarcity of building land leads to strongly increasing construction, property and rental prices.

The mentioned, increasingly high rental prices lead to social tension and problems along the inhabitants of Stuttgart. For the specific project, students are in the focus, but the concepts shall be valid also for other residential developments.

Most students do not need much space to live. Furthermore, one of the main criteria upon which they choose their place is their budget. Therefore, rents and operational costs must be affordable.

Our project provides affordable appartements for younger people and creates spaces on the roof of existing buildings to come together. The concept for affordability targeted in the concepts this summer semester. More affordable living space encourages more people to move to the downtown, which can stop the abandonment of the inner city. Residents will stay overnight, populate parks, bars and streets, creating a more attractive and social environment.

3.3.3 Concepts

Concept of Affordability and Economic Viability

We have many different aspects, which all combined lead to decreased operating costs. Operating costs can be divided in fixed a variable cost, e.g. heating pump and solar cells. These reduce our fixed operational costs which makes the rents more affordable and increases the market value. The calculated rent assumes that all apartments are open for anybody. There our rent lies in the relatively low, compared to other rents in the center of Stuttgart. For Building 5 we assumed, that after the renovation it will be used for bureaus. We calculated the rent accordingly.

The construction of housing unit alone is estimated to cost around 8.450.000 Euros. This only applies for the first time. If the concept gets reused, the fees for architect and engineers will be much lower during the repetition effect. Combined with the renovation of the complete Building 5 and considering federal funding options, the combined costs of both measures are 50.893.000 Euros. A major part of this comes from the property costs at around 18.000.000 Euros, which also include the value of Building 5.

Our first financing plan indicates that it would take 29 years to pay off the project, assuming it is bought by a private investor and with 20 per cent basic equity. However the investor had to pay more every

year, overall the project has a net return of 2,63 per cent. But, based on these results and the major impact of the construction costs we tend to the assumption, that the city should keep the property and let a non-profit organization, e.g. student union Stuttgart ("Studierendenwerk Stuttgart"), build and operate the housing unit, while renovating the Building 5 on its own. This would also make the rents more affordable, given the fact, that the student union is also public funded.

Concept of Social Viability

By creating a sustainable and affordable solution to add more living room to the city, one of the major urban issues of Stuttgart is tackled. The project gives residents the possibility to live in the inner city, in a modern building with an affordable rent. The concept of extension helps to utilize previously unused roof space and to create additional living space on an already sealed area. Especially in densely populated cities like Stuttgart, this is a good solution to reduce the lack of housing. Compared to a normal new building, this concept requires little to no new surface to be sealed.

The settlement of the university campus has some positive effects for both the university and its neighbors. For students, living directly on campus offers the advantage of noticeably short distances and thus the saving of travel time.

Furthermore, the construction of the addition is planned in such a way that the grid and the OPV create a particularly innovative living feeling. In the communal areas, you are outside but still inside. The OPV modules suspended in the grid allow some wind to circulate but protect against strong gusts of wind and rain.

The most important aspect of interior design is flexibility. The furniture is multifunctional and can disappear completely into the walls when not needed. This flexibility makes it possible to live with less living space than one would normally need.

The solutions of the project shall not only be applicable only on the chosen building, but also offer the opportunity to be transferred to other buildings in Stuttgart and (of course depending on the local conditions) potentially all-around Europe (Solar Decathlon Europe). The main goal is to create a flexible and universal but individual design that can be adapted to different scenarios and local project specific profiles. The solution to achieve this is a modular concept. The addition consists of several individual modules that can be put together individually according to the conditions on site. The lightweight construction of the concept with wood increases the likelihood that the building can bear the additional load of the addition.

3.4 CESA

3.4.1 Responsibility for Public Relations

The project will be accompanied by public relations work throughout its duration.

The responsibilities of different persons or groups of persons (elective subjects integrated into the study program) are time-dependent.

In order to maintain an overview of the individual disciplines, a person responsible for each of the ten disciplines was recorded. As Communications Manager, Luisa Claus is responsible for the central tasks of the discipline "Communication, Education and Social Awareness”. She will take on the role of organizer, responsible for public relations, communication activities and special events of the project.

As already mentioned in past deliverables, public relations could be integrated into the elective subject “HFT goes green”. Some of the students working on public relations this semester are now continuing to work on public relations for the SDE. They form the communication team and support the communications manager.

The elective "HFT goes green" aims to make the HFT Campus more sustainable, greener and more climate-neutral. The university competition Solar Decathlon Europe 2021 in Wuppertal will also focus on a sustainable and climate-neutral campus expansion, which pursues the goal of a CO2-neutral campus. This will enable students to actively participate in interdisciplinary groups in order to contribute to the objectives of the elective, but also of the Solar Decathlon Europe 2021 (hereafter abbreviated as SDE). Past projects have already shown concepts for façade greening for university buildings, urban gardening raised beds or even the construction of noise and fine dust sensors.

3.4.2 Overall Communication Project

The aim of the coLLab team is to share its values, ideas and key messages with different target groups at local, national and international level. This will be done through events, a variety of social media platforms and publications.

The following objectives of the overall communication project were defined.

1. to present problems (in the construction industry) regarding the climate issue and motivation for participation/contribution to the solution
2. to show how the coLLab project tries to solve the problems.
3. to inform in order to then catch up with public opinion (citizen participation) and make the concept sustainable in the long term (use public feedback).
4. to strengthen the image of the HFT.
5. to attract more participants to the project and keep them informed.
6. to inform about the Solar Decathlon Europe and the exhibition at the end of the competition.

Furthermore, communication within the team is an important part of the communication strategy. The following goal was defined:

7. good cooperation/agreement in the (core) team

These communication goals were assigned to the different sub-reports. Three communication strategies were developed from this.

3.4.3 **Communication Sub-Report**

The project is a student research project. It is a project that researches current topics in the field of sustainable urban and building development and wants to pass on the course of the project as well as the findings/results. In addition, information about the course of the Solar Decathlon Europe 2021 should be provided and interest aroused.

Target Group Specific Messages

In the following the communication goals are adapted to the target groups.

HFT-Internal the aim is to raise interest in the project and to attract more participants, both at student level and at the level of administration, professors and staff.

Problems of the building industry regarding the climate-matics shall be communicated to the general public. The main aim is to bring these topics close to the target group. The aim is to make it clear in what way each person contributes to climate change through their living habits. In addition, suggestions for solutions are made that can be implemented to motivate the individual. The coLLab project should serve as a good example. A visit to the exhibition of the demonstration units in Wuppertal should be encouraged. The opinion of the general public can also contribute to the positive development of the project. Surveys will also be used to ensure the social sustainability of the project.

Above all, professionals should be kept informed on an ongoing basis in order to arouse their interest in the project. In this way sponsors can be acquired.

In order to arouse the interest of pupils and future students in the project and in studying at the HFT Stuttgart, information about the project will also be addressed to this target group.

External media can in turn reach all of the above mentioned target groups and extend the reach of the own communication strategy. For this purpose, these external media are continuously supplied with project-specific information.

Online Strategy

Similar topics are published on all channels for external communication. However, the different media deal with the topics in different depths. This automatically links medium and target group with each other. Each individual of a target group can, however, determine the depth to which the information is desired and decide on a medium. The media are linked to each other via links. It is recognizable which medium deals with the topic in which depth.

The following (social) media are already in use:

- Website
- Instagram
- YouTube
- LinkedIn

Offline Strategy

External communication should also be implemented in the form of the following measures:

- Events
- Visual Identity
- Print Media
- External Media

3.4.4 Education Sub-Report

In order to develop a good project, the cooperation with many students, professors, research staff and industrial partners with different expertise is of great importance to us, as our name coLLab suggests.

A communication strategy was designed to ensure the collaboration of the different stakeholders.

Target Group Specific Messages

In the following the communication goals are adapted to the target groups (as shown in the diagram).

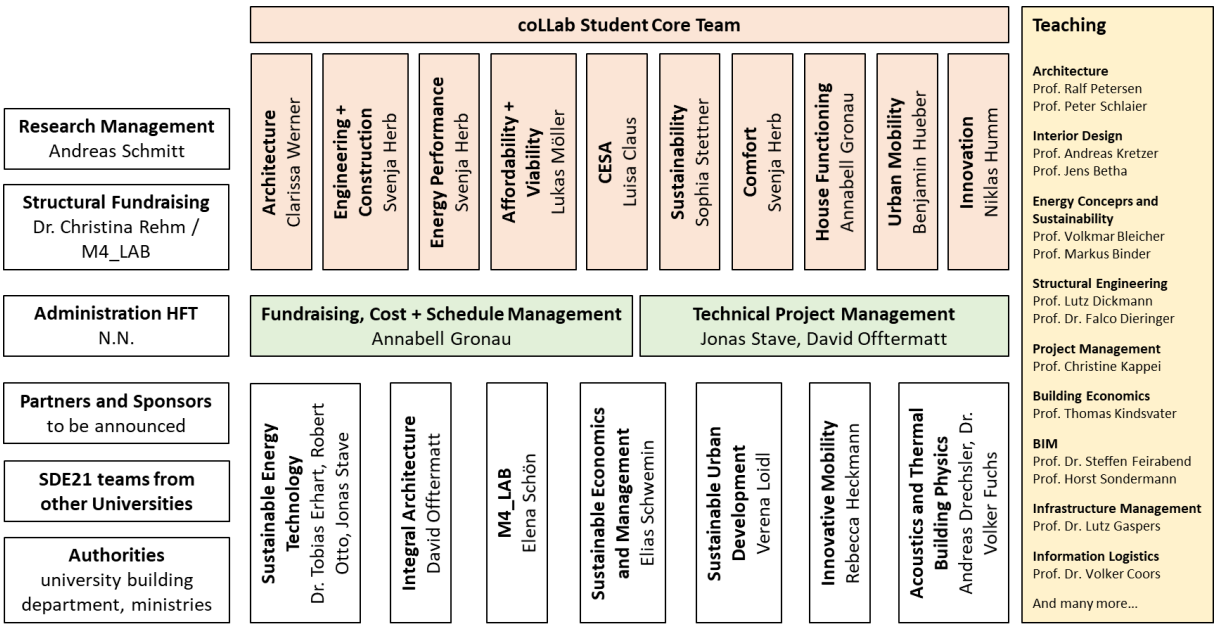


Fig.3.11: Target Groups Education

The aim of HFT-internal communication is to promote interdisciplinary cooperation between the various departments. For each work package there is a coordinator who is a member of the student core team. This coordinator is responsible for the quality and time management of the respective work package and coordinates the subjects involved. Reliable communication between the students and supervising professors involved must be ensured in order to optimise the planning result. Support from the HFT's internal research as well as administration must be ensured.

The processing of the SDE21 fits in with the university's sustainability strategy. Within the framework of the five design fields for sustainable development, HFT Stuttgart uses EMAS (Eco Management and Audit Scheme) as a fixed element of its sustainability strategy. EMAS is the environmental management certification of the European Union and is one of the most important environmental management systems to guarantee sustainable business management. EMAS activities are coordinated by the university management and the in-house Technical Department.

Concerning the research department the EnSign Reallabor project maintained by the IAF is worth mentioning, since it deals with the transition of the inner-city campus of the HFT Stuttgart into a climate neutral campus. It has already initiated a number of renovation measures. The current transdisciplinary project i_city - intelligent city researches the development of cities into sustainable, intelligent and livable urban spaces. Through the HFTmobil project, innovative logistics, payment models and energy concepts are developed.

In order to further optimise the planning result, communication with Professionals is beneficial. Although the participating universities are in competition with each other, close cooperation is planned at various levels, not least to achieve and utilise synergetic effects. In addition to the (public) project funds requested, further funds in kind and cash are needed to realise the competition

contribution. To this end, a wide variety of partners from business and industry must be found and approached. This acquisition of sponsors ensures an intensive exchange between the university and the industrial partner and, in the sense of a transfer company, also focuses on the exchange of knowledge.

Communication with the city and the university building authority as well as ministries is important for the eventual realisation of the project.

Online Strategy

The following (social) media are already in use:

- Moodle
- Onedrive/bwSync&share
- Confluence

Offline Strategy

Internal communication should also be implemented in the form of the following measures:

- Projects
- Events
- Further Deepening of Topics

3.4.5 **Social Awareness Sub-Report**

The issues addressed by SDE21 are not only of interest to the construction industry. Urban housing and living is of importance to the general public. For this reason, our goal is to communicate urban sustainability issues to this target group. SDE21 and our project serve as an example for this.

on this topic are available at the HFT in research and teaching beyond the coLLab project.

Target Group Specific Messages

In the following the communication goals are adapted to the target groups.

The goal of HFT-Internal communication is to improve collaboration between the different communication teams (official, teaching and research) in order to transfer knowledge about the topic of sustainable built environment to the public. The expertise in this area is at the HFT through the different departments.

Knowledge transfer is intended to inform the Broad Public about the importance of the issue and possibly call for action. Pupils should be introduced to the topic and interest in an education with a focus on this topic should be aroused. The general public should be stimulated to talk about the controversial topic and thus increase the publicity.

3.5 Sustainability

3.5.1 Circularity

Materials

In the current design, certified wood is the predominant building material. Wooden houses store CO2 instead of emitting new CO2, which results in a very good performance of grey energy. Only certified wood is used in the design, as this is the only way to ensure that it is a truly sustainable building material. Components made of certified wood are for example wooden beams for the grid, terrace planks, wood-aluminum windows and large parts of the interior like multifunctional furniture. Natural rubber flooring from the manufacturer Nora was selected for the floor covering. Rubber was chosen because it is made from natural materials and is very durable. The flat roof is sealed at the top by an EPDM rubber membrane. For the exterior walls, a vapor barrier made of building paper is used, which is an ecological solution. Recycled materials are also used in the design. The wood insulation material used consists largely of wood shavings, which are produced as waste material in planning mills. The so-called HOIZ insulation is an organic insulation material certified with the Cradle-to-Cradle Gold standard. A further advantage of the insulation is that the natural materials required only cover short transport distances. To ensure that HOIZ-Bio insulation also meets the highest fire protection regulations throughout its life, it has a bio-based impregnation made of whey and soda. In addition to the certified wood, only recyclable, high-quality and pollutant-tested building materials are used. For example, instead of normal OSB boards ESB boards are used, which are awarded the Blue Angel. To enable a closed loop recycling and according to the guideline “manual of recycling”, materials of biotic or metallic origin are preferred. Non-recyclable materials of mineral or fossil origin such as mineral fiber insulating materials, PVC or laminate floor coverings as well as solvent-based paints and adhesives are consistently replaced by unproblematic substances if possible. Materials that are to be classified as hazardous substances are not used.

Construction

In the concept, great importance was attached to the fact that all components can be dismantled as easily as possible. Therefore, only connection techniques that can be released as easily as possible and without damage are used. For example, on the roof the film is only laid and weighted with planter boxes. The boards are fixed to the wooden substructure with staples and/or screws. However, the membranes for wind proofing must be tacked, otherwise their function cannot be guaranteed. The flooring is laid on the underlying layer (ESB boards) without a fixed connection. The ESB boards are screwed to the wooden beams underneath. Overall, only screws are used as a connection technique in the floor construction. The interior design should be simple and unpretentious. The furniture should be easily accessible and there is no need for flaps and drawer lands. It is made from natural wood panels. Timber-steel plug-in connectors are used for the timber-frame construction, which can therefore be easily dismantled. The variant does not require glue and is therefore advantageous for later dismantling.

Maintenance

In the context of maintenance, durability of the selected materials is important to reach a long-life span. For this reason, care is taken to ensure that the materials used last as long as possible. Due to the wood frame construction, the storey additions have a very high wood content. The wooden elements have a life span of 50 years and thus do not need to be replaced during the observation period. The horizontal sections of the grid are protected with a thin replaceable board and sheet metal, so the main structure will last 50 years. Only the terrace boards may need to be replaced prematurely. Due to the grid and the built-in OPV, these are better protected than a terrace would normally be. The horizontal installation still makes them vulnerable to wetness and humidity. However, this is not a problem. The decking boards are easily accessible and fastened with simple screw connections that

can be easily loosened. This also applies to the outermost layer of the facade. This is made of recycled wood and, like the grind and the terrace, is not structurally protected from wetness.

Circularity concept

The circularity of the current design was calculated with the UMI. The result is an Urban Mining Indicator of 74%. Comparing the individual components with each other, it is noticeable that with the Closed Loop Potential (CLP), most building parts achieve a result of around 60-80%. This is due to the high proportion of wood and its advantages: the biotic material wood is not only available in sufficient quantities in sustainable reforestation but can also be used in several cascades. At its end of life, it can be returned to the natural cycle or it can be used to produce sustainable thermal energy. The worst result was determined for the roof (post-use), partly because of the large mass of the planting substrate and due to the fact that the sustainable HOIZ insulation cannot be used here and must be replaced with ESP. To make the green roof possible, foils are needed, which also have a negative impact on the result. The loop potential, on the other hand, shows greater differences. Ceiling and foundation have a result around 80% (pre-use). This is due to the proportion of downcycled material in the flooring, which is not considered in the CLP. Since there are no downcycled materials in the roof and exterior wall, the result of CLP and LP is the same (pre-use). In post-use the exterior walls, the ceiling and the foundation have a better result (>88%) than the other components. This is mainly due to the fact that the energetic recycling of non-certified renewable materials (rubber flooring) and the possibility of downcycling (gypsum plasterboards) are considered here.

Carbon footprint of the construction

The life cycle assessment is made with the UMI and supplemented with an excel calculation based on data from Ökobaudat and the provided GWP data from Ecoinvent. The results are given in t CO2-eq and represent the so-called global warming potential (GWP). The observation period here is 50 years. The construction would cause about 9.4 t of CO_2 equivalent. As expected, construction (6.8 t CO2eq) accounts for a significantly larger share than the services system (2.6 t CO2eq). In the case of foundation, interior walls and ceiling, the high wood content leads to a negative GWP. Exterior walls and roof have a worse result. In the roof, the used EPS insulation and the waterproofing membranes cause a lot of CO2. In the case of exterior walls, this is mainly due to the large windows. The production of the insulating triple glazing is very energy intensive. In addition, a windproofing membrane is used here, whose CO2 footprint is also not insignificant.

The most relevant parts of the service system are the PV system (1.2 t CO2eq) and the connected battery (0.8 t CO2eq). The OPV used here leads to a significantly better result than would be the case with conventional PV modules. Since a single-Si or a multi-Si system would have an impact of 2.5 or 2.1 the used OPV is just about 0.2 t CO2eq/1 kWp. This is because the OPV does not require the extremely high temperatures for production that silicon modules do and therefore requires significantly less energy. LiFePO4 technology was selected as the battery. The GWP is higher (169 kg CO2eq/kWh) than with the lead-acid variant (52 kg CO2eq/kWh), but the technical and the other environmental aspects outweigh this. A lithium iron phosphate battery does not contain any toxic heavy metals such as lead, nickel, cadmium and cobalt. This technology also has an advantage when it comes to recycling. The metals used can be recycled up to 100% and also the electrode materials and the polymer separator can be recycled up to 90%. The heat pump used for hot water supply produces another 0.4 kg. Other pumps for water supply, adiabatic cooling etc. as well as water pipes and cables have only a small share in the GWP of the HDU.

3.5.2 Sufficiency, Flexibility & Environmental Performance

Biodiversity

Green roofs and façades help improve the microclimate in and around a building by binding dust and CO_2 and providing shading. Additional green open spaces only improve this aspect while also providing the residents with high-quality spaces for meeting others, and relaxation. Our concept for the Building Design includes climbing plants as façade greening, green roof areas as parts of the meeting areas on the additional storeys, and the partial renaturation of the parking lot between campus buildings 5 and 1 & 3. The renaturation involves a concept for a "tiny forest" which connects the campus with the existing "Stadtgarten" and furniture that is a combination of benches and raised beds in which edible plants (mostly vegetables and herbs) are planted. Diverse plant selections were made for all these green areas with special focus on choosing climate-resilient plants that are very well suited as bee pastures and overall enrich biodiversity of flora and fauna. As part of an elective subject, some of the "campus furniture" has already been built and planted with tomatoes and other plants and has quickly become a meeting spot for students. Prototypes for insect hotels have also been built and placed on campus building roofs. As new storeys are added to an existing building, the terrain disturbance is kept at a minimum and no new areas are sealed, quite the opposite, as the parking lot in front of the building will get renatured. For the exterior lighting concept of the HDU a criteria catalogue was put together to make sure the lighting chosen keeps light pollution minimal.

Society

The living space per person in the additional storeys is kept as minimal as possible by creating one multi-functional room per unit that can be transformed according to the resident's needs from a kitchen, workspace, to a bedroom. This is made possible by having "function-walls" on either side of the free central space that include all necessary functions. On one side are the kitchen, bathroom, and the stairs for two-storey apartments. Functional furniture like foldable tables and the bed can be stowed away in the pivotable cabinets or "corps" on the other side, which are one of the main aspects of the interior design concept. To compensate for this minimal private space, communal meeting areas are placed on the south side of the extension, in front of the units, with additional more intimate seating areas on the north side. With the new architectural concept, there will be a café on the ground floor of the existing building and large, open offices and workspaces on the other floors. The addition can house students or guest lecturers, who will only have a very short distance to travel to their work/ study places on campus or even within the same building, thus reducing mobility emissions.

An accessibility concept for the whole building has been formulated to give wheelchair users, persons with reduced mobility and with further handicaps equal access and usage possibilities throughout the building. This includes making sure that all entryways into and within the building are (wheelchair-) accessible, two lifts (one existing, one new), accessible stairs and wide hallways make all floors equally accessible to everyone. There will also now be wheelchair-accessible toilets on all floors and the two-senses principle will be implemented. One barrier-free unit is also included in our concept, it is located on the fifth floor, the additional space for turning and moving is created by connecting two units into one larger apartment.

Climate

On the campus of the University of Applied Sciences, one currently finds predominantly asphalt roads and almost completely sealed courtyards. The planned restructuring of the parking lot in the space between Building 1 and Building 5 already counteracts this problem. Green roofs also act as a good balance for sealed surfaces, especially in urban situations. Green spaces are planned for the extension of Building 5 that can absorb water and contribute to a high quality of life for residents. Green roofs or uncovered green open space on the extension currently occupy 12 % of the roof area.

Important for the heat island prevention are the building materials, also those of the outdoor facilities. Solar panels are used for the elevation, these reflect the sunlight and counteract heating up of the

building below. The street canyon adjacent to the SDE building, is reinvented as a part of the competition. The parking spaces are replaced by an urban leisure area. It is vital to be able to assess the placement of vegetation and other shading geometry and its effect on outdoor comfort.

Durability

Two aspects are important for longevity: firstly, the flexibility of the construction or building, and secondly, the durability of materials. For the flexibility of the design prepared openings between the modules are provided. This way, multiple modules can be connected horizontally into one larger apartment. In addition, the building technology is distributed in a way that four modules are always supplied together, so that each module group can be rented out to a different group of people. The modules themselves can also be easily assembled and disassembled, and can, because of their modular nature be used as extensions in many different locations and on many different buildings.

For the HDU, mainly wood and wood-based materials are used, which have a good durability. In the exhibition, the materials are cleaned often to avoid leaving dirt in the equipment. Dirt could cause the equipment to need replacing. In addition to the materials in the HDU, the building equipment is installed so that maintenance can be done quickly and easily.

Building Materials

The building materials are mostly wood or wood-based materials. The wood comes from Germany or Austria and is therefore a regional product. Due to the timber frame construction, the building does not have a large thermal mass, but has mono materiality. In addition, the wood is also used in the cladding and finishes of the interior and can regulate the humidity and air quality. To not cause any environmental impact with the ingredients of the building materials, the products used have been considered according to the specifications of the Urban-Loop-Design Checklist.

3.6 **Urban Mobility**

In the first part the Location of the project is analyzed. The building is situated in the center of Stuttgart which is the capital of Baden-Württemberg. The project regards the campus of the University of Applied Science Stuttgart and the University of Stuttgart.

By the analysation five different types of mobility are analysed. They are Pedestrians, Public Transportations, Bicycles, Cars and Mobility impaired person. Because of the centricity ways by foot from the University and the students dorm are most important. In figure 2 it's shown how many centre-relevant offers are reachable by foot.

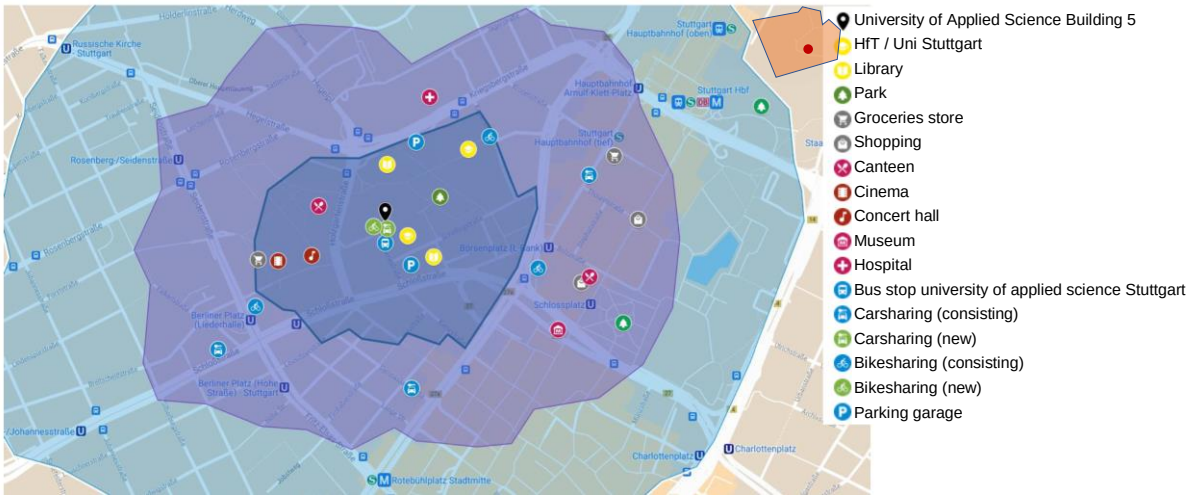


Fig. 3.12: Walking distance of University of applied science Stuttgart building 5

Although the mundane ways can be done by foot, students living in the new dorm also must go somewhere else. Additionally, the students visiting the Universities and coming from somewhere else must be taken in account.

3.6.1 **Survey of Mobility**

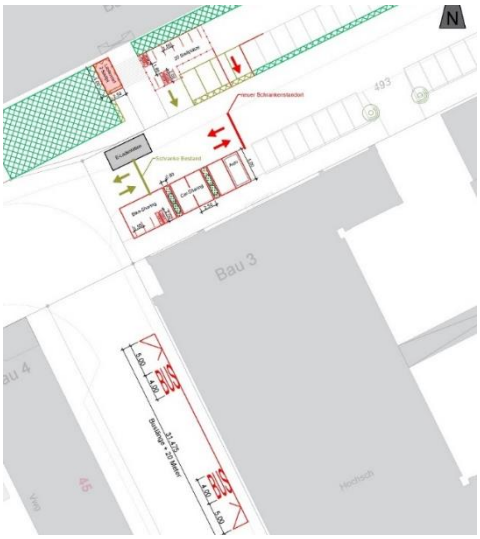
By the analysis there was made a survey at students' dorms in the inner city of Stuttgart to get a picture about the needs of students living in there.

One of the main aspects that have been figured out is that there is a need to offer a sharing car for the students living there. Regarding other kind of mobility such as public transportations or bike services the survey shows that both are already quite well although an own bus stop should be integrated in the campus and park sides for bikes do not exist in the necessitated way. Important is that many participants of the survey said that they want to use sharing bikes if they are next to the building.

3.6.2 **Conception**

One of the biggest difficulties by developing a concept of mobility is the diversity of students. Therefor four different types where created, the description can be reviewed in the full report.

Thereby recommendations about actions for the different types of mobility where made. The most important action is the development of a mobility hub next to the building site and bring most of the park sites out of the campus. In figure 4 it is shown how the facilities are arranged. It includes sharing offers of bikes and cars as well as parking lots for bikes, e-bikes etc.



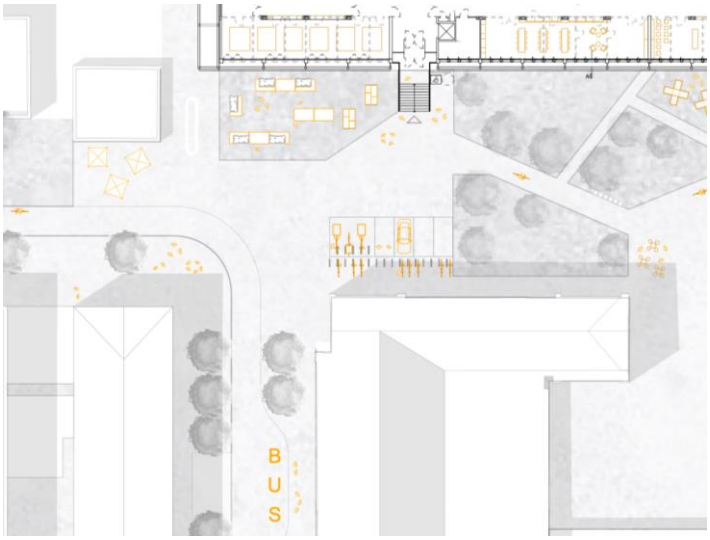


Fig.3.13: Arrangement of mobility hub

Fig.3.14: Mobility Concept on Campus

To make the campus more livable the road that crosses until now will be reduced and changed into a one-way-road. The vision for the future is, that the road is only assessable for adjacent owners like the students living in the new student's dorm, public transportations and public infrastructures.

The second step means a big intervention in the city's infrastructure, for which reason the city must change its attitude regarding car traffic. Thereby it would also be helping to reduce the street next to the campus shown in the picture on the right. This means the alteration from a car-friendly to a human-friendly city and also the transformation of the city to a future state what is a lope but can bring many advantages.

Fig.3.15: Mobility Concept for campus and surrounding

Additionally, there are developed the Smart multifunctional outdoor furniture (SMOF) that offer free space but also possibilities to charge devices like pedelecs, e-bikes or smartphones. A prototype is shown in figure 5.

They bring high qualities of stay and make the campus a more livable place for all students. Additionally they can also improve the environment by plants like shown on the picture. Special about the furniture is, that it's very easy to build and is made of old formwork panels from building sites.

3.6.3 Demand of Energy by Mobility

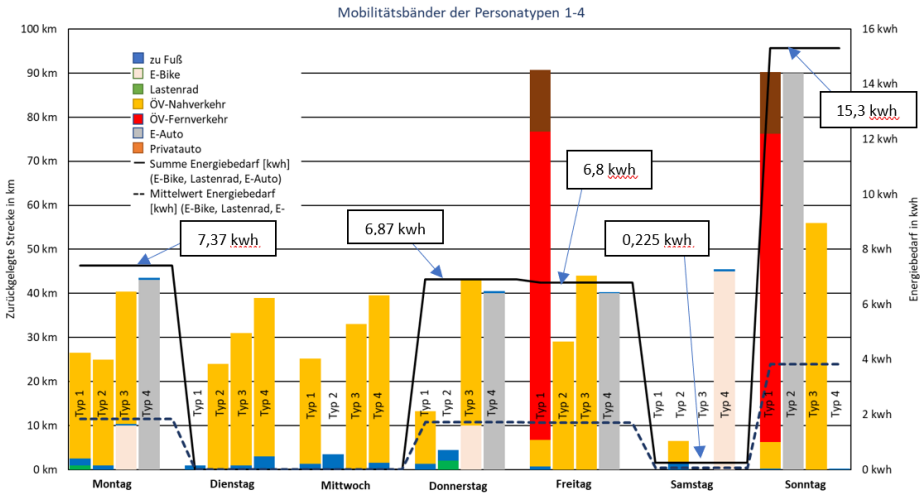
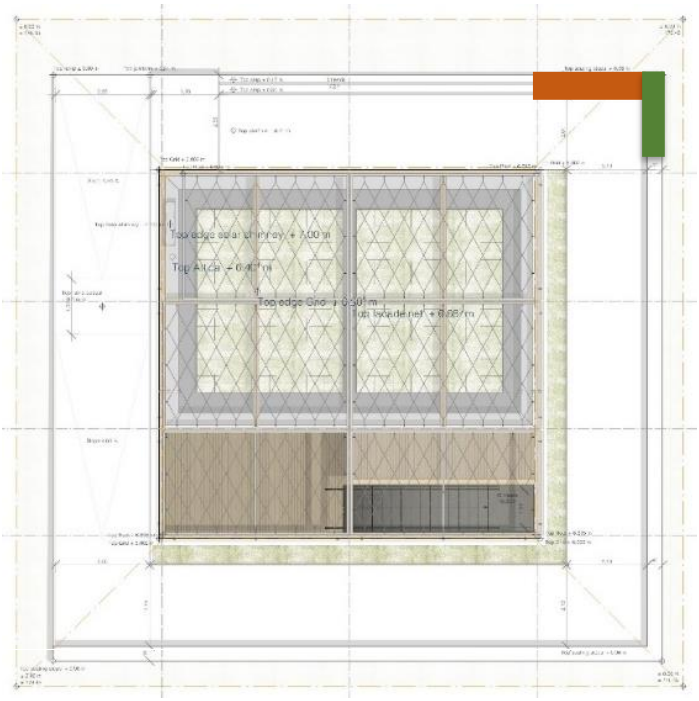


Fig.3.17: Distances travelled and energy demand

To integrate the concept of mobility into the whole project the energy demand of the mobility concept must be evaluated. Therefor figure 6 shows the ways travelled with the sharing car and e-bikes dependent of the time and the energy that is needed by these mobility offers. This will be an important way of energy management in the future when most of our energy comes from inconsistent renewables and must be saved and used at specific times. So thereby the project goes a new way where all consumers and producers become prosumers.

3.6.4 Mobility Concept on HDU

The main factor of the mobility concept is a mobility hub in the centre of the campus where different kind of mobility are used. One of them are pedelecs and e-bikes that must be loaded electrically. In section 3 the concept shows a smart multifunctional outdoor furniture (SMOF) that provides space to linger but also the possibility to load electric devices like pedelecs and e-bikes and even smartphones etc. To show this at the HDU one module of this furniture is placed on the solar campus. In picture 6 the position of the furniture is shown (orange) just as the position of Information terminals which will be placed to show the concept in general. So, the furniture can already be experienced in its actual function while wating to enter the demonstration Unit of the team coLLab. Additionally there will be the possibility for the visitors of the SDE21 to have a look on a website that shows the mobility concept. The website will easily be reachable by instructions at the smart furniture and barrier free for smartphones.



To make the mobility concept more visible there will a pedelec be placed at the furniture combined with a bike-trailer. This will also be the vehicle to go for shopping for the cooking challenge (green).

4 ARCHITECTURE DESIGN REPORT

coLlab

4.1 General Architectural Concept

The general goals of the urban planning and architectural concept are discussed below. The existing situation and its problems will be explained in more detail. In addition, our visions of how the design can be integrated into the site are highlighted. The restructuring measures are used to show how this concept can be applied to the Housing Demonstration Unit (HDU). The Building Design Challenge interior concept for the HDU is exemplified and the structural design explained. Detailed solutions for the integration of solar systems and information on reconfigurable functions round off the fourth chapter.

4.1.1 General goals

“CoLLab” means collaborative laboratory, which wants to offer new forms of living collectively in urban situations on small surfaces. Furthermore, coLLab describes an extension that enters into a symbiosis with the existing building and adapts to existing structures. Moreover, the project should not only have a positive effect on the environment, but implicitly take up the human as its scale and focus on the importance of common space and social networks. The main architectural concept of coLLab stands for a minimal and smart private living space and a maximized common space. In addition, the room itself should offer the residents space to adjust individually and also to let their creative freedom unfold in their own four walls. Furthermore, the thoughts of the common area from the intelligent furniture to design more individually should become a guiding theme.

4.2 Site Integration

The HFT campus can be described as an arrangement of different buildings, some of which create qualitative urban planning situations, while others are separated from each other by oversized streets and car parks. When thinking of a campus, associations such as courtyard situations, pedestrian-friendly, human scaled, lively, ... come to mind, but which are hardly to be found on the chosen site. The individual buildings tend to function on their own and have little to do with each other except that they stand close together. After the lectures at 7 p.m., the campus is a lonely place, as employees, professors and students do not live on the premises or spend their free time there and therefore go home.

Fig.4.1 Campus overview with extension

In terms of urban development, building 5 forms the end of the campus and is oriented towards the two main buildings. A huge square which is used as a car park is located in between. On the east side a lower building with an almost identical façade structure forms the transition to the park. On the opposite side of the main buildings is a multi-storey car park and two other university buildings. In order to get to the new building and work studios, a large road must first be crossed. In contrast to the surrounding buildings, building 5 is very narrow and long, but fits well into the ensemble in terms of urban development. There is great potential in the public areas, which could unite the campus through a people-friendly design and diversified range of uses.

The aim is to create a lively and urban quarter where people work and learn, as well as live and enjoy their leisure time by adding concepts of urban living to the campus. To achieve this, not just living space but also new uses and diversified services must be created to attract different groups of people. By reactivating and using the space in front of Building 5, the campus should become a human friendly – instead of car friendly - area and promote an interlinkage to the other buildings. Above all, the cell structure and clear grid of the existing building offers good conditions for accommodating new uses. The ground floor should open up to the outside and allow insights into the interior. In the existing building, places such as inventor workshops, co working offices and cafés are conceivable.

4.2.1 **The Neighbourhood**

In context of the city the campus appears isolated from the city center and is located on an island-like area. It is neither linked to the city center nor to the adjacent residential area. Huge and highly frequented streets cut off the campus from its surrounding. Furthermore, the buildings on the campus do not have the high density expected in an urban area close to the city center. Most of the surrounding buildings are constructed massively in brick or concrete.

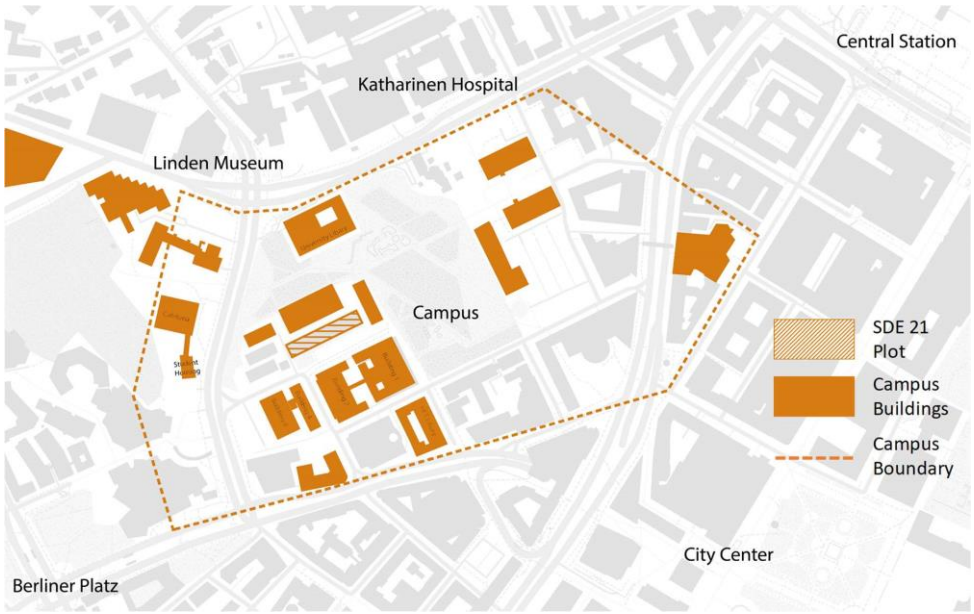


Fig. 4.2 Campus site

On the site, the buildings on the campus are used by research labs, for teachings and studies. Therefore, there is a lack of space for living, social interaction or sheltered places for leisure activities. In front of the building a space opens to the two main buildings of HFT. Although this space leads to the adjacent park, it is exclusively occupied by parking lots. Furthermore, a bypass road cuts between the university buildings, making it difficult for pedestrians to pass and to get from one to the other. In general, there are large public spaces on the campus, but these are hardly usable for pedestrians as

they are only intended for motor traffic. The only exception is the park, where many people come together when the sun shines and which poses an important air corridor and a green lunge for the neighbourhood.

4.2.2 **Site Concept**

In socio-economic as well as urban planning terms, the HFT campus holds great potential that is far from being exhausted. It is exciting to see how the campus contributes to sustainable urban development with energy-efficient buildings from the university's main research areas, using interdisciplinary technologies for spatial data and simulation.

At the moment, the use of Building 5 is limited to teaching and research. In the course of the renovation of the existing Building 5, opportunities for a variety of uses are to be seized. In order to demonstrate the range of new options available, catering and space for start-ups will be offered. In the future, the building will not only be a place for applied science, but also a house full of innovation, a place to exchange and, last but not least, a place for social interaction. The addition of storey will also create new incentives: Living and studying on campus. An exciting interface between teaching and leisure, it will initially offer students affordable living space. The vision of long-term use is a functioning community and the emergence of an intercultural village on the roofs of Stuttgart. On the top floor, pensioners, refugees, single parents with children, visiting professors, families and people in need are to be offered a home. Through social mixing, we expect valuable social interactions and a growing house community. This should be strengthened by joint projects such as urban gardening on the open space. The intergenerational transmission of knowledge or language tutoring programmes for refugees or international exchange students. The campus with its transformation into a car-free zone, as well as the transformation of Building 5, should become a social meeting place for residents and visitors and create a social togetherness. This will add positive value to Stuttgart's urban space and university atmosphere.

In order to realize this vision, various construction measures will be taken on the campus and in front of Building 5. On the one hand, measures that will be implemented in the short term and in the near future, and on the other hand, measures that require a major redesign of the campus. In the first step, we plan to integrate a Stuttgart initiative, the so-called "Wanderbaumallee", to green the parking lot in front of Building 5. This initiative designs and builds wheelbarrows that are filled with soil and trees. The Wanderbaumallee - as the name suggests - wanders from neighbourhood to neighbourhood and over a period of time provides more quality of stay, greenery and useful plants as well as seating for local people. This simple measure would already lead to an improvement of the current situation with very little effort.

The second step in redesigning the campus is self-built furniture. In the interdisciplinary project HFT Goes Green, simple furniture was developed, which was assembled from old panels. The campus furniture offers additional seating areas where students can spread out, study or exchange ideas. In addition, planting opportunities are provided to grow either crops or flowers typically used for architecture models. In Summer 2021 the realisation of the campus furniture will be accomplished, which will then provide new opportunities for social interaction.

Further down the road, the plan is to incorporate the mobility concept. Currently, a Mobility Hub is being built in front of Building 5, which will provide charging stations for e-bikes and parking facilities in the future. Further bicycle parking, e-car charging stations and sharing offers are planned and will be integrated into the urban space.

Along with the mobility area, the oversized street in front of Building 5 will be rejuvenated and declared a one-way street. This street currently serves as a shortcut for motorists to avoid a traffic light of another route. This measure should lead to a decrease in motorized traffic and ensure that there is only room for necessary motorised traffic on the campus.

The above-mentioned measures lead to the creation of a kind of entrance situation at this corner in front of Building 5. The four adjacent buildings form an urban square, which becomes a lively prelude to the campus area through green spaces, seating and mobility nodes. This area is defined as a shared space where all road users can move equally and where exciting interactions are created.

The currently existing parking lot in front of Building 5 will not be banned completely, as a certain amount of space will be needed for employee cars in the near future. Nevertheless, the minimum required parking space will be determined and the remaining parking space will be allocated to the public green space. The adjacent urban garden is to be extended towards the campus and a smooth transition to the green spaces is to be created.

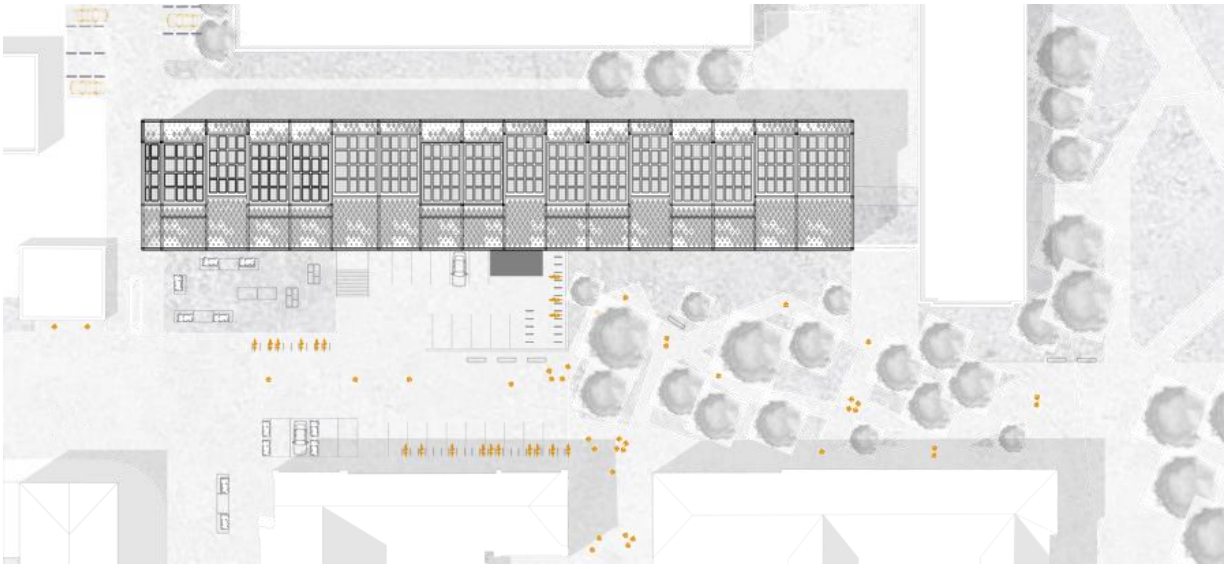


Fig. 4.3 Site concept

4.2.3 **The whole building**

The chosen building for the renovation and addition of story – called “Building 5” - was constructed between 1956 and 1959. Reinforced concrete was chosen as the construction, which is executed as exposed concrete. The facade is very strongly vertically structured. The exposed concrete facade columns alternate with non-load-bearing artificial stone columns. The corridor walls are bricked and loadbearing. The ceilings are ribbed concrete ceilings or solid flat concrete ceilings. An analysis for the solar potential of the buildings resulted in an annual yield of 1,200 kWh/m²*a.

Fig 4.4 Existing building - "Building 5"

Utilisation concept

The first floor of Building 5, which can be accessed barrier-free via an outdoor platform lift, will be opened for community use. The reinforced concrete skeleton structure makes it possible to open up the dark corridor existing in the existing building and divide it into 3 open zones. The part on the left will be used as a greenhouse, the PflanzBar. The technique of hydroponics will be applied here. So it is possible to grow and harvest vegetables, herbs or mushrooms all year round. The vertical cultivation of the products makes it possible to use every square meter highly efficiently and thus make a large yield possible. The greenhouse benefits from the surplus energy produced by the solar façade, which can be used to power the necessary LED plant lights. Also, the collected rainwater will find a reuse here.

In the first zone, located to the right of the entrance, a sharing café, the “TeilBar”, will be created. The products grown in the greenhouse can be stored, passed on or even processed here. It will also be possible to purchase leftover products from nearby supermarkets, bakeries or restaurants at a low price. Next to the TeilBar is the TinkerBar. Here used furniture can be repaired, rebuilt or exchanged. There should be room to customize his own turning corps as needed. Be it to repair a damage again, to insert another shelf or to mount a cupboard door. But here it also has space for other workshop uses, to be able to use as many items, as long as possible. So there should also be a place here for furniture, which is no longer needed. Thus, if a chair is needed, a new one does not have to be purchased, because a selection of used chairs can be created here piece by piece. To accommodate the emerging furniture warehouse, a storage area will be created in the basement. The basement will provide space for technology, as well as data centers.

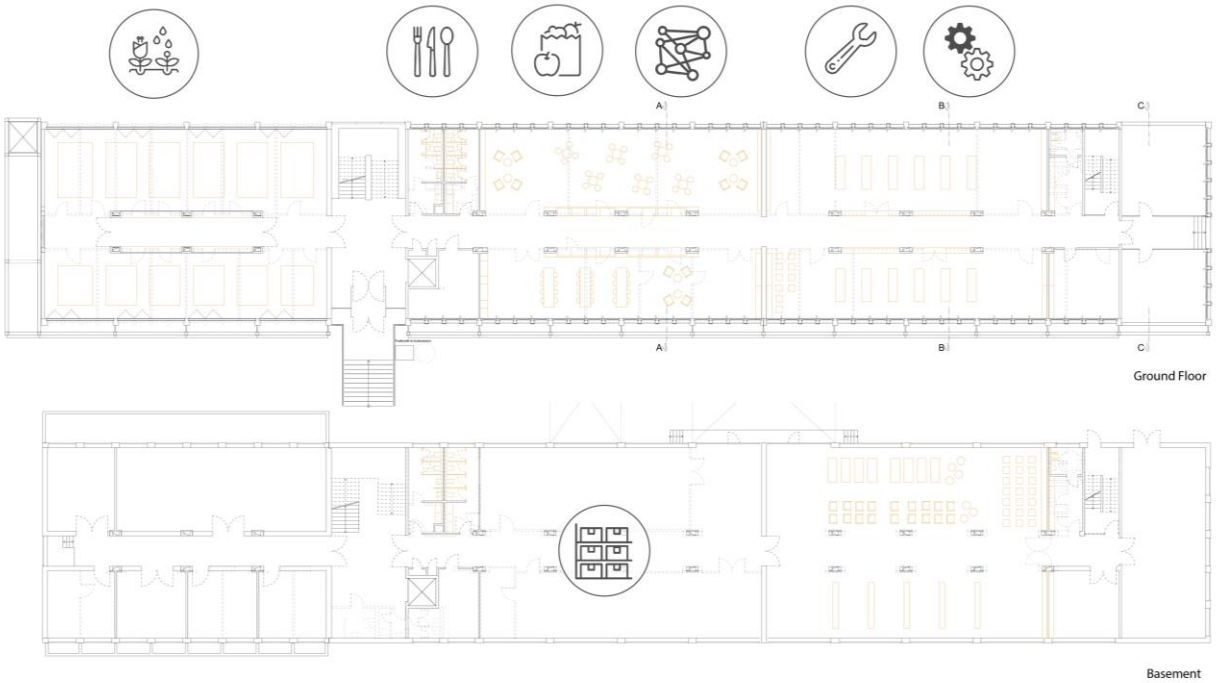


Fig 4.5 Floorplan basement and ground floor

On the upper floors, which will mainly be used for offices, it should be possible to react flexibly to different scenarios in the future. In this way, different users with different needs will be able to adapt the office space according to their needs. The previously dark central corridor can be dissolved and so-called open space office areas can be created, which can promote communication within the team. Just as it is possible to create large open spaces, it should also be possible to offer closed office spaces. Due to the renovated facade, it will no longer be possible to connect to the non-load-bearing pilaster strips with a separating wall. Automatically, larger office rooms can be created, which can be closed across the corridor.

Fig. 4.6 Floorplan first floor and second floor

4.2.4 **Renovation**

Fig. 4.7 Photo of the existing building with its southern façade

The existing Building will be renovated mainly to reduce energy consumption, but also to improve the quality of the rooms. One measure is the modification of the façade. The old concrete façade has many thermal bridges. Therefore, it's very important to reduce the heat transmission here, but we also want to keep the appearance of the old façade. The vertical pillars and horizontal ceilings give this building a unique character, which would be destroyed by putting a thick heat insulation on it.

The possible solution for this building is unconventional, but very innovative. First the white, non-weight-bearing concrete pillars, old windows and balustrades will be removed. The grey pillars and

ceilings remain. Now we have an empty grid, which can be filled with a new, prefabricated element. This new element is manufactured in wood, so its lightly and has a good insulation. With this measure, the weight of the whole building is reduced, so there are more possibilities for the two extra storeys, which will be added. The necessary pillars for the structure of the building will be insulated with a special aerogel-plaster. This will reduce the heat transmission through concrete parts.

1. Existing Building

2. Removal of non-structural parts

3. Installation of wooden elements and plastering of main pillars with ceilings

Fig 4.8 Measures of the existing building's renovation

To keep the appearance of the vertical pillars, the new wooden elements will have the same grid size, as the old façade. But here the new wooden pillars will be used to integrate a technical installation. Ventilation wings will be built into the pillars. Through these wings, fresh air can flow into the rooms. They will open, if its too hot (above 26 °C) or if the CO2 concentration in the room is too high. The two solar chimneys are responsible for the air to steam out. They build up a negative pressure, so the air flows from the rooms into a main channel and through these chimneys out of the building. With this measure the natural ventilation is improved, and energy is only used to control the wings in the façade and inside the solar chimneys. Approximately up to 20 MWh are saved per year compared to a conventional ventilation system.

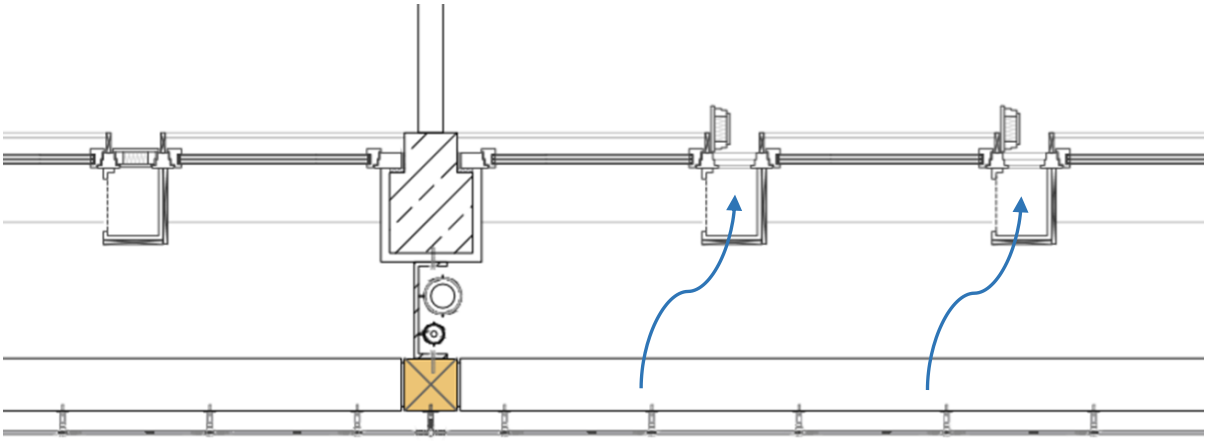


Fig. 4.9 Cutout of the ground plan with new wooden pillars as air-wings (left: closed, right: open)

To reuse the potential of the warm air, which would be blown out by the solar chimneys, heat pumps will be installed. They use the warm air of the old building to generate heat for the two extra storeys. Yet, it is not clear, if the air will directly flow into the heat pumps or if absorbers inside the solar chimneys will be used. But this is an important step to create a synergy between the existing building 5 and the two extra storeys with its student housings.

Another useful installation for the old and new part of the building is the grid, which will be installed with some space in front of the façade. Many functions are integrated, such as shading, OPV-cells and

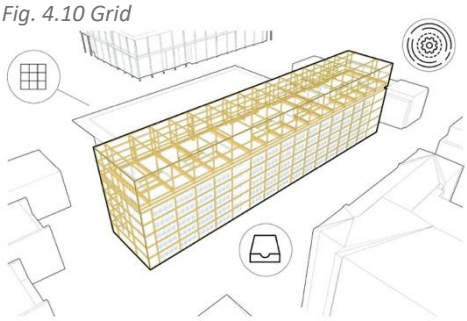
also attachment for pipes and other technical necessities. As you can see in the upper illustration, pipes for freshwater, wastewater and also for heating or cooling can be installed between the grid and the main pillar.

4.2.5 **Addition of Storey – architectural concept**

The planned addition is seen as an extension of the existing building, which is not intended as a foreign body, but is to be integrated into the existing building and the social environment of the campus. Based on this claim, an architectural concept will be developed that enables student living in minimal space. Private space requirements are kept as small as possible, and flexible, spacious areas are available for communal use.

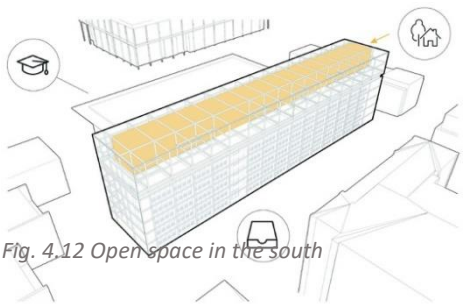
The special feature of the design is that the extension not only works on the chosen Building 5, but can also be placed on similar existing structures. In order for the concept to be not only future-proof and innovative but also to be able to survive on the market, a transferable solution is sought. To achieve this, some basic conditions for the design must be met: the modules must be flexible in their size. From these requirements, an architectural basic construction is developed, based on the existing building, the so-called grid. It is a constructive skeleton, which is adaptable in size depending on the existing building and its load bearing structure. The innovation of the design is to develop a flexible and adaptable system that creates high-quality living space in a minimal area and stands in symbiosis with its surroundings.

Fig. 4.10 Grid



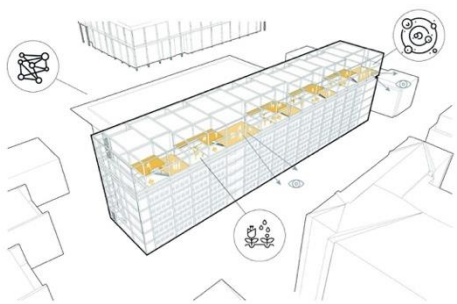
The existing structure forms the basis of the grid, which can be scaled and adapted according to requirements. Thus, the design can react to similar existing structures and guarantee the transferability of the concept. The Grid fulfills other functions in addition to the transferability of the design.

Fig. 4.11 Housing



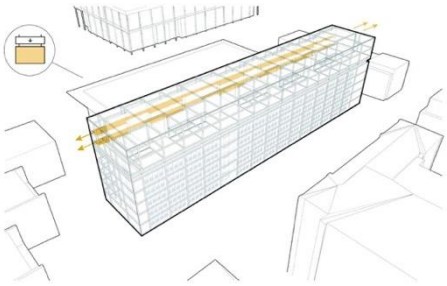
It includes the Living Block: wall panels are placed and lined up to create two- or one-story living modules for one or three people. They form a bar and are placed on the north side of the building. In order to create variety and to break up the block, the individual modules are shifted in the grid to each other. In addition, this creates zoning and private addressing.

Fig. 4.12 Open space in the south



Green and open spaces are also oriented along the structure of the grid. Are located in front of the residential units, oriented to the south side and offer view relationships to the campus and the adjacent urban garden. The green and open spaces consist of terraces that provide privacy at different levels and at the same time places for communication and interaction. This creates interweaving between the two levels, quality and varied public places for community use.

Fig. 4.13 Access of the housing units



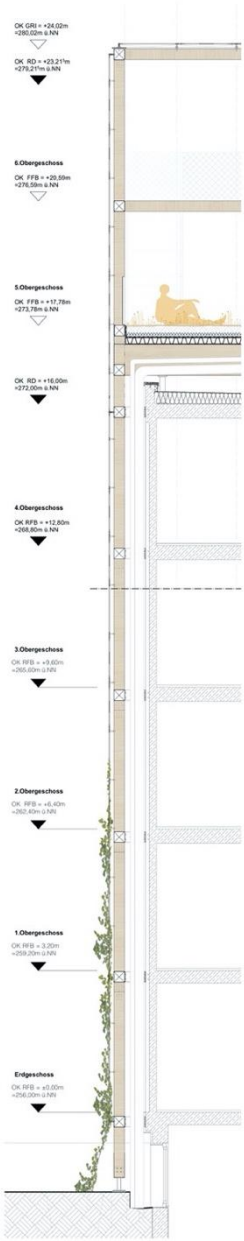
The circulation is located North of the residential units and is also connected to the grid. The staircases of the existing building are extended towards the north and lead directly to the arcades on the north side. The access also serves as an escape route, which is why the southern part functions without the creation of different fire compartments and can therefore provide maximum flexibility.

The grid significantly determines the appearance of the exterior and the facade. Pipes of the extension can run behind the grid. In front of the grid, the façade is fixed, a net structure with OPV modules. This very light looking and translucent façade - grid together with net - is also put over the existing façade.

Fig. 4.14 Floor plan 5th floor

Fig. 4.15 Floor plan 6th floor

The floor plans show that there are both two-story and single-story residential modules to meet different needs - single households and shared apartments or small families can find a home in the extension. The so-called functional walls are lined up in the grid and can be brought to the construction site prefabricated to a large extent. The shifting of the functional walls breaks the monotony and creates a varied outdoor space. This is reinforced by the different levels in front of the residential units.



A special feature of the extension is the facade. As described above, the grid is used as a structure for both the existing building and the extension. The wooden beams are placed in the grid of the existing building, creating a visual connection between the extension and the existing building. Attached to the wooden structure is a grid of wire ropes covered with diamond-shaped, translucent PV cells, so-called organic photovoltaic modules. These are attached to the net by plexiglass letters. The measures for energy production and energy saving are visibly integrated into the architecture and the appearance and show an innovative solution how solar architecture can work: The facade has to fulfill different functions together with the OPV modules. They serve as shading (summer thermal protection), must simultaneously allow sufficient light to pass through and must produce a certain energy yield. To meet these three requirements, a tool was created to simulate and calculate the optimal orientation and placement of the modules. This results in the site-specific appearance of the façade and, in our case, three different sizes of OPV cells.

The simulations show that there is not enough solar gain on the lower floors of the existing building to place OPV modules on the grid there as well. Therefore, ground-based greenery is provided on the lower floors to provide shading. The façade of the residential units and common boxes consists of vertical wooden slats. To break up the wooden façade and make entrances more recognizable, horizontal wooden panels are used above the openings.

4.2.6 Housing Demonstration Unit – Architectural Concept

Fig. 4.17 Rendering HDU

The HDU is significantly based on the Building Design and includes all conceptual considerations, innovations and ideas of the elevation. The frame of the HDU is the constructive grid, which contains two modules, forms the exterior space and is the basis of the facade. The relationship to the building design stands and falls with the formation of a two-storey unit. This is necessary so that the natural vertical façade greening on the south and east side of the unit interweaves w ith the planned industrial mesh façade and creates an architectural field of tension. The qualities that are created in the urban open space to the south of the residential units are primarily created by the delightful visual relationships of the visitors in vertical, horizontal and diagonal planes. This creates an indispensable exchange that allows social interaction. A single-storey HDU cannot cover this potential spatially and socio-economically, especially since the atriums as in the Building Design could otherwise not be shown.

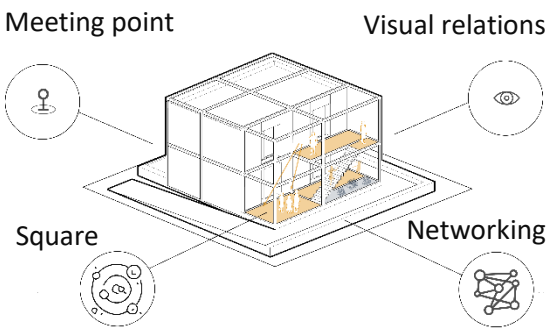


Fig. 4.18 View relations within the HDU

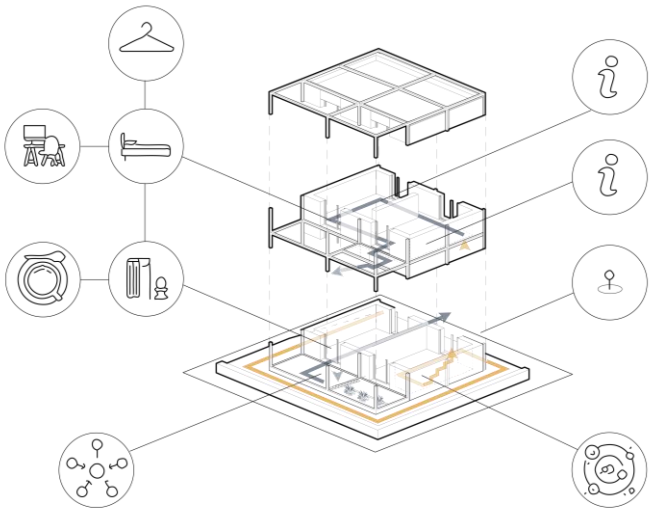


Fig. 4.19 Public Tour of the HDU

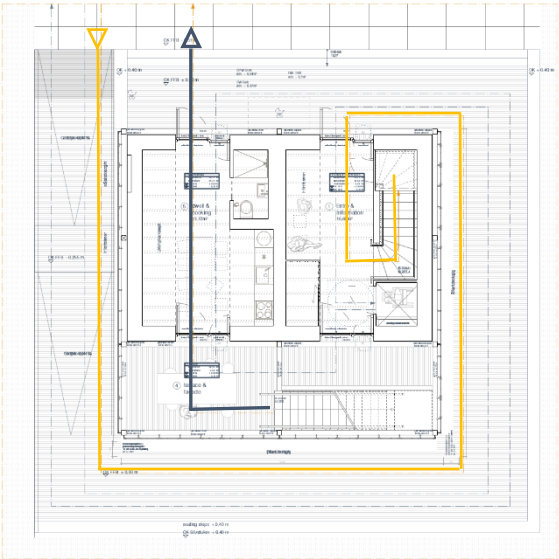


Fig.4.20 Ground floor plan

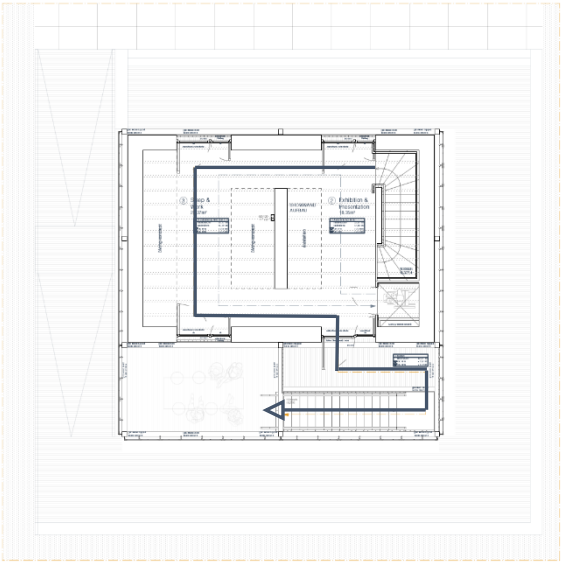


Fig.4.21 First floor plan

The HDU is accessed via a northern ramp that replicates the actual path from the existing building via the elevation to the residential units. Upon entering the HDU, one not only notices the eye-catching façade, but also the generous open and communal areas, which are not yet directly accessible from the outside. The entrance situation starts with the integrated solar chimney, which is in line with the outer wall of the residential unit and borders on the solar envelope. From the ramp, the visitor enters a platform that provides information on the problems and challenges of urban densification as they walk around the façade. A seating step borders the platform and offers waiting visitors a place to linger with a view of our demonstration unit. Exemplary of the design, the access area to the residential units is located to the north and offers HDU visitors a defined first access to a single-storey arrival space. This space explains the general aims of the project and presents the existing situation. From there, a staircase or, for those with walking difficulties, a lift leads to the upper floor.

The architectural design is explained in more detail in the exhibition room. Visitors can interact with the presented concepts and discovery them. A central wall with two openings allows the modularity of the units to be perceived and creates a horizontal connection among the units. There, living situations such as working and sleeping can be experienced and a wide variety of living space concepts can be simulated by the visitor. An external staircase connects the two floors in the outdoor area. The tour of the open space shows the interconnectedness of the floors and makes it possible to experience the common space from many angles as one walks through it. Once on the ground floor, one is guided through the exemplary fully-fledged residential unit. There, the focus of the demonstration is on communication. Spatial situations such as the living, cooking and dining areas are demonstrated here. After the exhibition has intensively dealt with the solar chimney, the unit is now not only to be perceived visually, but also made physically tangible, which contributes to the comfort and feeling of space. Finally, the entire demonstration unit exits straight out to the north. Seating steps to the north of the platform invite visitors and strollers to linger.

The architectural design of the HDU corresponds to that of the Building Design. The grid and the OPV mesh façade attached to it are formative. The façade also optimally fulfils the requirements of shading, light transmission and energy generation. The solar architecture is visibly integrated into the appearance and is brought closer to the visitors through various interactive offers within the HDU. On the west side is the solar chimney which serves for natural ventilation and allows passive cooling systems like night ventilation. On the roof of the HDU as well as on the top of the grid there are OPV modules too, to guarantee even more energy yield.

As in the overall design, ground-based greenery is to be provided, climbing up the mesh façade. These are to be grown in advance using buckets and simplify transport on site to the construction site. We also envisage greenery on the roof. These are prefabricated in modules using plastic cassettes made from recycled material, so that the unit can be easily assembled and dismantled. Through our façade concept, we make an important positive contribution to our environment and enable insect diversity and habitat for bees. In addition, urban gardening will take place in the green area within the HDU's open space.

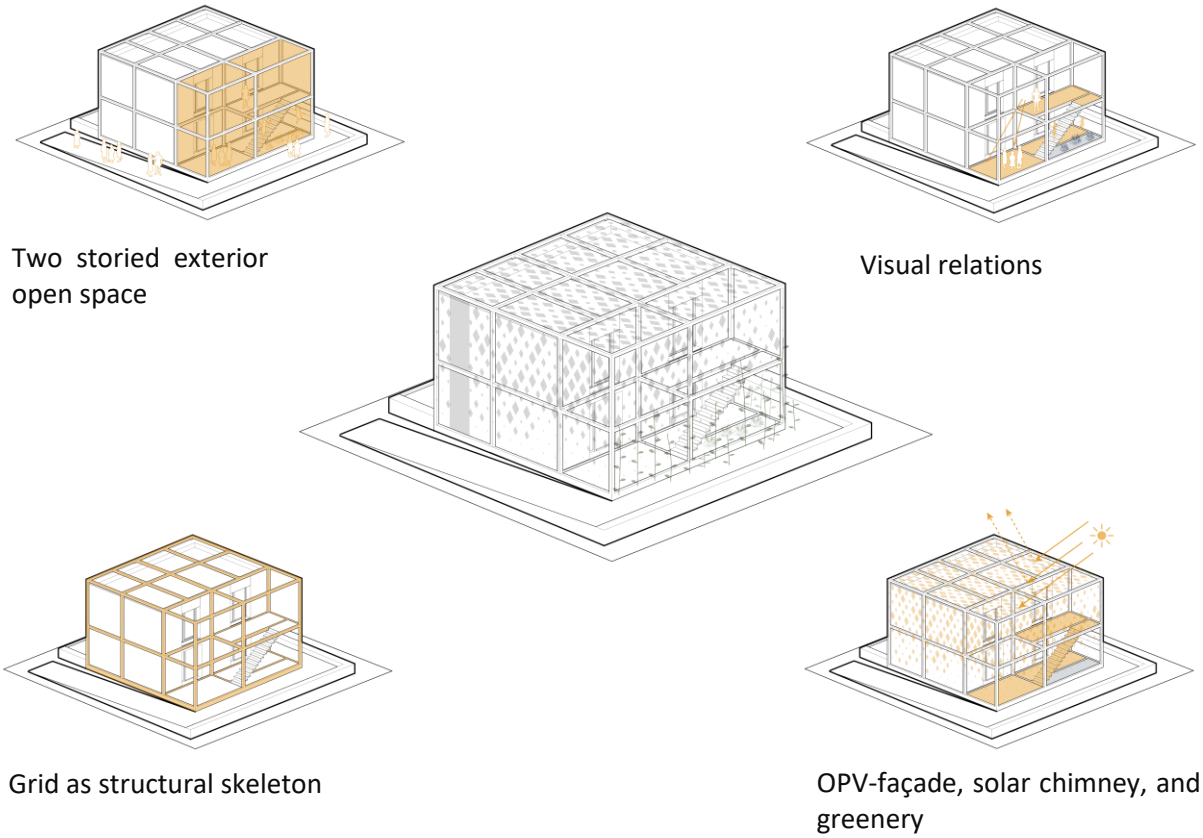


Fig. 4.22 Architectural elements transferred to the HDU

4.2.7 **BIM**

In the course of the digitalization of the construction industry, new communication channels are increasingly emerging. Building Information Modeling [BIM] represents a method of checking cross-trade data into a database using a data model. BIM-based processes have proven that the interdisciplinary work of all project participants creates added value in planning. This leads to an increase in quality and minimization of risk. In order to transfer projects from a single source of truth [SSOT] to operation, more transparency is needed in the processes on the one hand, and on the other hand, the involvement of all project participants in the traceable data exchange and its collaboration.

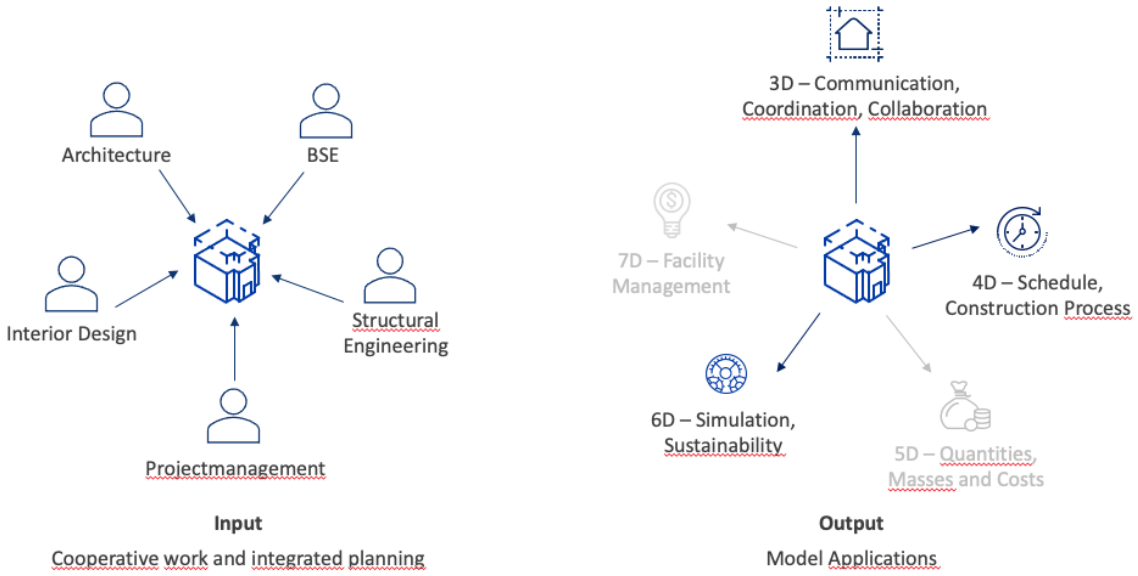


Fig. 5.24 BIM Members oft he SDE-BIM Team

coLLab – collaboration is key

In addition to the mission statement of our team "coLLab" [collaborative laboratory], the BIM method can help to increase the quality of collaboration and the transparency of planning even before the realization in Wuppertal.

Close cooperation between the planning teams promotes interdisciplinary work and collaberation in the SDE-BIM team.

BIM use cases

Coordination of specialist trades: 3D - coordination, communication, collaboration

The communication of the planning teams takes place in a weekly Jourfix via the platform Zoom. The communication was supplemented by the work with a coordination model in Solibri. For this purpose, the specialist models of the respective planning teams were regularly brought together and checked for their collisions and rules.
By connecting the coordination model with BCF live connector and BIMcollab, issues can be documented, exchanged and processed among the planning teams.
The subject models were created in different programs therefore, the IFC data models were exchanged according to the open BIM method.

Benefits

- Improvement of planning quality and work preparation.
- Efficient and structured problem identification and resolution.
- Central, transparent and traceable documentation of conflict resolution and planning changes (planning history).
- Reduction of cost and schedule risks.

Implementation

1. Quality assurance and publication of the professional models.
2. Quick check of the specialist models and preparation of the BIM status report.
3. Merging of the specialist models into a coordination model.
4. Check of the coordination model according to the specifications of the BAP.
5. Preparation, execution and documentation of the BIM coordination meeting.

6. Publication of the issues as BCF.
7. Transfer of the issues into the technical model and processing of the issues.
8. Continuous, model-based coordination with the specialist disciplines.
9. Ensuring the processing of issues.
10. Status monitoring of issue processing.

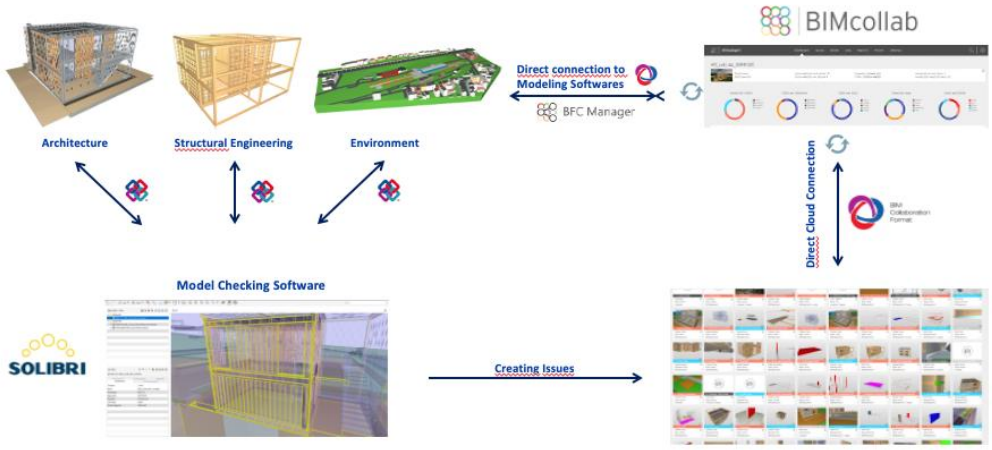


Fig. 5.25 Coordination process with BIM

Scheduling of the execution: 4D - Construction sequence simulation

The linking of scheduling with the building model forms the basis for the construction process simulation. It allows for flexibility, interoperability and accuracy at an early stage of planning.

The linking of the individual work steps of the schedule with the model elements, allows not only a detailed planning but also an intelligent timing of the activities.

Model elements are thus linked to the schedule data: start-finish dates, predecessors and successors as well as to the process ID and then simulated.

Benefits

- By linking model elements and the schedule, conflicts can be detected and resolved at an early stage. This makes it possible to create a seamless schedule.
- Increased schedule reliability through simplified communication within working project teams.
- Increased acceptance of projects with public interest through the creation of visualizations and improved communication.
- Validation of the feasibility according to the time schedule with the help of the visualized construction process.

Implementation

1. Merging of the specialized models to the overall model.
2. Linking of the model elements with the corresponding scheduling processes.
3. Creation of a construction process simulation.
4. Evaluation of the sequence on the basis of the simulation and processing of critical points in the time scheduling.
5. Check of the coordinated schedule on the basis of the construction process simulation.

! The structures of the project, model, schedule and bill of quantities must be coordinated with each other.

! Newly added activities or elements (e.g. due to disruptions in the construction process) usually have to be linked additionally and can lead to additional work.

Fig. 5.26: Excerpts of the construction process simulation of the Demonstaion Unit - SDE-BIM Team

Visualization: 6D simulation and VR-inspection

Visualizations and simulations were created for project and planning meetings. These enable transparent communication of the planning content with all project participants.
In addition, the project can be brought closer to external persons through VR inspections and arouse their interest.

Benefits

- Comprehensible representation of complex relationships in geometric and visual form
- Improved support of decision making
- Increased public acceptance through comprehensible communication of the construction project

Implementation

1. Definition of the required representations.
2. Quality assurance of the coordination model according to the specifications of the BAP and the provision of the overall model.
3. Check of the model for visualization requirements.
4. Adjustment of the LOD, material properties and illumination sources, if necessary.
5. Quality assurance of the specialized models.
6. Creation of visualizations (images, films, animations, interactive visualizations, etc.) on the basis of BIM models and with the help of suitable software products.
7. Testing and using the visualization.

Fig. 4.27 Rendering HDU on basis of BIM Model

4.2.8 **Interior design**

The whole Building

Residential units that will be inserted into the GRID offer space for individual design and creative freedom within the inhabitant's own four walls. The interior design is based on the concept of the residential modules. These are formed by the juxtaposition of functional walls. A living module consists of two intelligent walls in a row and the outer facade on the north and south sides. Within these functional walls, intelligent furniture and technology components are placed and optimally arranged.

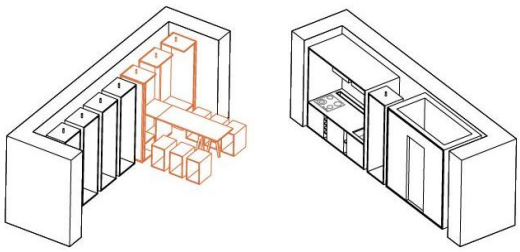


Fig. 4.28 Visualization of concept

Thus, a bed can be folded out, a table can be pulled out or chairs can be cleverly stowed away. Between the functional walls, an open space is formed that can be adapted to the needs of the occupants. While the functional walls within the living modules are always the same, the residents can individually design and appropriate the space between the walls. This guarantees transferability to existing buildings with different constructive raster and roof areas.

The interior fittings determine the functional walls. This consists of individual cabinet elements that can be rotated, the so-called rotating corps. These corps stand out from the room envelope due to their floating mounting on a ball-bearing swivel rod. This creates a light, loose spatial structure and gives room to breathe. Joints between the corps reinforce the effect and make it possible to perceive the room in its full depth. The cabinet modules are not the elements that define the space (as in a built-in cabinet) but the walls themselves.

The rotating corps are not standard furniture elements, but are specially designed for the HDU. Each corpus contains its own function and is specially designed for its function. One corpus is used to store

clothes, another can be folded out to form a table for working, and in another one books and personal items can be stored. Thus, many different spatial situations can be represented in one room.

Based on the guiding principle of architecture, the basic idea of the measures is: as much as necessary and as little as possible. The occupant is to be given an individualistic way of living. The fact that the resident can turn the modules according to the time of day and the situation in which they are used allow an independent individual configuration. In addition, it is possible to calm the room completely without irritation by turning all the rotating baskets with the closed side towards the centre.

Fig. 4.39 Rendering of the rotation corps

Opposite the corps there is a bathroom and a kitchen element. These are also visually separated from each other by a joint and can be completely prefabricated in themselves.

Fig. 4.40 & 41 Rendering of kitchen and bathroom modules

Furthermore, we also follow the principle of simplicity in the interior construction. Thus, all wiring and electronic lines are laid on the surface and made visible. This offers several advantages: On the one hand, it saves on the installation level, which means that we need less material for the wall construction than with a standard wood-frame construction. On the other hand, the system is inherently flexible and can also respond to subsequent conversions. In addition, the entire wall does not have to be broken open when renewing or replacing the cables, thus saving maintenance costs and time.

The great advantage of this concept is that it guarantees transferability to any floor plan and that the corps offer maximum flexibility. It is possible to configure whether one or the other is to be dispensed with or with which contents it is to be filled. In addition, the elements are prefabricated and subsequently implied into the room, to facilitate assembly and the construction process.

HDU

In order to do justice to the amount of content that was developed in the project “coLLab” for the Solar Decathlon, in addition to the 1:1 representation of a residential module, there are also rooms for the exhibition of the disciplines and the general question. How do we live, live and work in the city of the future using the example of an extension and renovation of an existing building?

The HDU consists of four modules, which correspond to the housing units of the addition. One module shows the housing unit of the extension itself, the other three deal with the contents of the overall project. Within the HDU, an arc of tension is formed scenographically through the public tour, which leads from the large whole further and further into the small and detailed and ends in the residential unit as a "grand finale".

In the entrance area, the selected urban situation, the HFT campus in the center of Stuttgart, is presented by an urban model and the problem of the housing shortage in inner cities is visualized by an audio installation.

The staircase leads to the next module upstairs, which deals specifically with the existing building and visually presents the proposed solutions for additions and renovations. All exhibition content was developed over the 2.5 years of the project and produced for the exhibition by students. In the next module on the upper floor, we have a closer look to the residential module. There is a "hands on" testing station where you can get acquainted with the rotating corps and test their functionality yourself. This test station intends to reinforce the individual character of the corps and to point to the workshop planned in the existing building, where the corps can be replaced or repaired by yourself. Opposite a film is played, which shows a situation within the housing unit.

Via the outside terrace one gets back to the first floor and enters the residential unit via the terrace. The special feature of the residential unit consists of the modularity and possibilities of prefabrication, which play an important role in the implementation of the HDU.

The bathroom, kitchen and bed elements can be completely prefabricated and delivered to the construction site as a whole.

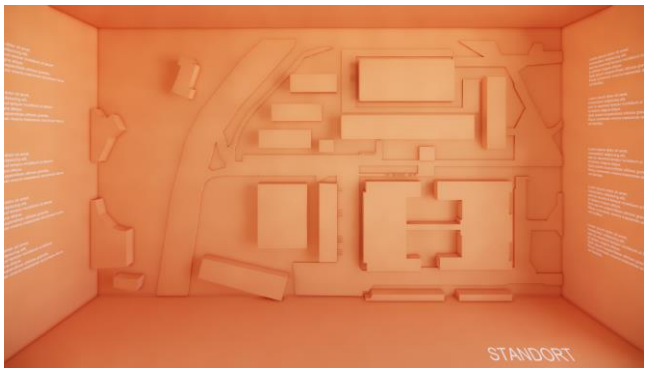


Fig. 4.42 Visualization of the site plan

The rotating corps are made of multi-layered board material and are mounted on revolving fittings. Slots are provided on the sides through which old sailcloth is stretched. In this way, the furniture can be covered by the residents themselves and adapted to individual requirements. Old sailcloth is a waste product that finds a new use in this project. Prototypes are currently being designed in the HFT workshops to work out the exact construction of this principle.

All materials are tested through in-depth analysis and research on the points of sustainability, durability and optics. All furniture is constructed according to the urban mining principle. This means that all connections can be dissolved without destroying the furniture and the materials can be separated by type. So the materials can be added back to the material cycle or reused for other extensions and projects of this kind.

Scenography

In order to present the concept of the living units - functional walls with individual living space in between - these niches are highlighted in color and made recognizable in the exhibition area as well. For this purpose, there are already many color studies with clay plaster based on the color palette of a cooperation company. For example, the staircase area will also be completely executed in this color palette, and exhibition contents will be color-matched.

Fig. 4.43 Color studies

4.2.9 **Lighting design**

The concept of as much as necessary, as little as possible also applies to lighting. At present, various variants of the lighting design for the interior are still being developed and reviewed on the basis of the interior concept. The basic objectives of the lighting design are to comply with the rules and to use light only where it is needed and, above all, when it is needed. For example, the light should be dimmed via sensors or only come on where people are present.

Fig. 4.44 Visualization of lighting concept outside

In addition to the requirements, the wooden facade is also to be staged in the outdoor area. For this purpose, luminaires are attached to the grid and the exterior façade is staged via grazing light. At the same time, these grazing lights are also to illuminate the open spaces, i.e. ramps and platform construction. Furthermore, the illumination of the wooden façade causes the translucent OPV modules to be illuminated from behind and thus appear dark. This results in an image opposite to the daytime view, in which the OPV cells form an overall image together with the rope net structure.

Surface-mounted wiring and lighting rethought

When implementing the lighting concept, that surface mounted wiring is used so all laid cables are visible. In terms of deconstructability, separation of building materials by type and ease of repair, electrical installation with surface-mounted wiring offers many advantages. In order to allow easy and flexible installation of lights even for laymen, the DCTAPE system was developed for the project. This new type of surface-mounted installation consists of a thin zinc conductor strip that can be glued to ceilings and walls. Lights (and in future also USB sockets) then can be flexibly plugged into the DCTAPE by the user. Thus, the lighting can be adjusted individually to his needs.

This also happens in the bathroom. There, the ceiling light can be used to create a “light shower” that vitalizes the body in the morning hours and supports the release of melatonin in the evening by changing the color temperature and illuminance, thus helping the user to fall asleep (Human Centric Lighting).

Direct current use

The electricity generated by the OPV façade can be temporarily stored in the battery without any conversion losses on the DC side, or it can be used directly at the Safety Extra Low Voltage (SELF) level to operate the building automation system and the LED lighting. For the lighting, the specially developed DCTAPE surface-mounted installation system is used, which has an integrated DALI bus in addition to a 48V supply. (In the HDU, direct use of DC-power is not possible due to rules of the competition).

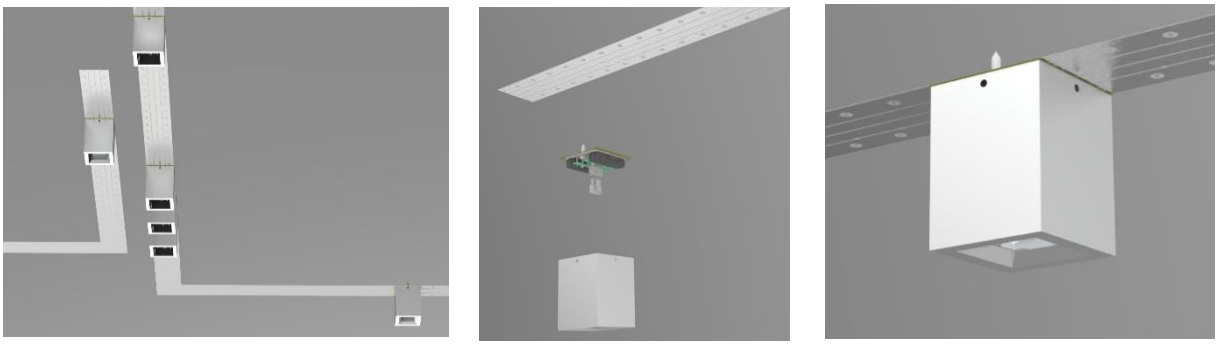


Fig. 4.45: DC tape use case

4.2.10 **Lighting Quality**

The general goal is to illuminate the HDU with natural light as much as possible. To this end, simulations are set up and different atmosphere variants are created in terms of occupancy. The aim is to ensure lighting qualities during the day as well as at night. In the interior, lighting situations are created based on various usage scenarios.

The lighting concept follows the concept of interior design, i.e. different situations are to be represented in one room. Care was taken to use lamp types that can vary both in their brightness and in the colour of the light. The focus should always be on the time of day and the person, and the lighting scenario should be adjusted accordingly (HCL).

For this purpose the following scenarios were developed:

1) Basic lighting: Clear and wide-area illumination of the room - Visual task: walking without stumbling, recognising obstacles

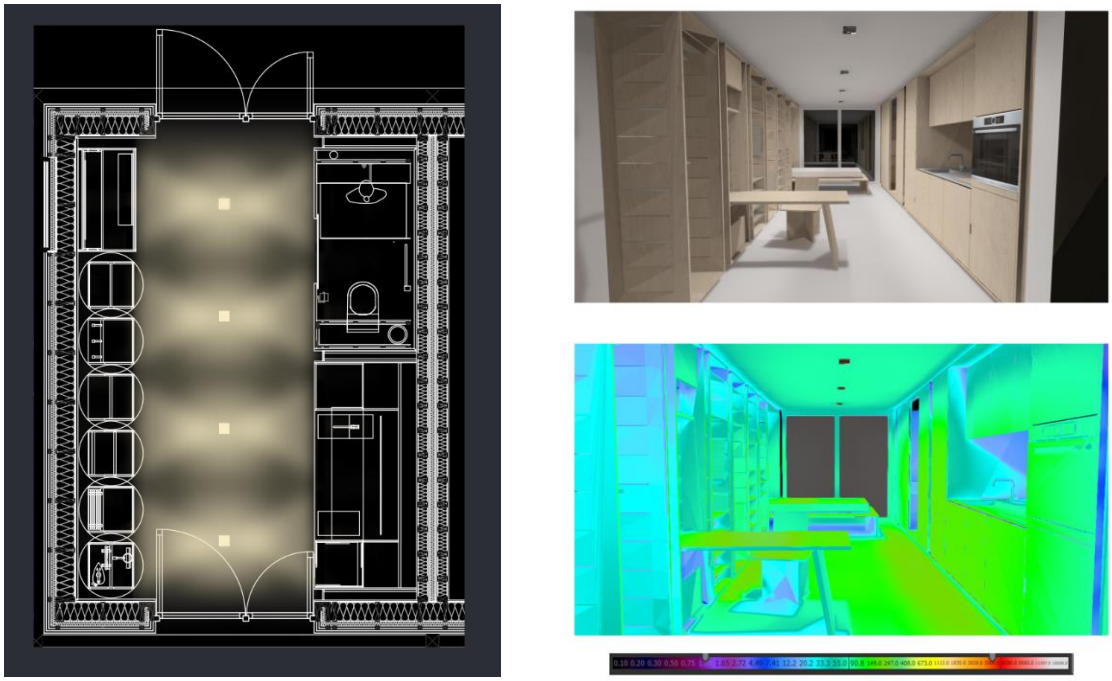


Fig. 4.46 Lighting Scenario 1

2) Light alarm clock: daylight-like for pleasant waking up, simulation of sunrise - visual task: clear illumination of the whole room with light similar to daylight

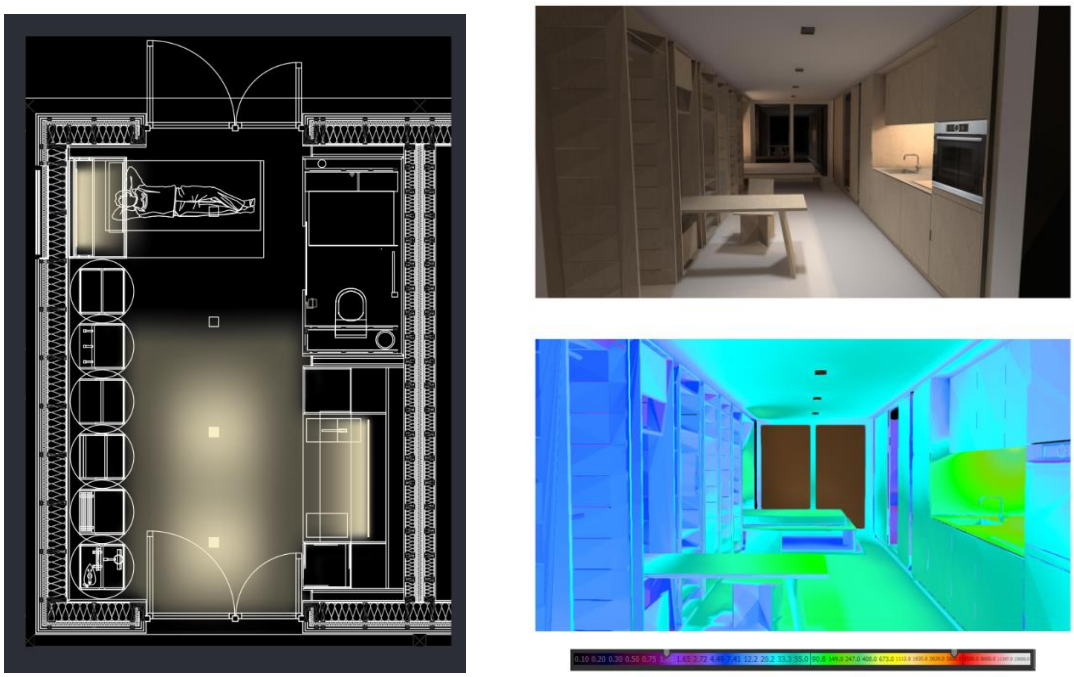


Fig. 4.47 Lighting Scenario 2

3) Light shower: bright, bluish light to wake up in the shower

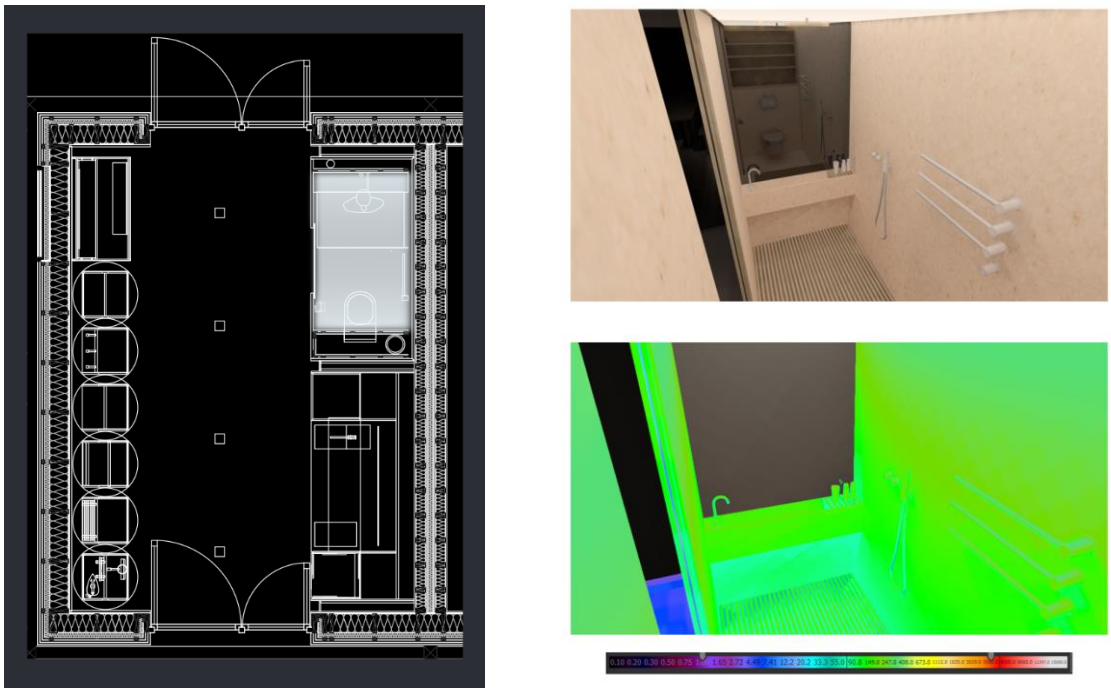


Fig. 4.48 Lighting Scenario 3

4) Working: directional, colourfast light, clear illumination of the working area - Visual task: mirror-free digital work

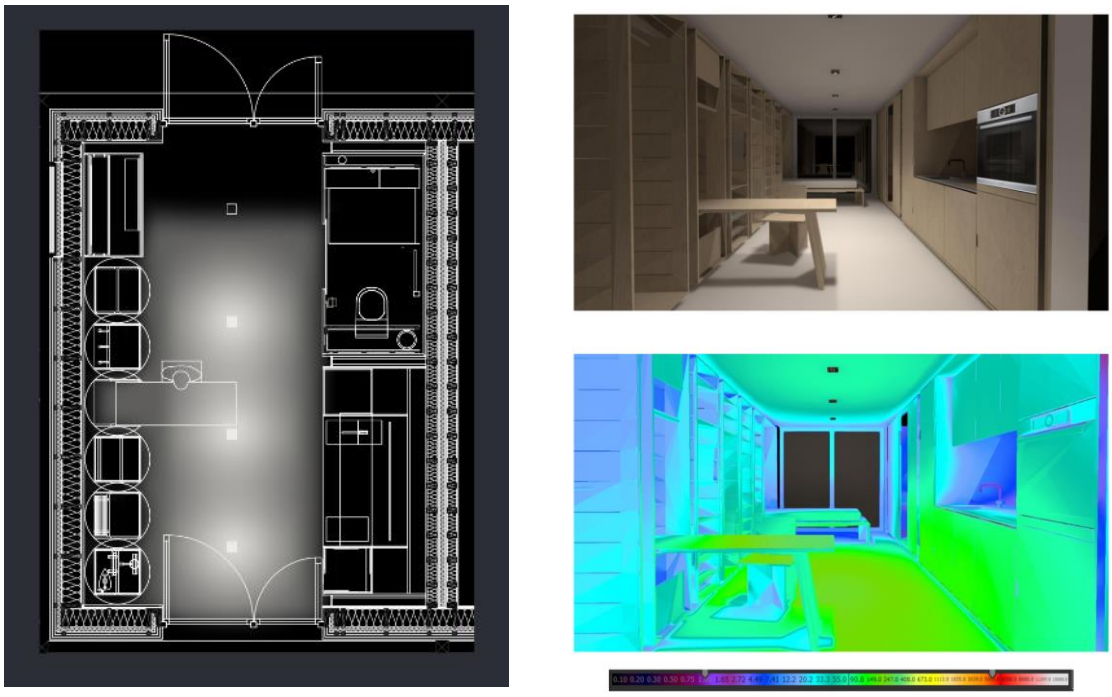


Fig. 4.49 Lighting Scenario 4

5) Cooking lighting: colourfast bright illumination of the work area - visual task: cooking, cutting, reading recipes

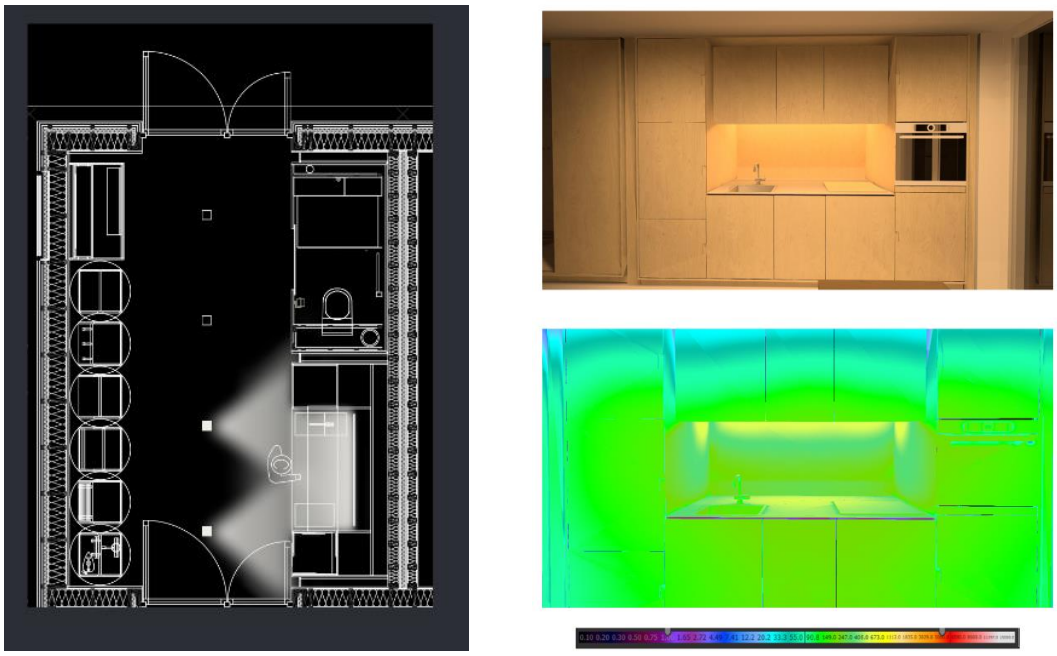


Fig. 4.50 Lighting Scenario 5

6) Mood lighting: for a cosy ambience, warm light, preparing for the night - Visual task: walking without tripping, recognising obstacles

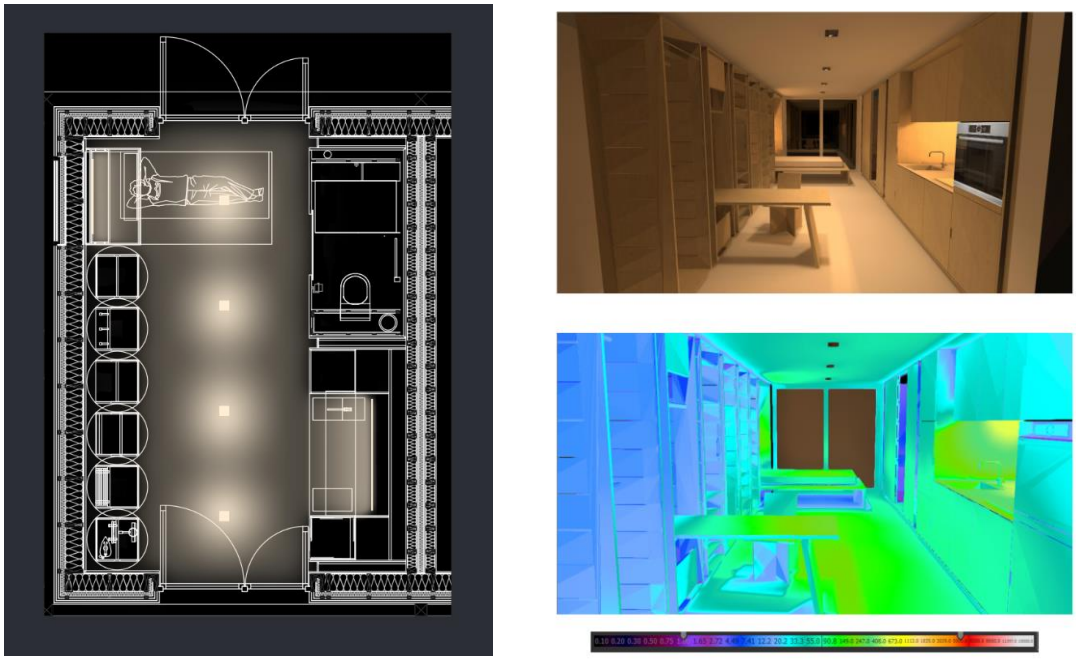


Fig. 4.51 Lighting Scenario 6

4.3 Structural Design

4.3.1 The whole building

The load transfer of the extension is based on the structure of the existing building. Due to the way the building was constructed at the time between 1956 and 1959, we already assumed that the existing building has load reserves.

The existing building has an area of 89m x 15.5m and consists of an attic, four upper floors, a ground floor and two basement floors. The main structure was designed as a concrete frame structure with stiffening cores and walls. The exposed concrete facade columns alternate with no load-bearing artificial stone columns. The load bearing column cross-sections change over the stories. These go from 27cm x 20cm on the 4th floor to 50cm x 35cm on the 2nd floor. The floor slabs have a thickness of 32 cm and are designed as 3-field continuous beams with spans of 5.5m-2.5m-6.5m. The loads of the floors above are absorbed by the beams in the longitudinal direction of the building and transferred to the supports. The building stiffening is realized by an elevator core as well as isolated reinforced concrete walls, which are carried out from the roof to the foundation.

Since the existing building was built between 1956 and 1959, DIN 1045 (1952) still applied at that time. For this reason, the materials used at that time were referred to differently in the existing structural plans. According to today's standard (Eurocode 2), concretes between C30 / 37 to C 40/45 were used as well as the construction steels B500B and S355.

A substructure of wooden beams acts as an intermediate level and ensures the possibility of constant load bearing from the modules and the rest of the new building. The substructure is arranged in the module axis every 5 m in the longitudinal direction of the existing building. The intermediate level serves to distribute the horizontal and vertical loads of the new building into the load-bearing column grid of the existing building.

The initial permission was to plan a top-up concept that can be used as a general solution for different buildings. So that it can be transferred to other building-geometrics very easily. In addition, the extension should adjust to the original structure of the building and the environment, to create one unit. Based on those premises, Key object of „the Grid “construction developed.

Fig. 4.52 Visualization of day and night lightning atmospheres

4.3.2 **HDU**

The Key object of the Extension is they so called the „Grid “. It wraps around the existing building, the Extension and suggests a uniformity to the viewer. The construction is not only in symbiosis with the existing building due to the adapted supporting structure, but also due to its appearance.

The constructive grid is visible and significantly structures the extension. The frame of the grid also highlights the individual living modules, common rooms and outdoor areas.

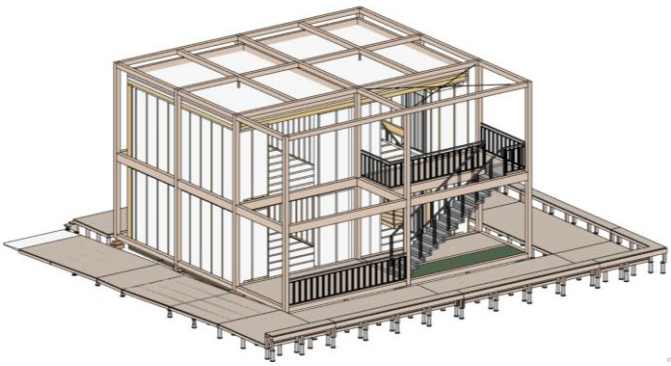


Fig. 4.53 Visualization of the gridded HDU

The Grid forms around the HDU with a Length of 9,93m & the width of 9,72m. The total height of the Demonstration Unit is 6,25m.

The beams and columns of the grid are made out of solid wood, with a dimension of 16/16cm.

On the north and south side of the HDU there are 3 rows of studs each. On the east and west side, the grid consists of 4 rows of studs each.

The beams of the grid are based on the floor structure of the HDU. On the south side of the building, they form the supporting framework for the terrace and the staircase.

The load is taken up by the grid through 36 cm column feet and transferred to a rigid foundation.

The horizontal bracing of the grid is provided by a steel cable that spans across the ceiling. Vertical bracing is provided by the steel frame structures on the sides and the timber frame walls.

The structure of the grid is adapted to that of the existing building and thus also to the structure of the facade of the extension. Although the story extension has a different architectural language, the constructive grid refers to significant characteristics of Building 5. The grid, and the individual living modules, are built in wood because of the many advantages. Wood and timber frame constructions offer a reactively low weight, which is ideal for Extension. In Addition to that, wood is a renewable raw material what can assure environmentally friendly building. Because of the high degree of prefabrication, the construction time also can be decreased. Furthermore, wooden structures create a pleasant living environment.

The ground floor of the HDU includes the living area, the Kitchen and the arriving space. In the upper floor you can find the private space, with the Sleeping and Work Area.

Fig. 4.54 Visualization of the Grid structure

Walls:

The walls of the HDU are made of wood stud walls. The load-bearing elements are the exterior walls and room partition walls of the HDU. The wood stud structures of the exterior walls are made of a C16 wood with a beam thickness of 7/24. The corners of the exterior walls are designed so that the long walls pass through and the short ones bump.

The interior partition walls are also made of wood stud construction and were dimensioned to 6/12 in C16.For bracing, all exterior walls were applied to the HDU.

Ceiling:

The Ceilings are made out of 7/24 beams. In the apartment partition ceiling the beams are vertically offset at a distance of 2 cm from each other. Reason for that, is the sound decoupling.

Due to our ongoing design coordination with our main sponsor, Baufritz, there are still discrepancies between the present preliminary draft of the structural report and our work planning. The same applies to the calculations of the façade statics, for which we are in final coordination with the structure office. We will provide the current status of the work planning and the associated final static calculations as soon as possible.

4.4 **Solar System Integration**

This chapter deals with the integration of the solar systems on the design as well as on the HDU. In addition to the conceptual explanation, the focus is on the constructive implementation, detailed solutions and first ideas of maintenance. Last but not least, additional properties and the economy of installation are dealt with briefly.

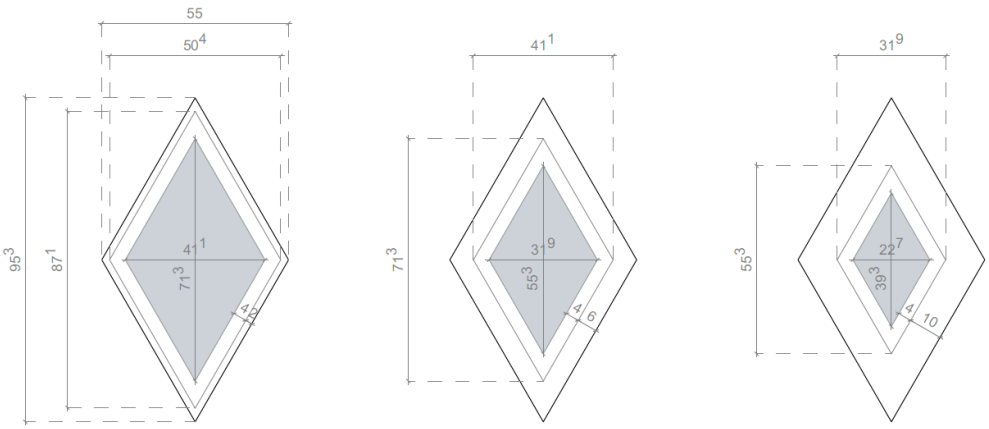
4.4.1 **The whole building**

General: Photovoltaic

With the more widespread use of photovoltaic systems to produce clean energy directly *on* or *near* the building, one of the main arguments against using them extensively on façades and roofs is the optics of conventional photovoltaic modules. More and more concepts are being developed for this, specifically for building-integrated photovoltaics which also take over other tasks of the thermal envelope or shading systems, but they are usually very site-specific and hard to transfer, or lack a certain innovative and aesthetic aspect or try to disguise the fact that photovoltaics is even being used.

For the Solar Decathlon the use of solar energy is a big part of the overall concept for the whole building, and consequently for the House Demonstration Unit, utilizing both innovative photovoltaic systems and so-called solar chimneys. It only follows, that the solar systems are also a major aspect of the architectural concept, that rather than hidden away, they determine the building's aesthetic while also having several technical functions. The whole façade was created in close cooperation between architects, climate engineers, civil engineers, and the corporate partners for the photovoltaic system and the steel mesh.

Innovative organic photovoltaic (OPV) technology is being used on the façade and roof with individual, diamond-shaped OPV cells. These are set into the steel cable mesh attached on the outside of the GRID



structure which surrounds the whole building (in both the design and building challenges). The cable mesh has large diamond shaped openings, about 95.3cm in height and 55cm in width, with a 60° angle at the top/ bottom. The opening size was determined to best cover all available façades of the HDU and then adopted for the whole building. The photovoltaic cells are made with polymer based organic semi-conductors which are “printed” onto a thin film, and “laminated” in between two base plates to protect it from outside influences. The cells that are used here are a “traditional” dark blue color and the thin layers make them semi-transparent. They are laminated between two polycarbonate sheets without a frame. It was decided to use three different OPV cell sizes, the largest filling out the mesh opening at 71.3cm height, the other two smaller sizes at 55.3cm and 39.3cm height, with corresponding base plate sizes. These sizes were determined after the opening sizes of the mesh, as the corporate partner who manufactures the OPV cells is quite flexible with sizing.

As part of a bachelor thesis, a parametric simulation was developed using the programs Rhino/Grasshopper with the plugins Ladybug and TRNLizard. TRNLizard represents the interface from Grasshopper to TRNSYS18. The simulation is used to determine the optimal placement of the OPV cells on the facade. The criteria for the placement of the shading elements for Building 5 in Stuttgart are optimal shading of the windows in summer and at the same time allowing radiation to pass through for solar heat gains in winter.

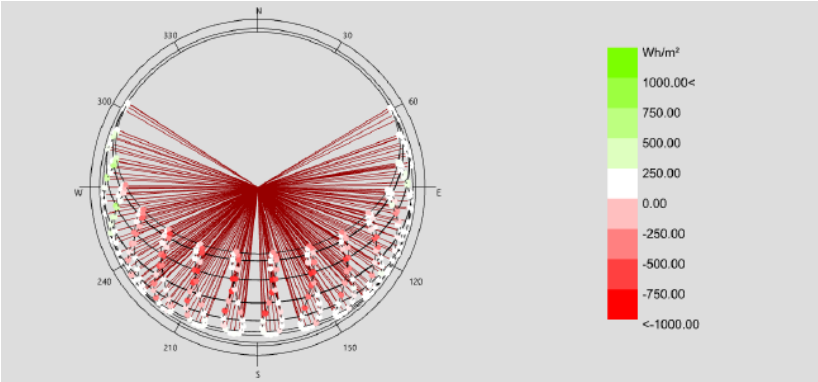


Fig. 4.56 Classified hourly direct irradiation (red is sunshade bottom, green is sunshade top)

The basis for the observation is the position of the sun at the location of the extension as well as a preliminary thermal building simulation with a movable sunshade. The control signal of the movable sunshade can be used for the classification of the hourly direct irradiation values into positive and negative irradiation (sunshade top: positive, sunshade bottom: negative). The evaluated direct radiation has an affiliation to a sun position and is shown in the figure above as an example for the location Stuttgart.

Now it is necessary to define viewing areas on which the shading geometry will be placed later. In addition, test points on the windows are determined. By means of a geometrical approach as shown in the figure left, a weighted, evaluated direct radiation can then be assigned to each viewing area. This results from the number of intersections of the solar vectors with a viewing surface and the sum of the associated weighted direct radiations and is shown in the following figure. The evaluated direct irradiation assigned to the viewing areas are then "translated" into a shading geometry. The shading elements are scaled accordingly, whereby the degree of

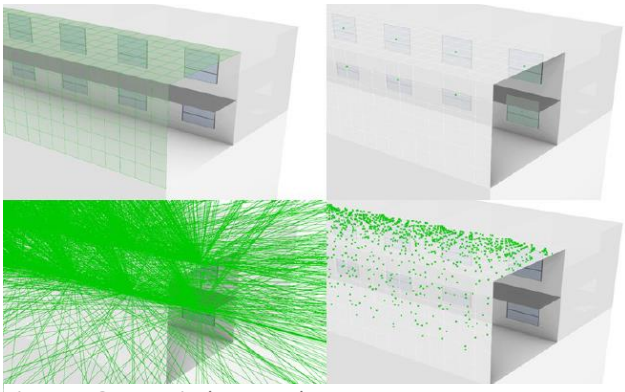
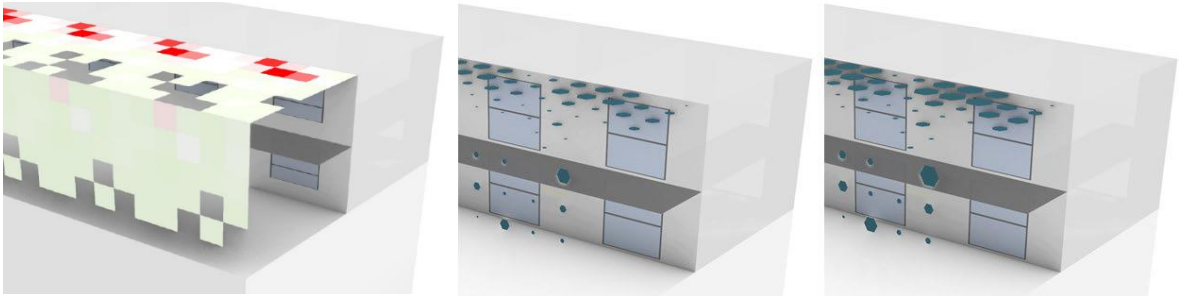


Fig. 4.57 Geometrical approach

scaling is adjustable. Thus, further optimization is possible, e.g. with regard to daylight and solar energy harvesting (OPV).



The result shows the optimal placement of the OPV cells on the façade and roof, taking the criteria into account. The simulation and the resulting shading matrix are constantly updated as changes are made to the design or other parameters. One of the biggest advantages of this simulation tool is its transferability: with the right inputs, a customized, optimized shading model can be created for each site and project.

Shading geometry considerations are currently being explored in greater depth and will be captured in a paper, which is expected to be published in 2022.

4.4.2 **HDU**

The HDU has the same general concept for the photovoltaic system as the whole building does. The GRID is spanned with a stainless-steel mesh which has integrated OPV cells, the sizes are the same for the whole building and the HDU. On the HDU though, a few of the OPV cells on the façade will be replaced with info plaques for visitors to read while they are waiting and walking around the building towards the entrance. At the bottom of the façade there will be greenery and no OPV cells, to represent the concept of the design challenge, and because waiting visitors would obstruct PV cells from the sunlight here. The placement of the OPV cells was again determined through parametric simulation. The biggest difference to the design challenge is that the mesh with OPV spans the whole roof as well as the southern, eastern and western façades, to increase the energy production area.

General: Solar chimney

The second way solar energy is used is for ventilation with solar chimneys. Similarly, to wind towers in for example Hyderabad, India, they use solar heat for natural ventilation. On the design challenge two solar chimneys are integrated into the façade in front of the existing stairwells. Their fronts are fully glazed to increase the heat development at the top of the tower – this creates a pressure difference that draws the used air out of the building, into the chimneys. Because of their optics the solar chimneys are visually structuring elements for the southern façade, and in the case of the one on the left, clearly indicates the main entrance to the building. The HDU also uses a solar chimney for natural ventilation which works in a similar way. It is also visually integrated into the western façade, and on this smaller building gives off the impression of the modernised version of an old-fashioned chimney at the back of a house.

4.4.3 **Constructive solution**

The photovoltaic cells are suspended in the diamond-shaped openings of the stainless-steel cable mesh attached to the wooden GRID. This works the same on the HDU as on the whole building. The mesh structure has a slightly parabolic shape to better put the forces acting on it into equilibrium.

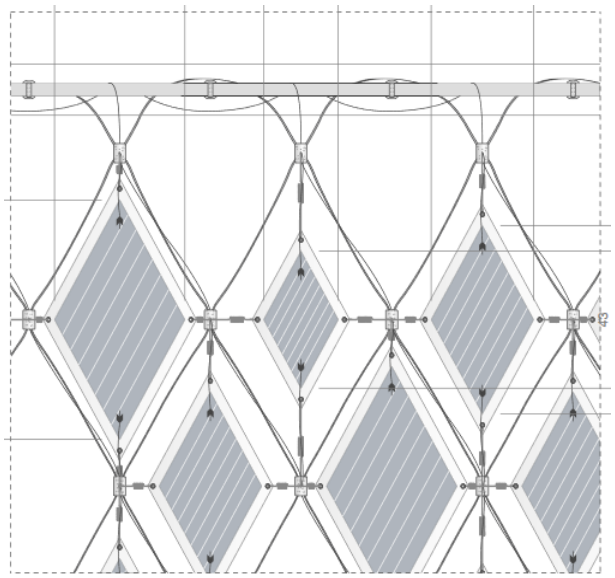


Fig. 4.61 Connection of the OPV cells with the steel cable mesh

The exact curvature will be determined over the summer in building workshops with the help of calculations by the civil engineers. The curvature of the mesh does not influence the OPV cells, as these are attached with spring connectors on all four tips of the diamond shape. These connectors have some give and do not connect the cells and mesh entirely rigidly, so that forces acting on the cells are transferred into the steel cables, which can withstand much higher loads. The exact make and function of the connectors is currently still being assessed. The cells themselves are laminated in between two layers of transparent polycarbonate, which is very lightweight in comparison to glass or even acrylic glass, this of course also helps determine the connectors that will be used. Above the opaque roof of the HDU, the cable mesh will not be permanently attached to the wooden beams of the GRID but will be within foldable or removable frames. This allows for maintenance of the greenery and roof structure underneath.

The solar chimneys are fully glazed structures that reach above the height of the buildings they supply with air. On the design challenge this means the top of the two solar chimneys is even with the roof of the addition as only the old building is connected to them. The offices and work rooms in the renovated building are connected to the chimneys through ventilation ducts in the suspended ceiling. When the solar chimneys heat up in the sunlight, the pressure difference draws the used air out of the rooms into the chimneys, where the warm air rises up and leaves through openings at the top. This system passively uses the thermal energy of the sun to increase natural ventilation in the building. The solar chimney of the HDU is on the western façade and is about 40cm higher than the top of the GRID. This one is connected to the residential module on the ground floor, the other rooms in the HDU will use natural cross ventilation. The residential module has a hatch into the solar chimney that can be opened manually when it is in use or to explain the function to visitors. When opened, the air can enter past the adiabatic cooling through the open window, is pulled through the hatch into the solar chimney, and rises up towards the opening at the top. The cross-section of the solar chimneys was determined through calculations on the pressure differences and thermal simulations, for both the whole building and the HDU. The back of the solar chimney in the HDU is a medium-density fiberboard painted black, to absorb sunlight and heat up the air inside.

4.4.4 **Additional properties**

The photovoltaic cells that are used are made of environmentally friendly organic polymer semi-conductors that include no rare or toxic components. Ultra-thin layers that are printed onto a thin elastic foil make thin-film cells in a special coating technique which not only uses very little material but is also very energy-efficient. The OPV cells consequently have a very short energy payback time of only a few months. The thin-film technology also makes for very lightweight cells, only about 450g/m² (+/-50g), and makes them flexible and easy to roll and thus very versatile. In the design for the SDE they will of course not be flexible anymore, as the thin-film is laminated in between two polycarbonate plates. This protects the OPV cell itself from outside influences and gives it a more rigid structure to withstand wind pressure and other impacts. Like most thin-film technologies, the organic PV cells react better to unideal conditions than crystalline PV cells. They can produce energy at very low light or even artificial light and are less affected by being partly shaded, which means better overall energy

production in winter, at dusk or dawn, and during bad weather. They are also less affected by high temperatures although this is less pertinent for our design, as the cells are completely exposed to the outside air and can cool down easily where they are suspended in the steel mesh. All of these advantages make organic photovoltaics an innovative technology for the future to, at least partially, replace crystalline PV. They are however not yet as efficient: where monocrystalline PV can reach over 20% efficiency now, the organic PV cells are currently only at about 4%. Higher efficiencies of 12% or even higher have been reached in laboratory conditions but are not yet commercially available. It can be assumed though, that efficiencies will increase in the near future and make organic PV even more advantageous.

As described in 4.5.1 The whole building, the solar systems are integral parts of both the architectural and energy concepts. The OPV cells, suspended in the steel cable mesh, give both the HDU and the whole building of the design challenge a unique aesthetic, showing off the energy producing system instead of hiding it away. Apart from producing electricity for the building, the photovoltaic cells also act as shading for the rooms behind them, protecting them from the summer sun while still letting in sufficient daylight, effectively replacing conventional blinds/ sun shading. The solar chimneys on the other hand are fully integrated into the façade.

4.4.5 **Maintenance**

On the roof of the HDU foldable or removable frames hold the OPV cells instead of the cable mesh. This makes maintenance on the roof, the greenery on it, and also on the OPV cells possible. All OPV cells are suspended in the mesh with spring connectors and can be removed separately, which makes replacing singular broken cells very easy. The polycarbonate lamination material also makes them easy to clean, but the many separate cells make cleaning a bigger effort than a large area of flat PV modules, especially when you have to be careful not to damage the wood of the GRID. The large majority of OPV cells is installed horizontally on the façades though, where dust and dirt cannot settle as well on the cells' surfaces and the rain can easily wash it away. The façade greening which climbs up the mesh from the bottom will also have to be maintained so it does not grow over any photovoltaic cells. This should not pose any problems for the competition though, only for post-use and for the façade greening on the design challenge.

4.4.6 **Economy of installation**

The OPV cells are a type of thin-film technology which uses very little material and no rare or harmful substances. The production is very energy-efficient on top of that, making it more sustainable and economic. The organic cells themselves have a rather low efficiency at only 4%, but this can be expected to increase in the near future, and is offset by the lack of efficiency loss at low light and high temperatures. The many separate cells make especially installation quite time intensive and high effort. The effort is rewarded, as the unique placement of these singular cells, determined through parametric simulation, means optimal shading from the heat of the summer sun and at the same time ample daylight. This saves energy on both cooling and artificial lighting while also producing energy for the other building functions. It can also be argued that the innovative aspect of this installation which also gives the building its characteristic aesthetic, is worth the higher effort. The solar chimneys increase the efficiency of the natural ventilation, saving the energy that would be needed for mechanical ventilation.

4.5 **Reconfigurable Features**

The rotating corps as an essential part of the interior concept are volumes, which are placed over a central axis and can rotate 360° around this axis. There is, depending on the function, one open side

and three closed sides or two open and two closed sides. Thus, the rotating corps can be tried out by the visitors while walking through the unit and a closed as well as an open front can be presented.

The lift sits on the interior staircase in the entrance module and has a platform that folds vertically against the wall when not in use. At the push of a button, the platform folds down and the visitor can drive onto the platform. Then a safety bar folds down and secures the visitor. The lift then travels fully automatically to the upper floor. Once at the top, the safety bar opens and the visitor can ride down from the platform. The lift then returns automatically to the lower floor and folds back against the inner wall.

The solar chimney has a ventilation flap in the outer wall inside the room, which can be opened manually or automatically by sensors. This ventilation opening is located behind the rotating cords and is therefore difficult to access for visitors.

The bed also works on the principle of rotating corks. Two revolving cords together make the width of the bed. However, the furniture is not turned up, but unfolded. During the day, the bed disappears completely behind the wall of the wardrobe, and the mattress and pillows are attached to the frame by means of straps. In the evening, the frame is opened into the room and the straps are released.

5 ENGINEERING & CONSTRUCTION REPORT

coLlab

The Engineering and Construction Report is divided into 5 parts. At first, the climate and the radiation on the facades, as well as location specific energy potentials are analysed. Then, the energy concept of the building is described in the chapter “final energy concept summary”. Afterwards the tested measures to reduce the energy demand in the existing building and additional story are described and evaluated. Then, it is described how the remaining energy demand was covered as sustaibaly as possible in “decarbonization of energy supply”. In the next chapter it is described how the energy concept was transferred to the HDU and the HDU is described. Lastly, the Life Cycle Carbon Footprint for the HDU is determined.

5.1 **Location Analysis**

This chapter contains an initial climate and energy potential analysis of the building site in Stuttgart, Germany. The building chosen for the competition is “Building 5”, a university building on the downtown campus of the HFT Stuttgart. A radiation analysis of Building 5 is conducted, and the potentials of server waste heat and wastewater as renewable energy sources are assessed.

5.1.1 Climate Analysis

Stuttgart is in the centre of the state of Baden Württemberg in the south west of Germany. Like the rest of the country it is located in the Marine west coast climate zone. This is also shown in the psychometric chart (Fig. 5.2). Temperatures are limited by -9.4 at the bottom and 34.9°C at the top, but the majority of the values range from -2 until 27°C. Mostly, the relative humidity is between 40 and 80%. In green the ASHRAE comfort standards are plotted. As one can see in Fig. 5.2, regularly only heating is necessary to fit the dots into the comfort frame. Too hot or humid Hours are rare, therefore buildings are normally not equipped with air conditioning or dehumidification.

Over the course of the year four seasons appear. Winter, the cold season is between December and March and Summer starts in May and lasts approximately until September. In Summer the average temperature is 20.5 °C, rain occurs regularly. But these by comparison mild summers are going to get hotter and the chances of more extreme severe weather and natural disasters is increasing with the progressing global climate change. The "Deutscher Wetterdienst", the national meteorological service, also released future weather data for 2045. When comparing the temperature profile in the same summer week of the weather now and the future one (Fig. 5. 1) especially the differences in the daily peaks are striking. To rate the rise in temperature two values have been calculated: the number of hours underneath the frost line and the rated hours above 27°C. The former decreases until 2045 from 360 h/a to 226 h/a. Latter started in 2015 at 363 and will double until 2045 to 912 Kh. Those values exemplify the impact of the climate change on the local climate of Stuttgart.

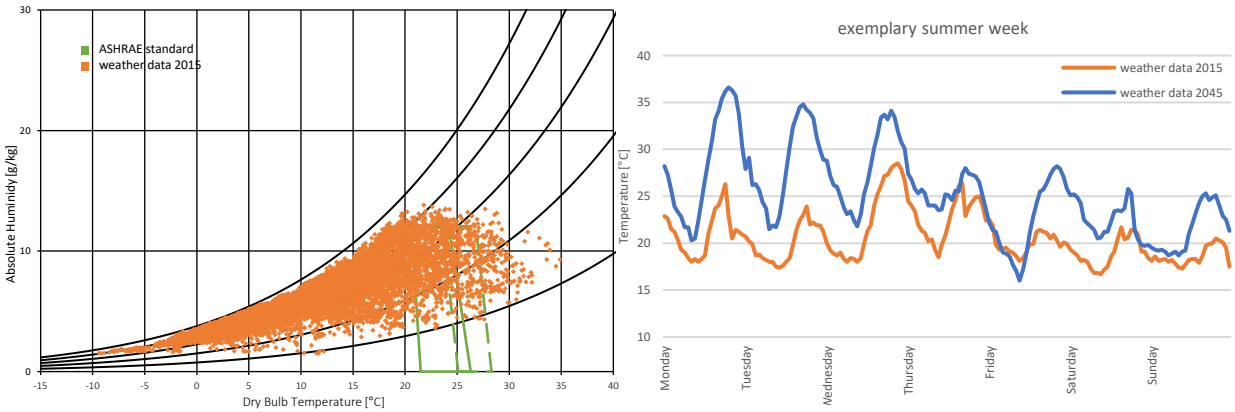


Fig. 5. 1 comparison current weather with future extreme weather in exemplary summer week

The main wind direction does not change over the course of the year. The most regular wind is from WWS and has a speed between 0.5 and 3.5 m/s, as visualized in Fig. 5.3.

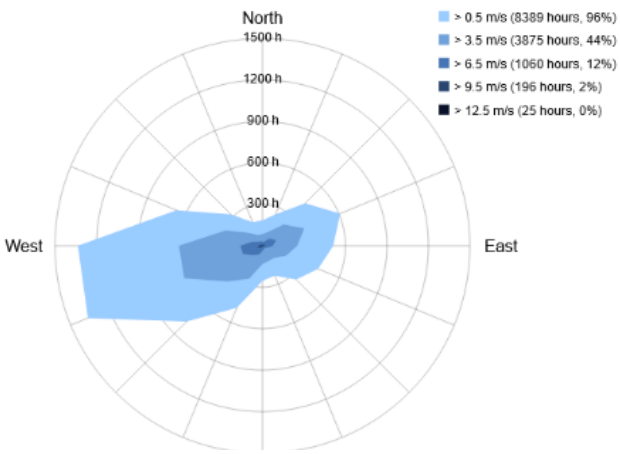


Fig. 5.3 wind rose

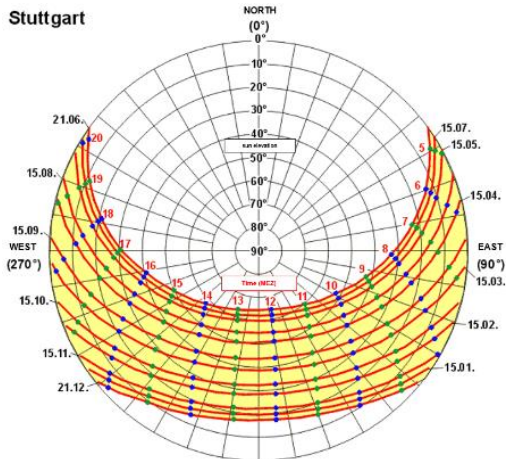


Fig. 5.4 altitude of the sun

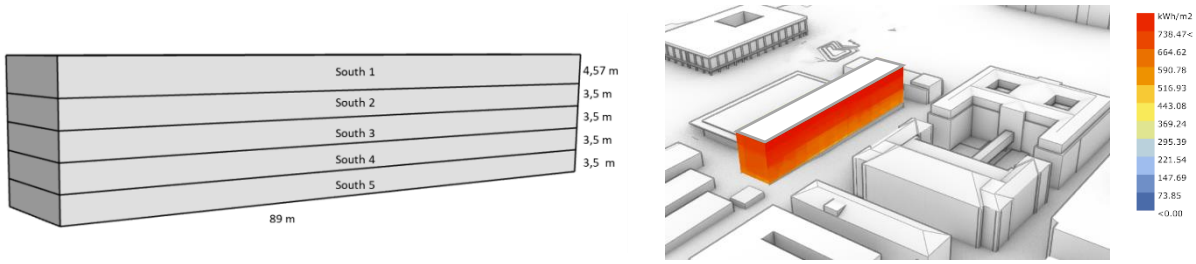
Radiation Analysis

In order to determine, what part of the building's façade can be used for solar energy generation, a radiation study with honeybee (RADIANCE) is carried out first.

The building's south facade was split into 5 parts, according to Fig. 5. 5. When analysing the results on a monthly basis, it stands out that over the winter months only up to 50% of the solar radiation falls on the lower two sections. Therefore, it is not recommended to place PV panels here.

	Clear Fraction of Facade Parts due to Surrounding Buildings											
	Janurary	Februray	March	April	May	June	July	August	September	October	November	December
South 1	0.98	1.00	0.99	0.99	0.99	0.98	0.98	0.99	1.00	1.00	0.99	0.98
South 2	0.83	0.90	0.91	0.92	0.91	0.90	0.91	0.93	0.92	0.91	0.89	0.83
South 3	0.73	0.83	0.87	0.88	0.87	0.86	0.87	0.89	0.89	0.85	0.79	0.70
South 4	0.50	0.66	0.77	0.82	0.82	0.80	0.82	0.84	0.82	0.72	0.57	0.45
South 5	0.41	0.59	0.71	0.77	0.78	0.76	0.79	0.81	0.77	0.65	0.48	0.35

Fig. 5. 5 monthly FC Values of the façade



5.1.2 Renewable Energy Potential Analysis

Server Cooling

An option for warm water production is using the waste heat of the four servers located in two server rooms in the basement and the fourth floor. In this case, the current air-cooled servers will be replaced by servers with a water-fed cooling system, which is more efficient in cooling and needs less energy and space than air-cooling systems.

In this system, the water in the cooling system floats over the server's circuit board and absorbs the heat. The warm water is led through a heat exchanger to heat the water that is used as an energy source for heating and warm water. After this, the water in the cooling system is led through a second heat exchanger that uses rainwater out of a cistern to cool the water before floating over the circuit board again. Water on a temperature level of 25 to 30 ° Celsius can be extracted from the circuit board.

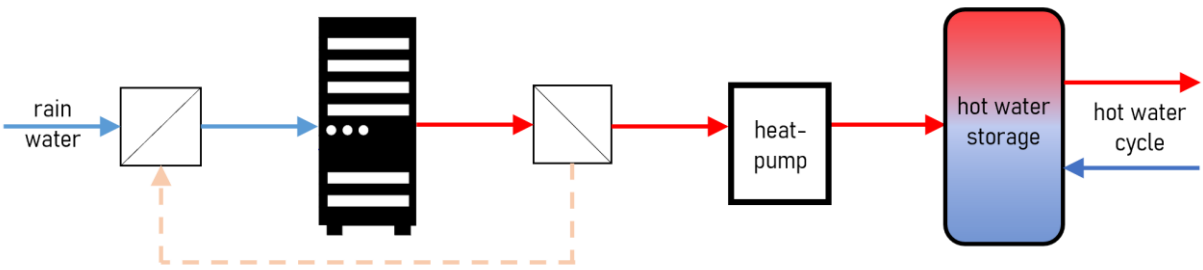


Fig. 5.7: hot water production scheme (source: own representation)

Wastewater

The use of wastewater in a sewer as a heat source for a heat pump is possible under three basic conditions. First, there must be a sufficient heat supply in the sewer section for the use of a heat pump, and second, it must be possible to install a heat exchanger in the sewer. In addition, the average dry weather flow rate should be at least 15 l/s to ensure the performance of a heat pump.

At the location in Stuttgart, the potential for a wastewater heat pump was discussed in consultation with the "Amt für Umweltschutz" (Office for Environmental Protection) and the "Stadtentwässerung" (Municipal Drainage). From this it emerged that one of the main sewers is less than 100 meters from Building 5, which can be used without major restrictions (see Figure xx).

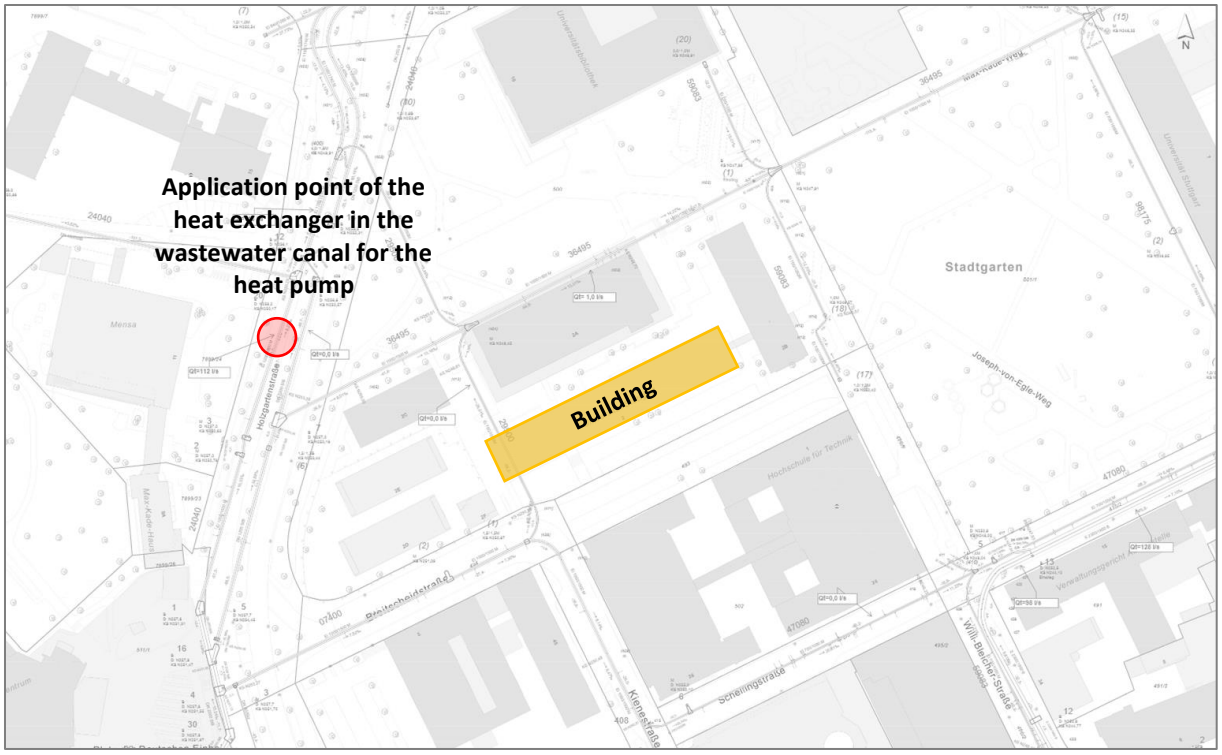


Fig. 5.8: wastewater potential map

In this main sewer, even in winter, the average temperature is above 12 °C and the dry weather flow rate is constant at 112 l/s over the year. Thus, the use of a wastewater heat pump at the site with the parameters of a wastewater temperature of 12 °C and a flow rate of 112 l/s is guaranteed. A restriction is that the wastewater temperature should never fall below 10 °C during the year because of the wastewater treatment. Due to the high dry weather flow rates, even with very high mass flows in the primary circuit of the heat pump, there would be no temperature drop of more than 2 °C, which is why there are no restrictions in this respect under current conditions.

5.1.3 Conclusion

From the previous analysis, it is evident that wastewater is the most suitable as a heat source for the heat pump due to the high potential and constant year-round availability. To avoid the installation of an additional system, the use of server waste heat through fluid server cooling is not implemented.

Furthermore, to be able to harvest solar energy from the south façade, a solar system which works well on partially shaded conditions, like organic photovoltaics is to be implemented.

5.2 Final Energy Concept Summary

In this chapter the final energy concept is summarized. First, an overall overview is given, that includes passive measures and active measures. Then the active part of the system and its controls are explained.

5.2.1 Whole Building – Active and Passive

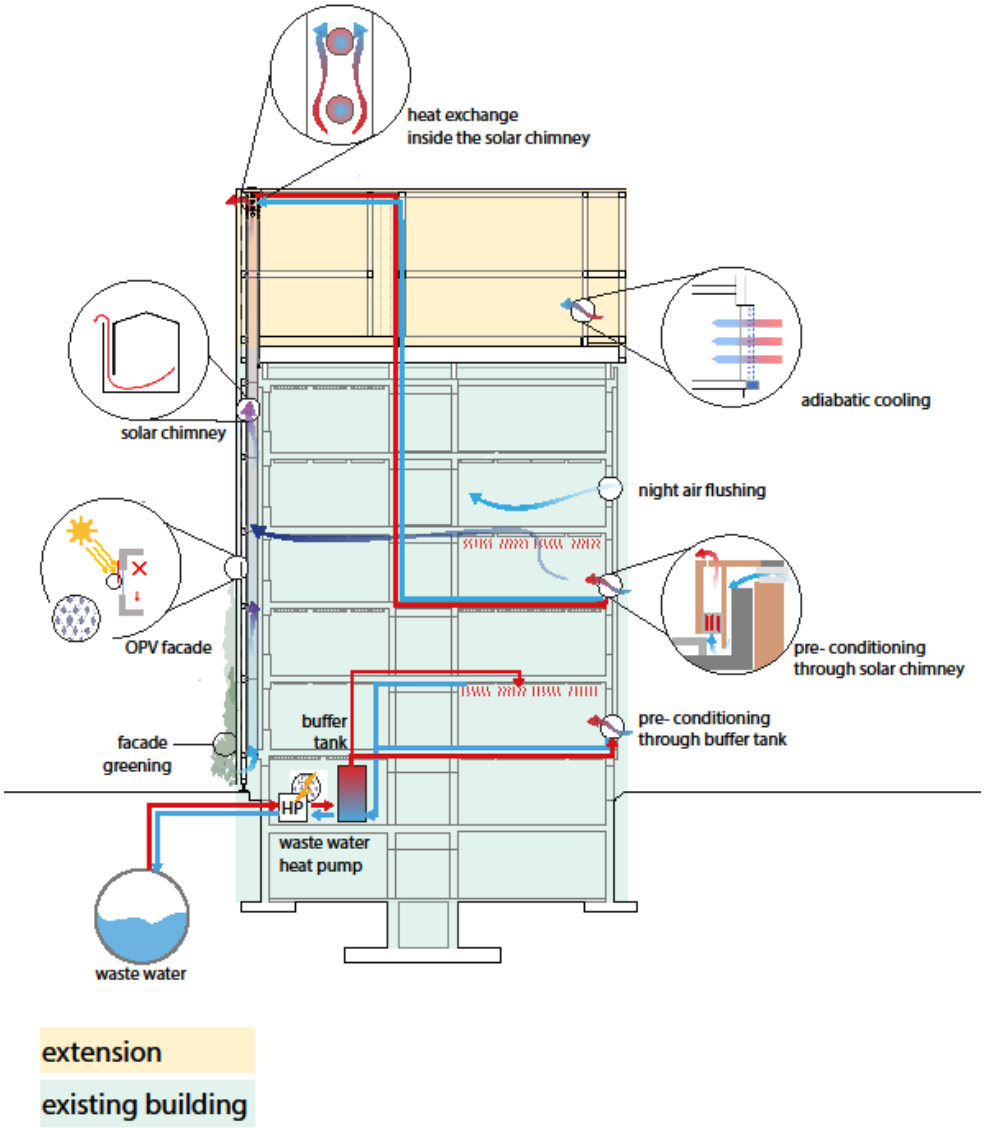


Fig. 5.9: energy concept

Ventilation Concept

The low-tech ventilation system for the renovation part of the coLLab project consists of decentralized trickle vents to ensure a hygienic air change rate year-round. These trickle vents are intelligently combined with a heating element to pre-heat the supply air in winter ("pre-condition through buffer tank" and "pre-condition through solar chimney"). A solar chimney is used to naturally exhaust air out of the building through thermal buoyancy. At the top of the solar chimney an air to water heat exchanger is placed and connected to the supply air heating element via a run-around coil heat recovery system to pre-condition the supply air in selected rooms. In the rest of the rooms, the pre-conditioning element is supplied with warm water from the buffer tank. During shoulder seasons and in summer the heat exchanger in the solar chimney is bypassed and natural ventilation is boosted. The

non-load-bearing pillars of the façade of the existing building are replaced by vertical ventilation flaps that allow for nighttime flushing without endangering the safety of the building.

The residential modules of the extension feature cross-ventilation from the operable windows and are not connected to the solar chimney. In summer the supply air is adiabatically cooled with a water feature in front of the window.

Space Heating and Domestic Hot Water

The main sewer near building 5 serves as the environmental heat source for a heat pump. The heat is distributed in the exiting building via radiant ceilings panels, in the extension there are radiant floors. To cover the domestic hot water demand in the building, decentralized fresh-water stations are placed in the residential modules.

OPV Façade – Shading and Renewable Energy

The GRID is the basic architectural construction and is based on the existing building. It is a constructive skeleton, which is adaptable in size depending on the existing building and its load bearing structure.

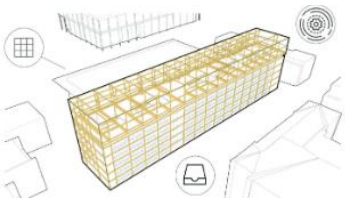


Fig. 5.10 the GRID

The spaces between the wooden structure of the GRID are filled with organic PV collectors (OPV), which function as shading elements for the windo and generate electricity renewably. They are automatically scaled and distributed based on simulation results in accordance with the greatest benefit for indoor comfort. On the roof of the residential modules, monocrystalline PV collectors are placed.

5.2.2 System Design - Active

The main part of the heating and DHW demand is covered by two 40 kW cascading brine/water heat pumps in bivalent-parallel operation with wastewater as the environmental heat source. The peak loads are covered by the existing district heat. The PV System generates electricity for self-consumption. To improve the self-consumption rate, a battery storage is included.

PV System and Battery

The PV System consists of organic photovoltaic modules and monocrystalline silicon-based photovoltaic modules. If there is electric yield, the priority is to directly cover the existing building demand. If there is surplus afterwards, it is fed into the battery for later use. When the battery is full, the electricity is fed into the grid. An increased self-consumption rate of solar power reduces the decentralized feed in energy into the grid during peak hours. Hereby, the control complexity to maintain the target frequency in the grid is reduced. If the building demand cannot be met by means of the battery or direct use, electricity is extracted from the grid.

Heating

Even without the power needed for the heat pump, the electricity demand of the building significantly surpasses the yield generated by the PV-system. Therefore, the heat pumps are operated heating demand driven, eliminating the need for a large puffer tank. The heat pumps operate parallel since the temperature of the wastewater is constant year-round (12°C). A COP of around 7 is maintained, even

on cold days with high loads. For smaller loads, only one heat pump, and for higher loads two heat pumps are running. Peak loads are covered by the existing district heat.

DHW and legionella protection

If there is solar power excess, and all other building electricity demand has been met, the heat pump is operated, regardless of heating demand. This mainly happens during shoulder seasons and in summer. The generated hot water is stored in the puffer tank and used for domestic hot water production in the residential modules that make up most of the domestic hot water demand. The hot water from the buffer tank is used to supply decentralized fresh water stations in each module. The energy is passed to the incoming fresh water via a heat exchanger. If the desired temperature level is not met, the DHW is further heated electrically. Since the DHW water volume after the fresh water station is less than 3 liters and only heated according to demand, no further legionella protection is required. In the existing building, there are only a few taps (café, tea kitchen) that require domestic hot water. Therefore, electrical decentralized instantaneous water heaters are installed here.

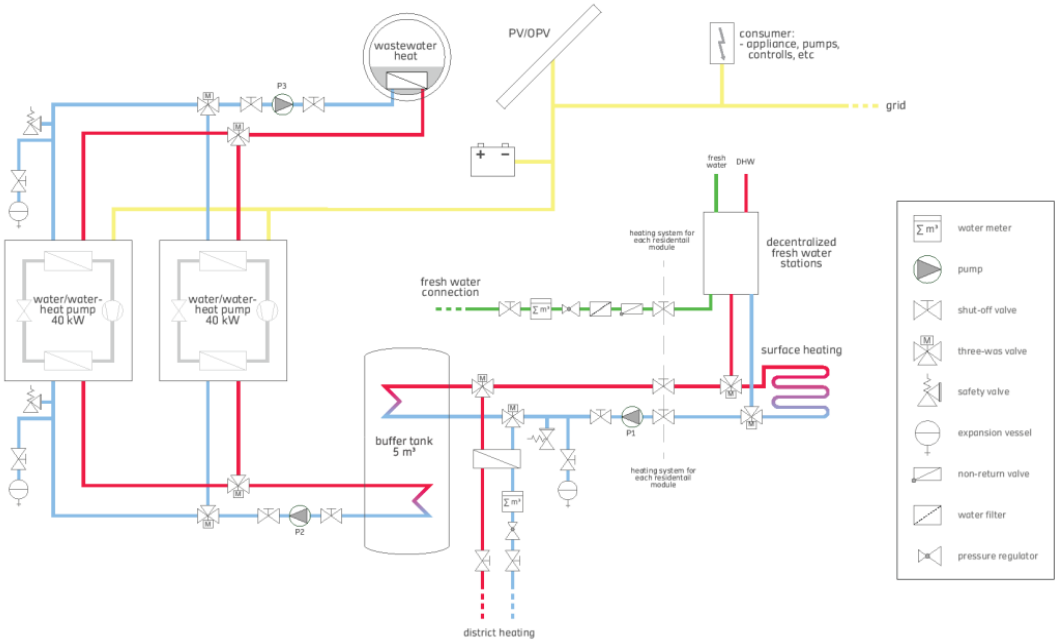


Fig. 5.11: Energy system with DHW for the extension

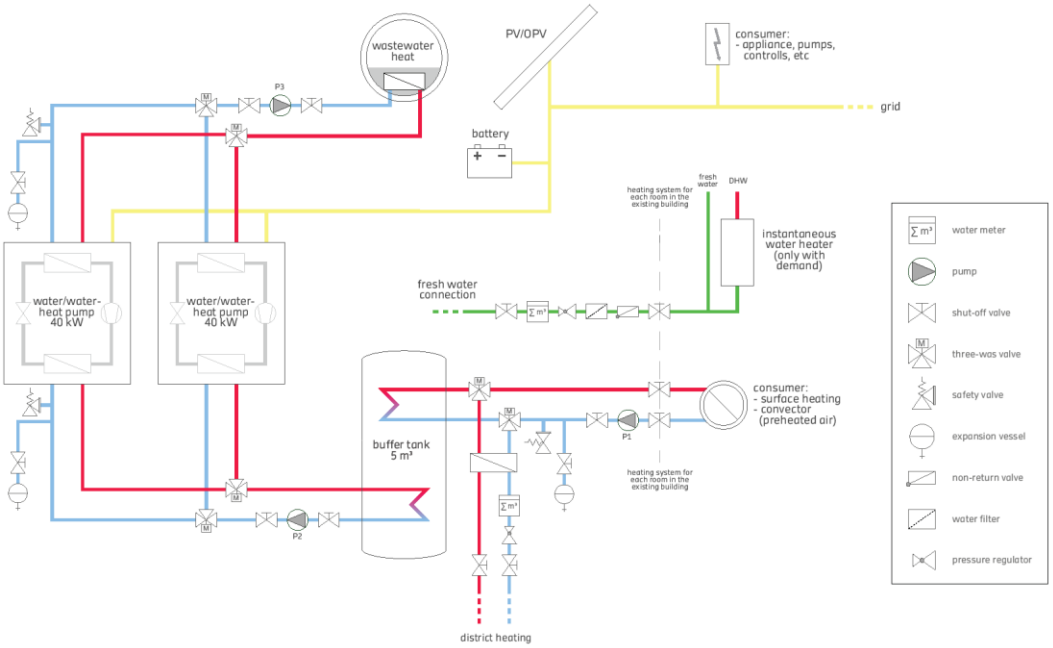


Fig. 5.12: Energy system with DHW for the existing building

5.3 Reduction of Energy Demand

In this chapter it is described how the energy demand was reduced and how comfort was increased in both, the existing building and the extension. For each part, multizone building models were generated with TRNSYS. All simulation inputs and assumptions are documented in the appendix.

5.3.1 Existing building

Overheating Protection

To protect the building from overheating, different shading and natural ventilation strategies are tested and their performance evaluated with the simulation model. The diagram below shows the results compared by the metric Kelvin hours above 26°C operative temperature during operation time.

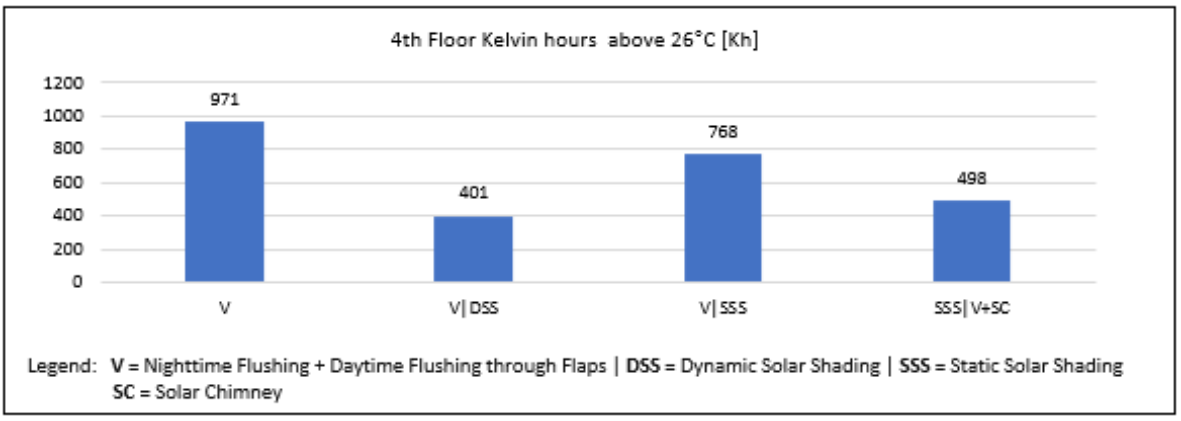


Fig. 5.13: Overheating hours (Kh) of the evaluated measures

V - Nighttime Flushing and Daytime Flushing

In this variant, the building is naturally ventilated through ventilation flaps, which replace the non-load bearing columns of building 5 (refer to architecture report). Because of these ventilation flaps it is possible to ventilate the building at night without endangering safety. The flaps are motorized and opened according to the outside and inside temperature conditions.

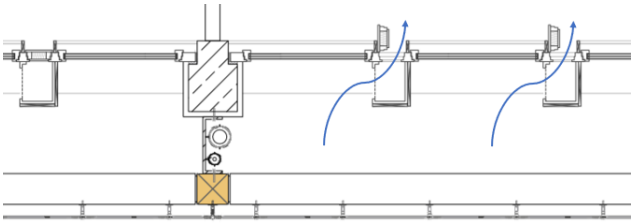


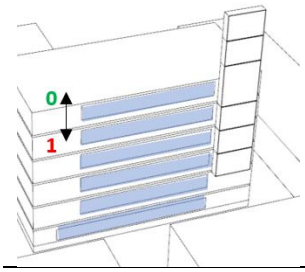
Fig. 5.14 Ventilation Flaps

V|DSS - Nighttime Flushing and Daytime Flushing and Dynamic Solar Shading

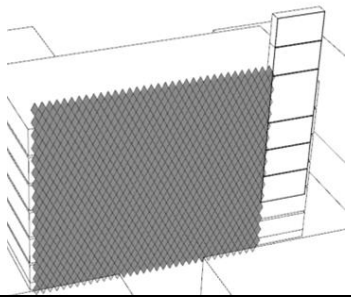
In addition to ventilation, dynamic shading is applied in this version. The shading is controlled by incidence radiation (shade closes above 140 and opens again at 120 W/m^2) on the windows and room temperature (above 24°C). This measure significantly lowers the Kelvin hours above 26°C operative temperature to 401. In the next step, a static shading system that aims to replicate the performance of the movable shading system as closely as possible is generated and tested.

V|SSS - Nighttime Flushing and Daytime Flushing and Static Solar Shading

Step 1

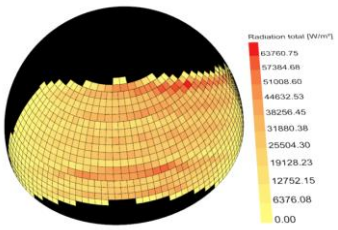


Step 2

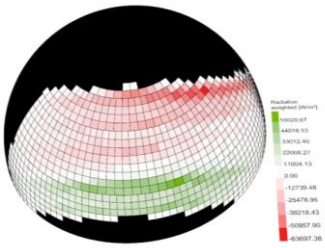


Step 1 - One thermal simulation with operable vertical shading with user-defined control parameters provides the maximum achievable shading performance as a reference (V|DSS).
Step 2 - Planar surfaces (base surfaces) that represent potential locations for OPV Modules are defined. The diamond shape was chosen for design reasons

Step 3



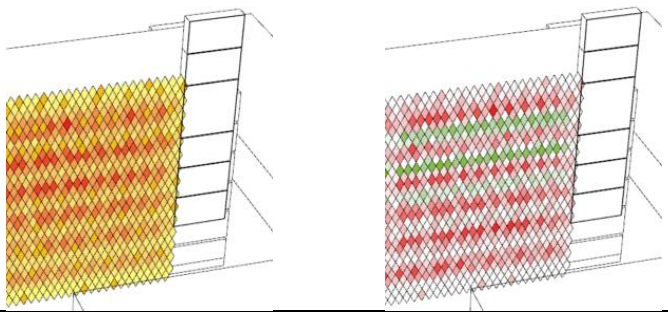
total radiation



radiation weighted by shading signal

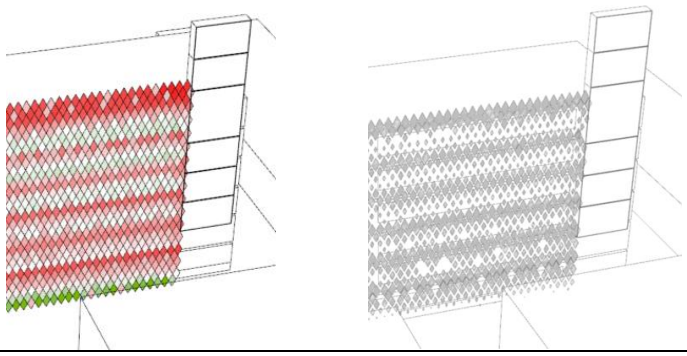
Output of the initial simulation are the shading signal and the radiation on the windows that are to be shaded.
The radiation values are bi-linearly interpolated (azimuth and zenith) onto a subdivided skydome and weighted as positive or negative by the shading signal.
(green: sun positions, where solar gains are desired; red: sun positions to be shaded).

Step 4



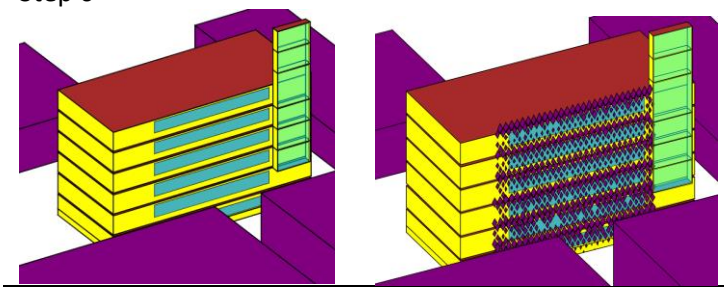
The radiation values for each sky patch (step 3) are projected onto the base surfaces, by window surface discretization and backwards raytracing. Other structural Shading elements, like balconies or surrounding buildings are taken into account.

Step 5



Next, it is determined whether mainly desired or undesired radiation enters through each base surface.
Hereby, the weighted radiation is divided by the total radiation for each base surface. The result is the geometric scale value for each shading element.

Step 6



Lastly, the generated shading geomtry is inserted into the TRNSYS multizone building model as a shading group. The dynamic shading from version “V|DSS”, was turned off entirely and the simulation was run with static shading only.

Fig. 5.15 Generation of Shading Geometry

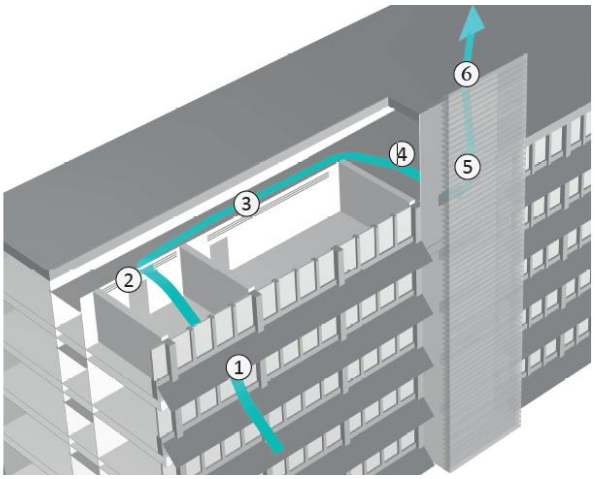
Even though the static shading is designed to mimic the dynamic shading as closely as possible, it cannot fully reach its performance. However, only static shading is still significantly better than no shading at all. Next, it is tested if an increase in natural ventilation can lower the overheating hours further.

SSS|V+SC Static Solar Shading and Solar Chimney

To increase natural ventilation potential, a solar chimney is implemented into the TRNSYS simulation. In a solar chimney, thermal buoyancy is generated through solar radiation and thus results in negative pressure in the building. The resulting airflow contributes to the comfort of the users by getting rid of internal heat loads, which are high in office spaces. The solar chimney is used for nighttime and daytime flushing. The Kelvin hours are reduced to below 500 in combination with the static shading system.

Implementation

The last version “SSS|V+SC” is implemented into the design.



1. window/ ventilation flap
2. acoustic transfer vent
3. suspended ceiling
4. suspended ceiling
5. chimney inlet
6. chimney outlet

Fig. 5.16 Solar Chimney airflow through building

Two solar chimneys are installed (refer to architecture report). Fig. 5.16 shows the airflow through the building and the solar chimney. The solar chimney can be used to lower the energy demand in winter as well, which is assessed in the next section.

Reduction of Heating Demand

The existing building in as-is condition features a heating energy demand of 105 kWh/m² per year. As a first step, the envelope is insulated according to EnEV standard (walls: 0.24 W/m²K; windows: 0.15 W/m²*K) and the existing heating system is replaced by radiant ceilings. Hereby, the heating demand is lowered to 35 kWh/m² per year. With weekend setback of the heating system, the energy demand can be lowered further

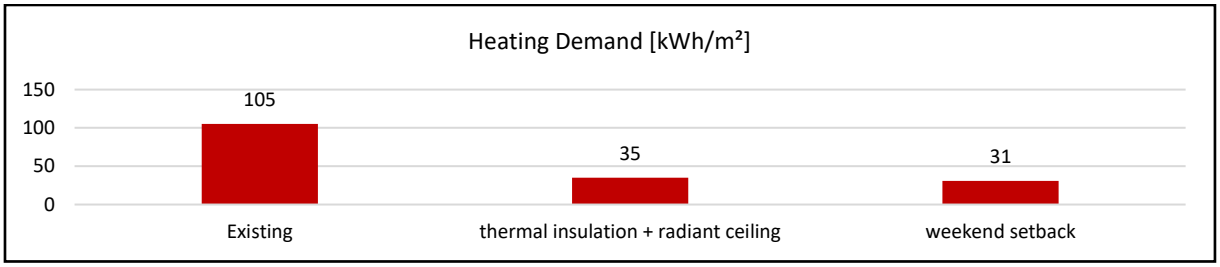


Fig. 5.17 Basic Evaluation

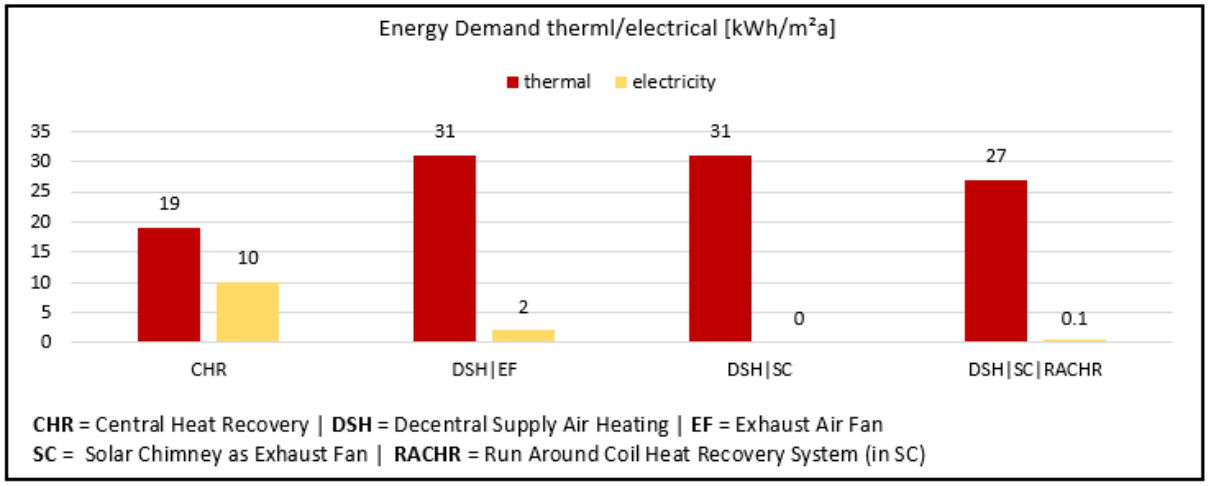


Fig. 5.18 Measures to reduce heating energy demand

CHR Central Heat Recovery - Supply an Exhaust Air Heat Recovery

It is recommended to pre-condition the supply air, to increase comfort. When applying a full ventilation system with supply and exhaust airducts and a central heat recovery, the heating energy demand can be lowered to 19 KWh/m^2, as seen in the diagram above. However, the energy required for fan operation is quite high.

DSH|EF Decentralized Supply Air Heating

Decentralized trickle vents can be implemented to ensure a hygienic air change rate year-round. These trickle vents can be intelligently combined with a convector to pre-heat the supply air in winter without a supply air fan. The air is exhausted through a central exhaust air fan. Since there is no heat recovery, the heating energy demand rises again. However, this also leads to a significant decrease in energy needed for fan operation, while still pre-conditioning the supply air.

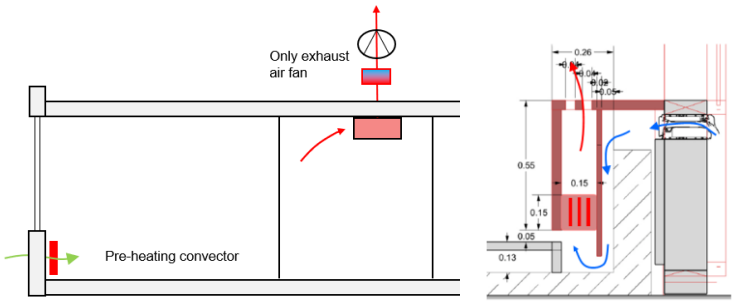


Fig. 5.19 left: DSH|EF visualized; right: supply air convector

DSH|SH Decentralized Supply Air Heating and Solar Chimney as Exhaust Fan

The exhaust air fan is replaced by the solar chimney (refer to overheating section), which uses thermal buoyancy to naturally exhaust air out of the building. With this low-tech system, there is no electricity demand for a fan.

DSH|SH|RACHR Decentralized Supply Air Heating, Solar Chimney as Exhaust Fan and Run Around Coil Heat Recovery System

At the top of the solar chimney an air to water heat exchanger is placed and connected to the supply air heating element (convector) via a run-around coil heat recovery system. The output of the heat recovery system is high enough to supply the convectors of two of the large lecture rooms in the east of the building. In the rest of the rooms, the convectors can be supplied with warm water from a buffer tank to pre-condition the air.

Implementation

The DSH|SH|RACHR was chosen to be implemented into the system, as it requires the least HVAC equipment and the lowest overall energy demand.

5.3.2 Additional Story

In this chapter the focus is laid on the additional story and the optimization of the additional story is described. The model of the “basic evealuation of passive measures” was developed in the simulation studio interface of TRNSYS. The “paramtric model” utilitzes TRNSYS to assess the model performance as well, but uses the TRNLizard interface in grasshopper for parametrization.

Basic Evaluation of Passive Measures

For the additional story, an initial study of passive measures, like overhangs, ventilation and the increase of thermal mass is carried out. For this initial study, only the overheating hours (Kh) over 26°C are regarded.

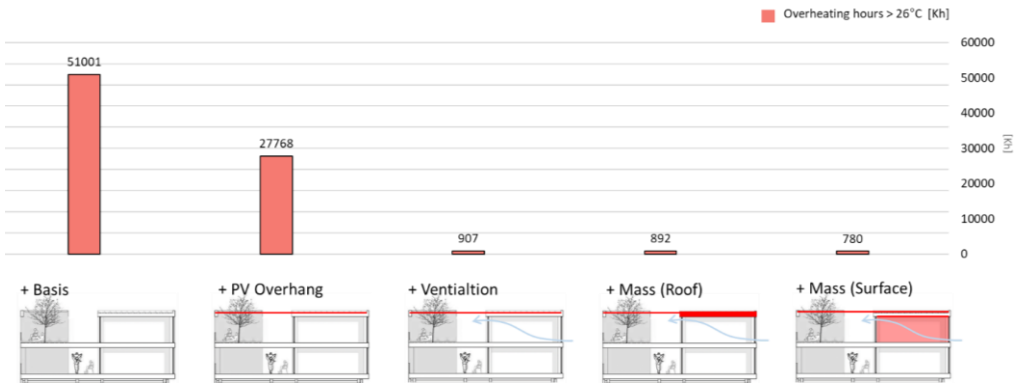


Fig. 5.20 Overheating Hours Passive Measures

The study shows that ventilation and shading is key to decreasing the overheating hours. Furthermore, it is more effective to place thinner thermal mass (in this case clay panels) over a large surface area, as opposed to thick thermal mass (solid wood roof) over a smaller surface. The basis variant from the initial study already features very little overheating hours. However, due to the 8 m overhang, daylight access and heating demand are influenced negatively.

Parametric Model

In order to find an optimal solution for the design, a parametric tool was developed as part of a bachelor's thesis (1). The tool was developed in the visual script editor Grasshopper and used to optimate the design in terms of daylight, energy demand, and overheating hours. Through this tool, the coLLab Design is transferable to many other locations.

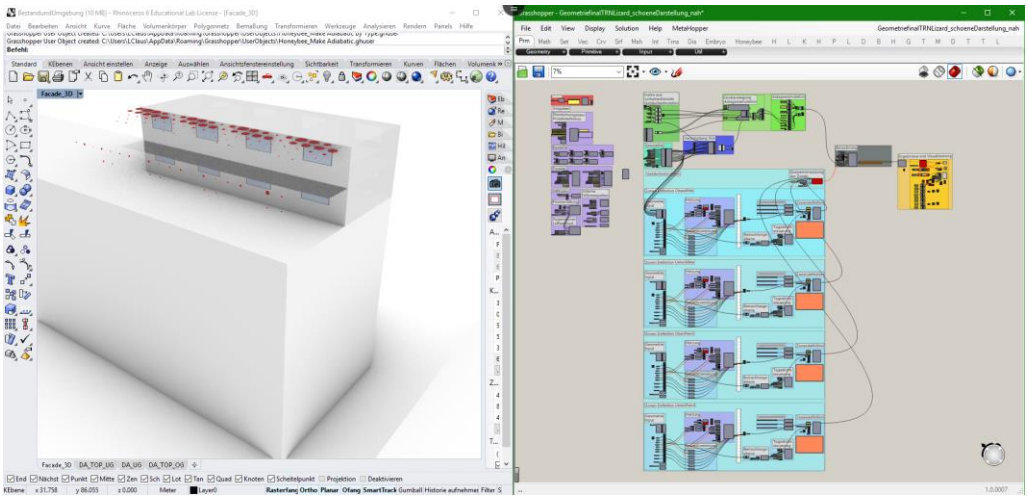


Fig. 5.21: screenshot from the tool in operation

The parameters of the model are varied within two categories: Building and HVAC System. Within the category building, the parameters window size, dynamic movable shading on the of the north window, the surface material on the inside of the room and the insulation standard of the envelope are varied. For the insulation standard, the passive house standard (U-value walls: 0.15 W/m2K; windows: 0.24 W/m2K) and the EnEV standard (U-value walls: 0.24 W/m2K; windows: 0.24 W/m2K) are compared. In the category HVAC, two energy systems are assessed: a brine/water heat pump, which uses solar thermal collectors as their environmental heat source and an air/water heat pump, which uses the

outside air as the environmental heat source. For each of these systems the parameters heat pump power and buffer tank volume are varied.

Each variant is simulated with movable shading for the south window at first. The resulting shading signal is translated into structural shading geometry that is implemented in the form of OPV (refer to existing building section “V|SSS”). The thereby generated shading system is implemented as OPV modules. The thereby generated OPV area is used to determine the electric yield of the system in the variants. The roof of the additional story is covered with thermal flat plate collectors.

The parameters described above are varied in each simulation and the results are evaluated in terms of residential daylight autonomy (RDA), overheating protection (Kh), final energy demand (kWh/m2), solar coverage (%) and the overall reduction of the primary energy demand (%). The results of the different variants are plotted in a parallel plot, where each line represents a simulation with different sets of parameters. For daylight, high values are ideal, for overheating protection low Kh values, for final energy demand low values, for solar coverage high values and for reduction of primary energy demand low values. According to these goals, the best variant is chosen.

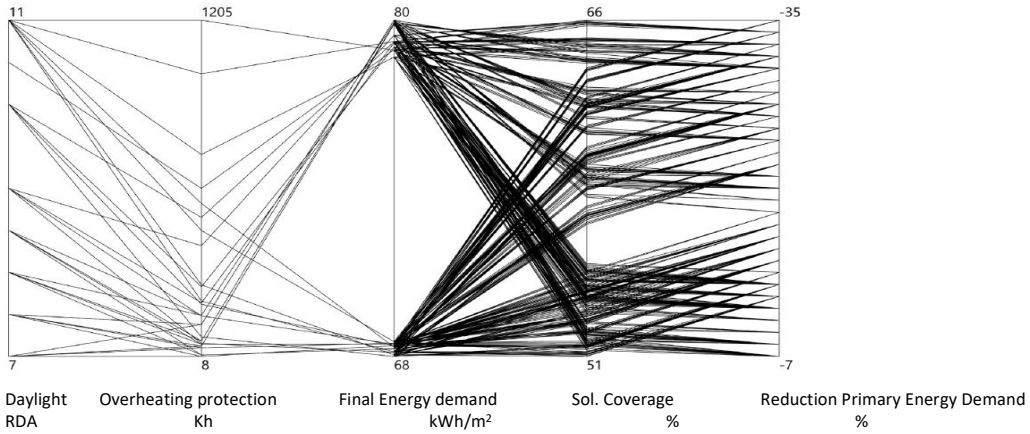


Fig. 5.22: parallel plot all variants

The best variant is the one highlighted in the parallel plot below. It features a combination of parameters with the best overall performance.

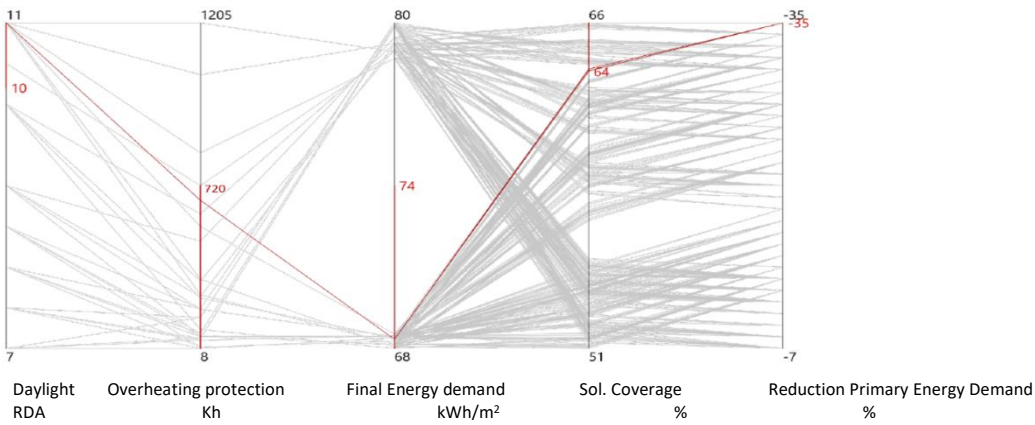


Fig. 5.23: parallel plot final variant

The detailed results of this optimal variant can be seen below:

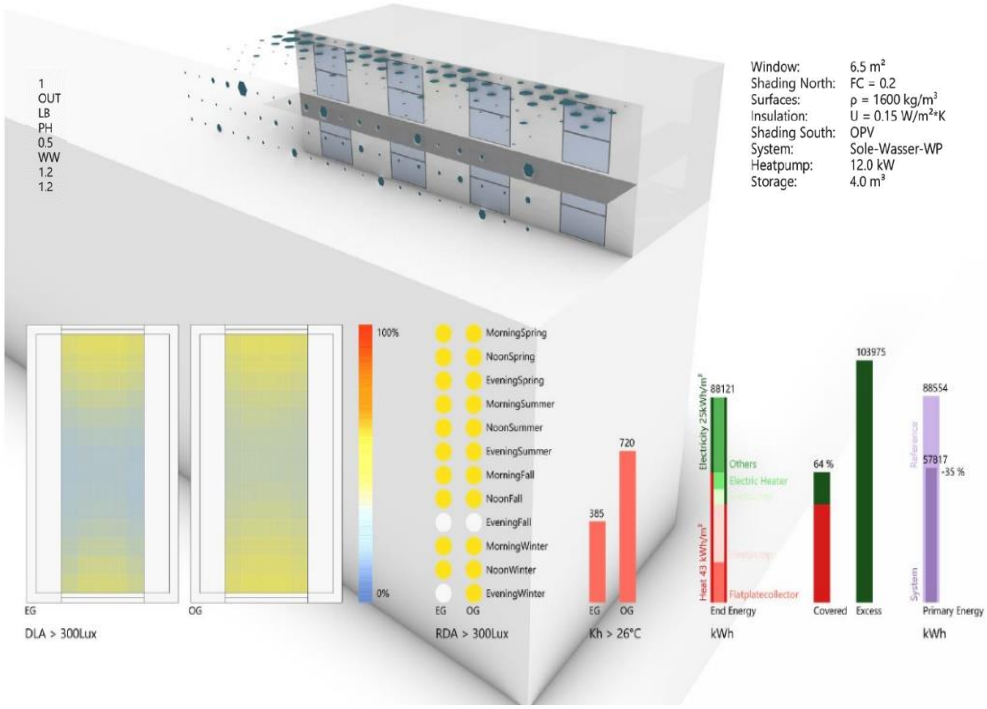


Fig. 5.24: Detailed view of final variant

A window with an area of 6.5 m^2, dynamic shading of the north window, surface mass in the form of clay panels and the passive house standard are the parameters chosen in the building category. In the HVAC category, a brine-water heat pump (12kW) with solar thermal collectors as the environmental heat source and a buffer tank size of 4m^3 was chosen as the best option.

All parameters from the building category are implemented into the design.

Heat Pump – variable environmental heat source

The tool only incorporates solar thermal collectors and outside air as possibilities for the environmental heat source of a heat pump. However, depending on the actual location of the building that is to be extended vertically, there might be other environmental heat sources, which feature a higher potential and can be used for the heat pump. In the case of Building 5, waste-water from the main sewer nearby was found to be the most promising (refer to potential analysis). This heat source is chosen for the whole building (existing+extension) and the system performance analyzed and optimized in the chapter “decarbonization of energy supply”.

5.3.3 DHW Domestic Hot Water

The demand for domestic hot water is mainly in the residential units of the extension. In the existing building, there are only a few taps (café, tea kitchen) where domestic hot water is required. In order to ensure an optimal supply of domestic hot water, the following types of domestic hot water generation were investigated during the conceptual design phase:

	type of installation	heat source	temperature level
1.	hot water tank	heat pump and electric instantaneous water heater	55 to 60 °C
2.	central fresh water station with hot water ring ducts	heat pump and electric instantaneous water heater	55 to 60 °C

3.	decentralized fresh water station	heat pump and electric instantaneous water heaters	demand-dependent
4.	decentralized instantaneous water heater	electric instantaneous water heaters	demand-dependent

The decentralized installation of domestic hot water generation systems supports the idea of modularity of the overall concept, as each consumer can tap the required amount of hot water exactly as needed. In addition, the installation of decentralized fresh water stations and instantaneous water heaters makes it easier to comply with hygiene regulations compared to centralized domestic hot water production and hot water tanks, since the decentralized installation types fall below the 3-liter rule. Furthermore, energy can be saved because the temperature level does not have to be maintained at 60 °C throughout to prevent the formation of germs and legionella. With decentralized systems, domestic hot water is only produced when required. In contrast to instantaneous water heaters, decentralized fresh water stations require even less electrical energy due to the preheating of the hot water. Since the decentralized fresh water station must always be connected to the surface heating's own heating circuit and this is associated with increased installation and control effort, installation in the existing building does not make sense due to the low consumption-Since the decentralized fresh water stations overall have the most advantages, the domestic hot water in the extension is to be provided via decentralized fresh water stations. In the existing building, only electric instantaneous water heaters are to be installed due to the small number of consumers and the lower installation and control costs. The string diagram for the system can be found in Appendix C.

5.3.4 Total Monthly Energy Demand without building services

Thermal demand

The heating demand of the existing building and the extension was determined using thermal simulation and corresponds to the final variants of the TRNSYS simulations (refer to chapters additional story and existing building). The heating demand for the entire building is 186,589 kWh/a. The DHW demand was derived from the "European reference tapping cycles" (profile: 3 XL) and is constant over the year at around 1,400 kWh per month (2).

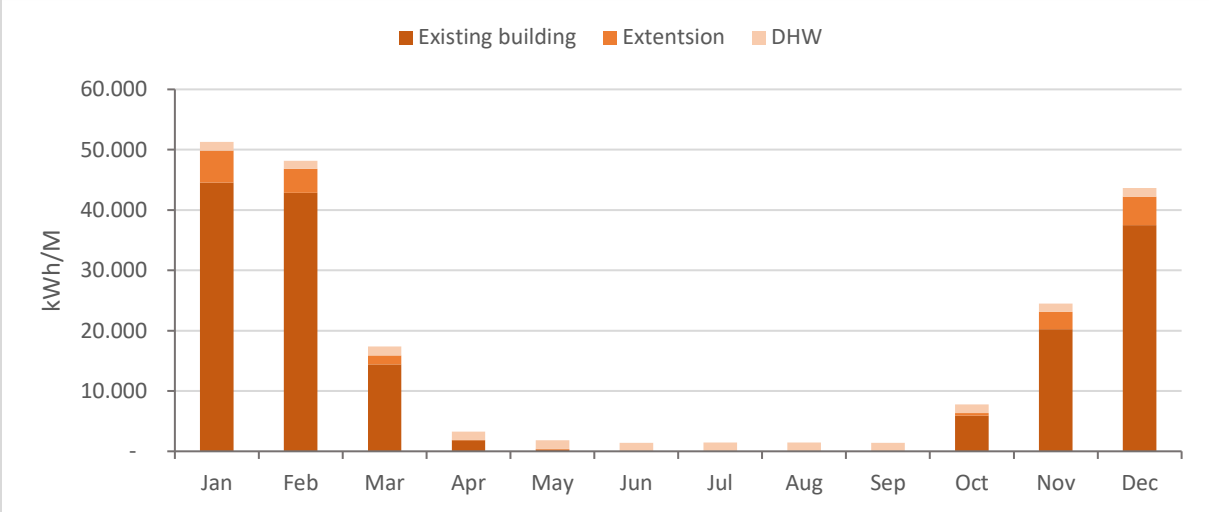


Fig. 5.25: thermal demand

Appliance demand

The electricity demand was determined separately due to the different types of use with the office use in the existing building and the residential use in the extension. In both cases, daily profiles were created and used to calculate the annual electricity demand. In the existing building, separate daily profiles were created for each type of room, such as offices, seminar rooms, server rooms, etc. In these profiles, the electricity demand of the individual consumer devices was entered for the respective hour. By extrapolating the daily profiles to the year, a static demand was created that was repeated on a daily basis, which did not correspond to the real electricity usage. Therefore, real annual profiles from one office and one residential use were used. The annually determined demand was distributed over the entire year and thus comes very close to the real electricity consumption of the existing building and the extension.

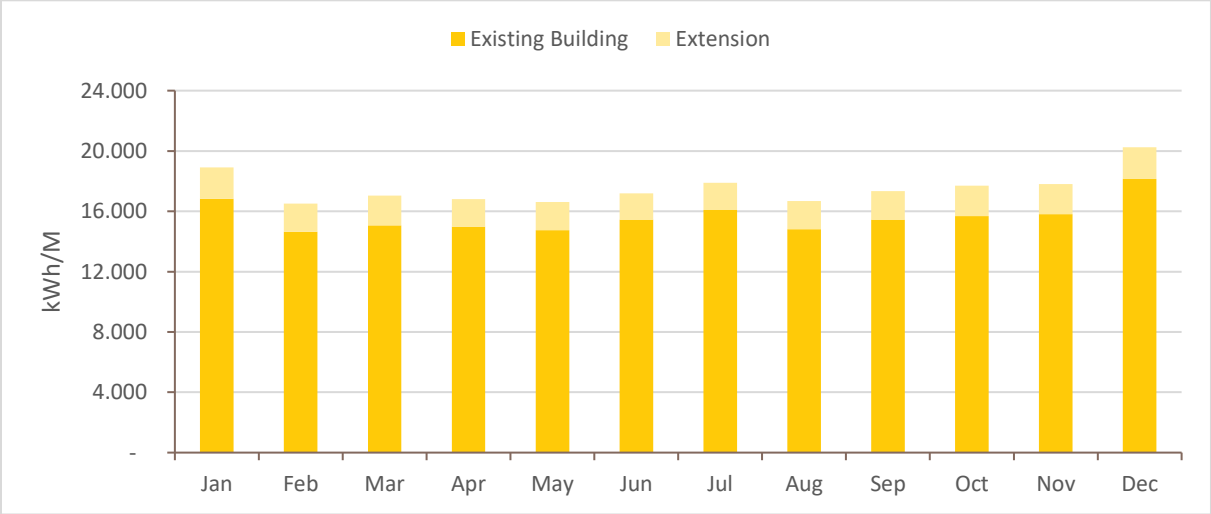


Fig. 5.26: appliance power demand

5.4 Measures to Decarbonize Energy Supply

5.4.1 PV system

For electricity production, monocrystalline silicon-based photovoltaic modules with an efficiency of 21.6% are to be installed on the entire roof of the extension. In addition, the organic photovoltaic modules integrated into the grid are used not only as shading elements, but also to generate electricity. As opposed to silicon-based photovoltaics, organic photovoltaics feature high low-light efficiency, making them less sensitive to shading (3). Therefore, they are more suitable for the use on the partially shaded façade (refer to radiation analysis).

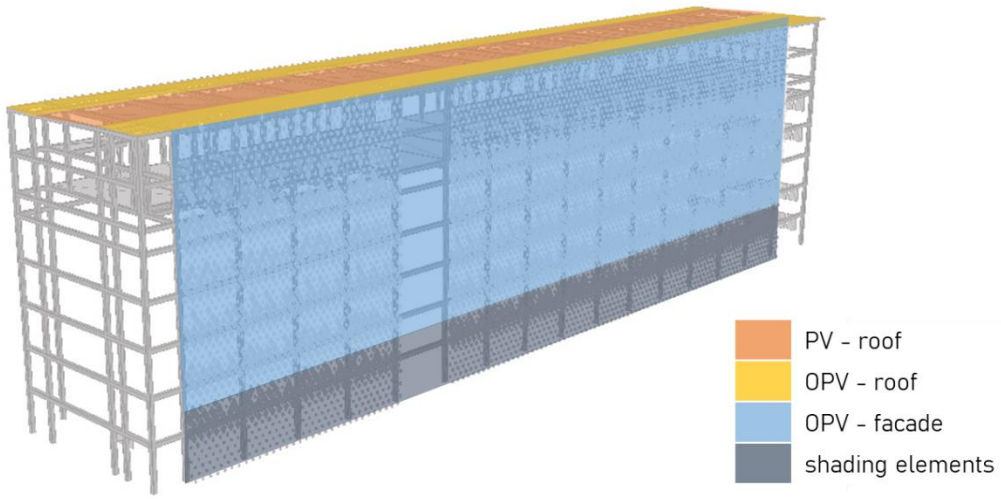


Fig. 5.27: Position of the different solar modules

Furthermore, their high power-to-weight ratio makes them suitable for renovations that include the addition of a story (4). The current efficiency of commercially available OPV cells is around 5% and therefore significantly lower than silicon-based photovoltaics. However, improving their efficiency is a widely pursued research objective, which already resulted in cells with laboratory efficiencies ranging from 15-20% (5). The façade of the lowest floor is shaded heavily, and no PV modules are placed here. Instead, shading elements of the same diamond shape as the OPV modules are implimented.

The areas and the power generation for the PV and OPV modules are shown in the following and table:

	location	**area**	**power generation**
monocrystalline silicon-based photovoltaic (PV)	roof	560 m²	10,958 kWh/a
organic photovoltaic (OPV)	roof	218 m²	790 kWh/a
	facade (south)	291 m²	1,046 kWh/a

Figure 15 shows the number of PV and OPV modules per month. A total of 128,266 kWh/a of power is generated.

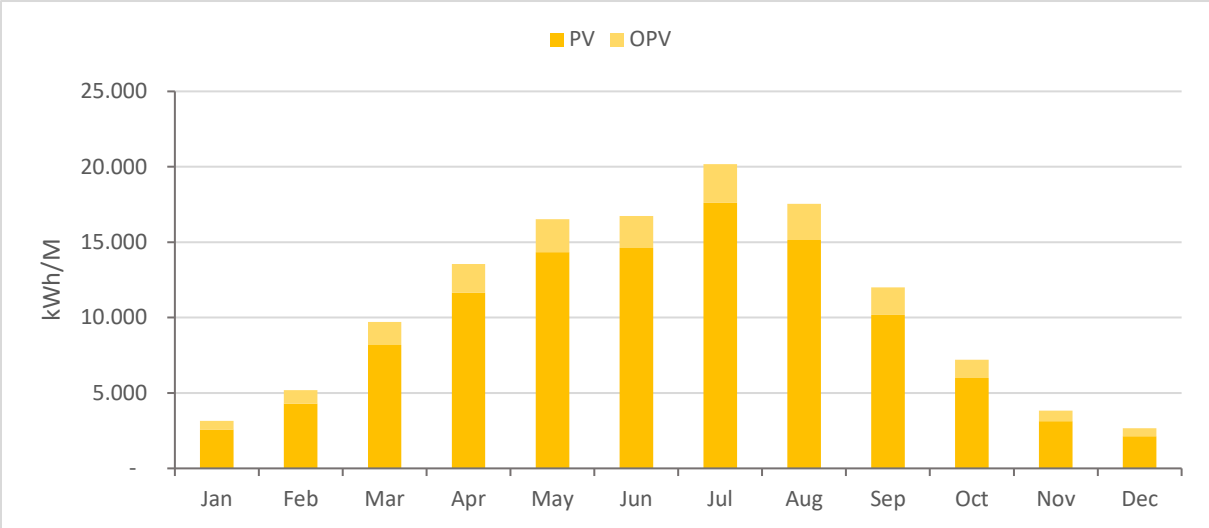


Fig. 5.28: solar power generation

5.4.2 Parametric study of systems components

The final values for the heating demand and appliance demand, as well as the DHW demand are implemented into a dynamic HVAC System simulation model generated with TRNSYS.

To find the best possible combination of dimensions, two of the main components of the active system (refer to final energy concept summary - active system) were studied parametrically.

- **Heat pump capacity**
- **Battery storage capacity**

The rated power of the heat pump is based on a temperature of 12°C in the primary circuit, due to the collected data on the wastewater. As the heat pump is demand-controlled, the temperature in the secondary circuit is between 25 and 35°C depending on demand. A temperature difference of 3K was applied to the primary circuit and 5K in the secondary circuit. Because of the constantly high source temperature in the primary circuit and a low required supply temperature, a COP of 7 can be reached. The heat pump data used for the study is from the brine/water heat pump model Vitocal 300-G, BW/BWS 301.A29 from Viessmann. The calculation method for the heat pump input is listed in the appendix.

The control of the heat pump is designed for different operating conditions.

- The heat pump is to run demand-driven when the storage tank temperature is below the required supply temperature for the heating system. If there is excess solar power at the same time, it is used to power the heat pump
- The other two operating states run when there is a solar power excess and there is currently no heating energy demand, which mainly happens during shoulder seasons and in summer
    - When there was heating demand in the past 48 hours, the heat pump is run until there is no more excess or the tank temperature is above 40°C
    - When there was no heating demand in the past 48 hours, the heat pump is run until there is no more excess or the tank temperature is above 30°C. This mode is used to lower the amount of energy that has to be used to heat the DHW in the fresh water stations

The battery was integrated into the simulation in simplified form. Storgage loss was neglected, and no specific battery characteristics were considered.

The different combinations of parameters are to be compared by means of carbon footprint. Hereby, the CO_2 emissions of the system components during the life cycle were taken into account in the first step. For this purpose, data from Ökobaudat (6) and data from the research report "Life cycle assessment of PV system and battery" of the city of Zurich (7) were consulted.

Furthermore, the emissions during operation over a period of 20 years were considered. These emissions were calculated on the basis of the non-coverable thermal and electrical energy demand from the simulation results, which must be covered by grid purchases or district heating. For this purpose, an emission factor of 200 g CO_2e/kWh was used for grid electricity and an emission factor of 148 g CO_2e/kWh (8) for district heat. The data for the CO_2 emissions of the system components and the CO_2 emissions during use are shown in Figure 16, with varying battery storage sizes and heat pump capacities. With increasing system size (battery, heat pump) the CO2 emissions during manufacturing and removal increase. At the same time, the emissions decrease during use due to the higher coverage rates with increasing system size.

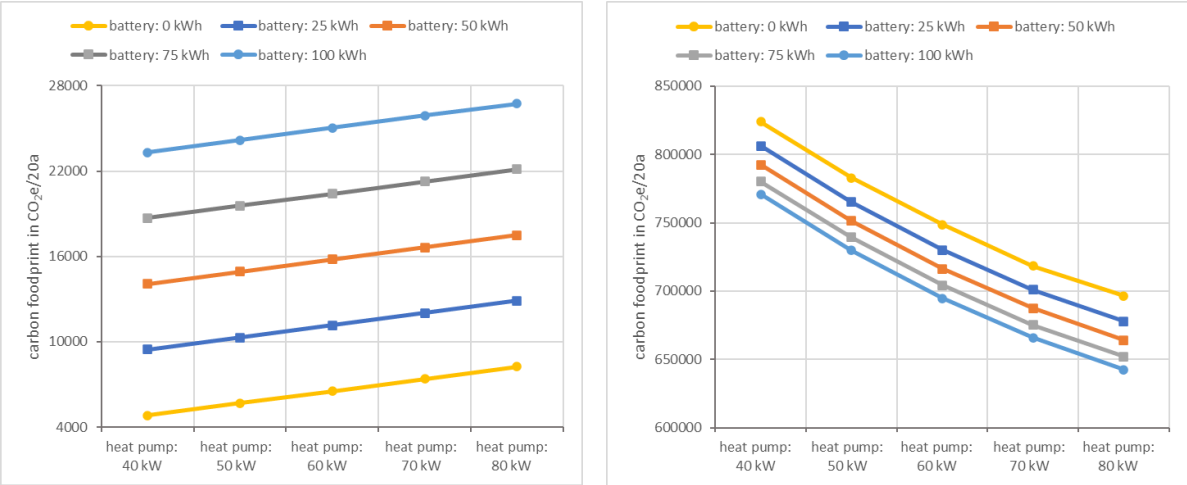


Fig.5.29: Parametric Study: left - CO2 emissions of the components; right - CO2 emissions in use (over 20 years)

Fehler! Verweisquelle konnte nicht gefunden werden. on the left shows the combined carbon footprint from the manufacture and removal of the system components and from use over a 20-year operation period. By considering all emissions within the 20 years, the optimal system can be determined. The first thing that can be seen is that the heat pump with 80 kW is the most suitable size for the system in order to reduce the emission of Co2 as much as possible, this is due to the excellent COP of the heat pump. The analysis is more difficult for the size of the battery. A larger battery seems to improve the carbon footprint. This can be seen by the increasing solar fraction with increasing storage size in the right of figure 17. However, the emissions decrease significantly less with storage sizes of 50 kWh and larger. The same can be observed for the solar coverage rate of the electricity demand. Therefore, a capacity of 50kWh was chosen to be implemented into the design.

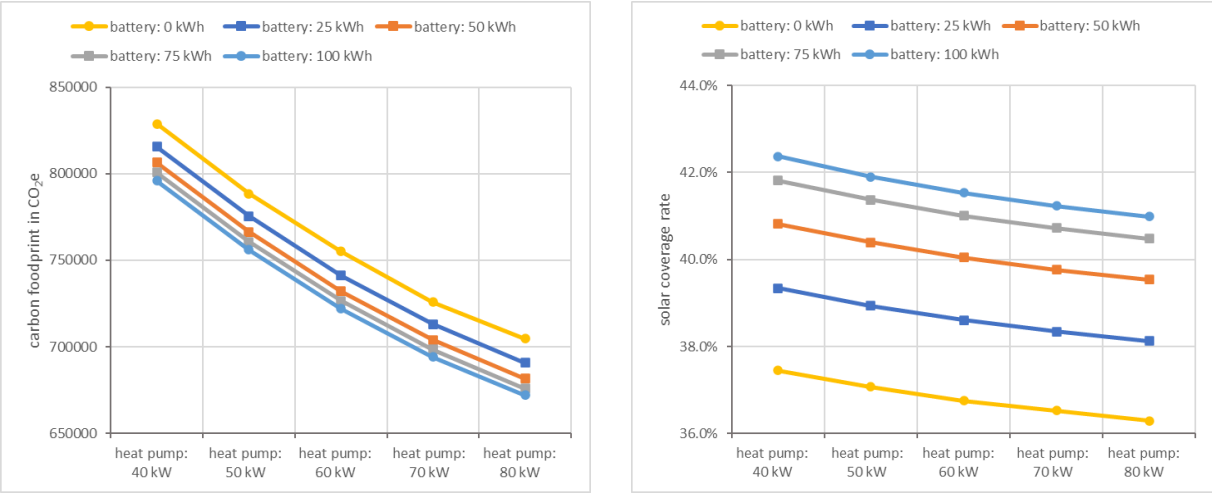


Fig. 5.30: Parametric Study: left - CO2 emissions over 20 years; right – solar coverage rate

5.4.3 Total monthly energy demand and supply

The following figures show how the required energy is provided to cover the electrical and thermal demand. The left bars in the diagrams show the demand and the right bars how this demand is met. Both the existing building and the addition are considered. The coverage rates are obtained from the simulation described in the previous chapter.

Figure 18 shows the coverage of the thermal energy demand (DHW and heating). The thermal heating energy marked in dark yellow is provided by the heat pump. This amount of energy is divided into the electrical and thermal parts of the heat pump. The light-yellow marked part is covered by electric reheating and makes up the lowest coverage, since this only happens with the electric reheating of the DHW in residential modules. The remaining heat demand of 13.9 % is covered by district heating.

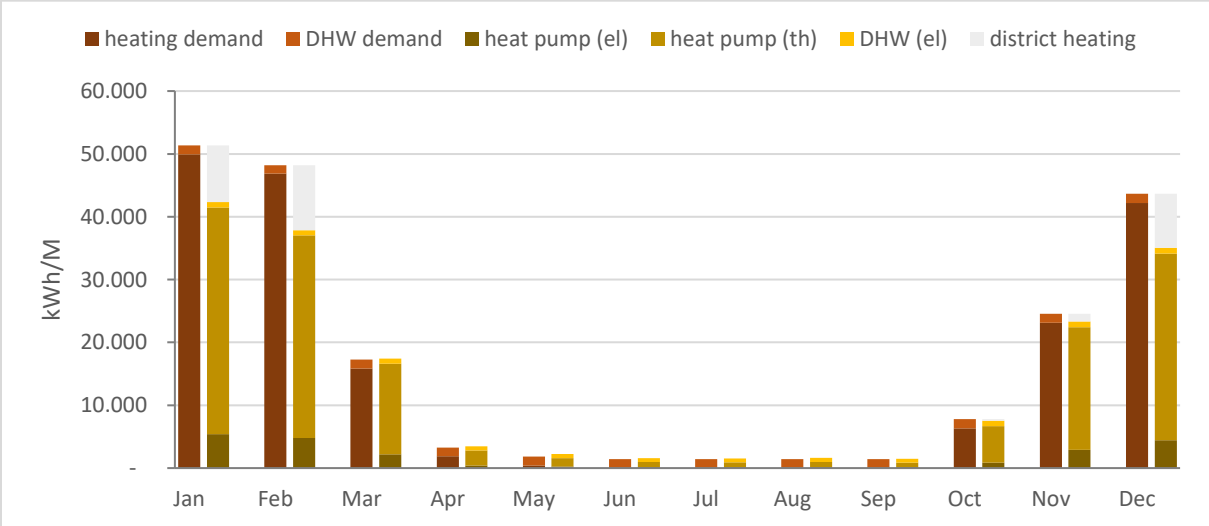


Fig. 5.31: thermal energy demand and supply

The electricity demand in Figure 19 is composed of the demand of household appliances (appliances, lights, etc.), the electric domestic hot water reheating, the demand of the heat pump and the other pumps. This demand can be covered to 35.3 % by the solar direct use and to 4.2 % by the solar electricity stored in battery. In total, 39.5 % is covered by solar energy. The remaining demand is covered by the grid.

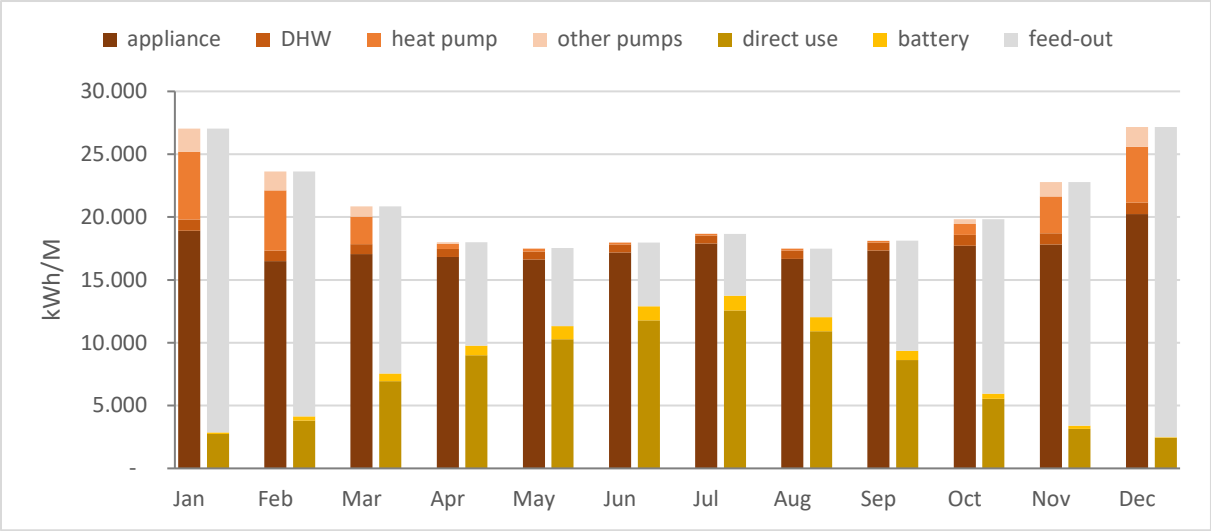


Fig. 5.32: electrical energy demand and supply

Figure 20 also shows how the energy generated by solar power is used. 68.4% of the generated electricity is consumed directly. The battery increases the consumption rate to 74.4%. In total, only about a quarter of the generated energy is not used and fed into the grid.

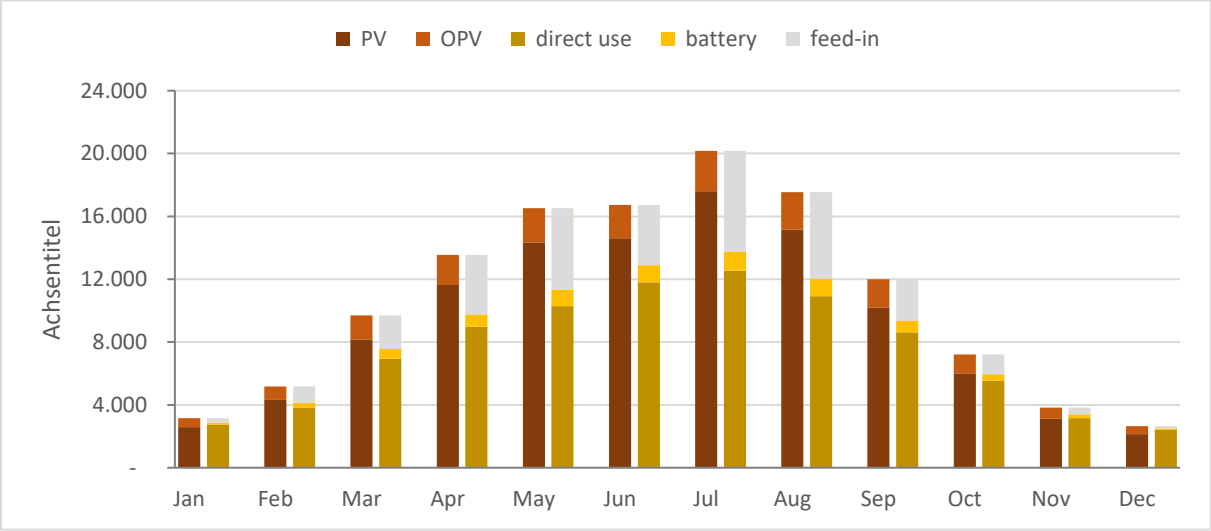


Figure 5.33: PV system generated power

5.5 Housing Demonstration Unit (HDU)

In this chapter it is described how the Energy Concept of the Design Challenge was transferred to the HDU. The transferred elements are evaluated through an initial whole-year TRNSYS simulation in terms of Kelvin hours. The same Trnsys model was then used to optimize the controls and operation of the HDU during the competition period. Lastly, the Sim Room Model, which is used to determine the annual energy demand for the Carbon Footprint Calculation is explained.

5.5.1 HDU in competition period

Energy concept of HDU in passive mode of competition weeks

For the HDU the energy concept, described in “summary of final energy concept”, is transferred. The passive key aspects of the energy concept, which are transferred to the HDU, are to be shown.

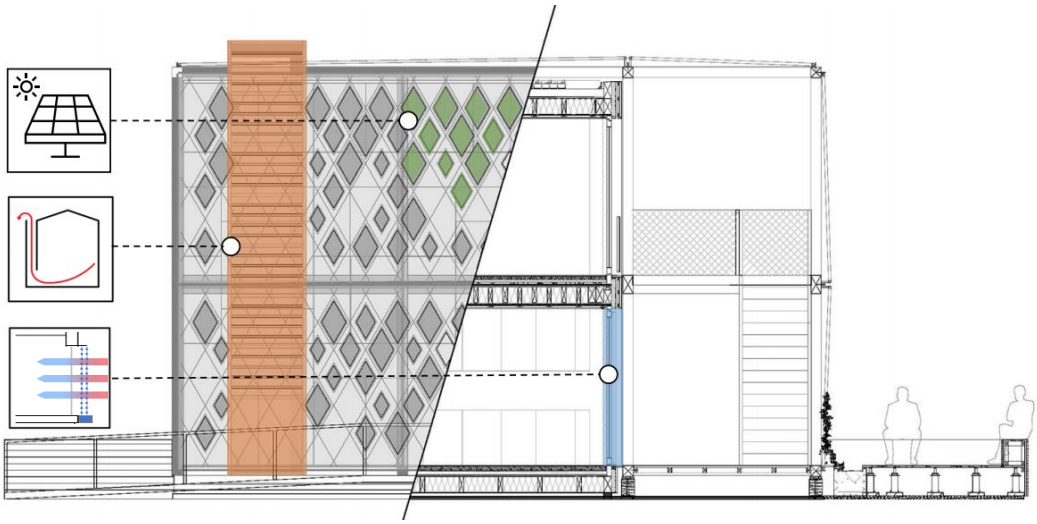
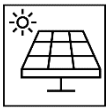


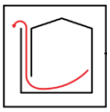
Fig. 5.34 Overview of the Energy Concept for the HDU

Solar Shading – Organic PV façade



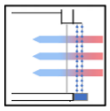
The GRID will be applied to the housing demonstration unit and is filled with OPVs as shading elements. The OPV distribution and size is generated, according to the climatic conditions present in Wuppertal, as well as the orientation of the HDU on site (same methodology as described in “reduction of energy demand- existing building”). The OPV modules cover the east, south and west facades, as well as the roof of the demonstration unit.

Solar Chimney



The solar chimney of the energy concept is transferred to the demonstration unit as an enclosed space about 15cm deep and 1.5 m wide, which overhangs the two floors in height by about 50 cm. It is attached to the western facade and is completely glazed on this side, the back and the interior is equipped with highly absorbent materials. Due to this structure, the temperature inside the solar chimney is much higher than outside. Air with a higher temperature has a lower density, which is why there is a temperature stratification with cooler air at the bottom and warm air at the top. These density differences cause a thermal buoyancy inside the chimney. The interior of the demonstration unit is connected to the solar chimney by an inlet. When the inlet is open, air is drawn out of the room because of the thermal buoyancy described above. The result is an increased air change rate in the HDU.

Adiabatic Cooling



For water to evaporate, energy is required, which is extracted from the air in the form of heat during adiabatic cooling. It is precisely this principle that is to be used in the extension and transferred to the demonstration unit. For this purpose, ribbons are stretched in front of the windows in the demonstration unit. Water runs along these ribbons. The water is collected in a container at the bottom and pumped up into a above the window, as seen in Fig. 5.35. When the window is opened, the outside air flows past the ribbons, is humidified and cools down. In addition to the adiabatic cooling using the ribbons in front of the windows, dry mist fans will be installed outside of the demonstration unit to ensure outside comfort for waiting visitors. The fans work by distributing tiny drops of water into the air. As a result, the outside air will be adiabatically cooled but for a person standing in front of a dry mist fan the air will not feel humid.

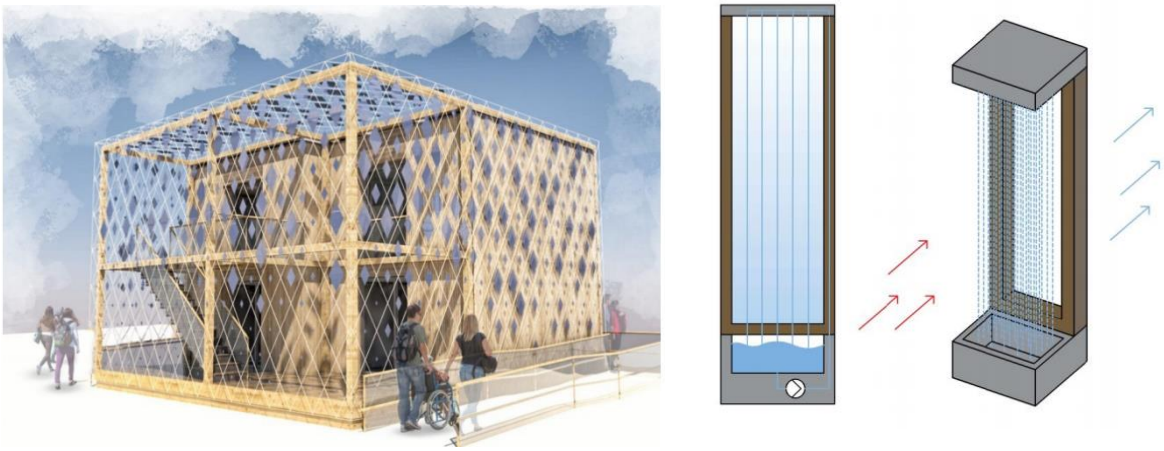


Fig. 5.35 left: parametric design of HDU, right: adiabatic cooling construction concept

The adiabatic cooling system consists of three basins. The upper and lower basin in front of the window. Between these the threads are stretched and the water runs down. Another technical basin is necessary for maintenance. Various devices are installed here to ensure smooth operation. When using such water installations in public places or indoors, some measures have to be taken to ensure the long-term function, hygiene and safety. Fig. 5.36 figure shows a scheme of the adiabatic cooling system with necessary equipment.

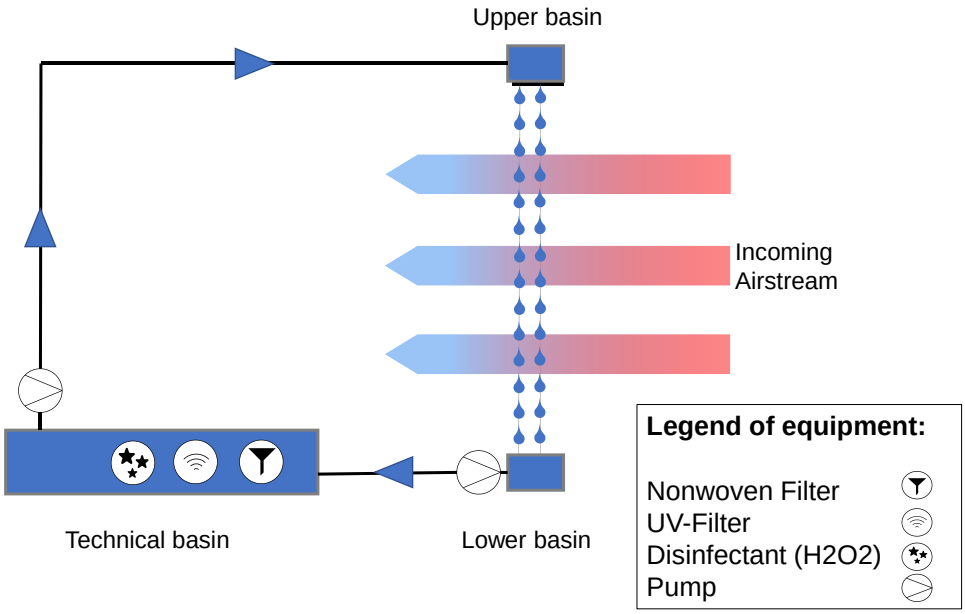


Fig. 5.36 Scheme of the adiabatic cooling system

In order to prevent limescale deposits, it is important to use water with as little lime as possible for the water feature. For this purpose, a reverse osmosis system is used, which treats the water when it is first poured into the system.

Another point is to ensure water hygiene and prevent dirt deposits due to external influences. Therefore two methods are used that offer double protection. During the day, a UV filter in the technical basin cleans the water. Floating algae, bacteria and germs are quickly killed by the UVC light waves. In addition, a nonwoven ensures mechanical-biological cleaning. There are various products on the market that combine both cleaning methods in one device. The electricity required for operation during the day can be generated by the PV cells. During the night, an additional method is used that does not require any electrical energy. For this purpose, a special disinfectant is added to the water. This agent, more precisely hydrogen peroxide (H2O2), is also used for cleaning aquariums or indoor wells. It is completely harmless to humans in low concentration. It has a disinfecting, antibacterial and odour-eliminating effect on the system. The remedy must be added manually every evening.

Dynamic Performance Analysis of the passive measures included in the HDU

In order to determine how effective the measures are for the housing demonstration unit, annual simulations of the different variants were carried out and compared in terms of Kelvin hours over 26°C. The cooling concept for the summertime and competition week relies heavily on natural ventilation. In the variant "SS|NV", adding natural ventilation through the windows drastically decreases the kelvin hours already. However, the full potential of the ventilation concept is reached by increasing the air changes in the HDU with a solar chimney and by passively cooling the incoming air through evaporation.

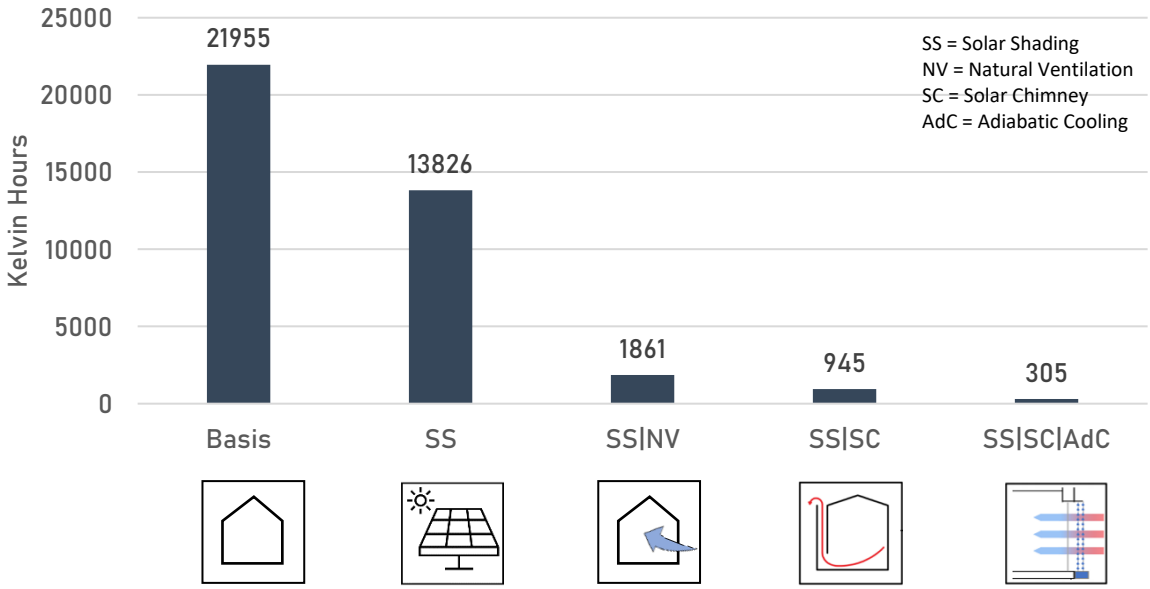


Fig. 5.37: optimization variants HDU

Regulation of ventilation during competition weeks

The key elements of the HDU energy concept were designed following a dynamic performance analysis of the whole year. It is to be shown how the solar chimney and particularly its control influences the performance of the HDU during the competition. Because during this time, the HDU is in passive mode only this simulation can't be compared to results of the SimRoom Simulation. Instead the simulation engine TRNSYS was used in combination with TrnFlow. The performance will hereafter be judged by

the standards of the 2.3 version of the rules. In the dynamic building simulation, the Indoor Air Temperature and the CO_2 concentration were focused on optimizing.

The control diagram below shows how the ventilation of the HDU is regulated. T_{air} stands for the Indoor Air Temperature, T_{amb} for the Ambient Temperature and the CO_2-limit depends on the Sliding Average Temperature. Above 15°C the CO_2- limit of 950ppm which is the one specified in the rules applies. Below 15°C Sliding Average Temperature the Ambient Temperature is so low that additionally ventilating the building results in Indoor Air Temperatures falling below the defined thermal comfort limits. Because the Temperature is prioritized over the CO_2 concentration during those cold times a CO2- limit of 1600ppm is permitted by the control. The figure below illustrates the low and high thermal comfort limits.

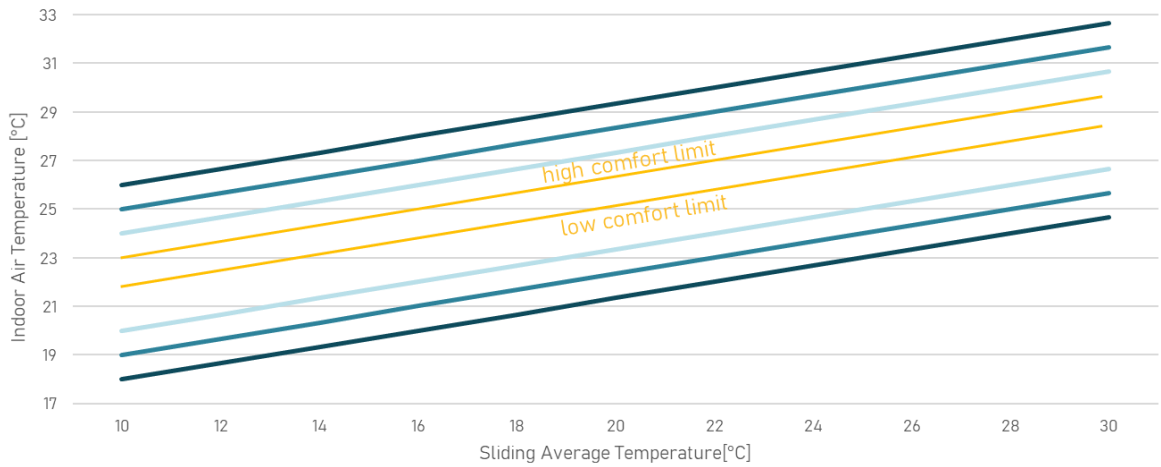


Fig. 5 38: control limits of the ventilation

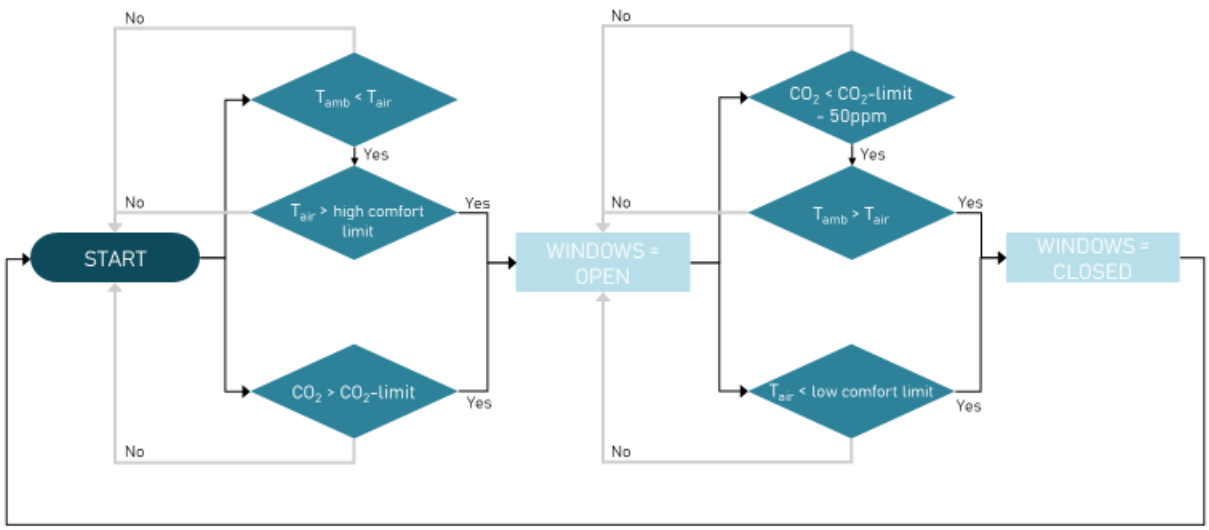


Fig. 5.39: control scheme ventilation

The figure below shows a comparison between the results of a basic simulation without the solar chimney and the final simulation including the solar chimney and its regulation. The assumptions taken for the final version are to be found attached, the ones for the basic version only differ in the control and type of ventilation. Instead of using the described regulation strategy, the windows are opened during daytime (8-18) in such a way an air change rate of 2 1/h is achieved. Also, there is no solar chimney attached. The building is therefore manually controlled, which is shown on the left-hand side

of the figure seen below. Hereby, thermal comfort cannot be ensured in the demonstration unit, because people realize too late that comfort limits are to be exceeded or fallen below.

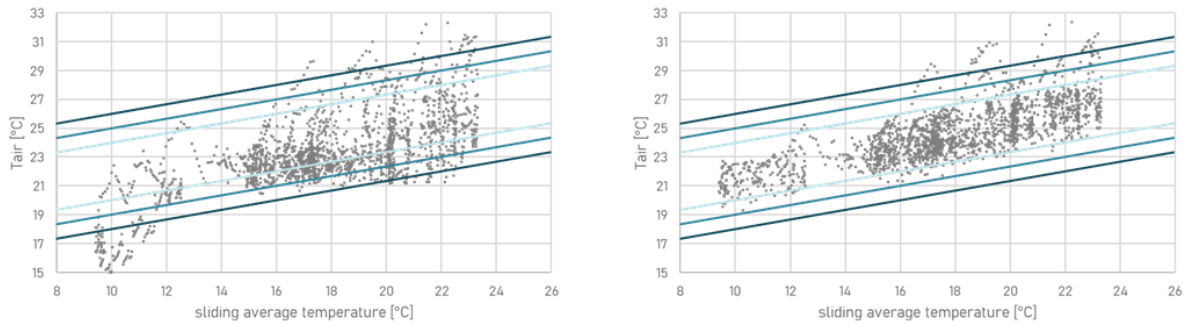


Fig. 5.40: left- manual control; right- automated control

Even with the automatic control a few hours are above the thermal comfort limits. But during those times the Indoor Temperature is mostly equal to the Ambient Temperature. Those hours can only be moved into the comfortable limits with additional measures. These could include passive ones like extra thermal storage capacity or active measures like an active cooling. During the times when the Indoor Air Temperature is above the Outdoor Air Temperature the thermal comfort can further be optimized by a more effective ventilation. An example would be a Cross ventilation, where all windows are opened. This measure would be manually controlled so not every window has to have an automatization. Therefore, the Cross Ventilations is part of the comfort concept but not applied in the final simulation of the competition weeks.

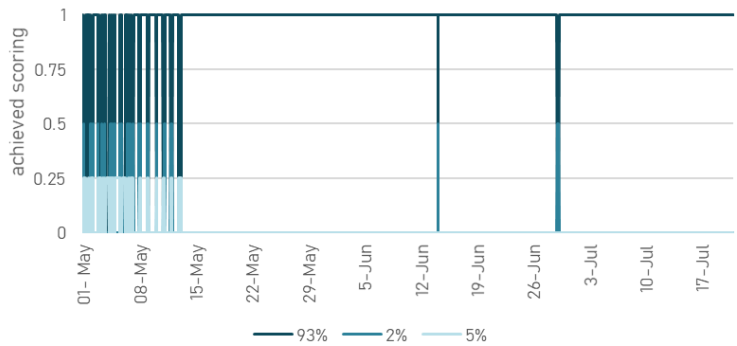


Fig. 5.41: expected indoor CO_2 concentration

The figure above illustrates that most of the time the CO_2 concentration indoors is in the best category and therefore scored the full points. Only during cold phases- especially the first two weeks of the period under review- the comfort limit of 950ppm is exceeded.

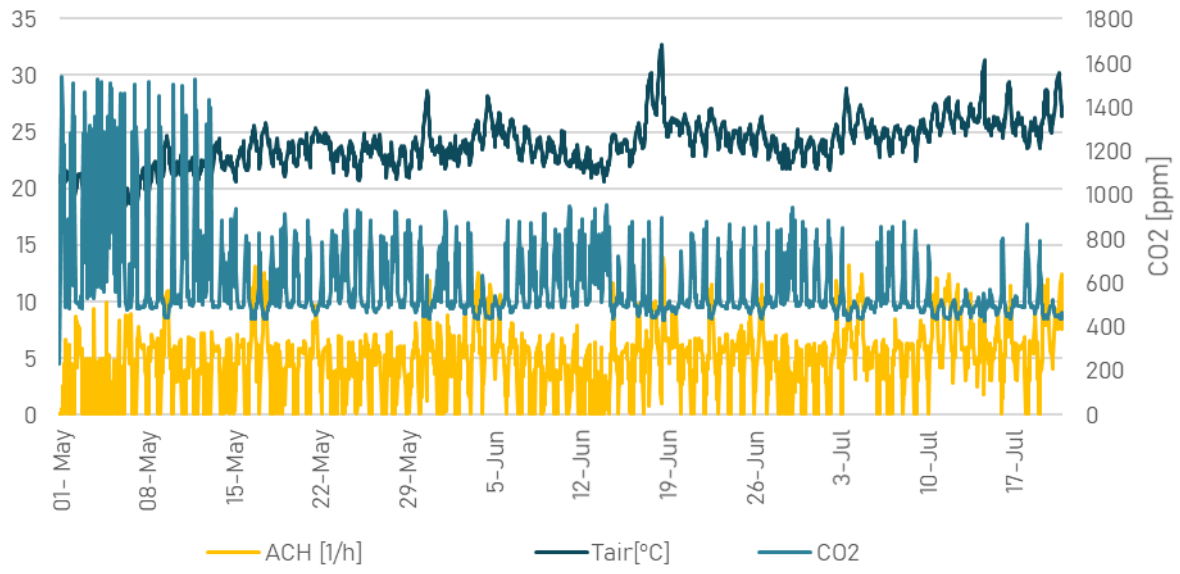


Fig. 5.42: expected room condition

When comparing the Air Change Rate (ACH) with the CO_2 concentration and Indoor Air Temperature (Tair), one can see how the low temperatures in the first week result in less ventilation and therefore higher CO_2 concentrations. In contrast peaks of temperature lead to a higher air change rate and a CO_2 concentration close to the outside condition of 400ppm.

5.5.2 **HDU in after use**

Energy concept of HDU for after use

For investigating the operation throughout the whole year and not only in passive, but also in active mode, a SimRoom simulation was carried out.

To generate heat for hot water and heating in the design challenge, a heat pump using the thermal potential of wastewater is included. Due to the high temperatures of this heat source, the COP of the heat pump is about seven. To portray this in the SimRoom simulation a geothermal heat pump is set. In addition to a component- integrated heating system, which represents the floor heating of the energy concept, a COP of 4.28 is achieved in the simulation. Hence, the actual electricity demand for heating will be lower than the results of the simulation indicate.

There is no active cooling set for the demonstration unit, because it is not part of the energy concept. The effect of the adiabatic cooling cannot be included in the simplified simulation using SimRoom.

The energy supply and a monthly overview of the heating, DHW and cooling demand are illustrated in the section “Life Cycle Carbon Footprint”.

While the energy concept of the existing building includes a run-around coil heat recovery system to pre-condition the supply air in selected rooms the one for the extension does not. Hence no heat recovery is set for the demonstration unit. Because of the installation of the solar chimney, it is presumed that the hygienic as well as an elevated ventilation can always be set.

In total 4 simulations are carried out, one for each different orientation and slope of the OPV modules. The respective solar outputs are calculated with a rate of efficiency of 4%. The Table below illustrates the cumulative areas for the different façade orientations and the respective power generations.

	area [m²]	power generation [kWh/a]
roof (0°)	36.3	723.96
east façade (90°)	19.5	231.16
south façade (90°)	8.7	128.5
west façade (90°)	16.3	191.9

The OPV- Modules are not included as “structual shading”, because their different sizes and locations result from a dynamic simulation with an external sunscreen with a Fc value of 0,2 (refer to reduction of energy demand-existing building). Therefore, this sunscreen is also implemented in the SimRoom Model to represent the shading generated by the OPV modules. In the TRNSYS Model used to develop the control scheme for the HDU, the OPV moules are considered as shading groups.

There is still “structual shading” implemented at the south façade. It is supposed to represent the stairs and its landing above the terrace. But as seen below, the only window shaded by structural shading is the one on the eastern ground floor. Therefore, only half of the actual dept of the landing is considered in the simulation.

Fig. 5.43: north view of the HDU

5.6 **Life Cycle Carbon Footprint**

There is no active heating of the HDU in the competition period. However, since the LCA is to be conducted for a period of 50 years, active heating is simulated in SimRoom.
The thermal heating demand for the HDU is **34.30 kWh/m²** and **46.16 kWh/m²** for DHW. These values are calculated based on a residential profile. The SimRoom model was used to determine all energy demands listed.

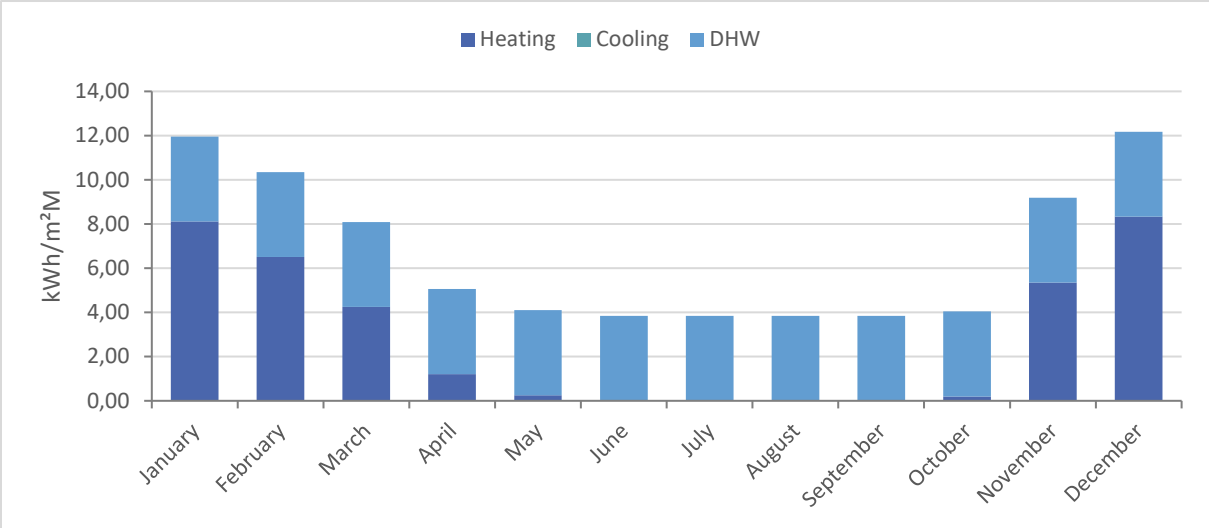


Fig. 5.44: Heating demand HDU

It is assumed that to cover the electricity required to meet the thermal energy demand, a brine/water heat pump with a COP of 3.5 is used. The electricity demand is calculated by dividing the thermal energy demand by the COP. The total annual electricity demand of the HDU is listed below.

	Electricity Demand kWh/a
Appliances, Lighting, etc.	3360
DHW	1188
Electricity for Heating	880
Auxillary Energy and Pumps	1440
Mobility	180
	Electricity Generation kWh/a
Energy Generaton: PV Roof	1136
Energy Generaton: PV East	293
Energy Generaton: PV South	148
Energy Generaton: PV West	256

The energy generated by the PV elements seems low. This is due to the fact that the OPV elements, which are described in the HDU section of this report, have a relatively low efficiency of 0.04. The OPV elements cover all sides of the GRID, besides the north side (refer to architecture report). Within the design challenge, the opaque roof of the residential modules is covered in regular PV elements. However, to avoid too much technical equipment only one PV system is used for the HDU.

In accordance with the SDE21 Rules an emission factor (GWP) 200 g CO_2/kWh for electricity is used. For a period of 50 years, the following CO_2 equivalences were determined:

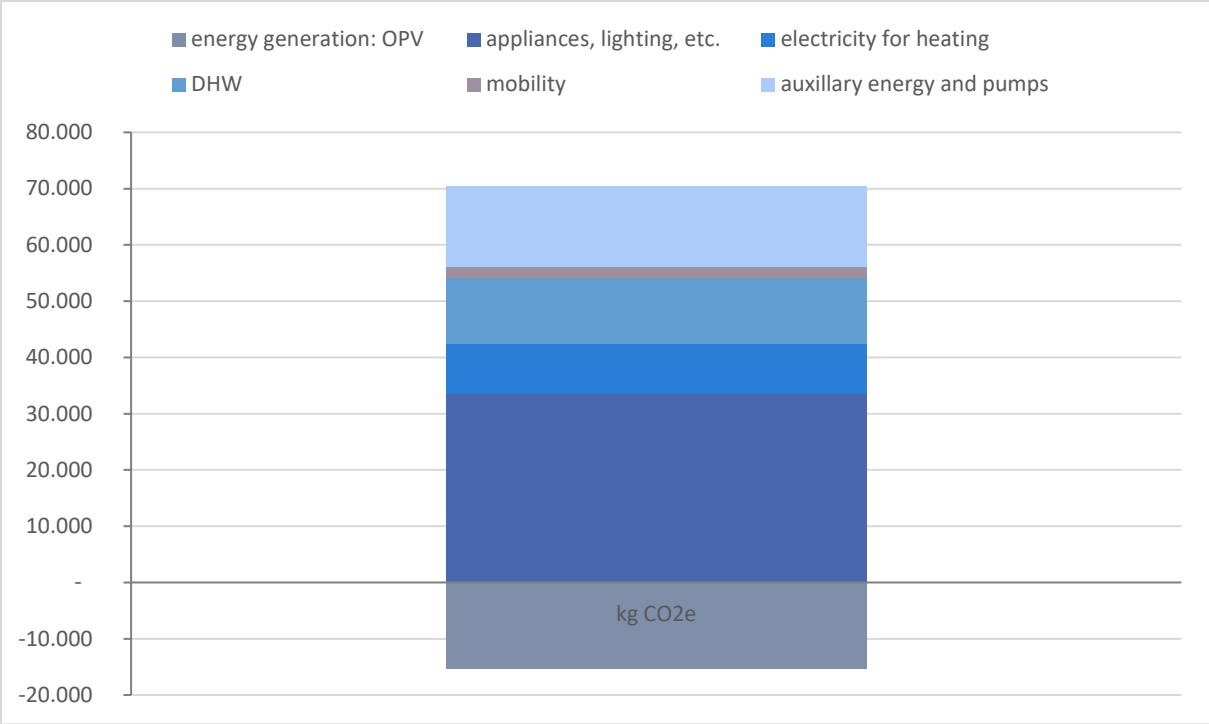


Fig. 5.45: CO_2 Equivalencies of Operation Period

The CO_2 equivalencies from the other life-cycle phases were determined as a part of the sustainability contest (UMI Tool) and are seen in the diagram below. With all the assumption made the total Carbon Footprint of the building is **45281 kg CO_2e/50a**.

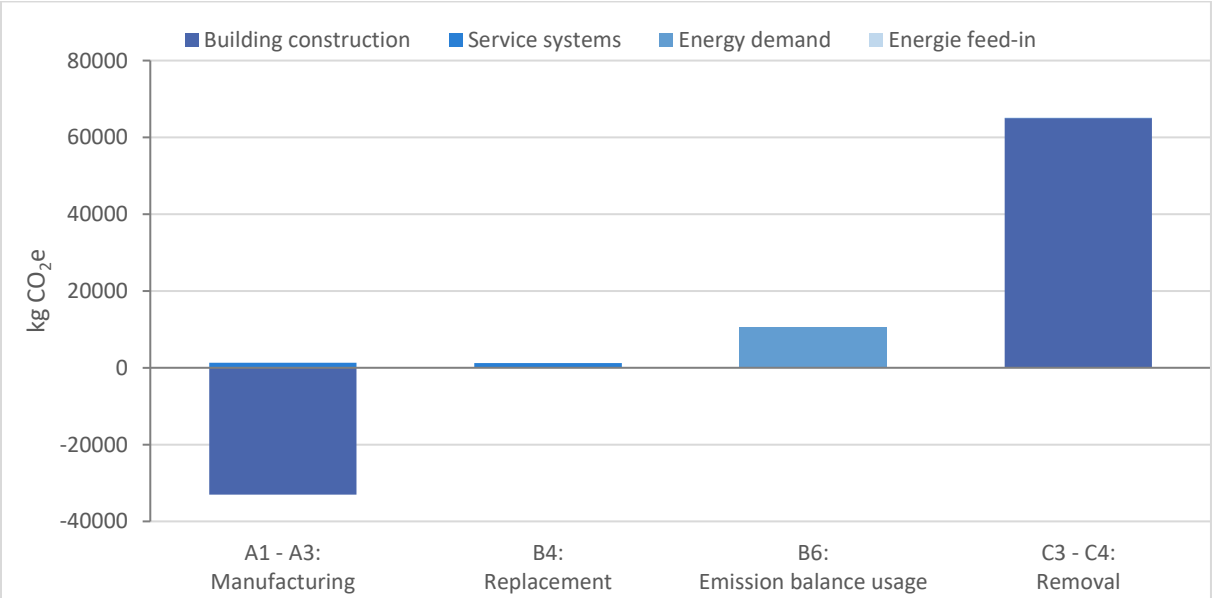


Fig. 5.46: Life cycle analysis

The carbon footprint was also analysed separately for the service systems. This includes the electrical installation (cables), the water installation, the PV system (OPV), the battery, the heat pump, and other pumps. It was assumed that all components, with exception of the electrical installation need to be replaced once in the course of the 50 years. Taking all assumptions into account, the total carbon footprint of the service systems is 2646 kg CO_2e/50a. Compared to the rest of the system, service systems are only responsible for a small part of the carbon footprint.

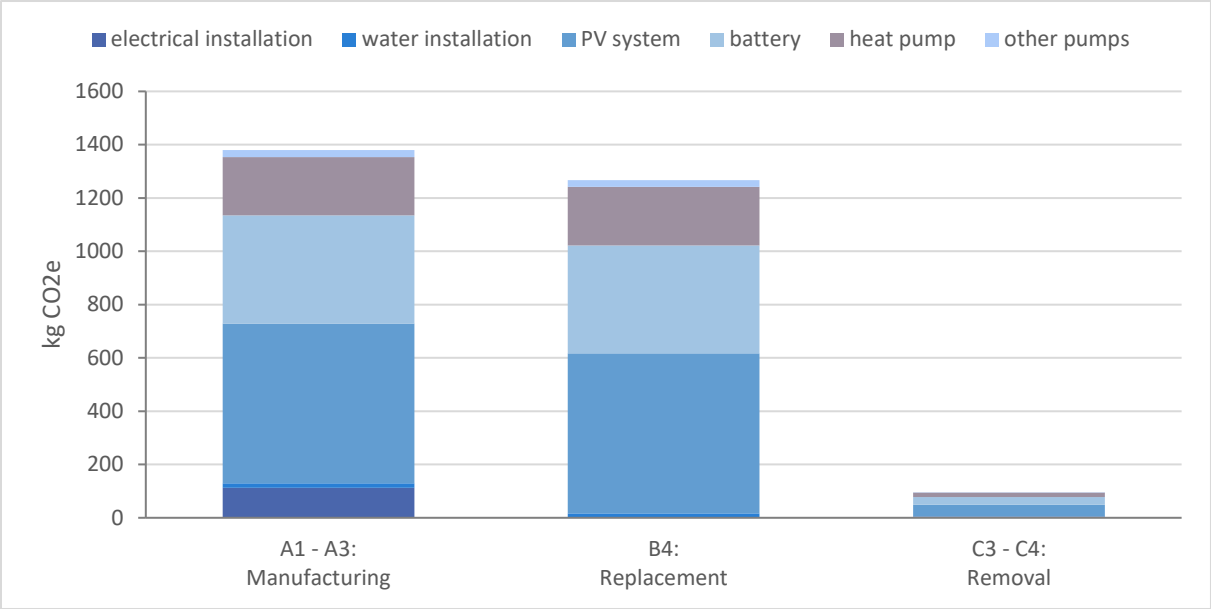


Fig. 5.47: life cycle analysis of service systems

6 AFFORDABILITY & VIABILITY REPORT

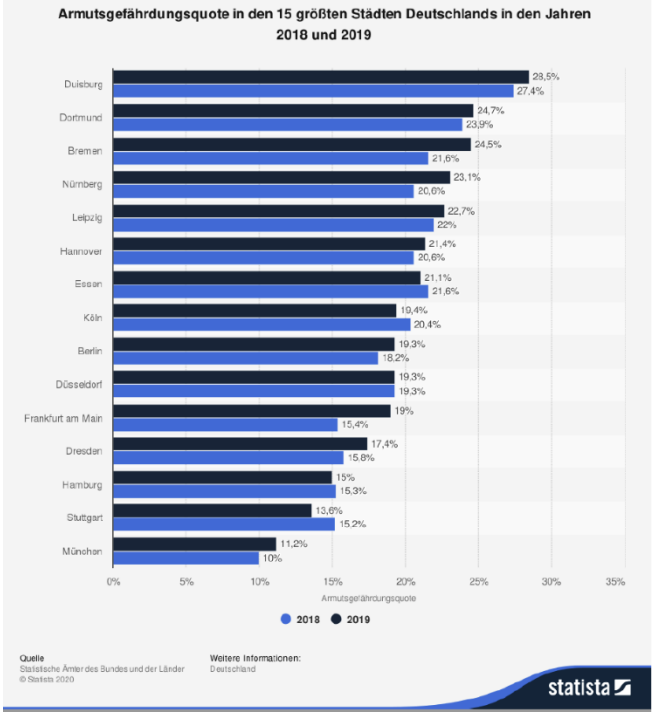
coLlab

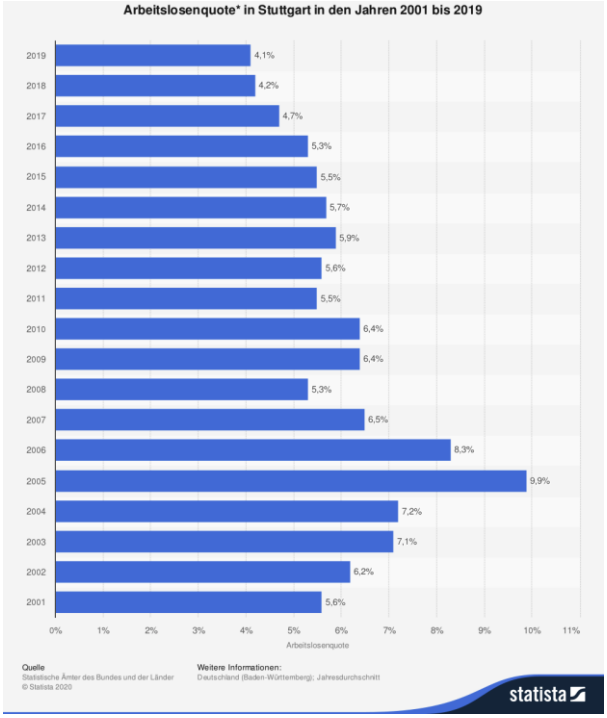
6.1 Analysis of the Context

6.1.1 Situation, Urban Situation

Urban Densification - an increasingly discussed term. More and more people are moving into metropolitan areas (Tichelmann 2019, S. 3). Because of the limited building land in cities, the offer cannot meet the demand. The scarcity of building land leads to strongly increasing prices (Bundesinstitut für Bau- Stadt- und Raumforschung 2017, S. 5). At this point the affordability comes into play because many people do not have the resources to pay the high rental prices – for example students. The chosen location, the HFT Stuttgart campus, is placed directly in downtown Stuttgart. Therefore, the described situation is perfectly suitable for our project. Stuttgart (and the campus) indicates a lack of free building land and a high potential to use existing constructions to be renovated and extended. The property is very well connected to public transport. It is surrounded by other university buildings and a directly adjacent park. A parking garage, a congress center and a hospital are located in the immediate vicinity. The nearest subway station is also only a few meters away. Consequently, it can be assumed that the location is attractive for many different interest groups and will continue to be attractive in the future. The investment risk should therefore be low.

Stuttgart is surrounded by hills and therefore located in a “Kessellage” or “Boiler Location”. An expansion of the city is consequential limited. Lacking land to build on leads to the question how the urgently needed residential demand shall be supplied. Urban Densification in form of new utilization, vertical or horizontal extensions can be one way to tackle the problem. The region of Stuttgart has a strong industry. Many global corporations, as for instance Daimler, Bosch and Porsche, are based in and around the city. However, there are also many successful middle-sized companies. Combined, these companies create a large supply of jobs, which, on the one hand, creates a population with high buying power and, on the other hand, a rather low unemployment rate of just 4,1 per cent (Fig. 4.2). Hence, only 13,6 % of the residents were threatened by poverty in 2019 (Fig. 4.1), which is the second smallest proportion, in comparison of the 15 biggest cities in Germany.





However, an increasing number of residents combined with an overall strong economy builds the perfect bridge to the next paragraph, because this and hence, a high demand for apartments, lead to a tight housing market.

6.1.2 **Housing Market**

Stuttgart is already a very dense city. Hence, there is nearly no space left to construct new buildings. Building a new house in Stuttgart is expensive. The price of the property is already a major part of the construction costs, which is a phenomenon typical for big German cities, and their part is growing continuously. In Stuttgart, the value of building property skyrocketed in the past ten years (Fig. 4.3) even in comparison with rents and construction costs.

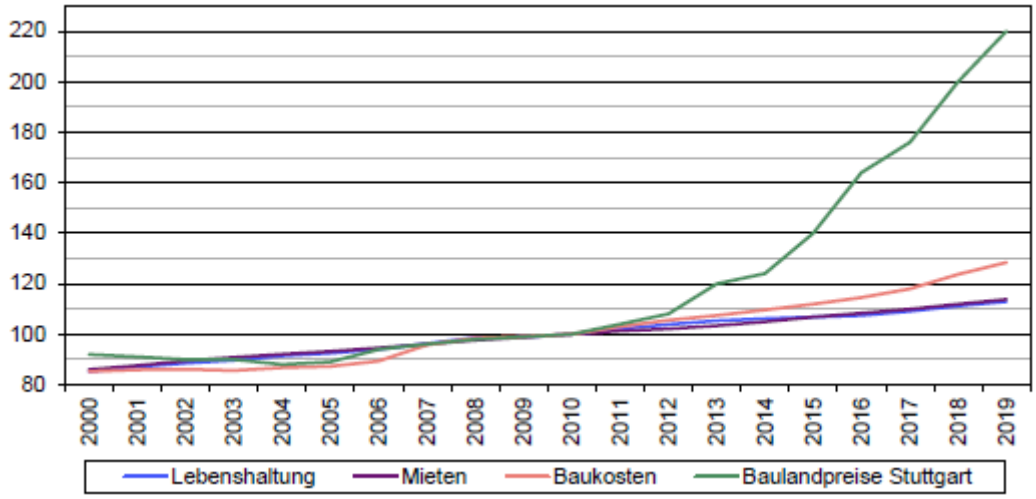


Fig. 6.3: Living costs, rents, construction costs and prices for building property over the past 19 years in EUR/sqm (Source: GMB 2020)

Therefore, the real estate prices are increasing strongly (Bundesinstitut für Bau-, Stadt- und Raumforschung 2017, S. 1). In 2019 the rent index in Germany was headed by Stuttgart (F+B). This implies the demanding housing market to be found in the capital of Baden-Württemberg.

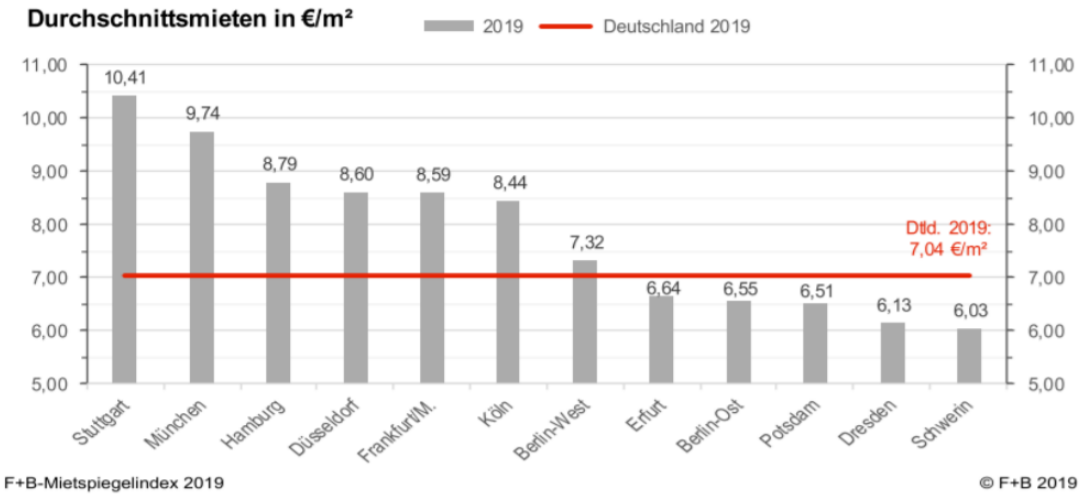


Fig. 6.4 Rental prices in Germany

As mentioned earlier, one reason for rising rental prices is the shortage of building land and resulting high prices. Fig. 4.3. shows the expected demand for residential units in comparison to the completions. The higher the discrepancy there, the higher the potential for rising prices. As Fig. 4.3.

shows the high level for the rental prices, Fig. 4.5. reflects the rising purchase prices for residential buildings.

In conclusion, the rental prices in Stuttgart are remarkably high, compared to the national average. For many people with a low income, it is a challenge to pay these prices. Affordable housing is urgently necessary, as it is in many regions in Germany (Tichelmann 2019, S. 3).

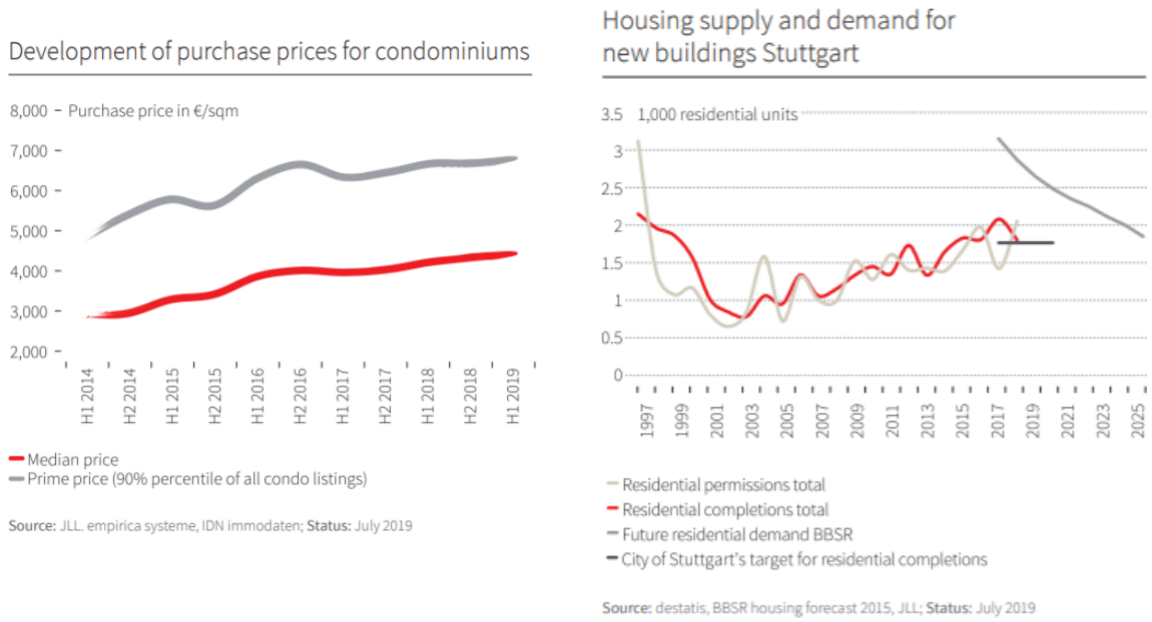


Fig. 6.6: Housing supply and demand for new buildings in Stuttgart

Structure and aspects of built environment, housing situation, socio-economic background, addressed inhabitants in Stuttgart many single/two person households (also students) can be found (Fig 4.6.), but the supply for small apartments is limited. Especially for small households, solutions for communication and community are interesting. These facts shall be addressed in the upcoming development.

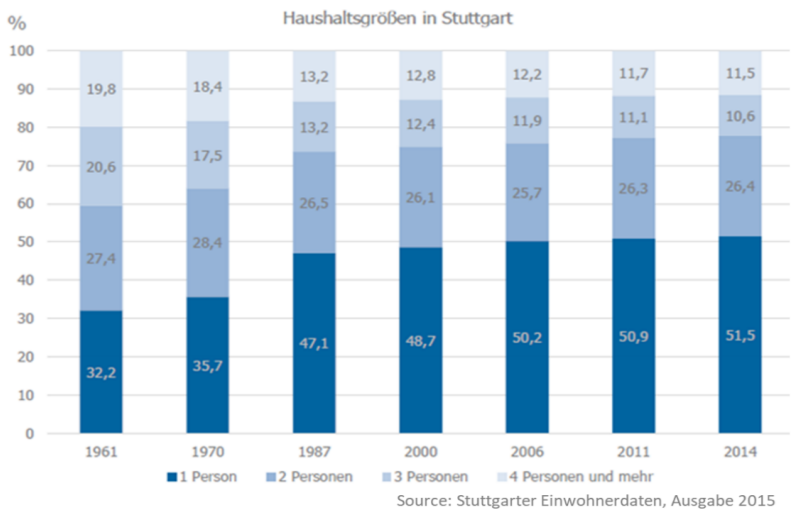


Fig. 6.7: Household sizes in Stuttgart

Many existing buildings bear the potential to be extended vertically. So does the chosen building at the HFT campus. The potential as well as the transferability shall be tested and proven during the SDE21.

The mentioned, increasingly high rental prices lead to social tension and problems along the inhabitants of Stuttgart. For the specific project, students are in the focus, but the concepts shall be valid also for other residential developments.

6.1.3 SWOT Analysis of City, District and Unit

The following analyses are based on the studies from the last semester and will be developed further in the upcoming deliverable.

City	
Strength	Weaknesses
• High rental space demand • Yield of the building increases → Upgrading of the existing real estate through more intensive land use. • Subsidies for top-ups • As the capital of Baden-Württemberg, Stuttgart is an attractive business location.	• Limited locations, as suitable roof surfaces are required. • Feasibility depends on legal factors (building law, development plan) • In Stuttgart, the infrastructure has grown with the city so that the infrastructure is almost fully utilized.
Opportunities	Threats
• Urban sprawl into important green spaces can be contained. • Curbing the lack of rental space • Urbanization → demand increases • The development to date suggests that the demand for apartments will continue to rise in the future. Therefore, secure rentals can be expected in the long term.	• Population density increases, infrastructure overload possible. • Building law

District	
Strength	Weaknesses
• Its location in the city center offers many possibilities for activities after work, which can be reached within short distances.	• Difficult construction conditions, little available BE space at inner city construction sites • Possible lack of acceptance by neighbors (shading, deterioration of the microclimate) • In the city center, increased noise is to be expected due to the high volume of traffic and the many visitors. • Change of the historical townscape
Opportunities	Threats
• Vitalization of a quarter through redensification	• Even though it is unlikely, the closure of the university or a change of location of a company can reduce the demand

Unit	
Strength	Weaknesses
• Flexible planning + short realization time (due to wooden frame construction) • Lower construction costs than a comparable new building -> no need for costly soil investigation and site development • The existing buildings can be used during the construction phase	• More complex maintenance work • Controversial for historical buildings • Existing building must have suitable statics
Opportunities	Threats
• Increase of sustainability through timber frame construction. • Further remediation measures can be carried out during the increase	• Fire protection • Vacancy

6.1.4 Relevance for transformation and description of urban issues.

As mentioned above, Stuttgart has a strong economy and most of the residents are employed and have a good buying power. However, the lack of housing is one of the major urban issues in Stuttgart. More than 75 % of the population in Europe lives in cities, and with the ongoing urbanization the number is expected to rise in coming years (Weith, 2021, S. 3). This creates high rental and property prices, as mentioned above, which create social tension. People with less money aren`t able to increase their savings, which leads to a bigger gap between wealthy and poor residents.

Also, more than 50 per cent of all households are single households (Fig. 4.7). Often people move to Stuttgart for their work or to study. More than 25 per cent of all residents do not have a German citizenship[1]. So, at least some of them do not know anybody in town. Nearly 25 per cent of the people between 18 and 39 years feel constantly or at least often lonely[2]. Social isolation is a growing urban issue in modern cities.

Also, the inner cities become constantly more abandoned. Most of the people indicate, that their visiting the inner city to go shopping[3]. Because of the lack of space and the high rental prices many clubs and bars had to be closed and the total number of people actually living in the Inner City of Stuttgart is actually decreasing (footnote 1).

More single households also need more space. However, space in Stuttgart is expensive, as mentioned above. We believe that these urban issues, barely enough affordable living space and social isolation are two of the most important urban issues regarding our target group – students.

Our project provides affordable appartements for younger people and creates spaces on the roof of existing buildings to come together. The concept for affordability will be described in 1.3 Concepts. More affordable living space encourages more people to move to the inner city again, which can stop the abandonment of the downtown. Residents will stay overnight, populate parks, bars and streets, creating a more attractive and social environment.

[1] https://www.stuttgart.de/service/aktuelle-meldungen/februar-2021/bevoelkerungsentwicklung-im-jahr-2020-in-stuttgart-ruecklaeufig.php (visited on March 7th, 2021)
[2] https://de.statista.com/statistik/daten/studie/1014929/umfrage/umfrage-in-deutschland-zur-haeufigkeit-von-einsamkeit-nach-alter/ (visited on March 7th, 2021)
[3] Institut für Handelsforschung IFH (Hg.) (2015c) , S. 4.

6.2 Targets & Objectives of Concept

6.2.1 Social Scenario and Urban Issues

Now we are mainly focused on students as residents. So, most of our target group is in their twenties to early thirties, interested in new technologies, innovations, sustainability and has a limited budget. In addition, they are often free time-, lifestyle and career focused.

Most students do not need much space to live. Furthermore, one of the main criteria upon which they choose their place is their budget. Therefore, rents and operational costs must be affordable. In the younger generations, sustainability awareness is becoming increasingly relevant, not least due to the fridays for future movement. This is noticeable in their mobility behavior, the type of food they eat, and so on. It is therefore also becoming increasingly important for providers of student housing to take the sustainability aspect into account in order to be able to offer attractive housing in the long term.

It is also mandatory for students to have a good and stable Internet connection, which is often not provided in the more affordable outskirts of the city.

Because of the ongoing COVID-pandemic nearly all their courses take place online. It will be seen what parts of online study will stay after the pandemic.

Besides the focus on budget, students also want to have shared spaces, where they can meet with their fellow students and get to know new people.

However, we do not want to just focus on students and will examine different possible target groups.

Combination of citizens - suitable for the district?

The stated target group fits the choses district perfectly. It is the city center and right on the campus. Shopping centers, bars, clubs and the main train station lay within ten minutes of walking distance. Also, many companies are based right in the city center. Especially the park next to the campus is crowded with students during the summer.

Neighborhood - sharing and cooperation

The project is based right on top of a campus building, which is a special situation. So, we have two completely different kinds of utilization. Students live on top of the building while some of them study in the building below. Also, professors and employees of the “Hochschule für Technik” work there during the day.

Both parties share one stairwell, hence, they also share one entrance. Furthermore, students may party on the roof since the early morning, while professors and employees already come to work.

6.2.2 Strategic Objective

What are the main goals of the project?

1. To find possibilities to reduce the rental prices by extending existing structures and reducing the construction cost, as well as decreasing the operation cost.

2. To develop a flexible, modular way of standardized design to enable different high executions in the same system keeping high quality in architecture and construction.

3. To find a way to reduce soil consumption and the housing shortage by developing ideas for small, functional residential units keeping the idea of communication among them.

4. To contribute the global fight against the climate change by developing a resource saving and CO2-neutral concept for the construction and operation of buildings.

5. To discover solutions for collaborating districts regarding social but also mobility related aspects.

Objectives of social scenario

Included above.

General and specific urban issues that are solved

The stated objectives tackle a variety of detected issues, that must be solved in the upcoming years:

1. Rising Rental prices and a shortage in offered residential area.

2. High construction cost led to high rents. Prefabrication, industrial construction and modularization keeping an individuality in architecture are needed.

3. Urban densification and an increasing soil consumption must be addressed.

4. The climate crisis has an impact on the whole world. Concerning this matter, parts of the responsibility can be shifted to the construction and operation of buildings.

5. In many cities, as well as in Stuttgart, the urban mobility is not yet developed sufficiently to reduce emissions and provide comfort for the citizens.

6. The urban heating is an issue in Stuttgart due to the mentioned valley location.

6.3 Concepts

Measures to reach the objective

Mainly it should be mentioned that our university offers a lot of different expertise. Different teams of different faculties and different special areas and courses will develop concepts to solve the stated objectives. All this effort will be channeled by the collab Team. All the disciplines are already analyzed, and the work is distributed to different courses and persons responsible. The affordability and viability related objectives will be a product of the proved solutions of the other disciplines. Especially during the last semester, we frequently discussed our result together and adapted our concepts accordingly.

Show and document project measures and concept that solve urban issues. Integrate in HDU

The development of the planned measures for our project will continue while the project proceeds. Of course, a documentation of the ideas and the implemented methods will be elaborated. The best possibility to show these concepts will be an integration into the Demonstration Unit.

6.3.1 Concept for Affordability and Economic Viability

Focus on residents

Effects on operational costs

We have many different aspects, which all combined lead to decreased operating costs. Operating costs can be divided in fixed a variable cost. The fixed costs are ever occurring costs which must be paid monthly or yearly, such as water, electricity, heating, taxes etc. Variable costs include upkeep or unexpected maintenance. The fixed costs are in total much higher. By building an energy efficient housing unit with solar cells on the roof and in the mesh, we decrease the costs for electricity, which has a direct impact on the residents. The heating pump decreases the energy costs and is directly supplied with photovoltaic energy. The solar chimney is used for ventilation. This increases the comfort during the warm seasons without using energy for air-conditioning.

Furthermore, since 2021 there is a tax on produced CO2 which is now also applied to buildings in general. One ton of CO2 equals now 25 Euros. In 2025 this will already be 55 Euros[4]. Keeping the carbon footprint low has a direct positive impact on the fixed costs every year.

The renovation of Building 5 will also increase its energy efficiency. The new facade has a much better insulation and therefore less heats get in and out of the building, decreasing the energy costs. Also, the façade in the south effectuates the amount of sunlight entering the rooms, which makes them more comfortable in the summer season and creates less need for ventilators or energy consuming air conditioning.

[4] https://www.bundesregierung.de/breg-de/themen/klimaschutz/co2-bepreisung-1673008 (05.07.2021)

Affordability for the residents

There are two types of apartments: the ones with one floor and roughly 32 m² of space and the ones with two floors and ca. 68 m² of space to live. For the first type we calculate the rent with 18,45 €/m². Base on the official numbers this is the mean. However, for apartments this size it's an affordable price, keeping in mind that living in the inner city of Stuttgart is popular and especially in small apartments expensive. In total the basic rental equals 597,96 €. For the second type we calculate the rent with 16,78 €/m², which is also the mean. In totals this equals 1.087,68 € basic rent per month. Precise calculations can be found in appendix A. However, this is the rent we calculated if all if the apartments would be offered on the free market and for everybody. If a public institution, as for example the "Studierendenwerk Stuttgart" (student union Stuttgart) would buy or rent this rooms, it would only be possible for students to live there. However, the rent for them would decrease, because it would be subsidized by the state of Baden-Württemberg. So, depending on the use of the apartments, whether they are open for everybody or just for students, the rental costs are in the lower sector, given the fact, that this are new build homes with low operational costs.

Focus on Property Owners/Investors

Estimated real-life construction cost

Estimating the construction costs becomes harder, because of the current market situation. Especially the prizes for wood and steel skyrocketed in the last month and it is hard to predict where the will land. So, for our calculations we included surcharges between one and five per cent for risks, based on this and other unpredictable factors which could increase the prices. For the construction costs we must divide the project in two parts. The first one is the new module of the roof. The second one is the renovation of the existing building beneath it, the Building 5 of the Hochschule für Technik. All costs are estimated based on the German norm DIN 276. Starting with the property which would be expensive if it must be bought by an investor. Because it is owned by the state and not available for the public to buy, we had to define the property borders. To estimate its value, we used the capitalized earnings method. That we added the value of the Building 5.

Fig. 6.8: Dimensions of the considered building

Based on calculations given in appendix B, this would be approximately 18.000.000,00 Euros. The precise calculation can be found in the appendix. These costs are not included in our top-up module, because we believe that every building, where our modules could be built on, is already owned and the property already paid for.

For the housing unit on the roof, we calculate in total (KG[5]200 – 700 based on DIN 276) with ca. 8.450.000 € excl. taxes. There included are the costs for development (KG 200), the costs for the building and services (KG 300 and KG 400), costs for outdoor facilities (KG 500), equipment (KG 600) and additional building costs (KG 700, for example fees and incidental costs). The precise calculations are attached in appendix C. It must be added that fees for architects and engineers are calculated as if a whole new building is constructed. Based on our standardized design these fees will decrease drastically if the housing unit is to place on different buildings. Because the design only varies in size there must be fewer engineers' calculation the essentials as for example statics on the new building.

All the rest stays the same and the building services, such as pipes, wires and so on, are separate from the main building and easily attached via the surrounding frame.

Table 1: Estimated construction costs for the housing unit (extract from the affordability calculation).

Kostenzusammenstellung				
Summe Grundstück	KG 100	0%		- €
Summe Herrichten und Erschließen	KG 200	6%		584.310,92 €
Summe Baukonstruktionen	KG 300-400	64%		6.425.544,61 €
Summe Außenanlagen	KG 500	2%		227.862,26 €
Summe Ausstattungen	KG 600	4%		356.584,10 €
Summe Baunebenkosten	KG 700	24%		2.462.781,89 €
Vorsteuer			1.605.752,87 €	
Gesamtkosten				**10.057.083,77 €**

For the renovation of Building 5 the costs are much higher. This applies only in our specific scenario and will change drastically if the unit is placed on a different building. As mentioned before, the costs for the property are a major factor. The costs for building and building services (KG 300 and 400) are at roughly 19.203.000 Euros excl. taxes. This includes every enhancement in the facade and a complete redesign and renovation of the inner area, as well as constructional changes, which are necessary to add the housing unit on the roof. Financing costs are also included as well as decreases based on potential funding from the federal government. In total this equals construction costs with 50.893.000 Euros for the renovation.

Table 2: Table 1: Estimated construction costs for the renovation of the existing building (extract from the affordability calculation).

Kostenzusammenstellung				
Summe Grundstück	KG 100	36%		18.188.210,21 €
Summe Herrichten und Erschließen	KG 200	6%		2.815.109,83 €
Summe Baukonstruktionen	KG 300-400	38%		19.203.364,57 €
Summe Außenanlagen	KG 500	1%		328.509,83 €
Summe Ausstattungen	KG 600	3%		1.683.190,96 €
Summe Baunebenkosten	KG 700	14%		7.056.216,49 €
Summe Finanzierungskosten	KG 800	9%		4.707.733,13 €
Vorsteuer			5.722.807,59 €	
Bundesförderungen für effiziente Gebäude				**3.088.825,00 €**
Gesamtkosten				**50.893.510,03 €**

[5] KG stands for Kostengruppe in German and means cost categories.

Financing plan for implementation - ROI etc.

For the first financing plan we made a cash flow analysis and assumed that a private investor would by the property. This means that all costs must be included, also the property costs. A positive and cost decreasing effect comes from the federal funding for energy efficient buildings ("BEG – Bundesförderung für energieeffiziente Gebäude"[6]) by the German KfW bank. The new funding program was launched on July 1st 2021 and grants repayment bonuses. In our case these bonuses add up to 3.088.825 Euros (calculation in appendix D). We assume that 20 % of the project are financed by equity capital which leaves 40.714.808 Euros left. These will be borrowed with a fixed interest from 1 per cent for the first ten years. Yearly there will be a redemption rate of 3 per cent, which makes it an annuity of 1.628.592,32 Euros. This would mean that the whole project is paid off after 29 years.

The rent for the business rooms in the building five is calculated with 1.244.700,84 € per year with an increase of 1,5 per cent every three years. This increase is set rather low to keep housing affordable for the target group students. The total rent of the apartments on the roof is calculated with 194.421,11 Euros per year with the same increase every three years. The part of the operational costs, which will not be paid by the tenants, e.g., property management, upkeep and risk for vacancy is calculated with a 4 per cent deduction from the rental income. This means that there would be a total yearly income of 1.338.383,42 Euros every year which is less than the annuity. However, the rent increases every three years, this will not change during the financing period.

Nevertheless, the building has a positive net return of 2,63 % which is based on the yearly net income divided by the used capital.

$$\frac{1.338.383{,}42\ €}{50.893.510{,}03\ €} = 0{,}0263 = \mathbf{2{,}63\%}$$

This makes it in total a profitable project because the rate of return lays between 2 and 3 per cent. Nonetheless and mainly since the property costs are this high, it would be in total more profitable if a public institution or the city of Stuttgart would realise and operate the whole building and the housing unit.

Effects on unit value - how is market value enhanced by energy etc.

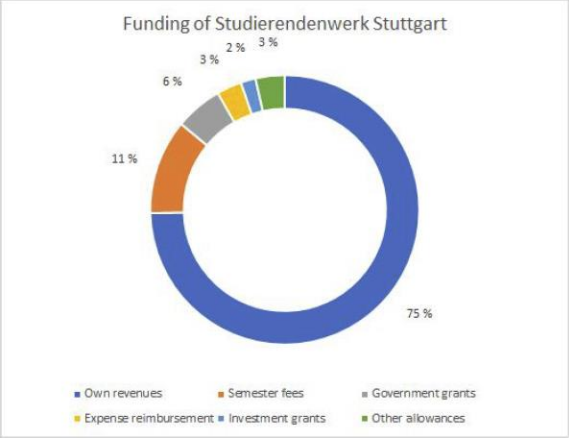
As mentioned earlier, there is a high demand for small apartments in Stuttgart. The Building 5 lays in the inner city, directly next to the "Hochschule für Technik". The location is one of the main factors when it comes to the value of real estate. As mentioned earlier, the energy efficient construction leads to decreased operational costs, which increase the market value. Furthermore, comes the overall positive public perception with "green building" which becomes more popular every year[7]. So, popularity on its own will raise the market value even further. Because on the specific construction characteristics of the housing unit, it can be fully taken apart after the end of its lifespan. The goal is to make it possible, that every building material can be separated and therefore recycled or in best case directly reused. These reusable materials can then be sold or used when building a new housing unit.

[6] https://www.kfw.de/inlandsfoerderung/Bundesf%C3%B6rderung-f%C3%BCr-effiziente-Geb%C3%A4ude/ (04.07.2021)

[7] https://www.usgbc.org/articles/green-building-accelerates-around-world-poised-strong-growth-2021 (05.07.2021)

Operating models and business models

There are many different operating models which come to our mind. As mentioned before, one way to operate and fund this project is to use an organization like the “Studierendenwerk” (student union) which is a non-profit organization. It acts primarily for needs and solidarity but is not intended to maximize profits. Their goal is to help students find student housing and provide affordable services.



The “Studierendenwerk” has offices around Germany that provide student housing in cooperation with universities. “Studierendenwerk” in Stuttgart owns 33 dormitories in 14 universities in Stuttgart with moderately cheap monthly rents. They are an organization that builds more and more student dormitories and have experience from this industry.

Based on the result of our first financing plan this is the preferred method. A private investor would have to be willing the pay more over the first 29 years. The rooms underneath the student homes can be used on the one hand by the city of Stuttgart for offices or rooms for the university. On the other hand, they could also partly be used by the “Studierendenwerk” itself as new office rooms.

6.3.2 **Concept for Social Viability**

Solving of urban issues

By creating a sustainable and affordable solution to add more living room to the city, one of the major urban issues of Stuttgart is tackled. The project gives residents the possibility to live in the inner city, in a modern building with an affordable rent, especially measured based on the low operational costs. Both residents and investors benefit from that. In this way, a revitalization of the campus and at the same time of the city center takes place. Students can live where they are studying and thus have short distances and more time for study and leisure. The communal areas integrated into the concept help to solve the problem with the feeling of loneliness. The residents have a flat for themselves, but if they want to get together, this is possible at any time.

The described concept is an extension of an existing building. The concept of extension helps to utilize previously unused roof space and to create additional living space on an already sealed area. Especially in densely populated cities like Stuttgart, this is a good solution to reduce the lack of housing. Compared to a normal new building, this concept requires little to no new surface to be sealed. The issues with pollution, heat and noise can be combated with the planned greening of the facade. Plants store CO2, absorb fine dust and absorb sound. To address the city's mobility problems, there will be a mobility hub that will enable residents to be environmentally mobile by bike or electric car.

Neighborhood support

The settlement of the university campus has some positive effects for both the university and its neighbors. For students, living directly on campus offers the advantage of noticeably short distances and thus the saving of travel time. From the university's point of view, this will lead to more satisfied students and a better image for the university. Students who live in the new apartments can, for example, take on a part-time job at one of the neighboring companies. The surrounding bars, cafés and restaurants can gain new customers. The refugees who live in the refugee accommodation in the

immediate vicinity can better interact with the students and possibly do urban gardening or cooking together. It could also be considered whether the neighbors can use the new Mobility Hub.

However, the immediate neighborhood will not only benefit from the people who will live there in the future, but also from the construction itself. The planned planting will positively influence the climate on campus and beyond. The hot temperatures in summer will be cooled down by the planting. The major particulate matter problem in Stuttgart can also be reduced. In addition, the newly renovated building will also be a clear visual improvement on the status quo.

Quality of living improvement

The construction of the addition is planned in such a way that the grid and the OPV create a particularly innovative living feeling. In the communal areas, you are outside but still inside. The OPV modules suspended in the grid allow some wind to circulate but protect against strong gusts of wind and rain. At the same time, they produce electrical energy and virtually pay for themselves, which is good for affordability. The insulation made from sustainable wood waste and the solar chimney integrated into the building also ensure a good living climate. The solar chimney cools the building in summer with little energy and is therefore much more cost-efficient than, for example, an air conditioning system.

In contrast to normal dormitories or apartment buildings, many communal areas are integrated in the current design. This does not necessarily reduce costs, but it is an especially important social aspect. Most of the flats in the addition are single flats. Spacious communal areas are necessary so that the residents do not feel lonely and can meet other people at any time. In addition, it should be possible to do urban gardening in these areas and thus produce one's own food without having a private garden.

Room Program and interior design - how react to needs and desires and solve urban issues

The most important aspect of interior design is flexibility. The furniture is multifunctional and can disappear completely into the walls when not needed. This flexibility makes it possible to live with less living space than one would normally need. Especially in cities with little space, flexible interior designs with creative solutions make sense. Despite the small amount of living space, the apartments are still designed in such a way that you can invite several people.

Like the grid and the other exterior design, the interior concept is also predominantly made of wood. The sustainable material creates a pleasant indoor climate and at the same time makes a positive contribution to combating climate change. The doors and windows are triple-glazed and provide good sound insulation.

Scalability

The solutions of the project shall not only be applicable only on the chosen building, but also offer the opportunity to be transferred to other buildings in Stuttgart and (of course depending on the local conditions) potentially all-around Europe (Solar Decathlon Europe). The main goal is to create a flexible and universal but individual design that can be adapted to different scenarios and local project specific profiles. The solution to achieve this is a modular concept. The addition consists of several individual modules that can be put together individually according to the conditions on site. Since the design is largely made of wood, it is a sustainable concept that saves climate-damaging CO2 during its implementation. Wood is available in large quantities in most European countries. Due to climate change, many trees will have to be felled in the next few years because they cannot cope with the hotter temperatures. It is therefore to be expected that, despite the current shortage, more wood will be available again in the future. There are also many buildings with flat roofs on which additional floors can be built. The lightweight construction of the concept with wood increases the likelihood that the building can bear the additional load of the addition. Due to the permanent move into cities, more and

more living space will be needed in the future and more and more cities will have similar problems as Stuttgart already has today.

The advantages of living directly in the city center are the short distances, the good transport connections and the time saved. In our concept, students benefit from this by living directly on campus. In the context of transferability, it is also conceivable that, for example, employees live directly above their office or salespeople above their shop. Living in additions is also conceivable for older people. The lift makes barrier-free living possible and integrated communal areas counteract the problem of loneliness. In this way, the problem could also be addressed that many older people occupy a large living space alone because rising rents make a move economically pointless or because they would have to leave their familiar surroundings to do so. If more of these older people move into Additions and larger flats become available, larger families can also benefit from the concept, for whom living in the modular flats of the Addition is out of the question due to lack of space.

To stop the progress of climate change, many existing buildings in Germany still need to be renovated to improve their energy efficiency. This is usually expensive and complex. It is therefore often the case that after such a refurbishment, the rent prices for the residents are increased. Often the rents then become so high that the residents can no longer afford them. One way to mitigate this increase in rents is to simultaneously increase the height of the building being renovated. In addition, a PV system can be integrated. Both measures will generate additional income in the future through new rental income and electricity sales. There are already some practical examples where rents had to be raised only moderately. In this way, an addition can help to create a socially affordable climate change.

7 CESA REPORT

coLlab

7.1 Responsibility for Public Relations

The project will be accompanied by public relations work throughout its duration.

The responsibilities of different persons or groups of persons (elective subjects integrated into the study program) are time-dependent. The specific tasks of the persons/groups in charge are explained in the following.

7.1.1 Communications Manager

In order to maintain an overview of the individual disciplines, a person responsible for each of the ten disciplines was recorded. As Communications Manager, Luisa Claus is responsible for the central tasks of the discipline "Communication, Education and Social Awareness”. She will take on the role of organizer, responsible for public relations, communication activities and special events of the project. She is also responsible for the team's communication through the available digital media and their content. In addition, she coordinates other team members in order to further advance the planning and execution of the discipline.

7.1.2 Communications Team

As already mentioned in past deliverables, public relations could be integrated into the elective HFT goes green. Some of the students working on public relations are now continuing to work on public relations for the SDE. They form the communication team and support the communications manager.

7.1.3 HFT goes green

The elective "HFT goes green" aims to make the HFT Campus more sustainable, greener and more climate-neutral. The university competition Solar Decathlon Europe 2021 in Wuppertal will also focus on a sustainable and climate-neutral urban expansion, which accompanies the goal of a CO2-neutral campus. This will enable students to actively participate in interdisciplinary groups in order to contribute to the objectives of the elective, but also of the Solar Decathlon Europe 2021 (hereafter abbreviated as SDE). Past projects have already shown concepts for façade greening for university buildings, urban gardening raised beds or even the construction of noise and fine dust sensors.

In order to meet the requirements of the discipline "Communication, Education and Social Awareness", working methods as well as interim results of the project will be published regularly during the project period.

In the last semesters, the "HFT goes green" introduced the core team of the SDE and the various electives that will advance the project. In the following semesters, the work for public relations was again integrated into the subject HFT goes green. The communication manager was supported in the creation of content for social media channels.

7.2 Overall Communication Project

The aim of the coLLab team is to share its values, ideas and key messages with different target groups at local, national and international level. This will be done through events, a variety of social media platforms and publications.

The following objectives of the overall communication project were defined.

1. to present problems (in the construction industry) regarding the climate issue and motivation for participation/contribution to the solution

2. to show how the coLLab project tries to solve the problems.
3. to inform in order to then catch up with public opinion (citizen participation) and make the concept sustainable in the long term (use public feedback).
4. to strengthen the image of the HFT.
5. to attract more participants to the project and keep them informed.
6. to inform about the Solar Decathlon Europe and the exhibition at the end of the competition.

Furthermore, communication within the team is an important part of the communication strategy. The following goal was defined:

7. good cooperation/agreement in the (core) team

These communication goals were assigned to the different sub-reports. Three communication strategies were developed from this.

7.3 Communication Sub-Report

The project is a student research project. It is a project that researches current topics in the field of sustainable urban and building development and wants to pass on the course of the project as well as the findings/results.

In addition, information about the course of the Solar Decathlon Europe 2021 should be provided and interest aroused.

7.3.1 Analysis

The following SWOT analysis describes the current status of the communication project. A strategy was derived from the identified strengths, weaknesses, opportunities and threats.

strengths	weaknesses
• innovative ideas for the design • first sponsors were acquired	• Poor communication with industry partners • No budget • Insufficient communication of the project to the outside leads to still too few sponsors
opportunities	**threats**
• Use of social media leads to more engagement in the core team • External communication leads to more sponsors	• Frequent change of personnel

Fig. 7.48: SWOT Analysis

From the SWOT analysis, it can be concluded that communication at this point in time should be designed primarily to attract sponsors and other collaborators to the project. In addition, there is no budget available yet, which is why the services of companies and employees cannot be countered by financial compensation. Also, the innovative ideas that were already designed should be communicated to the public.

7.3.2 **Strategic Planning**

Communication Goals

The goal of the Communication Strategy stems from these goals defined in the Overall Communication Project:

- to strengthen the image of the HFT.
- to attract more participants to the project and keep them informed.
- to inform about the Solar Decathlon Europe and the exhibition at the end of the competition.

Target Groups

These target groups were defined.

- HFT-Internal
- Broad Public
- Professionals
- Pupils, future students
- External media

Target Group Specific Messages

The communication goals described above are now assigned to the target groups or adapted to the target groups.

HFT-Internal the aim is to raise interest in the project and to attract more participants, both at student level and at the level of administration, professors and staff.

Problems of the building industry regarding the climate-matics shall be communicated to the general public. The main aim is to bring these topics close to the target group. The coLLab project should serve as a good example. A visit to the exhibition of the demonstration units in Wuppertal should be encouraged. The opinion of the general public can also contribute to the positive development of the project. Surveys will also be used to ensure the social sustainability of the project.

Above all, professionals should be kept informed on an ongoing basis in order to arouse their interest in the project. In this way sponsors can be acquired.

In order to arouse the interest of pupils and future students in the project and in studying at the HFT Stuttgart, information about the project will also be addressed to this target group.

External media can in turn reach all of the above mentioned target groups and extend the reach of the own communication strategy. For this purpose, these external media are continuously supplied with project-specific information.

Online Strategy

Similar topics are published on all channels for external communication. However, the different media deal with the topics in different depths. This automatically links medium and target group with each other. Each individual of a target group can, however, determine the depth to which the information is desired and decide on a medium. The media are linked to each other via links. It is recognizable which medium deals with the topic in which depth.

Website – available

https://www.collab.hft-stuttgart.de/

The website primarily serves as the official internet presence of the competition team coLLab. Here you will find the latest and most up-to-date information, which is intended to serve as a basis of information for companies and university members alike. A News page also allows the chronological progress of the project to be published through images and text and links to all new publications are displayed. The website also offers an overview of the contact persons for the various topics of the project.

Instagram – available

https://www.instagram.com/hft_collab/?hl=de

Instagram as a social network offers the possibility to share photos and videos. Here the focus is on meaningful pictures and graphics, which are only provided with short text passages, but do not serve the entire information spectrum. Especially in the younger generation, Instagram is a widely used medium. By means of concise pictures the attention for the SDE team and their work is to be aroused with these target groups. If you are interested, you will be forwarded to the team's website.

Youtube – available

https://www.youtube.com/channel/UCsW5jxaK1C8VhR9nUdiyRxg

YouTube is a video portal where videos can be uploaded, viewed, rated and commented. Again, short clips about teamwork and the progress of the project can be documented and published here. In contrast to other online platforms, the video is in the foreground here, which is intended to arouse interest in the SDE team through the primarily visual illustration.

LinkedIn – available

https://de.linkedin.com/showcase/team-collab

LinkedIn is a social network specialized in the profession and career. It is primarily used for the exchange of information between companies and for establishing business contacts. Through LinkedIn the latest information and future connections to sponsors can be published, but also new sponsors and partners can be recruited through concise pictures and texts. Besides team members can attach and maintain always new Business contacts.

Facebook - at a later date

Similar to Instagram, Facebook can be used to publish pictures and text on the social network. A meaningful picture and an explanatory text should also arouse the interest of the general public. In addition to the younger, student target group, the posts are also aimed at companies and sponsors. A further advantage of the medium is the publication of events, since groups of people can be explicitly invited to events of the SDE team.

Direct messages - at a later date

Direct messages in the form of a newsletter can be used to inform interested parties about the project quickly and directly. For this purpose, the so-called "Press Kit" is always kept up to date and sent out repeatedly within a certain period of time. The "Press Kit" consists of a project description in text form and representative image material that can be used further. You can register for the newsletter on the website. In addition, the newsletter is published via a researched trade press distribution list.

Twitter - at a later date

Twitter is characterized by similar features to the other social networks Facebook and Instagram. However, the texts on Twitter are limited to 280 characters, which means that information can be

distributed more quickly through short texts and so-called hashtags, as well as images and videos by politicians or technology companies, for example. Twitter can also be used to reach out to younger target groups, as well as more serious target groups such as academic communities and companies, to arouse their interest in the SDE team.

Offline Strategy

Events

External communication should also be implemented in the form of events or lectures. Lectures within the framework of the adult education center were already made possible at the last Solar Decathlon and would be conceivable again at this one. In this way, the latest project content or findings could be published during the competition. A further advantage is to support future connections to existing, but also new sponsors and partners.

Visual Identity (Merch)

In order to reach all target groups, a kind of merchandising is to draw attention to the coLLab project in the future. The merchandising is created with the help of the visual identity manual (Appendix B) to ensure a uniform appearance.

Print Media

Print media in the form of stickers or posters, for example, can be used for offline communication. This makes it possible to disseminate information offline without direct contact between people. During the Covid19 contact restrictions, this is a useful alternative to offline measures with contact between people. Another tool to make the project public or to establish company contacts is the creation of business cards. These always offer a good possibility to give the counterpart a reminder with contact data and website reference.

External Media

In order to reach a larger amount of people, we get in touch with local and national press. They should report when major milestones are reached in the project.

7.3.3 Operative Planning

The following is a list of the activities that will (should) be carried out prior to the competition.

Online Presence

Social Media allows to create a strong online community with individuals from all over the world. Team coLLab actively uses social media as a means to further spread information about environmental, urban and social issues. Therefore there is an active presence on Instagram, LinkedIn and the Website.

The themes of the posts/news on the social media channels can be described as follows:

- Show progress in all parts of the project (architectural design, engineering, activities, events, construction).
- Introducing the team and how it works to generate more engagement on the side of the students
- Provide visual content and explanations of many aspects of the design and its impact (in the form of drawings, diagrams)
- Introducing the Solar Decathlon competition and its mission to promote innovation in the green building industry and foster a great learning experience.

E-Mail Newsletter/Press Releases

An e-mail newsletter provides quick information to all external parties interested in the project. A link is integrated on the website where the newsletter can be subscribed to. A "press kit" will be created for this purpose and always kept up to date. This is then distributed to the subscribers of the newsletter.

Presentation via External Media

External media will be used to further publicise the "coLLab" project. One option is a kind of presentation of the project via other internal Instagram-instances of the university, such as the @hft_stuttgart profile.

Invitation Letter

To make acquaintances, friends and colleagues aware of the SDE21/22 event we have designed an invitation for the event. This can be attached to a verbal/email invitation and keeps the event in mind.

Events

Due to Covid19 restrictions, we have not yet been able to hold events.

During the competition various dissemination activities will take place. They have been grouped in the following categories:

Public Tours

Regular public tours will be provided to the visitors of the Solar Village during the SDE21 event. In Appendix D an elaborate description of the public tour is given. It is important to note, that our public tour includes not only an “as-built-example” of our building design, it also shows lots of aspects and ideas of two years of the project coLLab. We therefore divided our HDU into the living module, as an excerpt of the building design, and the exhibition modules. In the exhibition for example, there is an urban model of our location in Stuttgart, an exploded model of our building design, as well as detailed section models of our materials and HDU. Our ideas thus become tangible and accessible for the public.

Printed media

As part of the exhibition of the HDU, a painted hidden picture puzzle will be presented on one wall to show the complexity of our concept. This picture will also be printed and works as a give-away for the visitors of our HDU. Further printed media will include brochures and posters which will be on display or handed out to interested parties.

Audiovisual

The teams’ project video will be on display during the competition in Wuppertal, providing supplementary information and images to support the design of the prototype.

Online presence

During the competition we are going to be really active on social media. Posting daily on our social media channels is planned, so that people who cannot be there live can also benefit from the Solar Campus and the competition phase is documented on our social media channels.

Documentary Film

During the competition period in Wuppertal, the structure and course of the exhibition will be documented. A camera team from a professional film production company will visually record the competition and create a documentary film.

7.3.4 Implementation

The following table shows the implementation list.

Type	Name	Short Description	Date (Duration)
Posts	Instagram	Updates about recent happenings and activities	November 2019 - now
Posts	LinkedIn	Networking and updates about the project	Mai 2020 - now
Instagram Campaign	team presentation	Presenting the team member qith a quote	April 2020
Instagram Campaign	Presentation mobility types	Presenting the development of our mobility types	January 2021
Instagram Campaign	"What is"	Education about inovation in building sector and at the same time informing about the project	March 21 - now
Blog	Website coLLab	Reportings about current happenings in the process	April 21 - now
Instagram/ Youtube Campaign	coLLab Talk	Interviews about the sustainability in building sector with differents specialists form different fields	June 2021

Fig. 7.49: Implementation List Communication Sub Report

In addition to the successful use of our social media channels, we have also published a number of articles.

All dissemination activities of coLLab through national and regional newspapers as well as trade journals were recorded in the following table. This provides an overview of previous publications about coLLab, including information about the publisher, media type, title and date.

Type	Publisher	Title	Date
Website	HFT Stuttgart	SDE 2021 - Wir sind dabei!	29.01.2020
Website	HFT Stuttgart	TEDxStuttgart [de]construct the x am 12. September in Stuttgart	07.09.2020
Newspaper	Stuttgarter Nachrichten	Stuttgarter Studenten planen nachhaltig	12.02.2020
Magazine	Sonnenergie	Solar Decathlon Europe Die Teilnehmer des SDE21 stellen sich vor	01.03.2021
Magazine	Sonnenergie		
Newspaper	Westdeutsche Zeitung	Weltweite Bauvisionen sind in Wuppertal zu sehen	28.05.2021
Magazine	transforming cities	Hoch hinaus mit dem Projekt "coLLab" der HFT Stuttgart	07.06.2021
Podcast	M4Lab	Neue Etagen auf alte Häuser: Gebäudeaufstockung als Lösung gegen den Wohnraummangel	08.06.2021
Website	HFT Stuttgart	Solar Decathlon 2021/2022 Design Challenge Unser Beitrag für Wuppertal: HFT-Modell für Design Challenge eingereicht	09.06.2021
Website	HFT Stuttgart	Solar Decathlon 21/22: Das HFT-Team coLLab steht nicht still!	13.10.2021
Magazine	Bauphysik - Ernst und Sohn	Upcoming	upcoming
Website	Detail Online	Eine Zukunft für den Bestand	25.11.2021
Website	HFT Stuttgart	Viele Beteiligte, ein gemeinsames Ziel - Konzeption und Bau eines Gebäude-Prototypen als Wettbewerbsbeitrag für den Solar Decathlon Europe 21/22	15.02.2022
Magazine	BORN Verlag	Nachhaltigkeit zum Anfassen in Wuppertal	10.12.2021

Paper	BauSIM	A faster method for the simulation-based parametric optimization of structural shading	upcoming
Book	Print on demand	upcoming	October 2022

Fig. 7.3: Tracking Table of the Communication Actions

Please find attached the implementation List (Appendix E)

7.3.5 Assessment/Controlling

Website

Based on the statistics of visits to the website since it went online, the number of visits has not changed much. They are permanently at a level of about 50 visits per week. The bounce rate of the website is around 40%, which means that most people navigate to more than one page on the website. The average time a person spends on the site is 77s, which is a good value for a website.

The traffic source is mainly Direct or in Search. Since this semester, the website is also often found via a referral. This is related to the promotion of the website, e.g. in Moodle also for internal communication.

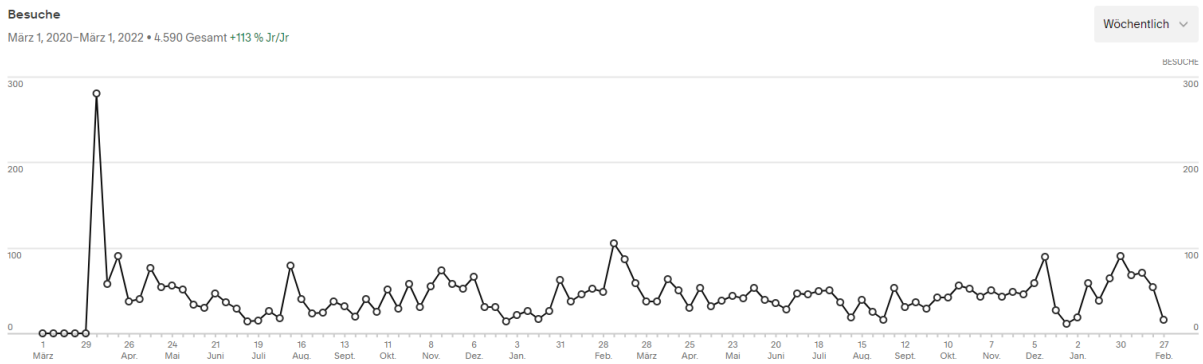


Fig. 7.-50: visits to the website

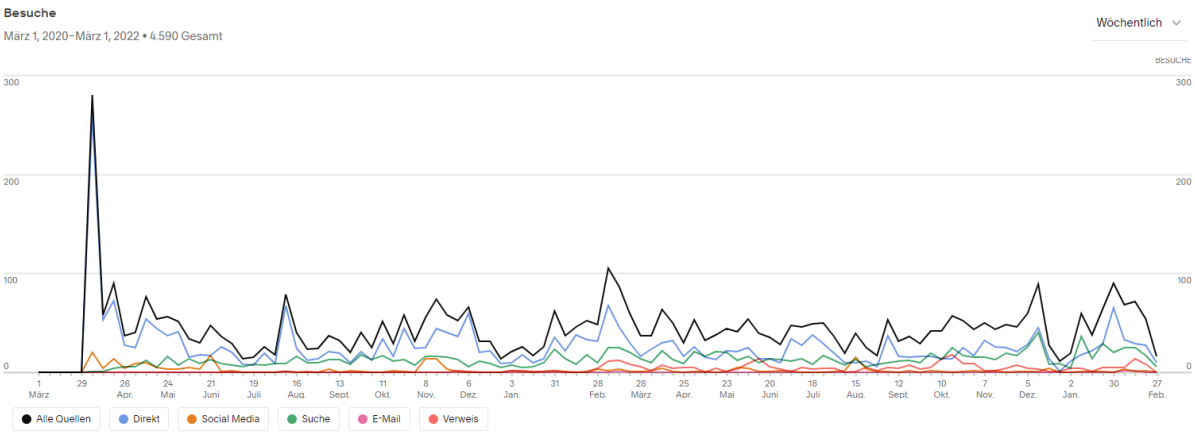


Fig. 7.4: visits to the website by traffic source

Instagram

On 21 November, we have 572 subscribers on Instagram. The number of subscribers has increased steadily, with 17 new subscribers last month. The following figure shows the statistical analysis. The age of the subscribers is mainly in the range between 18 and 34 years. The gender is about equally

male and female. The subscribers come mainly from Germany, but also international followers can be reached.

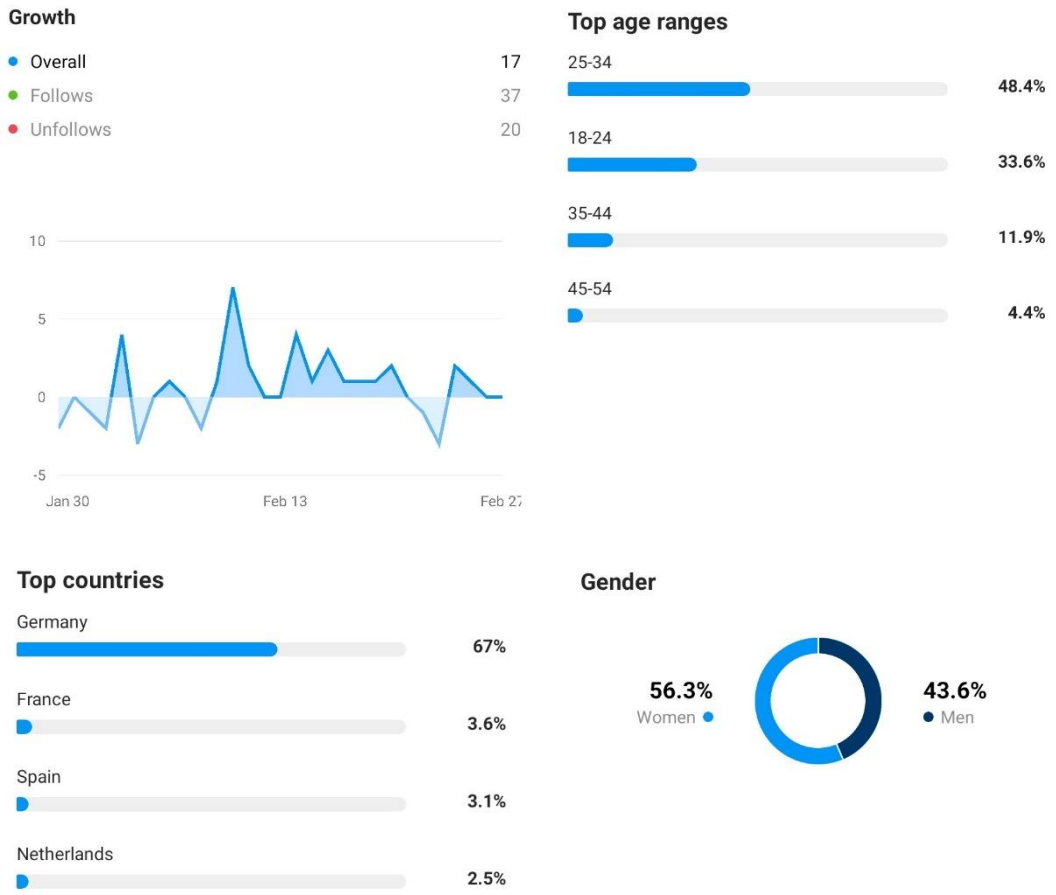


Fig. 7.5: Instagram Statistics

7.4 Education Sub-Report

In order to develop a good project, the cooperation with many students, professors, research staff and industrial partners with different expertise is of great importance, as the name coLLab (collaboration) suggests.

A communication strategy was designed to ensure the collaboration of the different target groups (stakeholders).

7.4.1 Analysis

The following SWOT analysis describes the current status of the Education project. A strategy was derived from the identified strengths, weaknesses, opportunities and threats.

strengths	weaknesses
• Large proportion of student employees, good communication at this level • High intrinsic motivation of the core team, initiative comes from students • relief for student employees through wages or other forms of recognition	• Recent change in the university management • there are still administration problems with the official announcement of partners

• Advanced elaboration of the design through cooperation of different students • Integration into the curriculum meets a lot of motivation from the professors • SDE21 fits in the broader strategy of the university • Contact was established with the other German teams	• It has not yet been possible to actively benefit from contact with other German teams
opportunities	threats
• integration into the curriculum makes it possible to communicate the topic of sustainable construction within the university	• Not for all fields of activity employees with specific expertise (at HFT) • Projects integrated into the curriculum work "past each other", no exploitation of the results possible

The SWOT analysis shows that at this time in the project, internal communication should be promoted above all. This will ensure a smooth planning process. In addition, communication with companies should be improved; the official announcement of partners already acquired is an administrative problem. In addition, communication with the other teams should be optimised so that they can better benefit from each other's experience.

7.4.2 **Strategic Planning**

Communication Goals

The goal of the Education Strategy also stems from a goal defined in the Overall Communication Project:

- good cooperation/agreement in the (core) team

In addition, the following objective can be added:

- mutual benefit through an exchange of knowledge between the target groups

Target Groups

The target groups for this sub-report are derived from the Communications sub-report. The defined target groups HFT-internal and Professionals are further differentiated.

HFT-Internal

- core team
- professors
- HFT internal students
- research
- administration/employees

Professionals

- academic communities

- other participating teams
- companies/sponsors
- already acquired companies
- Urban society, university building department, ministries

Target Group Specific Messages

The communication goals described above are now adapted to the target groups.

The aim of HFT-internal communication is to promote interdisciplinary cooperation between the various departments. For each work package there is a coordinator who is a member of the student core team. This coordinator is responsible for the quality and time management of the respective work package and coordinates the subjects involved. Reliable communication between the students and supervising professors involved must be ensured in order to optimise the planning result. Support from the HFT's internal research as well as administration must be ensured.

The processing of the SDE21 fits in with the university's sustainability strategy. Within the framework of the five design fields for sustainable development, HFT Stuttgart uses EMAS (Eco Management and Audit Scheme) as a fixed element of its sustainability strategy. EMAS is the environmental management certification of the European Union and is one of the most important environmental management systems to guarantee sustainable business management. EMAS activities are coordinated by the university management and the in-house Technical Department.

Concerning the research department the EnSign Reallabor project maintained by the IAF is worth mentioning, since it deals with the transition of the inner-city campus of the HFT Stuttgart into a climate neutral campus. It has already initiated a number of renovation measures. The current transdisciplinary project i_city - intelligent city researches the development of cities into sustainable, intelligent and livable urban spaces. Through the HFTmobil project, innovative logistics, payment models and energy concepts are developed.

In order to further optimise the planning result, communication with Professionals is beneficial. Although the participating universities are in competition with each other, close cooperation is planned at various levels, not least to achieve and utilise synergetic effects. In addition to the (public) project funds requested, further funds in kind and cash are needed to realise the competition contribution. To this end, a wide variety of partners from business and industry must be found and approached. This acquisition of sponsors ensures an intensive exchange between the university and the industrial partner and, in the sense of a transfer company, also focuses on the exchange of knowledge.

Communication with the city and the university building authority as well as ministries is important for the eventual realisation of the project.

The following diagram shows an overview of these target groups:

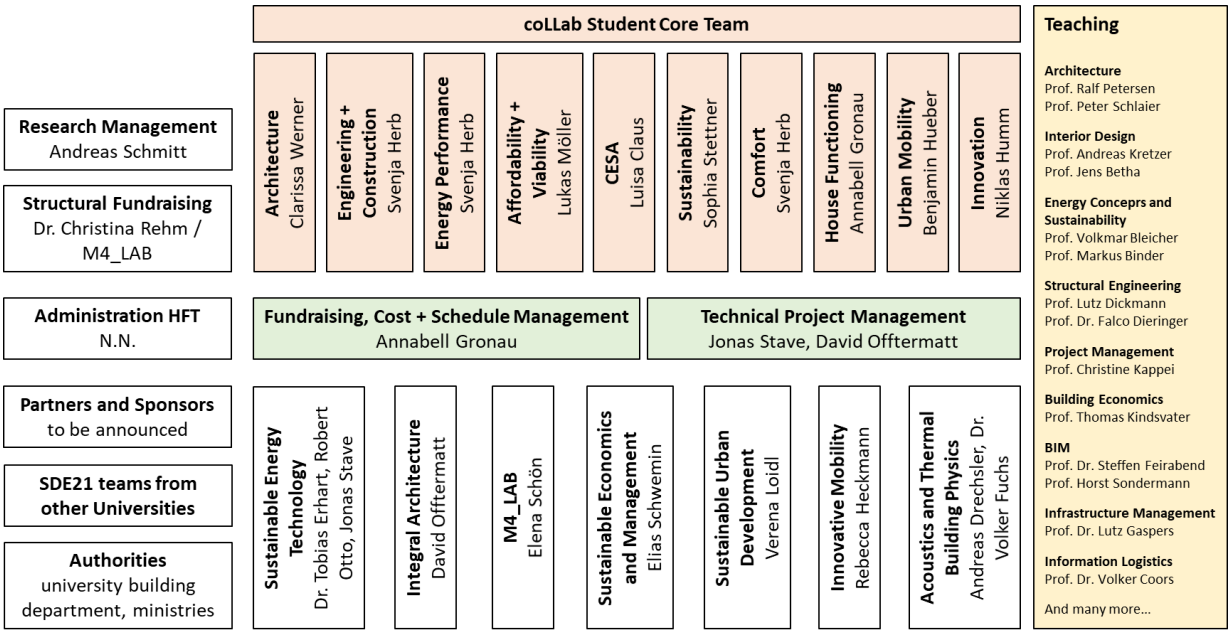


Fig. 7.6: Target Groups Education

Online Strategy

Moodle - available

Moodle (**M**odular **O**bject-**O**riented **D**ynamic **L**earning **E**nvironment) is an interactive learning platform which serves the exchange of information and offers possibilities to support cooperative teaching and learning methods. Only authorized persons can access the information provided by means of a registration key.

Onedrive/bwSync&share - available

bwSync&Share enables users, similar to Ondrive, to synchronize or exchange data between different computers, mobile devices and users. This is currently being used for internal communication and coordination within the core team to synchronize and exchange information and data between team members in a structured manner. All plan statuses, documents, protocols, photos, etc. are stored here. Digital learning and teaching content, scientific studies and administrative processes can thus be exchanged securely and easily. As a user of a participating institution, the storage space can be extended up to 50GB.

Confluence - available

Confluence is the wiki system of the HFT Stuttgart Information Centre and is available to all university members. The coLLab team uses Confluence as a project management tool. Jour Fixe are planned and tasks distributed via this tool. Confluence also facilitates communication between the subjects integrated into the project in this semester.

Offline Strategy

Projects

Many different study programmes are involved in the project on a curriculum-integrated basis. They work on the project in an interdisciplinary way. Appendix A lists all of these subjects.

Workshops

Applied workshops will build and test elements of the demonstration unit. The interdisciplinary nature of the workshop participants creates a lively exchange.

Events

Offline strategies within the framework of internal communication are to be used to take measures to reach more students from the various faculties of the HFT. The personal exchange between the project members and the students is in the foreground. For example, internal university events such as parties, science slams or other student lectures could arouse the interest of the students. Students of different courses of studies, who might not have had any contact to the competition before, might therefore want to actively participate in the interdisciplinary project development. This would also ensure a constant number of members over the duration of the competition.

Further Deepening of Topics

E.g. Bachelor's/Master's theses are offered as well as scientific dissemination is planned to further deepen the topics worked on in the various projects integrated into the degree program.

7.4.3 Operative Planning

In order to ensure that the integration of the project into the curriculum of various courses of study and the use of all resources of the HFT works well, the corresponding planning was started early on. In the past semesters the project was already being worked on in various courses. Many projects/courses will start in the following summer semester 2021. Please find an overview over the implemented courses in the Appendix A.

The projects/courses, in which topics from the coLLab project at the HFT Stuttgart are being worked on, run parallel. For this reason, ongoing coordination must be ensured. Measures have already been implemented for this purpose. These are described in the following:

Jour Fixe – Core Team

Once a week, a jour fixe takes place for the entire core team. Current topics and updates are discussed and tasks are distributed. This jour fixe is supplemented by topic-specific jour fixes. The Communication team, for example, also meets once a week.

Sharing of Results

For the university internal co-ordination Moodle serves as aid around documents, like e.g. the application for the SDE21 as well as current treatment conditions of the subjects to spread. Also basic material, like the breakdown of the 10 disciplines and the documents of the SDE organizers of the SDE21WAT Moodle platform are made available here. This ensures that students, student employees, but also professors, i.e. all those involved in the project, always have the same information basis and can get an overview of the project status.

FAQ - Participants

In addition to the usual functions of Moodle, a question-answer portal was set up. Here, all internal university participants involved in the project can ask questions or view answers. Thus the questions were subdivided here according to topics such as building physics, building services engineering, architecture, etc. The portal is maintained by the student core team, which always tries to answer the questions promptly. This supports the continuous exchange of information and the internal communication between all project instances.

Confluence

Confluence ensures communication at the level of the students involved in the subjects. A project coordinator (PC) is chosen for each project or course. This person has a different workload compared to the other course participants and should be "compensated" for it. The PCs are informed about the organisational structure and working methods of the core team and are integrated. Participation in the Core Team Jour Fixe is voluntary.

The PCs are responsible for updating the news tables in Confluence, checking conflicts with news tables of other subjects and bringing the other course participants up to date.

Jour Fixe – Professors

A jour fixe is held every fortnight, attended by all professors who offer a subject that contributes to the SDE. Current topics and updates are discussed and tasks are distributed.

In order to support scientific publications about the project, different measures are taken, as listed below:

Bachelor's Theses/Master's Theses/Project Theses

Some bachelor's theses on the Solar Decathlon have been worked on, some of which are supported by external partners. These have the following topics:

- "Parametric optimisation of the design for the Solar Decathlon Europe 2021 for different sites" – Luisa Claus (BA KlimaEngineering)
- "Life Cycle Assessment of Building Extension" - Lukas Fischer (BA KlimaEngineering)
- "Extending the calculation methods of TRNSYS for the simulation of outdoor spaces" - Svenja Herb (BA KlimaEngineering)

The topic of a thesis now provides the basis for the publication of a paper.

Employment

The integration of external companies makes it possible to remunerate and professionally supervise the project work of some students. This support will be defined as a sponsoring service in the future.

The exchange with the other German teams is very important to us, because we can benefit from the experience of the others. The following measures make this exchange possible:

Jour Fixe - Team Germany

There is a regular meeting of the leading roles of all participating teams from Germany. Here, experiences and ideas are exchanged.

Building Workshops

In the university's own workshop, the models (overall concept and HDU) as well as elements of the demonstration unit, such as the adiabatic cooling or the OPV façade, were built and tested.

7.4.4 Implementation

Over the past few years, internal university participation in the project has grown steadily. This could be achieved through the coordination of the permanent participants in cooperation with the core team of volunteers. Through, for example, course-integrated projects, summer schools (workshops) and presence in social media (both on university accounts and on their own), the project could be made more popular.

The following table holds all actions for internal communication/education:

Type	Name	Short Description	Date (Duration)
Event	Case Study Day	Presenation of the project coLLab to other students	14.01.2020 (2h)
Event	Factory tour timber construction company	The students involved were able to take part in a factory tour of a timber construction company.	04.10.2019 (4h)

Event	Kick-off workshop	At the beginning of the project, the students involved were in Wuppertal for a set-up workshop. Here they worked intensively on a first draft.	07.10.2019 (1 week)
Workshop	Facade workshop	Prototype for the OPV facade	27.09.2021 (1 week)
Workshop	Adiabatic workshop	Prototype for the adiabatic cooling	27.09.2021 (1 week)
Workshop	Screen painting workshop	Creating of the Team T-Shirts in an open workshop	13.12.2021
Event	OPV facade prototyp	Testing the first built prototypes of the OPV facade	02.02.2022
Event	Dinner Party Test	Testing the Dinner Menue for the competition	14.02.2022
Course	"MAKE"	Preliminary designs of the extensions with student housing	Winter Semester 19/20
Course	Building and monument conservation	Concepts for the renovation of the existing building	Winter Semester 19/20
Course	Construction and design	Development of a draft for the Solar Decathlon (Design and Building Challenge) from the results of MAKE; almost finished draft; MA 1:200	Summer Semester 20
Course	Simulation Tools	Simulation of the design of the building design and optimization for thermal/daylight requirements, simulation of active technology	Summer Semester 20
Course	Solar Heating and Cooling	Development of a concept for active building services engineering	Summer Semester 20
Course	Interior Design	Preliminary designs of the interior of the living modules	Summer Semester 20
Course	Mobility Concept	Concepts for mobility concept on the HFT campus and for the existing building	Summer Semester 20
Course	Profitability Calculation	Calculation of profitability	Summer Semester 20
Course	Economic efficency analysis	Profitability assesment, market analysis	Summer Semester 20
Course	HFT Goes Greem	Working on a project to make to campus greener - supporting coLLab with public relations and social media, development of different facade greening variants, ecological and economical comparison of different building materials	Summer Semester 20
Course	HFT Goes Greem	Working on a project to make to campus greener - communication strategy for coLLab, development of an energy concept for the solar chimney	Winter Semester 20/21
Course	Technical Design	Development of a draft for the Solar Decathlon (Design and Building Challenge); finished draft	Winter Semester 20/21
Course	Technical Concept	Development of a technical concept for the Solar Decathlon (Design and Building Challenge) in close cooperation with "technical design"	Winter Semester 20/21
Course	Certifications systems	Life cycle assesment, urban mining concept	Winter Semester 20/21
Course	Urban Mobility	Mobility Concept, focus existing building	Winter Semester 20/21
Course	Urban Mobility 2	Mobility Concept, focus quarter	Summer Semester 21
Course	Implementation Planning	Implementation planning of the HDU with details	Summer Semester 21

Course	Interior Design 2	Draft planning with details of the interior design of the HDU and public tour	Summer Semester 21
Course	Structure Planing	Finished planning with constructive details and structural calculations of the HDU	Summer Semester 21
Course	Construction costs	Building costs calculations and recommendation for adaption	Summer Semester 21
Course	HFT Goes Greem	Planing and implementation of the campus funiture for the urban design	Summer Semester 21
Course	Interior Desing 3	Execution planning with details of the interior design focus living module	Wintersemester 21/22
Course	Scenography	Execution planning with details of the interior design focus exhibition modules	Wintersemester 21/22
Course	Lighting Design	Execution planning with details of lighting design for the HDU	Wintersemester 21/22
Course	Implementation Planning 2	Finished implementation planning of the HDU with details	Wintersemester 21/22
Course	HFT Goes Greem	Planing and implementation of the mobility box for the HDU, planing and implementation of the plant trough for the HDU and after-use concepts	Wintersemester 21/22
Course	Facade construction	Conctruction of the wooden facade, 210 m²	Wintersemester 21/22
Course	Floor construction	Construction of the floor construction	Summersemester 22
Course	OPV facade construction	Construction of the OPV facade	Summersemester 22
Course	Prefabrication HDU	Prefabrication of the HDU in the workshops	Summersemester 22
Course	Competition and Construction	Construction of the HDU in Wuppertal	Summersemester 22

Fig. 7.-51: Implementation List Education Sub Report

Please also find attached the Implementation List (Appendix E).

Fig. 7.8: Facade Workshop

Fig. 7.9: Adiabatic Workshop

7.5 Social Awareness Sub-Report

The issues addressed by SDE21 are not only of interest to the construction industry. Urban housing and living is of importance to the general public. For this reason, our goal is to communicate urban sustainability issues to this target group. SDE21 and our project serve as an example for this.

7.5.1 Analysis

The following SWOT analysis describes the current status of the Social Awareness project. A strategy was derived from the identified strengths, weaknesses, opportunities and threats.

strengths	weaknesses
• HFT has competencies in the various subject areas related to the sustainable built environment • strong research and teaching in this subject area, which is already communicated by different university internal communication teams	• difficulties in the cooperation of the different university internal communication teams • low manpower and little capacity of the coLLab communications team makes intensive research on these topics impossible
opportunities	**threats**
• Collaboration with the other university internal communications teams • by informing the general public, the topic becomes more prominent	• Controversial topic, different measures are classified differently by various people

The SWOT analysis shows that communication with other university internal communication teams needs to be strengthened. In this way, the complex issue of sustainable built environment can be communicated with concentrated manpower. The content and competencies on this topic are available at the HFT in research and teaching beyond the coLLab project.

7.5.2 Strategic Planning

Communication Goals

The goal of the Social Awareness Strategy also stems goals defined in the Overall Communication Project:

- to present problems (in the construction industry) regarding the climate issue and motivation for participation/contribution to the solution
- to show how the coLLab project tries to solve the problems.
- to inform in order to then catch up with public opinion (citizen participation) and make the concept sustainable in the long term (use public feedback).

Target Groups

The target groups for this sub-report are derived from the Communications sub-report. The defined target groups HFT-internal and Broad Public are further differentiated.

HFT-Internal

- communications teams (HFT official, research, ...)

Broad Public

- students of all ages
- general public

Target Group Specific Messages

The communication goals described above are now adapted to the target groups.

The goal of HFT-Internal communication is to improve collaboration between the different communication teams (official, teaching and research) in order to transfer knowledge about the topic of sustainable built environment to the public. The expertise in this area is at the HFT through the different departments.

Knowledge transfer is intended to inform the Broad Public about the importance of the issue and possibly call for action. The aim is to make it clear in what way each person contributes to climate change through their living habits. In addition, suggestions for solutions are made that can be implemented to motivate the individual. Pupils should be introduced to the topic and interest in an education with a focus on this topic should be aroused. The general public should be stimulated to talk about the controversial topic and thus increase the publicity.

Online Strategy

The topics of sustainability in construction and our project are closely related. With our project, we want to set an example for sustainability in the construction industry. Therefore, the measures in the Communication Sub-report and the Social Awareness Sub-report partly overlap.

Social Media

Instagram, our website, LinkedIn and YouTube are used for online communication in the social awareness subreport. This strategy overlaps thematically with the online strategy in the communications subreport.

Offline Strategy

Events

The contents of the offline strategy for social awareness subreport are also already present in the offline strategy of the communications subreport.

7.5.3 Operative Planning

The following is a list of the actions that addresses our country of origin (Germany) and our home city Stuttgart in general.

Online Presence

Through our social media channels, we share general information about sustainability in the construction industry. In doing so, we present the information in a way that everyone can understand.

Contribution to events

By contributing to events (talks, courses, ...) we can communicate our convictions about sustainability in construction to the general public. Furthermore, we can reach an audience that we would not have been able to reach through only our channels.

We can address the topics through these actions on-site:

Events

The Germany-Day (Country and Culture Day), which is organized by all German teams, offers musical entertainment, a scavenger hunt for children and talks by professors and experts. In this way, target groups of all ages are addressed and information on sustainable building is conveyed in a manner appropriate to their age.

Public Tours

The guided tours deal with the topic from the big to the small. This means that sustainability as a whole is addressed first. Only then are our approaches to solving the problem communicated.

Exhibition

The exhibition in the HDU is intended to provide information not only about the project, but also about sustainability issues in the building sector as a whole. A quiz for children as well as adults, for example, will provide interactivity.

Further information on communication on-site can be found in the Public Tour Description (Appendix D).

7.5.4 Implementation

We successfully use our social media channels to communicate sustainability in construction and the SDE competition to the general public.

Furthermore the team has already been able to participate in several events that communicate sustainable construction to the general public.

The following table gives an overview over the actions:

Type	Name	Short Description	Date (Duration)
Event	TEDxTalk Stuttgart	Svenja Herb (Project Engineer) presents in the TEDxStuttgart format the relevance of inner-city redensification based on the coLLab project.	12.09.2020 (0,5h)
Event	Girls' Day	Young schoolgirls interested in STEM subjects were introduced to the coLLab project and the KlimaEngineering course.	22.04.2021 (3h)
Event	HFT meets IBA #7	The project Team presents the Project coLLab with focus on energy and material flows, circular economy for the urban region	21.10.2021 (2h)

Podcast	Stadtlabor - neue Etagen auf alte Häuser	Podcast episode of the HFT Research Podcast, team members explain the project and the concept of coLLab	15.06.2021
Event	Projektleitungstreffen EWB	Presentation by an elevator pitch. Networking meeting between project leaders from the research initiative Energiewende bauen	23.11.2021 (4h)
Live broadcast	Stuttgarter Wissenschaftsfestival	As part of the Wissenschaftsfestival, live broadcast from the competition site with HDU tour and interview of team members.	26.06.2021 (upcoming)
Event	Mehrwert erneuerbare Energien - Die erfolgreiche Energiewende im Gebäudebereich	Presentation of the 7 german SDE projects	23.03.2022

Fig. 7.10: Implementation List Social Awareness Sub Report

Please also find attached the Implementation List (Appendix E).

Svenja Herb (Project Engineer) presented in the TEDxStuttgart format the relevance of inner-city redensification based on the coLLab project to the general public.

Fig. 7.11: TEDx Stuttgart talk

Members of the coLLab team gave young girls an insight into the SDE project at the Girl's Day 2021. Girls' Day is initiated by the Kompetenzzentrum Technik-Diversity-Chancengleichheit e.V. and supported by the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth and the Federal Ministry of Education and Research in Germany. It gives girls the opportunity to learn about professions in the fields of IT, crafts, natural sciences and technology.

The Solar Decathlon and the coLLab project will be presented at the study information days for pupils (prospective students). This will increase awareness of the importance of sustainable construction in cities and present the competition as a positive example.

8 SUSTAINABILITY REPORT

coLlab

8.1 Circularity

8.1.1 Materials

In the current design, certified wood is the predominant building material. In addition, wooden houses store CO2 instead of emitting new CO2, which results in a very good performance of grey energy. Only certified wood is used in the design, as this is the only way to ensure that it is a truly sustainable building material. Components made of certified wood are for example wooden beams for the grid, terrace planks, wood-aluminum windows and large parts of the interior like multifunctional furniture. Natural rubber flooring from the manufacturer Nora was selected for the floor covering. Rubber was chosen because it is made from natural materials and is very durable. Also, thanks to the smooth surface, it is very easy to clean. To protect walls and roof from wind and water, INTELLO/DB+ foils are used in the walls and roof. This is a vapor barrier made of building paper and therefore an ecological solution for sealing the building envelope. The flat roof is sealed at the top by an EPDM rubber membrane made by Novoproof. Modular planter boxes provided by Helix are placed on this membrane to weigh it down.

Recycled materials are also used in the design. The wood insulation material used consists largely of wood shavings, which are produced as waste material in planning mills. The so-called HOIZ insulation is an organic insulation material certified with the Cradle-to-Cradle Gold standard. A further advantage of the insulation is that the natural materials required only cover short transport distances. To ensure that HOIZ-Bio insulation also meets the highest fire protection regulations throughout its life, it has a bio-based impregnation made of whey and soda.

In addition to the certified wood, only recyclable, high-quality and pollutant-tested building materials are used. For example, instead of normal OSB boards ESB boards are used, which are awarded the Blue Angel. To enable a closed loop recycling and according to the guideline “manual of recycling”, materials of biotic or metallic origin are preferred. Non-recyclable materials of mineral or fossil origin such as mineral fiber insulating materials, PVC or laminate floor coverings as well as solvent-based paints and adhesives are consistently replaced by unproblematic substances if possible. Materials that are to be classified as hazardous substances are not used. A list of the materials currently used in the respective components can be found in the plans from AR-30 01 to AR-30 02.

8.1.2 Construction

Renovation

The existing building is to be completely renovated. The goal is to achieve at least the EnEV standard. In addition, the original character of the façade is to be preserved. It is envisaged that the supporting structure will continue to be used and that the finishing materials will be removed. The current concept foresees that the existing concrete columns (not relevant for the statics) will be removed first. In the next step, the windows and parapets will be removed. They will then be replaced by new window modules (mainly made of wood and glass). The modular design used here enables easy installation and uncomplicated removal so that the windows can be replaced with low effort if necessary. The removed concrete supports are replaced by “ventilation flaps”, which are also made of wood. In order to achieve the desired energy standard, the existing thermal bridges must be reduced. For this purpose, aerogel plaster is applied to the outside of the load-bearing columns. This semester, further details of the renovation concept will be worked out. Drawings of the planned measures can be found in Appendix A 8.1.2 Construction of renovation.

Addition

In the plans AR-31 01 + AR-31 02 the pictograms of the connection techniques are integrated. In the concept, great importance was attached to the fact that all components can be dismantled as easily as possible. Therefore, only connection techniques that can be released as easily as possible and without damage are used. For example, on the roof the film is only laid and weighted with planter boxes. The boards relate to staples and/or screwed to the wooden substructure. However, the membranes for wind proofing must be stapled, otherwise their function cannot be guaranteed.

The flooring is laid on the underlying layer (ESB boards) without a fixed connection. The ESB boards are screwed to the wooden beams underneath. Overall, only screws are used as a connection technique in the floor construction. The interior design should be simple and unpretentious. The furniture should be easily accessible and there is no need for flaps and drawer lands. It is made from natural wood panels from Elka. Timber-steel plug-in connectors are used for the timber-frame construction, which can therefore be easily dismantled. In addition, no construction foam is used, so that dismantling and recycling afterwards is not complicated. The connection technology of the grid is in plan ST-20 19. The variant does not require glue and is therefore advantageous for later dismantling. For statics and the inclusion of the existing building, the grid is led down to the ground and is anchored there with point foundations. The interference in the ground is present, but minimal.

8.1.3 Maintenance

The maintenance effort in a building consists of different aspects such as cleaning of components, but also repair and replacement of building elements. For example, it is an advantage that the natural rubber floor is easy to clean thanks to its smooth surface. The topic of replacement is also dealt with in the UMI and the life cycle assessment, with the exchange of materials playing a primary role by influencing the life cycle mass. It also includes the replacement or maintenance of technical building systems. For the addition, the utilities are not led through the existing building, but are led along the outside of the grid. This pipe routing means that no shaft must be built during the renovation and the extension can be supplied by the building. Inside the apartments, the cables are laid visibly, so they are easily accessible at any time.

In the context of maintenance, durability of the selected materials is important to reach a long-life span. A material with a life span of only 15 years for instance, generates twice as many environmental effects as a comparable material with the same function and a 30-year life span, as it needs to be replaced more often during the building’s lifetime. The durability likewise has a big impact, as the less durable a material is, the more it will need to be maintained or replaced. This especially matters when a less durable material is installed between two more durable ones, for example sealings installed at a construction level. Not only the material’s inherent qualities influence its lifespan though. An incorrectly installed roof sealing or a faulty roof construction in general, can lead to the untimely deterioration of the materials, and in the worst case necessitate a complete roof renovation. Thus, to ensure the most optimal and long-lived constructions, all materials need to be matched in durability or be placed in such a way that maintenance is easily performed. For this reason, care is taken to ensure that the materials used last as long as possible. In addition, materials that have a shorter shelf life than others should be as accessible as possible so that they can be easily replaced. This can be ensured by using screw connections or easily detachable clamps. It is even better if materials such as the flat roof foil are only laid on and weighted down and thus no connection is necessary at all. Unfortunately, other waterproofing membranes must be stapled. Such connections are more difficult to dismantle but even better than glued joints.

Due to the wood frame construction and the wooden stanchions, the storey additions have a very high wood content. The wooden elements have a life span of 50 years and thus do not need to be replaced during the observation period. Only the decking boards may need to be replaced prematurely. Due to the grid and the built-in OPV, these are better protected than a terrace would normally be. The

horizontal installation still makes them vulnerable to wetness and humidity. However, this is not a problem. The decking boards are easily accessible and fastened with simple screw connections that can be easily loosened. This also applies to the outermost layer of the facade. This is made of recycled wood and, like the grind and the terrace, is not structurally protected from wetness. This also applies to the outermost layer of the facade. This is made of recycled wood and, like the grind and the terrace, is not structurally protected from wetness.

There is no reason for concern that planter boxes will last shorter than a normal green roof. However, replacement would not be a problem either, as the boxes are placed on the roof without a fixed connection, making them easily accessible and replaceable.

8.1.4 **Circularity concept**

The circularity of the current design was calculated with the UMI. This was based on the current status of the design. The calculation was carried out for the HDU, but it also fits for the addition. The foundation, the exterior walls, the interior walls, the ceiling and the roof were modelled. Here it seemed reasonable to create three exterior walls (exterior wall construction, doors/windows, grid) and two interior walls (ground and upper floor). For the calculation of the life cycle mass, option A (by volume and raw density) was used in most cases. Here, the factor "Quantity [n/m²] was used to indicate the share of the respective building product in the area of the corresponding component. For example, 0.13 was entered for the solid wood battens and 0,87 for the wood fiber insulation. Both together build one layer of the floor. The beams that build the grid have no insulation but air in the gaps. The calculated factor of n/m² is 0.12 in that case. Materials that cover the entire surface of a building component (e.g. flat roof foil) have a factor of 1.

When creating the components in the UMI, suitable materials were found in the database and assigned in most cases. A matching Ökobaudat dataset could also be assigned in most cases.

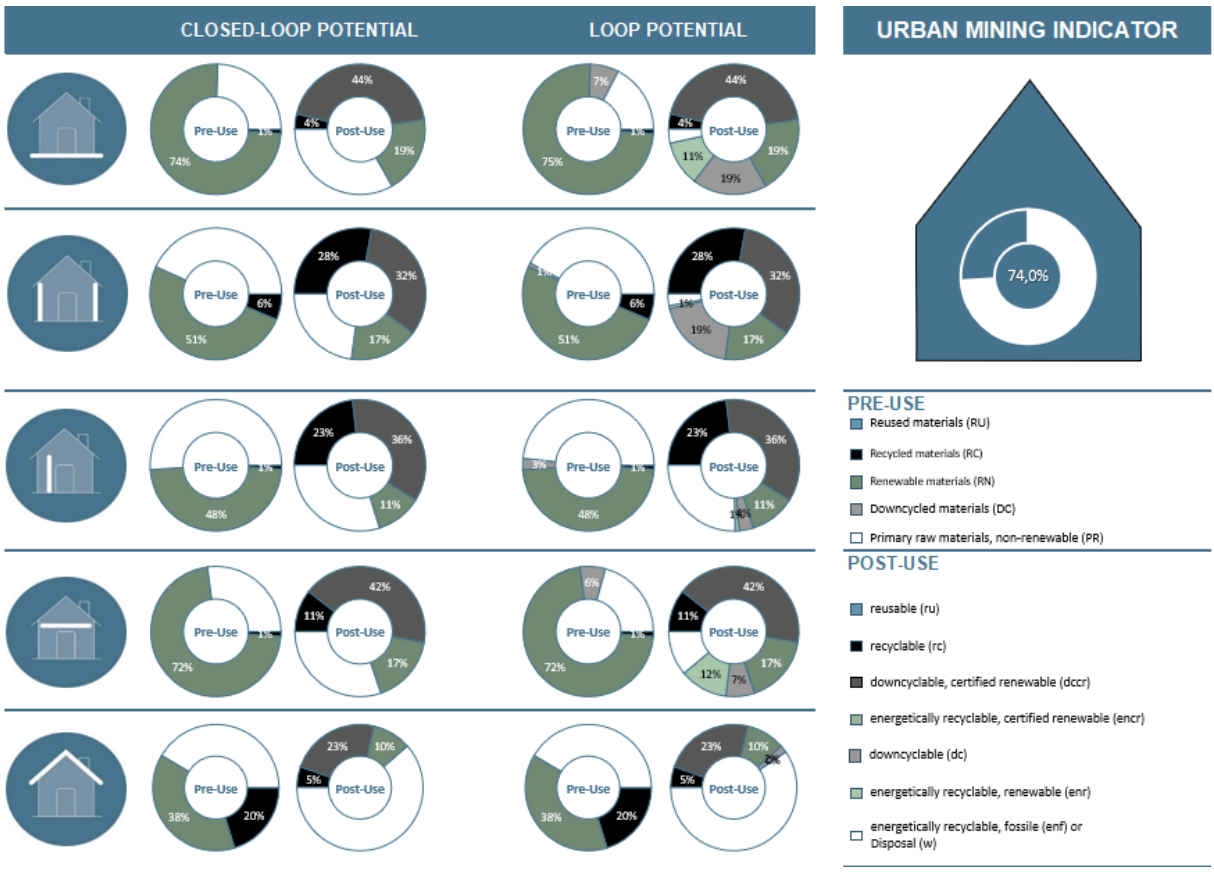


Fig. 8.1: Results of the UMI

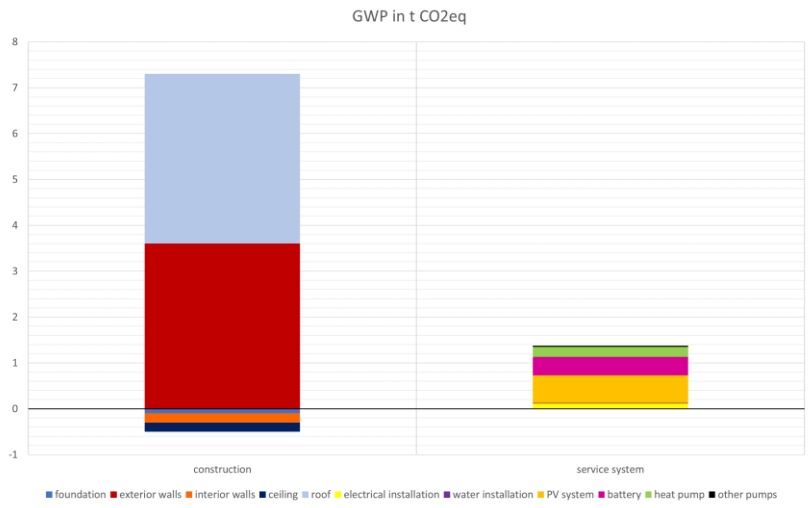
As shown in figure 8.1, the result is an Urban Mining Indicator of 74%. Comparing the individual components with each other, it is noticeable that with the Closed Loop Potential (CLP), most achieve a result of around 60-80%. This is due to the high proportion of wood and its advantages: the biotic material wood is not only available in sufficient quantities in sustainable reforestation but can also be used in several cascades. At its end of life, it can be returned to the natural cycle or it can be used to produce sustainable thermal energy. The interior wall (Pre-Use) performs slightly worse than 50% because the wood content is lower here and therefore the pre-use contains fewer renewable materials (RN) in percentage terms. The worst result was determined for the roof (Post-Use), partly because of the large mass of the planting substrate and due to the fact that the sustainable HOIZ insulation cannot be used here and must be replaced with ESP. To make the green roof possible, foils are needed, which also have a negative impact on the result.

The loop potential, on the other hand, shows greater differences. Ceiling and foundation have a result around 80% in pre-use. This is due to the proportion of downcycled material in the flooring, which is not considered in the CLP. Since there are no downcycled materials in the roof and exterior wall, the result of CLP and LP is the same (pre-use). In post-use the exterior walls, the ceiling and the foundation have a better result (>88%) than the other components. This is mainly due to the fact that the energetic recycling of non-certified renewable materials (rubber flooring) and the possibility of downcycling (gypsum plasterboards) are considered here. In the interior walls and the roof, the proportion of wood in the life cycle mass (LCM) is lower in each case, which leads to a worse result. In the interior walls, the gypsum boards have the highest proportion of the LCM, while in the roof it is the planting substrate. The roof performs particularly worst (post-use) because the end of life scenario of the plant substrate is classified as disposal.

8.1.5 Carbon footprint of the construction

The life cycle assessment is made with the UMI and supplemented with an excel calculation based on data from Ökobaudat and the provided GWP data from Ecoinvent. Most of the construction materials are included in the UMI calculation – external and interior walls, roof, ceiling, floor, windows and doors, as well as the external grid structure – with their respective life cycle masses. The service system cannot yet be calculated with the UMI. Therefore, this was calculated separately in excel. The results are given in t CO2-eq and represent the so-called global warming potential (GWP). The observation period here is 50 years.

Results



foundation	-0,1	t CO2eq
exterior walls	3,6	t CO2eq
interior walls	-0,2	t CO2eq
ceiling	-0,2	t CO2eq
roof	3,7	t CO2eq
total construction	**6,8**	**t CO2eq**
electrical installation	0,1	t CO2eq
water installation	0,0	t CO2eq
PV system	1,2	t CO2eq
battery	0,8	t CO2eq
heat pump	0,4	t CO2eq
other pumps	0,0	t CO2eq
total service system	**2,6**	**t CO2eq**
overall result	**9,4**	**t CO2eq**

Fig. 8.2: Results of the LCA

As seen in figure 8.2, the construction would cause about 9.4 t of CO_2 equivalent. As expected, construction (6.8 t CO2eq) accounts for a significantly larger share than the services system (2.6 t CO2eq). In the case of foundation, interior walls and ceiling, the high wood content leads to a negative GWP. In the roof, the used EPS insulation and the waterproofing membranes are the main problems. Exterior walls and roof have a worse result. In the case of exterior walls, this is mainly due to the large windows. The production of the insulating triple glazing is very energy intensive. In addition, a windproofing membrane is used here, whose CO2 footprint is also not insignificant.

The most relevant parts of the service system are the PV system (1.2 t CO2eq) and the connected battery (0.8 t CO2eq). The OPV used here leads to a significantly better result than would be the case with conventional PV modules. Since a single-Si or a multi-Si system would have an impact of 2.5 or 2.1 the used OPV is just about 0.2 t CO2eq/1 kWp. This is because the OPV does not require the extremely high temperatures for production that silicon modules do and therefore requires significantly less energy. LiFePO4 technology was selected as the battery. The GWP is higher (169 kg CO2eq/kWh) than with the lead-acid variant (52 kg CO2eq/kWh), but the technical and the other environmental aspects outweigh this. A lithium iron phosphate battery does not contain any toxic heavy metals such as lead, nickel, cadmium and cobalt. This technology also has an advantage when it comes to recycling. The metals used can be recycled up to 100% and also the electrode materials and the polymer separator can be recycled up to 90%. Heat pumps are an efficient technology for the CO2-free production of heat. The heat pump used for hot water supply produces another 0.4 kg. Other pumps for water supply, adiabatic cooling etc. as well as water pipes and cable have only a small share in the GWP of the HDU.

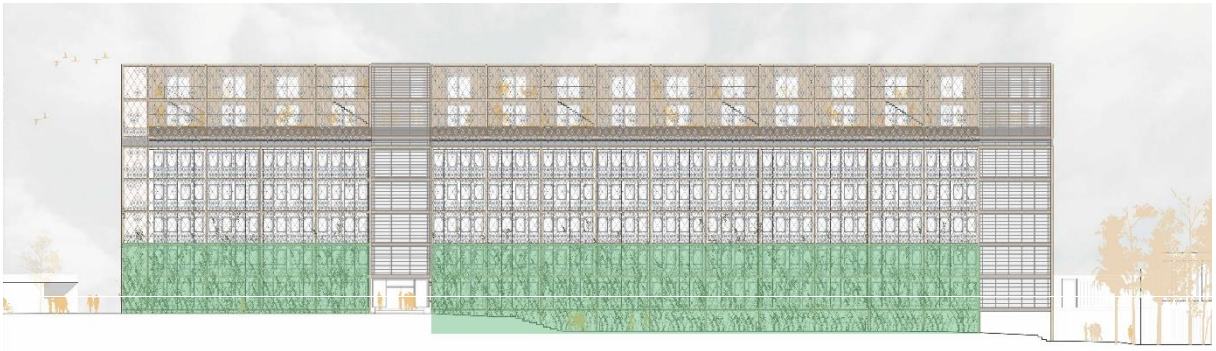
8.2 **Sufficiency, Flexibility & Environmental Performance**

8.2.1 **Biodiversity**

The biodiversity concepts are to a large part result of the elective subject “HFT goes green” which seeks to make our university more sustainable and is open to all students. The most advantageous part of this is, that many ideas and concepts are being implemented, even independently from the SDE21/22. Out of a combination of a few of these projects, including a “tiny forest” and a group that will build outdoor furniture for the campus, and the mobility concept, the new site plan was developed. Our overall concept seeks to increase biodiversity on and around the extended building and the whole university campus by creating new green areas. This also helps with the microclimate and helps reduce the heat-island effect of the city, as will be explained in more detail in chapter 1.2.3 climate.

8.2.1.1 Facade Greening

Façade greening will be climbing plants that grow from the ground up on the steel cable mesh attached to the wooden GRID. Within the openings of the mesh the organic photovoltaic cells are suspended, but these only start higher up where they will not be in the shade of buildings opposite to Bau 5. This



means however, that climbing plants need to be selected that will not overgrow the OPV cells. In Figure 8.3 you can see the façade greening.

Climbing plants from the ground up on the mesh can be different types of clematis, such as Clematis alpina, Clematis viticella, Clematis macropetala (single flowers) since they don't grow as strong and will most likely not overgrow the OPV cells. The common honeysuckle is also a good choice. All of these are excellent bee pastures. Edible climbing plants that don't grow too strong would be the hardy kiwi or the chocolate vine, but they are not specified as bee pastures. For the HDU we chose the mini kiwi.

8.2.1.2 Green Roof

Parts of the communal open spaces on the first residential floor of the addition are planted and act as a green roof, as can be seen in figure 8.4.

The HDU will have a modular green roof system underneath the OPV mesh, which consists of interchangeable plant troughs, planted with sedum plants. Green roof plants for our building are listed in appendix F 8.2.1.4, area. All the plants mentioned there are classified as bee pastures and some of them don't grow higher than 20 cm, so they can easily be planted underneath PV modules. There shouldn't be more than one type of sedum on one roof though, and 12 different types of plants would be ideal in terms of biodiversity.

8.2.1.3 Availability of habitats for animals

Two groups of the elective "HFT goes green" assessed the potential and developed concepts for insect habitats. One group worked on insect hotels in general and has built some prototypes that were placed on campus buildings as you can see in figures 8.5 and 8.6. They developed a flyer with information and instructions for building your own insect hotels which will be made available to all students.

Fig. 8.5: Insect hotel prototype

Fig. 8.6: Insect hotel placed on the rooftop of a campus building

The other group focused more in detail on wild bees and on developing bee hotels that might also be placed around the campus with informative signs to educate people on their importance. To offer these bees adequate food sources, a list of plants that are suitable as bee pastures (cf. Ministerium für Ländlichen Raum und Verbraucherschutz BW, Bienenweidekatalog 2019) has been put together. These plants can be planted around the campus, as part of the renaturation of the parking lot in front of “Bau 5”. Other bee pasture plants are also listed for the green roof and the urban farming. (See appendix F 8.2.1.4) The placement of insect hotels, as well as the plants that are suitable bee pastures are indicated on the site plan (Figure 8.7).

8.2.1.4 Ecologically valuable open spaces with climate-resilient, diverse plant selection

There are currently four different types of open spaces integrated into the design that meet different specifications. They are described in more detail in other sections of this report. The first is the façade greening, the second the green roof. The third is the “tiny forest” described in more detail under “climate-resilient, highly overshadowing trees and solitary shrubs”, and “urban farming” includes number four, the campus furniture. Figure 8.7 includes a site plan where these are indicated while appendix F 8.2.1.4 includes lists of climate-resilient, diverse plant selections for each of these points.

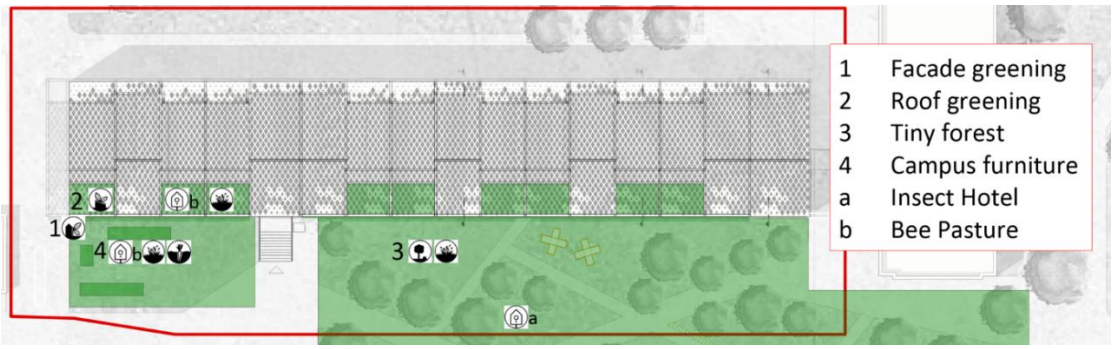


Fig. 8.7: Site plan with plants and animal habitats

8.2.1.5 Climate-resilient, highly overshadowing trees and solitary shrubs

As another project for “HFT goes green”, one group developed the part of the old parking lot to be renatured on the basis of the “tiny forest concept” (cf. boomforest). This was adopted for the site planning of our building design and a list of trees and shrubs was developed which would thrive in the dry urban climate of the city (see appendix F 8.2.1.4). Figure 8.8 shows existing and newly planted trees.

Fig. 8.8: Trees in the outdoor space

8.2.1.6 Urban farming

One group of “HFT goes green” developed outside furniture – benches, some of them with attached raised planting beds – made from recycled plywood form lining. Some of these will be placed in front of “Bau 5” (number 4 on Figure 8.7_site plan) and around campus. Over the summer of 2021 a few of these have been built and placed between two buildings on campus. The campus furniture has been planted with tomatoes and other plants and has become a meeting spot for students, as you can see in figures 8.9 and 8.10.

Fig. 8.9: The campus furniture as seen from above

Fig. 8.10: Part of team collab enjoying the new meeting spot

Apart from several pear trees within the “tiny forest project”, we suggest developing the urban farming area within the raised beds, as they will be easily cultivated and looked after that way and draw a lot of attention towards the urban farming scheme. We chose urban farming plants that are edible, either for their fruit, their roots (e.g. carrots) or flowers or – in case of herbs – their leaves, and don’t need too much attention. Quite a few of them also make a good bee pasture (see appendix F 8.2.1.4).

8.2.1.7 Minimised exterior illumination

The exterior illumination concept follows a catalogue of criteria that was put together to reduce light pollution. This means that the exterior light installations will be as minimal as possible while still providing enough light to see by. There are going to be 46 smaller lights instead of a few bigger ones, and they will face downwards rather than up, as this reduces overall light emission. In general, only spotlights on the façade of the HDU and on the platform will be illuminated, not the whole façades or the entire open space. The lighting concept uses optimal directing of the light to increase illumination with as few lamps as possible. The lights that are used are LED bar lights which do not contain e.g., toxic mercury and which have a very low energy consumption. The lights selected will have a radiation range of up to 3500K, but not more, warm white light with minimal radiation in UV wavelengths. This is the least harmful light to both the environment and the human eye.

8.2.1.8 Elevated construction with no basement or addition of another storey to an existing building

In the Design Challenge two residential storeys are added to the existing university building “Bau 5” on campus. This increases the urban density and use of the already sealed land while not consuming additional, undeveloped land. The only new ground disturbance will be for the point foundations of the wooden GRID structure which extends from the ground up to the new storeys, in front of the façade. These are very minimal and localised disturbances and will be compensated for by the renaturation of parts of the asphalted parking lot in front of “Bau 5”.

8.2.1.9 Minimization of terrain adjustments

No new surfaces will be sealed in the project, as the new building structures are placed entirely on an existing building. On the other hand, the only terrain adjustments made, are the renaturation of the parking lot with trees and other plants, decreasing the sealed area and thus the risks of flooding in the city while increasing plant and animal habitats. Another advantage of building on top of an existing building is that infrastructure such as roads, public transport, and shops are already in place, especially considering the university campus is so close to the city centre of Stuttgart. Mobility emissions are further reduced by housing students and guest professors in the additional storeys who will then only have a very short distance to walk to the other university buildings.

8.2.2 **Society**

The topics time-coordinated multiple occupancy and expansion of living space in transitional seasons are not part of our concept and are thus omitted from this report.

8.2.2.2 Offer of areas and rooms to be used jointly

The residential units are arranged linearly but by shifting some units to the south, dynamic outdoor spaces are created which can be used communally. The shifted units create recesses on the northern corridor with semi-private seating, to be used by the two or three adjacent units. The bigger outdoor spaces are to the south, where three units share one space, although other residents can of course also join them. These spaces can be used flexibly, according to the residents' preferences, for example for outdoor sports and games. Each space also has an adjacent "green" area which is planted with extensive roof greening and give a garden-like quality to the extension while also improving the microclimate. In figure 8.11 you can see shared spaces in the addition.

Fig. 8.11: Offer of areas and rooms to be used jointly

All in all, the outdoor areas are meant as communal spaces where residents (and visitors) can meet, spend time together and learn from each other. This compensates for the minimised private spaces, but more importantly it creates a village-like community and strengthens social relations.

8.2.2.3 Offer of mixed use

The location of the renovated and extended "Bau 5" on the university campus make the residential units ideal living space for students and guest teachers who will be able to walk a short distance to the buildings where they have or give lectures, thus reducing mobility emissions. The existing building will continue to house offices, lecture halls and workrooms as well, according to a new architectural concept, so the shortest distances to the work/ study place don't even require leaving the building.

This effectively means people can live and study (or work) under the same roof. On the ground floor of the existing building there will also be a café which is open to everyone on campus and living in the extension. (See appendix G 8.2.2.3)

8.2.2.6 Space flexibility within the unit

All units consist of one, or the two-storey modules of two, room(s) which contain all necessary functions. The functional parts are all situated along the two long walls of the unit. On one side are the kitchen and bathroom, and in two-storey units the stairs. The other side is made up of “moving corps” which contain necessary furniture, such as a table, chairs, and the bed, as well as individual storage space. The furniture is stored in them when it’s not needed, opening the central space for individual use. At night the bed can be folded down out of the biggest cabinet; for working/ studying and for dinner, a table and chairs can be brought out (see Figure 8.12 for details). This way the room contains many different rooms in one and can always be changed according to need.

8.2.2.7 Adequate privacy

The units all have glass doors on both ends, which gives residents a clear view on the shared spaces in the south and further on the university campus, and on the vineyards to the north. The walkways on the north and south both lead directly past all doors, opaque curtains are installed on the inside in front of the doors to ensure privacy. The disadvantage is that no views are possible when the curtains are closed. Shifting some units to the north/ south creates semi-private areas outside, in front of the units.

8.2.2.8 "More in one" components

The main feature of the interior design concept is multifunctional, pivotable cabinets with storage space. They contain a foldout bed and any other furniture, such as a work desk, dining table and chairs.

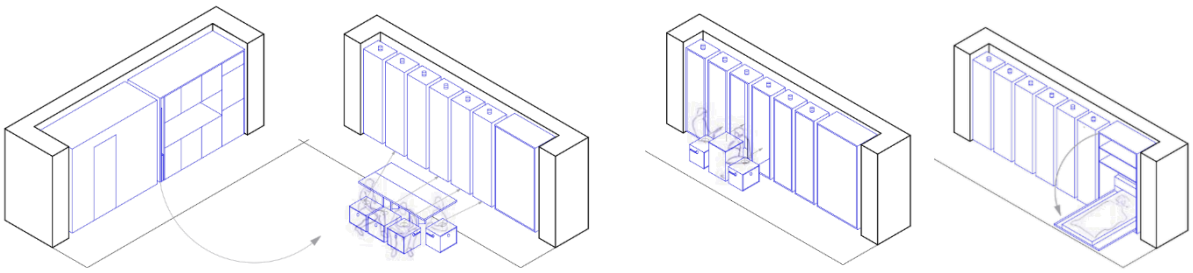


Fig. 8.12: Central living space and furniture serve multiple purposes: dinner, work, sleep situations

The furniture can be brought out or put away as seen in Figure 8.12 while the central space remains free and can be transformed according to the resident’s current need or fancy. In its adaptability and transformability, the central space contains not just one room but many – a kitchen, dining room, living room, bedroom, all while fitting into a small rectangular floorplan which makes it very easy to transfer to other buildings and extensions. The cupboards are in their entirety “more-in-one” components, but so is the flexible central space of the unit.

8.2.2.9 Accessibility for wheelchair users and people with reduced mobility and for further handicaps

The accessibility concept was conceived as an overall concept for both the new, residential storeys and the renovated, public part of the building with its offices, lecture halls and work rooms for the university. This concept aims to maximise independent use of the whole building for all people, including sensory and mobility impaired persons.

The university building has its main entrance on the southern façade, accessible at the moment only via a staircase. Currently the only barrier-free access is with a lifting platform at the northern back entrance. The goal is to make the main entrance as well as the walkway leading to it completely barrier-free, which means that a permanent lift will be built, next to the main entrance stairs. The sidewalk leading to the entrance will have a width of at least 1.8 m to make it easy for two wheelchairs, baby strollers etc. to pass by each other. There will also be a tactile orientation system on the floor which leads to the main entrance of the building. The main entrance itself must be easily identifiable as such by contrasting strongly with the rest of the building and being adequately lit at all (business) hours. This is already the case as it sits at the base of the fully glazed front of the stairwell, which will in the future be the equally glazed solar chimney, which contrasts strongly with the rest of the façade with its many smaller windows and pilaster strips. The only issue with the door is that the exterior door is quite heavy and the interior door, after the vestibule, is a double-swing door, which is not barrier-free. If possible, the doors will be automated to make handling easier for everybody.

All existing staircases, the exterior one and the two interior ones, will be fitted with handrails on both sides, at a height of about 85-90cm and 30cm longer than the staircase itself, and visually contrasting markings on the stairs, especially marking the first and last steps. The handrails will also have tactile and braille information inscribed on each floor for orientation. There is already an elevator which reaches all “old” floors in the building and is 160x170 cm and thus bigger than the minimum of 110x140 cm for a barrier-free lift. A second elevator of similar dimensions will be integrated into the GRID at the north-western corner, this one will only give access to the additional storeys. It is placed so that one exits onto the northern walkway which connects all residential units and thus makes step- and threshold-free access to all of them possible. There is a wheelchair passing area of 180x180cm in front of both elevators on all floors as well as a barrier-free control panel. Both elevators are outfitted with buttons with tactile and braille information and an indication system that implements the “two-senses-principle”. This means that the information about the current floor, the arrival and departing of the lift can be both seen and heard – at least two senses are always catered to.

The renovation:

All hallways have a width of 2.5m which means there is ample space for wheelchair-users or people using mobility aids to pass by each other and means there is enough waiting and turning space in front of all doors. Due to the new architectural concept, the floorplans are now very open, which increases accessibility. All remaining office and room doors comply with the accessibility regulations and have a space of at least 1.5m on either side of the door, starting 50cm to the side from the door handle as well as being a minimum of 90x205cm in size.

The wider glass doors that separate the fire sections in the hallway will have markings at 40-70cm and 120-160cm height to improve visibility of these. On all floors there will now be one barrier-free and wheelchair-accessible toilet.

The addition:

There is one entirely barrier-free and wheelchair-friendly unit on the fifth floor which is close to the elevator on the western side of the building. This works by combining two units into one, effectively doubling both the bathroom and the kitchen space which are now in the centre of the unit and include wheelchair turning areas. Wherever the units jut out a bit to create a more dynamic floorplan, the walkways lose some of their width. There is however still more than the minimum of 1.5m of breadth and there is ample space for turning and passing of wheelchairs at either end of these bottlenecks. All the new staircases in the southern part of the outside spaces and in the units will also have handrails at 85cm height that reach an additional 30cm horizontally into the room. The staircases themselves are all one meter wide and have visually contrasting markings on the steps. The doors to all units (and to the stairwells) all exceed the minimum dimensions of 90x205cm and have the adequate wheelchair-turning areas on either side, as seen in the plan, making it possible for people with reduced mobility

to visit all units themselves (if not the sanitary facilities). The entrances are also easily identifiable by strongly contrasting wooden cladding above the doors.

Fire safety:

The alarm system for the whole building is based on the “two-senses-principle” and has both auditory and visual alarms in case of emergency. In the additional storeys, the stairwells are separated from the rest of the building by F90 fireproof walls to ensure safe emergency exits. The bigger stairwell may prove to be spacious enough to have a safe short-term waiting area for people who cannot save themselves via the stairs without aid.

8.2.2.11 Sound insulation/ minimisation of sound insulation conflicts

The arrangement of the residential units creates more intimate seating areas to the north and larger communal spaces to the south. This allows residents to choose between two different situations in the outside spaces – the quieter northern or the lively, and louder, southern spaces. The separation of these areas by the units minimises sound insulation conflicts and thus conflicts between different user groups. All building parts are constructed to be soundproof to ensure protection inside from outside noise, as the communal spaces and walkways are directly adjacent to the residential units.

8.2.2.12 Perception of safety

The existing building has an elongated rectangular floorplan with long, straight central hallways in between the offices. The main stairwell is very central, the second stairwell is at the east end of the building and they both extend up to the addition. This setup of the floorplan is very straightforward, and you cannot easily get lost in it. On the additional storeys the hallways aren’t as central, there is a gangway to the north and connections between the bigger public spaces in the south (these also have stairs to change between the two levels). It is still possible to walk in a straight line from one end of the building to the other, in the north, and on the lower level, in the south. The outside spaces on the addition are very open with many visual relations between the upper and lower floor which increases overall visibility and overview on the happenings everywhere. The outside walkways will have illumination with motion-sensors to always make orientation possible. The main entrance of the building is easily identifiable and visually contrasting to the rest of the façade and will also have adequate lighting (motion-sensor) throughout the day. The way to the main entrance and to the elevator at the north-western corner will always be adequately illuminated, as well as the stairwells. These main routes to and from the building will have brighter illumination than the rest of the paths. There will be evacuation plans with emergency routes for all floors of the building, both old and new, including barrier-free evacuation routes and an alarm system based on the “two-senses-principle” (see “accessibility”). All these measures will help to increase the feeling of safety for all inhabitants and users of the building.

8.2.3 Climate

The geographic information system GIS-ImmoRisk (GIS) was used to assess potential natural hazards for the "Climate" criterion. The tool was initiated by the Federal Institute for Research on Building, Urban Affairs and Spatial Development. It is used to assess the risk situation of real estate locations nationwide and across the board due to natural hazards such as heavy rain, winter storms, forest fires, earthquakes and heat, and also - depending on the availability of the data basis - to carry out a qualitative or quantitative assessment of climate risks for the properties. Building 5 including the extension was considered as you can see in appendix H 8.2.3.

The topics “Construction elements with high thermal mass”, “Grey water usage”, “Precipitation water usage” and “Robust construction to prevent storm damage” are omitted in the concept and in the report.

8.2.3.1 Minimisation of sealing of open spaces/floor coverings capable of infiltration

The consideration framework of the calculation (ULD checklist) is based on the property boundaries of the mobility concept as you can see at figure 8.13. On the campus of the University of Applied Sciences, one currently finds predominantly asphalt roads and almost completely sealed courtyards. The planned restructuring of the parking lot in the space between Building 1 and Building 5 already counteracts this problem. Another improvement possibility would be to provide diffusion-open grass pavers in the bicycle parking areas through the new mobility concept. Also, in the near the rear entrance of Building 5, the sealed walkway could be made narrower to generate further infiltration area in the form of green strips.

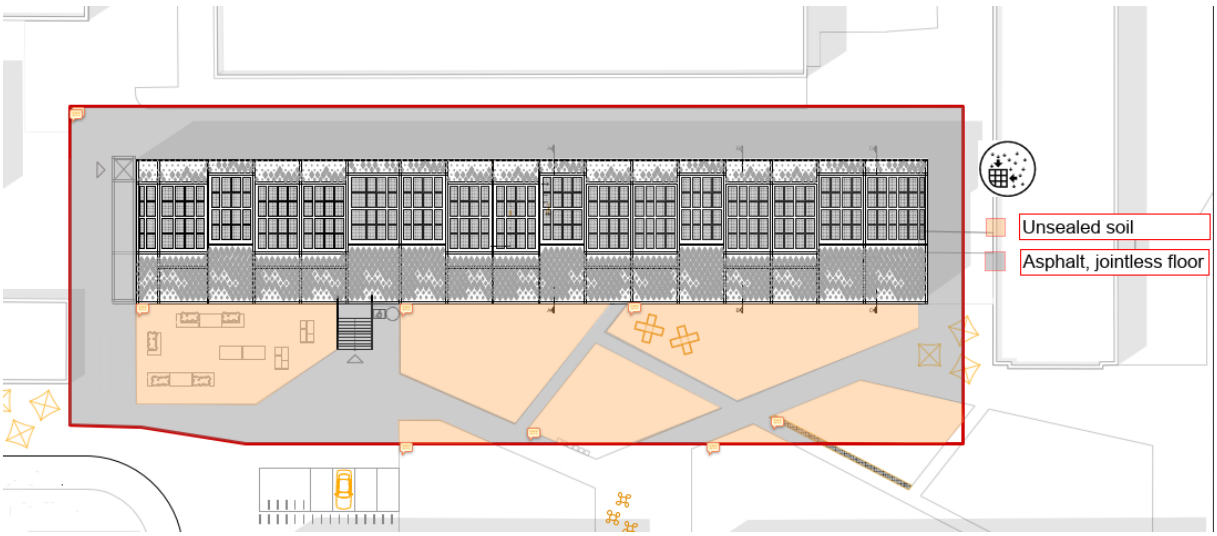


Fig. 523: Floor coverings

Nevertheless, the green spaces in Stuttgart and especially on campus are very small, which is why there is a lot of potential here to expand the green spaces to counteract the continued soil sealing.

According to the changes in the plant design, the areas were adjusted here and optimized with regard to the improvement measures. Thus, the previous draft contained the areas as follows:

Table 1: Before

Material	Area	Degree of reflection
Dark asphalt	1171,25 m^2	0,05
Grass	680,89 m^2	0,25

On the opposite, the new design has more green area compared to asphalt area:

Table 2: After

Material	Area	Degree of reflection
Dark asphalt	1104,05 m^2	0,05
Grass	775,74 m^2	0,25

8.2.3.2 Precipitation-retaining roof coverings

Green spaces are planned for the expansion of Building 5, which can absorb water and contribute to a high quality of life for residents. The green roof or non-covered green open spaces of the addition currently cover 12 % of the roof area. The roof surfaces of the addition are covered with PV modules throughout, with a gravel roof below. Due to the high percentage of PV area on the roof surfaces as well as the OPV modules in the GRID, the greened portion can only be increased with a loss of energy. At the current planning stage, however, the amount of regenerative PV area is the focus here, so that further green roof areas must be dispensed with. Possible plants that could be planted underneath PV are mentioned under “biodiversity – green roofs”. The calculation areas are shown in figure 8.14 and 8.15.

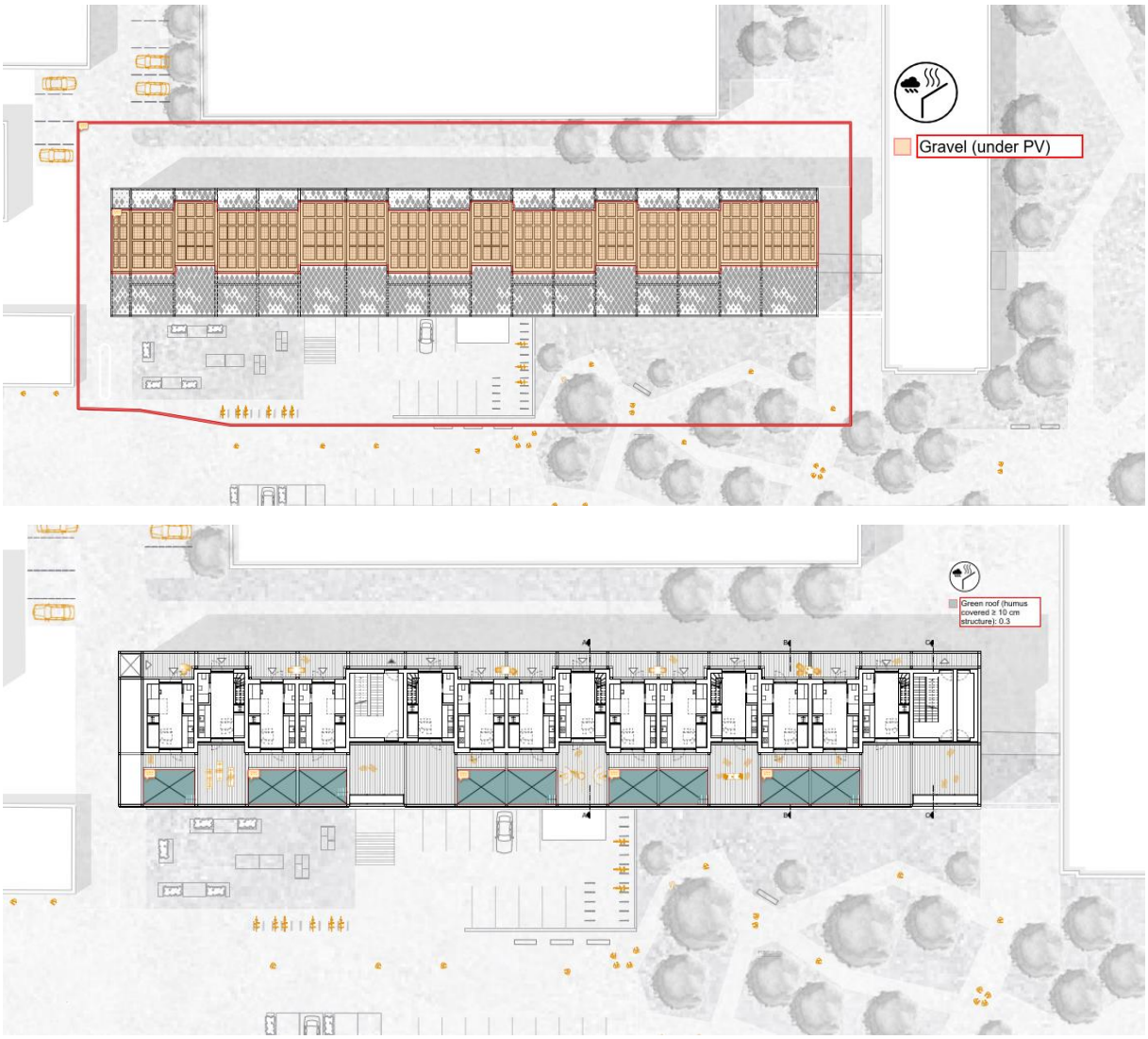


Figure 8.14 &15 Roof coverings

8.2.3.3 Decentralised rainwater infiltration on the own property

In Stuttgart, an average rainfall of around 700 l/m² per year can be expected. This rainfall must be drained away, for example by infiltration in open terrain troughs or in infiltration shafts filled with substrate.

The current concept for dealing with rainwater provides for natural rainwater infiltration in the outdoor facilities. Due to the green areas in the direct vicinity of the building and the proximity to the city park, the rainwater can percolate. A drainage system around the building must be considered in the revitalization of the outdoor facilities in the ground. A drainage system represents a standard.

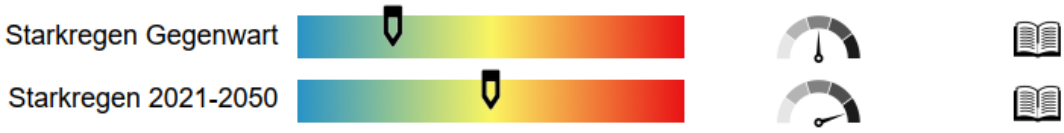


Fig. 8.16: Section from appendix H 8.2.3

According to the GIS, no high risk of heavy rainfall is to be expected until 2050; the qualitative assessment is currently at a medium risk, and an increased risk compared to the present. A reduced degree of sealing, as has already taken place in the course of planning, is therefore necessary.

8.2.3.6 Resilient rainwater runoff

For the resilient stormwater runoff, the stormwater pipes and their outlets were mathematically pre-dimensioned according to DIN in order to prevent damage from heavy rainfall events. The concept is presented in more detail in Appendix H 8.2.3.6. As can be seen in the plan, the drainage areas are always located within a “blue box”. If possible, two modules are always drained off together. The lowest point is always in the area of the partition wall, as this is where the bathroom and kitchen are located. The normal drainage will also take be placed in this area. In addition, the emergency drainage is going to be placed as a slot in the attic on the north side (marked with a red arrow). Possible design examples are shown in the following figure.

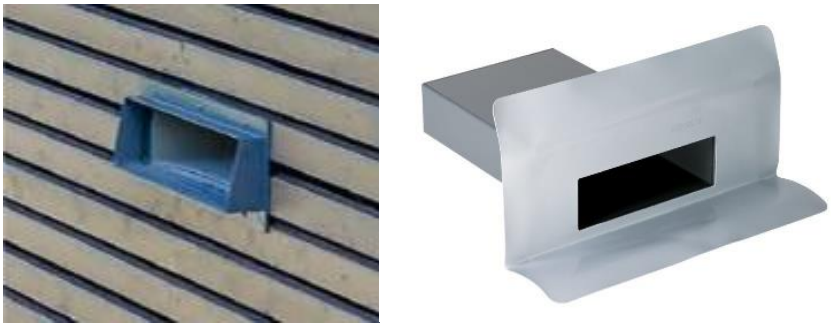


Fig. 8.17 Possible designs for emergency drainage openings

The water will then run onto the pergola on the north side, but not directly above the entrance doors. From this arcade, it will run onto the existing roof of Building 5, where it will be drained through the existing drainage system. This is acceptable because such an event occurs on average only once every 100 years and the overall roof area remains identical. This means that there is not more rainwater than before, so the rainwater that hits the elevation can be directed onto the existing roof. In Appendix H 8.2.3.6, the emergency drainage systems are dimensioned for the various situations.

8.2.3.7 Light-coloured open area sealants

Including the GIS, an increased to high heat risk is expected by 2098. A medium risk can already be expected by 2050. By this time, buildings should already be "Paris ready" for the Paris Climate Agreement so that they can be operated in a decarbonized manner without having to deal with additional influences such as heat. Against this background, this aspect must be taken into account in the planning of outdoor facilities and the selection of materials in relation to the heat island effect.

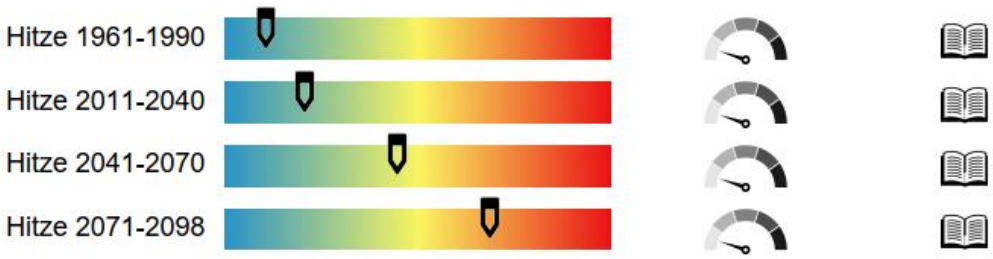


Fig. 8.18: Section from appendix H 8.2.3

To prevent the heat island effect, the materials of the outdoor facilities are important. Plan BD-10 01 was used for the analysis as you can see in Figure 8.19. For this purpose, the property boundary was used, which has been defined by economic efficiency.

Table 3: Calculation of reflection of open area

Material	Area	Degree of reflection
Dark asphalt	1104,05 m^2	0,05
Grass	775,74 m^2	0,25

The ULD checklist and the website D-Arch was used as a source. The reflectance values vary, the worst values were assumed. The reflexion of the open area is calculated in the Urban-Loop-Design Checklist.

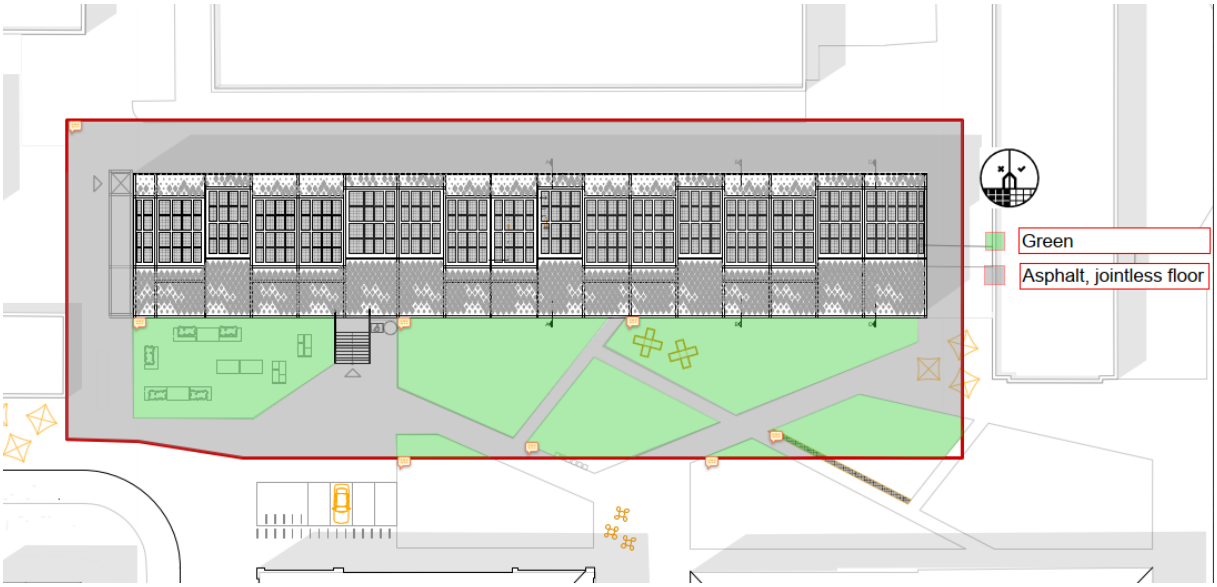


Fig. 8.19: Light-colored open area sealants

8.2.3.8 Light-coloured building envelope

Also important for the heat island prevention are the building materials. Solar panels are used for the elevation, these reflect the sunlight and counteract heating up of the building below.

Table 4: Calculation of reflection of building

Site	Material	Area	Degree of reflection
Roof	PV modules	682,08 m^2	0,1
Facade	Wood	2026,12 m^2	0,6
Facade	Concrete	1781,12 m^2	0,71

The website D-Arch and the VDE website were used as a source. The reflectance values vary, the worst values were assumed. The reflexion of the building is calculated in the Urban-Loop-Design Checklist and the used plan is in figure 8.20.

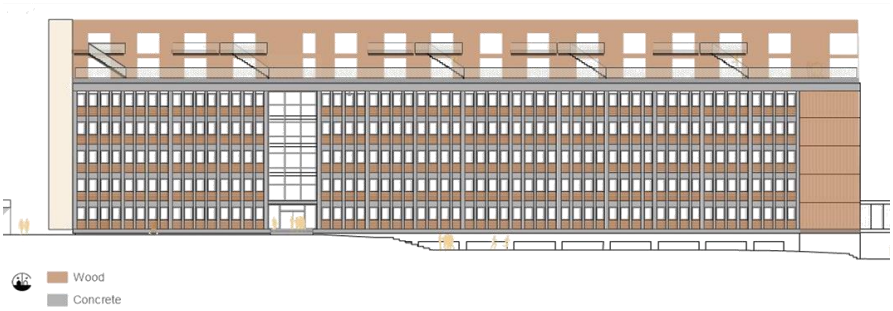


Fig. 8.20: Light-coloured building envelope

8.2.3.9 Cooling or shaded building exterior spaces

Fig. 8.21&22: Street Canyon adjacent to the SDE building and Example Design for the Street Canyon (coLLab HFT Stuttgart, 2020)

If the majority of new living spaces is constructed the way we envision and combined with innovative mobility concepts, areas previously used for parking or street canyons in general can be repurposed. Vegetation can be planted and liveable and vibrant outdoor spaces are created. Outdoor Comfort is vital here. The street canyon adjacent to the SDE building, shown in Figure 8.21, is reinvented as a part of the competition. An example for a possible design approach, tied to a mobility concept can be seen in Figure 8.22. Here, the parking spaces are replaced by an urban leisure area. It is vital to be able to assess the placement of vegetation and other shading geometry and its effect on outdoor comfort.

As part of a bachelor's thesis, a study was conducted to investigate outdoor comfort in the form of a simulation to better evaluate the effect of vegetation on the microclimate. Overall, the outdoor comfort in the urban street canyon can be improved significantly, when placing trees which provide shade within. The UTCI in the positions right under the tree and near the tree, indicate comfortable conditions for most of the summer months. These results were already processed in the DEL#3. The resulting conclusions were incorporated into the current planning of the outdoor facilities and represent the current state of planning.

8.2.4 Durability

The topic “Avoidance of damage-prone plastic or metal foils” and “Durable and recyclable supply lines” are omitted in the concept and in the report.

8.2.4.1 Variability of usage sizes:

The sanitary infrastructure of the extension is routed from the technical room in the basement to the extension along the grid. In the addition, the pipes are then distributed in shafts, whereby 4 modules are always supplied together. This way, 4 modules can be combined into one leasable area. According to the DGNB criterion ECO2.1.5 for residential buildings, load-bearing or non-load-bearing walls can allow change of use. The horizontal connections can link modules together. The connection is already prepared during installation and shown in figure 8.23.

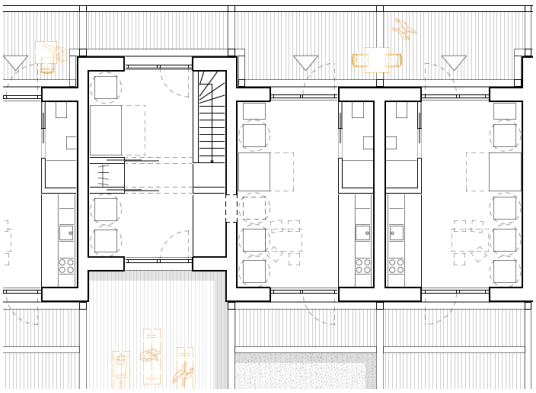


Fig. 8.23: Prepared horizontal connections

With a change of inhabitants and accompanying change of area, the interior components can be removed and the connection of modules through a passage or door is possible. As a result, differently sized units can be generated. The entrance on the north side allows such a change of use of the modules since each module is accessible through the corridor.

8.2.4.2 Possibility of change in use

According to the Urban-Loop-Design Tool, for office spaces of max. 50 m^2 the ceiling height should be min. 2.5 m. As can be seen in Plan BD-14 02, the ceiling height of the extension is higher than 2.5 m and thus suitable for office use. A floor plan change can be used to enable a later commercial use in the extension. As mentioned in the previous section, the spaces can be changed, for example by linking multiple units together. This allows for the creation of different spaces that can be rented. Additionally, co-working spaces can be offered in the double modules.

8.2.4.3 Modular building structure

The extension consists of modules, as shown in Plan BD-00 10 and BD-11 01. The interior is characterized by functional walls on both sides, in which smart furniture and technical components are installed. The wall modules can be arranged in virtually infinite linear rows - ensuring transferability to buildings with varying space on the roof. The modular design ensures easy and quick assembly and disassembly. In addition, the modules can be reused at another location.

8.2.4.4 Non-load-bearing façade

In the renovation of the existing building, the grid with the steel-cable-mesh performs various tasks. On the south side, energy is generated by the grid with the OPV, and the solar chimney is located there.

By hiding the supply lines, functional and design aspects are considered, and various requirements are fulfilled by the facade greening. Detailed aspects of the facade greening are discussed in the section facade greening in the chapter biodiversity. On the west side, the elevator is integrated into the grid and thus has another function on the facade. All these functions are generated by a new, external façade skin that is not required to support the building or the addition.

8.2.4.5 Durable, robust materials of exterior components

For the durable exterior materials, table 5 was prepared showing the durability of the materials. The information about the lifetime of the materials was taken from the document "Durability of component layers/materials " from the WAT.

Table 5: Durable, robust materials of the exterior components

Durable, robust materials		Durability [a]
Sealing	Green roof	≥ 40
Attic	Sheet metal	≥ 50
OPV	Laminated	20
PV	Glass	≥ 50
Mesh	Stainless steel	≥ 50
Wood from GRID	Larch	40
Wood in facade	Softwood	≥ 50
Window	Aluminium frame	≥ 50
	Glass	≥ 50
Wood in terrace	Larch	40
Green area on the addition	Grass	≥ 40
Railing	steel	≥ 50

The installed wood is not treated, and the joints do not require glue. The connections used for the grid are mechanical connections and are considered in plan ST-20 19. This makes maintenance of the GRID easy. Polycarbonate was chosen for the OPV and is therefore the material with the shortest service life. The other materials have a longer life span.

8.2.4.6 Durable, robust surface materials of interior components

For the durable interior materials, a table was prepared showing the durability of the materials. The information about the lifetime of the materials was taken from the document "Durability of component layers/ materials " from the WAT.

Table 6: Floor and wall materials

Durable, robust materials		Durability [a]
Floor covering	Rubber	20
Railing	Stainless steel	> 50
Wall cladding	chipboard	> 50

8.2.4.8 Repair-friendly and refittable routing of supply lines

The building technology for the HDU is installed in the cabinets as you can see in the ground floor plan (plan AR-21 01). There is enough space in the cabinets, so that the installations are easily accessible for maintenance. To have sufficient space, the installations were integrated into the planning at an early stage.

8.2.4.10 Cleaning and Service Catalogue

The HDU is designed as an exhibition space and therefore has high standards for cleanliness. Due to the high volume of visitors, surfaces and exhibits will need to be cleaned on a regular basis. In addition, there will likely be requirements related to the Covid 19 pandemic situation. That is why the cleaning intervals are very high.

Table 7: Cleaning and service catalogue

Component	Material	Located	Frequency	Cleaning agents
Ceiling coverings	Rubber	Ceiling	daily	Floor cleaning
Floor coverings	Rubber	Floor	daily	Floor cleaning
Interior wall coverings	Chipboard	Cabinet surfaces	daily	Water
Windows and doors	Glass surfaces	Windows/Doors	daily	Window cleaning
Windows and doors	Metal handle	Doors	twice a day	Water
Built-in furniture	Steel railing	Interior stairs	twice a day	Steel cleaner
Built-in furniture	Steel fittings	Kitchen	daily	Steel cleaner
Building outdoor facilities	Acrylic glass	Information panels outside	daily	Water
Building outdoor facilities	Steel railing	Outdoor space	daily	Steel cleaner
Building outdoor facilities	Wood terrace	Outdoor floor	daily	Broom

8.2.5 Building Material

The topic “Avoiding component layers” is omitted in the concept and in the report.

8.2.5.1 Priority use of regional building products

The OPV modules in the façade are to be produced by the French company Armor. In 2019, 45 % of the products were sourced locally (cf. Armor csr report 2019, p. 48). A design from Carl Stahl is to be used for the mesh. They only produce in Europe to reduce CO_2 emissions through logistics (cf. Carl Stahl). The Bau-Fritz company pays a lot of attention to regionally felled wood and the processing takes place in their own production facilities in Erkheim. The wood comes from Bavaria, Baden-Württemberg and Austria, the maximum distance can be up to 500 km, as you can see in figure 8.24. The components such as stairs and doors are made from wood felled between 5 - 50 km away from the production site,

as you can see in figure 8.25 (cf. baufritz Environmental Report 2020, p.32). Local wood is used to produce ELKA ESP boards. The wood has its origin max. 150 km from the production site (cf. elka). Natural plaster from quarries and FGD plaster from power plants are used in the production of Knauf plasterboard. To minimize the transport distance, the production facilities are built near the power plants and quarries (cf. Knauf Environmental Report, p. 34f). The average of the distances indicated is 234 km for the construction elements.

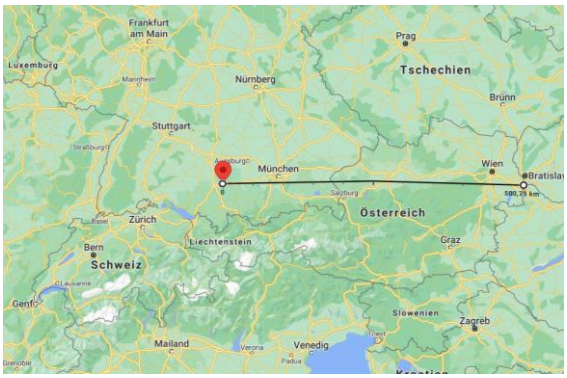


Fig. 8.24 and 25: Removal of origin and production

8.2.5.2 Lightness over mass

The GRID is to be built as a timber construction, the addition as timber frame constructions. Among other things, this ensures flexibility of use. The filling of the wood frame constructions of the walls with a lightweight, loose insulation reinforces this approach. On plan BD-14 02 you can see the timber frame construction. The very light profiles of the interior wall are braced by panel materials and then insulated. This way, a wide range of applications can be ensured, which, in addition to classic drywall constructions in the interior, also make building extensions and additions up to multi-story residential and commercial buildings possible (cf. Marity 2017). Sound insulation is ensured by the construction with intermediate insulation in the partition walls between the neighbouring modules.

8.2.5.3 Moisture-regulating, recyclable materials

Materials of interior components can be see at Plan AR-31 01 – AR-31 02.. Materials for moisture control are chipboards for the furnishings, the ESB-Boards on the ceiling and the wood-based panel on the walls.

8.2.5.4 Monomateriality

The extension is built as a timber frame. Due to the wooden frames and the blown-in insulation made of wood chips, the construction mainly consists of wood-based materials. These can be thermally or materially recycled. The detailed layers are shown in Plan AR-31 01 – AR-31 02.

8.2.5.6 Absence of biocides, formaldehyde, SVHC, …

To consider the environmental impact of the building materials in the HDU, there is a table in Appendix H 8.2.5.6. The avoidance of biocides, of emissions through formaldehyde, of flame retardants classified as SVHC (Substances of Very High Concern), of other SVHC, of halogenated foaming agents, of heavy metals as large-area shell materials or coupling to filtering measures and of subsequently applied coatings that are hazardous to waters is also considered there. After the table, the individual product data sheets are attached.

8.2.6 **Appendix**

Appendix A – Materials

Appendix B – Construction

Appendix C – Maintenance

Appendix D - Circularity concept

Appendix E – Carbon footprint of the construction

Appendix F – Biodiversity

Appendix G – Society

Appendix H – Climate

Appendix J – Building Material

9 URBAN MOBILITY REPORT

coLlab

9.1 **Analysis**

The building site is situated in the very central district called “Universität” in Stuttgart like shown in figure 1. It is on the campus of the University of Applied science Stuttgart and part of the university. The city of Stuttgart has an area of 207.4km², the district University consist of 45.54 hectare.

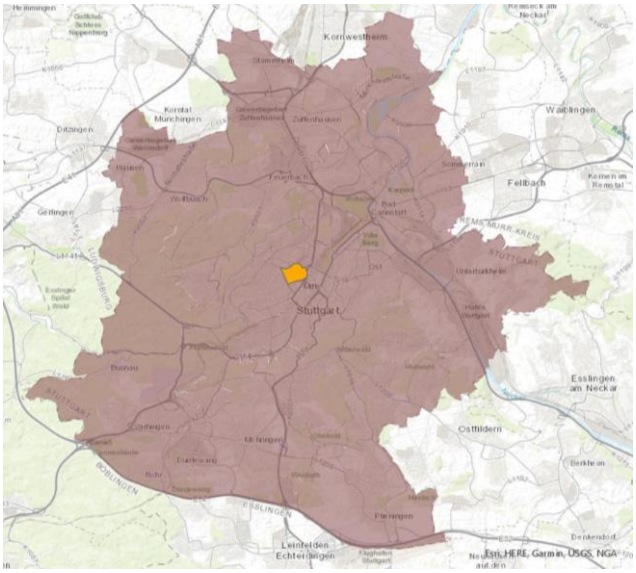


Fig. 9.53: Location of University of applied science Stuttgart in the city of Stuttgart

The topography is quite mountainous like shown in figure 2. It can be ascertained that the university is in a valley just as the whole inner city of Stuttgart. The airline distance to the river called Neckar is about 3.5 Kilometer.

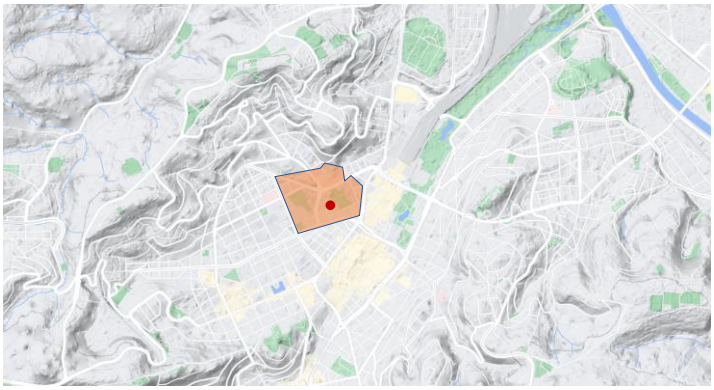


Fig. 9.54: Topography of Stuttgart

Around the campus there the residential buildings are manly constructed as row of houses or perimeter block development. This becomes apparent in figure 3. In the district of the University there are living 916 people, in the whole city of Stuttgart there are living 634.830 people.

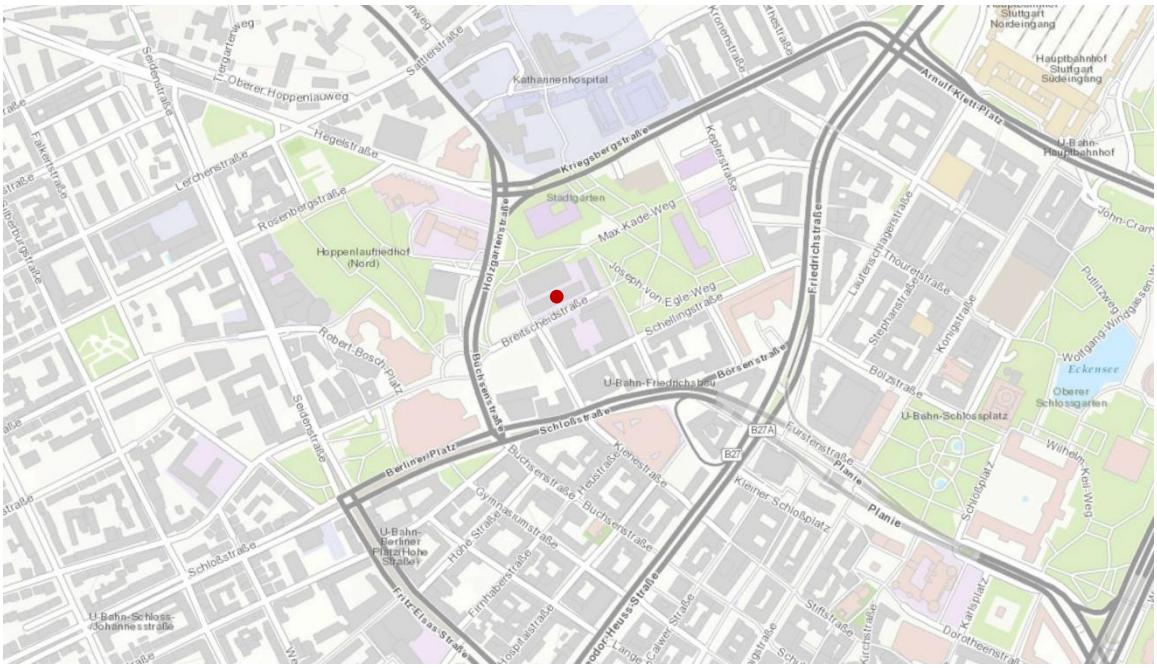


Fig. 9.55: Buildings surrounding the campus

Based on the general conditions in the neighborhood around the Campus in the city center and the traffic development plan of the city of Stuttgart, the current conditions in pedestrian traffic, local public transport, bicycle traffic, passenger vehicle traffic as well as the necessary conditions for people with restricted mobility were analyzed.

9.1.1 **Pedestrians**

The Stuttgart Mitte district is strongly characterized by pedestrian traffic, as can also be seen from the transport development concept of the state capital Stuttgart. "Walking is not only the simplest and most elementary form of locomotion, but is also environmentally and socially compatible, health-promoting, cost-effective, flexible and feasible without technical effort." (Pedestrian traffic concept of the state capital Stuttgart, June 2017) The share of pedestrian traffic in the state capital is at a "pleasingly high level" and is around 26%. In the inner-city districts, the share of pedestrian traffic is even higher, in some cases more than 30 %. Walking stages, such as to public transportation services and car parking areas, are not even considered here. Stuttgart's city center is characterized by its valley location. Almost one third of the 600,000 inhabitants of the state capital Stuttgart live here. Many sources and destinations in Stuttgart are reached by walking. These include, for example, educational institutions, cultural institutions, family and social institutions, public authorities, health care institutions, church and religious institutions, nature, leisure, sports and playgrounds, but also places relevant to tourism, such as viewpoints and city center routes. All these source and destination locations should be in the immediate vicinity, and they are.

Figure 3 shows that all student facilities in the city centre can be reached on foot within five minutes (dark blue). In addition, the time needed to reach the sharing facilities is significantly reduced. The newly created stop will connect the HfT more quickly to public transport. Within 10 minutes (purple), the vibrant centre of Stuttgart with its dining, shopping and nightlife options can be reached via Schlossplatz and Königsstraße. Several light rail stations also fall within this isochrone. In the 15-minute isochrone (light blue), the main railway station offers a connection to the national Deutsche Bahn network. In addition, all other important points in the city centre can be reached within 15 minutes.

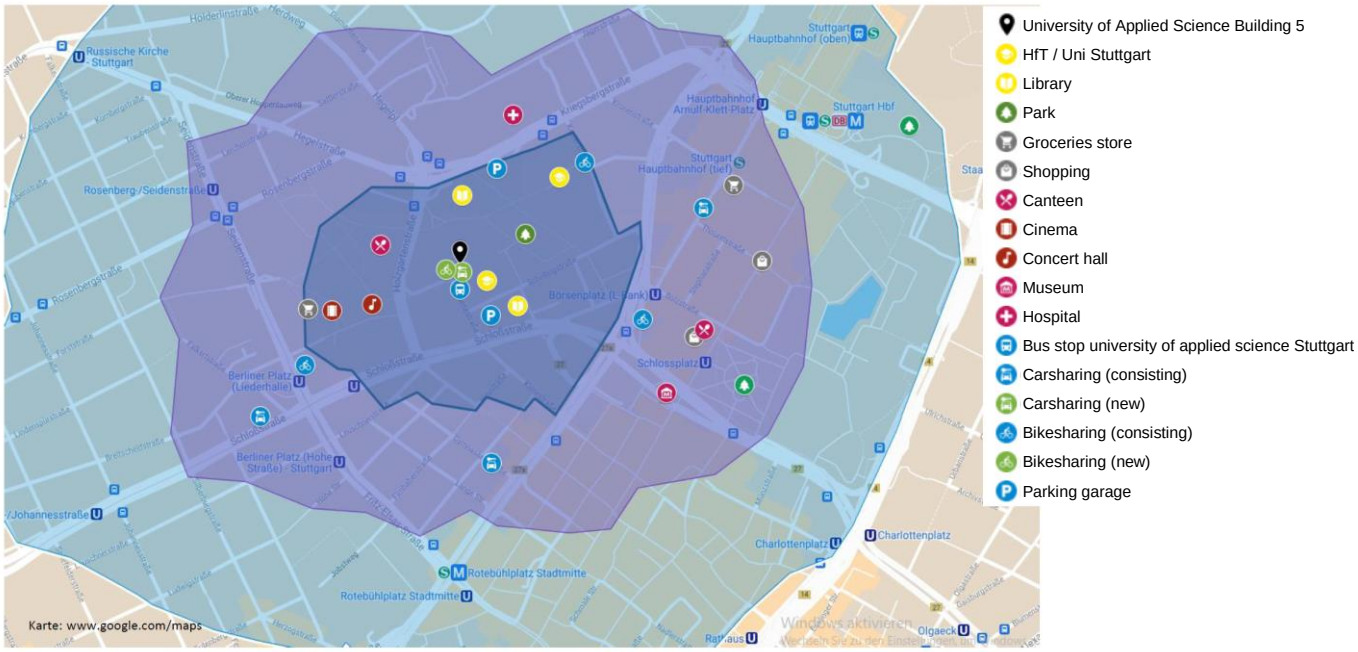


Fig. 9.56: Walking distance of University of applied science Stuttgart building 5

Figure 4 shows that almost all central points of the state capital can be reached by bike within 5 minutes (yellow). Every point in the Stuttgart basin can be reached in 10 minutes.

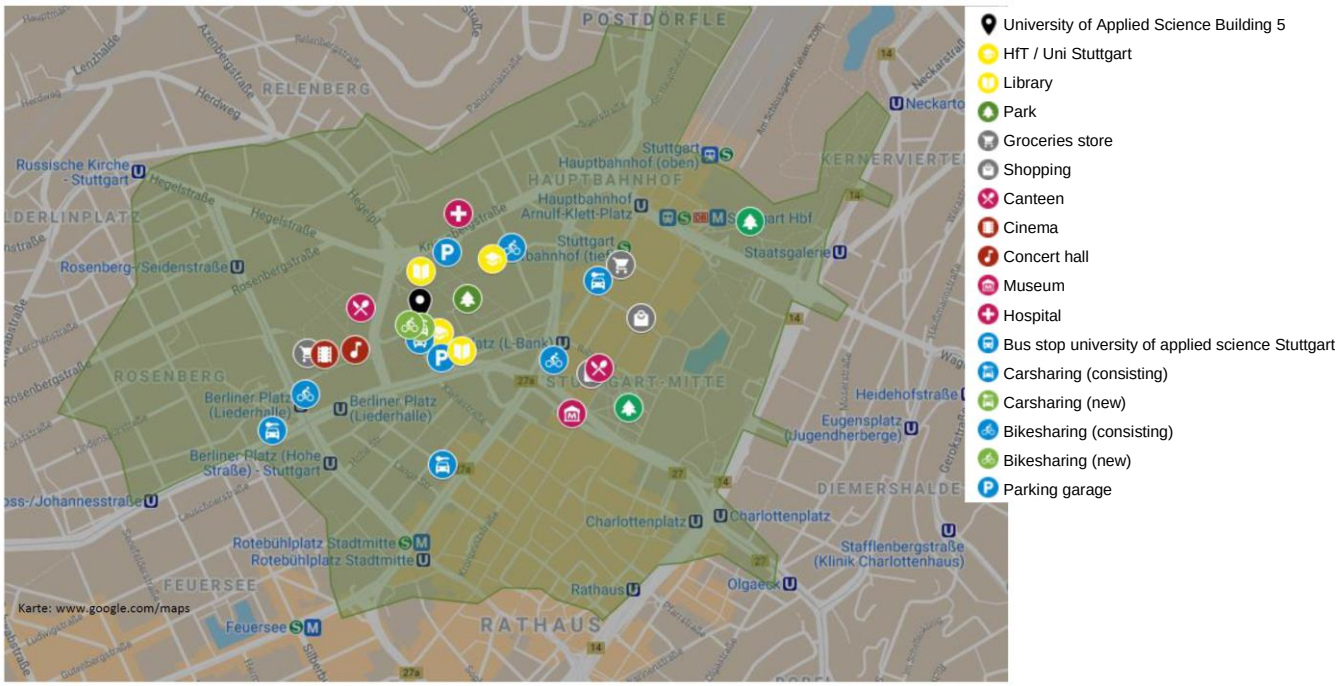


Fig. 9.57: Important spots of Stuttgart surrounding campus of University of applied science Stuttgart

9.1.2 **Public Transportations**

General conditions

The increasing electoral successes of the Greens in Baden-Württemberg reflect the broader environmental awareness in society. This was also reflected in the transport policy measures, in which public transport played a leading role. The Transport Development Concept 2030 was completed in

2013 and was intended to define the framework for future transport planning in the state capital Stuttgart (LHS).

The action plan "Sustainably mobile in Stuttgart" is named as an instrument for action of the VEK 2030. It defines measures that are to enable the implementation of sustainable mobility. The plan specifies to make public space attractive in the longer term in combination with innovative elements and thus to offer more quality of life. Two goals were defined for this:

- The number of conventionally powered vehicles in the city is to be reduced by 20 percent. Motor vehicle traffic should be avoided or shifted as far as possible.
- In order to improve the public transport offer, the framework conditions should be adapted in such a way that at-tractive alternatives to motorized private transport (MIV) can be offered. (Aktionsplan „Nachhaltig mobil“, 2020)

Status analysis of the campus location

For students on campus, there are already numerous public transport options in the immediate vicinity. The “Berliner Platz” and “Börsenplatz” tram stops and the “Katharinenhospital” and “Linden-Museum” bus stops are only a five-minute walk away. The S-Bahn connection is about a ten-minute walk to the stops at main Station and city center.

When analyzing the needs for student housing, the route to the university institution is decisive. The locations of the University of Applied Sciences, the Baden-Württemberg Cooperative State University and the university in the city center are within a ten-minute walk. The campuses of the university in Vaihingen and the University of Applied Sciences of Media are a maximum of 20 minutes away, and the University of Applied Sciences of pedagogy in Ludwigsburg is less than 30 minutes away by train. The most important stops are shown in figure 6.

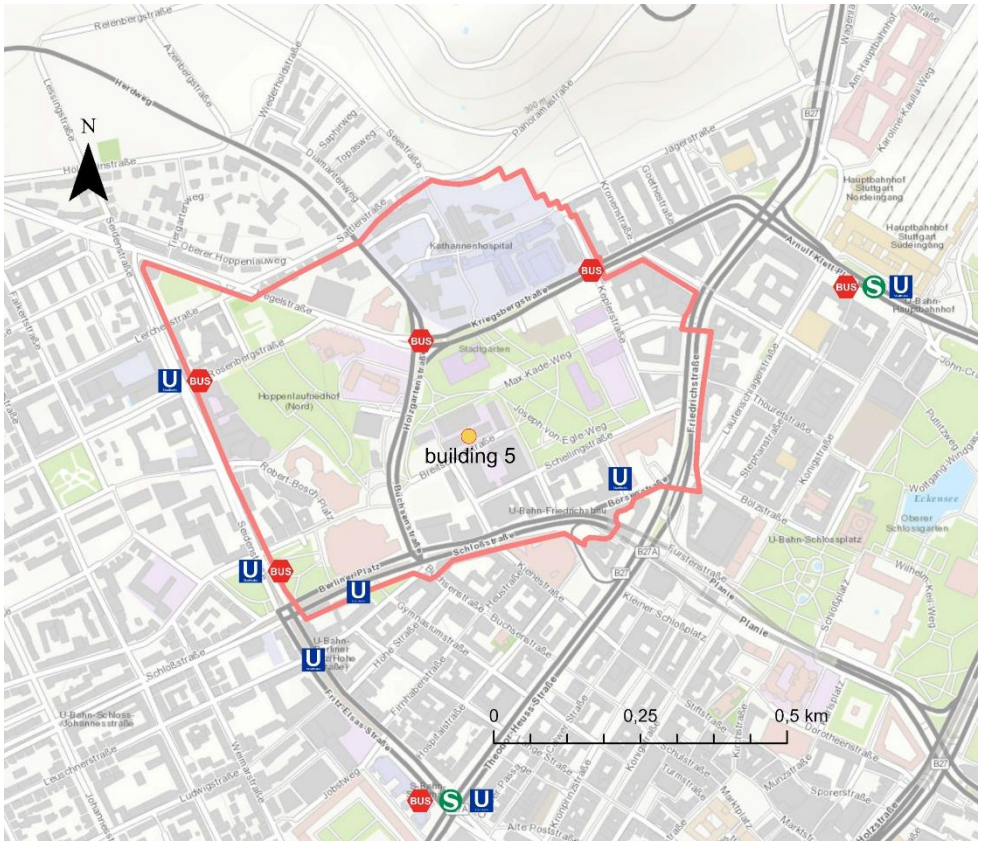


Fig. 9.58: Public transportations at the campus

9.1.3 **Bicycles**

Stuttgart offers a special feature for cyclists due to its topographical location. The city centre lies in a "basin". This means that altitude differences of more than 200 m are possible within a radius of a few kilometres. Depending on the destination and direction of travel, Stuttgart does not offer an optimal route for every cyclist. An e-bike or pedelec therefore has a special potential to encourage more people to cycle in Stuttgart. The electric assistance makes it easier for every cyclist to overcome the differences in altitude in the Stuttgart city area.

In the neighbourhood around the Campus in the city centre, bicycle lanes are only partially separated from the vehicle lanes. However, the side streets in the neighbourhood are suitable for bicycle traffic due to their low motor vehicle traffic. In the garden of the city, which forms the centre of the neighbourhood, the asphalted paths are also a good option for cycling. On the main roads, bicycle crossings are also designated next to the pedestrian crossings.

The parking facilities for private bicycles at Building 5 of the university are currently still very limited and the existing bicycle racks serve mainly university members who do not live on campus. Therefore, bicycles are usually parked against trees or railings. However, there are no secure or monitored parking spaces for bicycles in the vicinity of the campus, such as a bicycle garage or bicycle boxes. There are a few bike-sharing stations in the vicinity. Figure 4 shows where bikes are mainly placed by users.

Fig. 9.59: Bikestations at the campus in the city center

In the Transport Development Concept 2030 of the city of Stuttgart, the bicycle plays a major role as a means of transport. The share of cycling is currently 7% and is to be increased to 20% in the long term. To achieve this, all everyday routes are to be made accessible and all city districts are to be connected to the cycle network. In addition, the range of sharing systems will be expanded. The city of Stuttgart plans to invest 125 million euros by 2030 to implement this plan. (Landeshauptstadt Stuttgart, 2013)

9.1.4 **Cars**

When dealing with the motor vehicle aspect, in contrast to the other transport groups, a reduction of individual transport with combustion engines is the goal, in compliance with the sustainability concept.

Various concepts and implementations have already been developed in the past regarding this topic. One of the biggest problems here was the air pollution caused by fine dust and other air pollutant emissions, which are also caused by the flowing traffic. (Stadtklima Stuttgart, 2020) As a result, a reduction of conventionally driven car traffic by 20 percent was decided in the Transport Development Concept 2023. (Nachhaltig mobil in Stuttgart, 2017)

This is to be achieved, among other things, by implementing a parking concept in which parking for non-residents is to be made chargeable in most parts of the city. (Parkraumkonzept Stuttgart, 2020) In addition, a reduction in commuter traffic is being worked towards by means of various carpooling programmes. The potential here lies in the often-coinciding times and destinations of the journeys. (Fahrgemeinschaften für Pendler und Reisende, 2020)

A special feature of the concept is the introduction of an integrated traffic control centre. The Office of Public Works, the police, the Civil Engineering Office and the Stuttgarter Straßenbahn AG work together in this centre. The control centre provides a faster and more uncomplicated flow of information, which makes it possible to react better to road traffic incidents. (Integrierte Verkehrsleitzentrale, 2020)

Because the campus is located in the center of the city like shown in figure 5, it can be handled like the whole city center. The blue lines are showing the main roads.

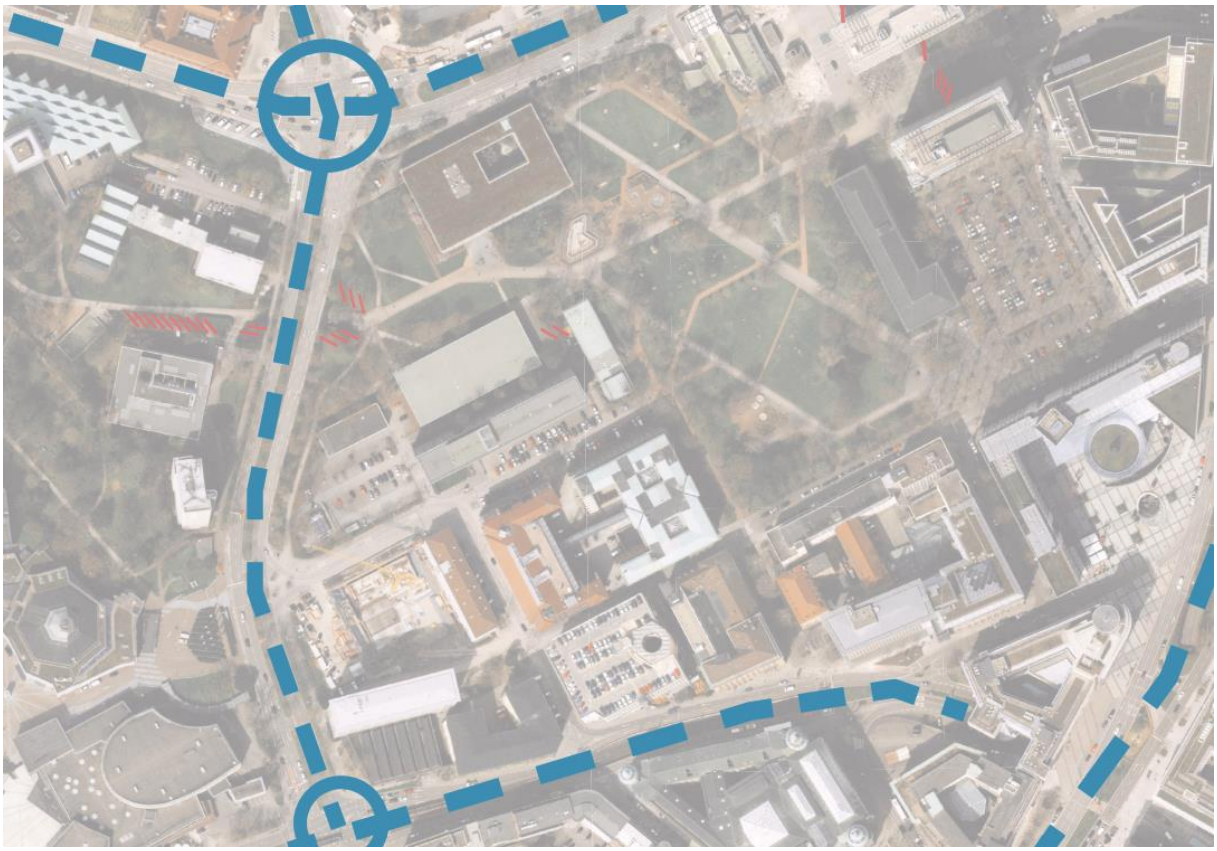


Fig. 9.60: Main streets at the campus

9.1.5 Mobility impaired

Mobility does not only include the different means of transport, but also those who are restricted in this area. This would be the mobility impaired. The group of the mobility-impaired includes not only the physically impaired, but also persons with a mental or temporary disability, which results in a person being restricted in their locomotion. A distinction is made between five subgroups based on the cause of the limitation: physical, age-related, temporary, mental or psychological. For these persons it is very important to pay attention to kerb heights, stairs and other obstacles, as many of the restricted persons cannot get over the mentioned hurdles on their own. These hurdles must be kept as low as possible and adapted to these persons.

In the Stuttgart Region, measures have been implemented for several years to make it easier for people with reduced mobility to get around in everyday life and to provide access to cultural facilities and leisure activities. An example of this is the 2018/2019 budget of the city of Stuttgart, which includes an additional 5.9 million euros for inclusion, which also includes accessibility. In addition, existing bus stops are being converted to be barrier-free through a special program of the Stuttgart Civil Engineering Office. The focus here is on the stops along the 40 bus lines, which form the stops of the city center lines and the direct connection to the main railway station. The “Verkehrsverbund Stuttgart (VVS)” offers its users the possibility of a barrier-free connection search. In addition, plans of barrier-free access to individual stops and a live overview of current lift malfunctions can be accessed online. Since 2020, the city of Stuttgart has offered an online city guide for people with reduced mobility, which lists shopping facilities, restaurants and other facilities needed in everyday life with details on the respective accessibility. For each property, information is provided on available lifts, guidance systems for the blind, door widths, step heights and toilet facilities.

9.2 Survey of Mobility

To get a picture about the behave of mobility of students, there was conducted a survey with students living in students’ dorms in the inner city of Stuttgart. The survey mainly included questions about their choice of means of transport and habits in mobility behavior. Furthermore, general questions such as age, gender, place of residence, etc. were developed. For the publication, we first determined the student residences that we were interested in. By selecting these, we determined our project area, which we defined as a radius of three kilometers from the HfT building five. These can be seen in the following figure 1.

Dormitory	Km	Beds
Max Kade	0,2	125
Wohnheim der Freunde	1,0	82
Wiederholdstraße	1,5	148
Birkenwald	1,6	55
Landhausstraße	2,0	49
Kernstraße	2,0	45
Alexanderstraße	2,1	76
Rosenheimstraße	2,3	346
Heilmannstraße	2,3	568
Rieckestraße	2,7	120
Sum		**1614**

Fig. 9.61: List of the dormitories surveyed

Fig. 9.62: Survey notice

Due to the restrictions that prevailed at that time because of the current COVID 19 situation, it was not possible to interview the test persons in person. We therefore decided to conduct a purely online survey, which was distributed via email distribution lists and notices, see Figure 2, with the corresponding QR code.

The first questions of the survey were related to the general information of the respondents. It should be noted here that the information on gender was relatively balanced. This implies that a good mix of the population was covered. The age groups identified reflect the intended target group of active students, with 20 per cent between 18 and 21 years and 80 per cent between 21 and 30 years. Thus, it can be said that the data collected comes from an acceptably representative target group cross-section.

9.2.1 **Pedestrians**

For almost all respondents, it is possible to walk the existing route. Possible reasons for the opposite would be, for example, mobility-impaired groups of people, such as wheelchair users or people with a visual impairment. When looking at the frequency distribution of the means of transport used, walking is either the most frequent or the second most frequent means of transport used in everyday life for 75 percent of the respondents. This is far ahead of the underground/light rail, the bus and the bicycle. Other means of transport, such as the normal car or the motorbike, perform relatively poorly, as the location of the survey relates to Stuttgart Mitte and means of transport with less effort (such as finding a parking space as an enormous expense) are preferred.

Most of the way chains from the dormitory are:

1. to the college/university
2. to work
3. to the grocery store
4. to leisure activities.

Here, 2/3 of the respondents indicated walking as their means of transport. Here, too, the central location, Stuttgart Mitte, is decisive for the clear result, as all localities are in the immediate vicinity. When it comes to alternative means of transport, such as e-scooters, hoverboards or Segways, which are supposed to replace pedestrian traffic, the costs involved are the main reason. Only half of the respondents would pay a separate contribution to be able to use an additional in-house sharing service. More than half would even prefer walking to the alternative means of transport mentioned. Additional offers, such as the shopping assistance Cargo-Robot-Waldi, would also not be used by 30% of the respondents. The remaining respondents would first test this offer before agreeing to regular use. In most cases, due to the central location of the Stuttgart Mitte campus, pedestrian transport is preferred by almost all respondents. Even if other means of transport are faster, there are a few respondents who would still walk. Approximately 80% make it dependent on the respective situation and the time difference. Here, even with a time saving of 10 minutes, half of the respondents would walk.

Barriers for pedestrians

Around the campus there are a few barriers for people walking. Thereby streets are the most frequent resistance even though there are traffic lights. In picture 11 it’s shown that the roads are surrounding the whole campus, some of them are even big roads with 4 lanes. They have to be passed to reach the main station, city center or even the cafeteria.

But the most impairing roads are the ones that have been tagged red in the picture. Especially road 1 is cutting the campus in 2 pieces. So in front of building 5 there would be a great capability for free space with very high quality if there wasn't that big road.

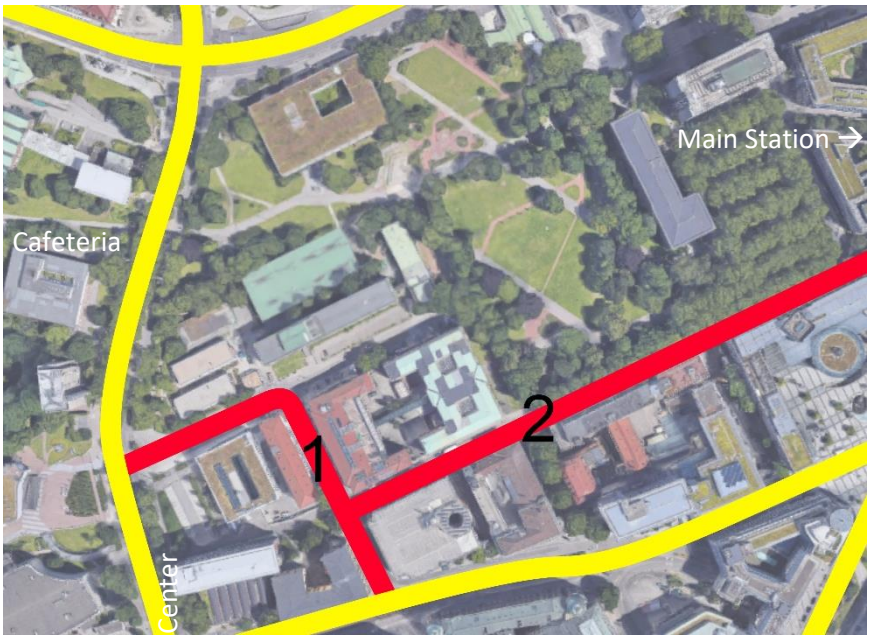


Figure 9.63: Map of campus with roads

9.2.2 Local public transportations

Results of the survey

To find out what potential exists for a mobility concept in public transportations, the final part of the survey dealt with questions about public transport.

According to the survey, most respondents use public transport either daily or once or twice a week. Both answer options were chosen by a quarter of the participants and thus most frequently. Overall, almost 80% of the students stated that they use public transport at least once a week.

The frequency of using public transport depends on several factors. The second question showed that the decisive factor was the level of costs. This was chosen by 82%. This was followed by the factor punctuality with 68%, and reliability and journey time with 61% each. Only about half of the participants considered the flexibility factor to be decisive.

Since the campus in the center of the city does not yet have its own bus stop, the question was asked whether the introduction of such a bus stop would make sense from the students' point of view. The possible answers ranged from 1 "not useful" to 5 "very good and useful". The numbers 4 and 5 were chosen by far the most frequently by the respondents, which can be interpreted as a very positive attitude towards the introduction of a "Student Stop".

The final question dealt with the willingness to use the SSB-Flex service. The shuttle buses serve as a supplement to the public transport network as a demand-oriented alternative. 13 students would use the service to get from their hall of residence to the city, while 14 students would not. With a share of 48% of the answers for "yes" and 52% of the answers for "no", one can speak of a very balanced opinion.

9.2.3 **Bicycles**

The bicycle is one of the three most important methods of transport for the residents of Stuttgart's inner city residential homes. About half of the residents currently use their own bicycle. Around 14 % of the residents are registered with a bike-sharing service. Overall, 40 % of the people surveyed use a bicycle, pedelec or e-bike daily.

If a station of a bike-sharing system were in the immediate vicinity of the residence, the use of this service could replace the use of their own bike by 41% of the residents.

The 36 residents surveyed have various means of transport at their disposal. Almost 53% of the respondents have their own bicycle. Around 14% are registered with the Regiorad bike-sharing service. A similar result was also achieved in a more general survey on the topic of mobility via the Instagram page of the HFT Collab. There, 11 % of the respondents said they used bikesharing.

Almost two-thirds of the residents would be willing to pay a contribution to have access to different and jointly usable vehicles (bicycle, cargo bike, etc.). A maximum of 10 residents of a hall of residence would share one vehicle each. If sharing services were available, their use could replace the use of a personal bicycle for 41%.

Barriers for pedestrians

Like shown above in picture 9.11 big roads are cutting through the city that can not be passed that easily. This also counts on the use of bicycles. In the whole city of Stuttgart it is quite hard to ride a bike like it was determined by a survey of the ADFC, the common German bicycle club[8]. What makes it hard to ride a bike nearby the campus is that there are no extra lanes for bikes and the possibilities to park the bike are very bad as well.

But like mentioned before there would be the will to use the bike if there where better conditions.

9.2.4 **Cars**

The basic approach is to shift trips from private to sharing vehicles. Because 39 percent own their own car or 79 percent have access to it, there is great potential for sharing. This is also reflected in the frequency of weekly use.

If we look at the evaluation of the sharing systems, the use of the offers is low to complete. This is true for all reasons for travelling, only for leisure activities 18 percent use sharing systems. The survey revealed a desired flexibility and reliability in leisure, work and supply trips. According to the respondents, this is currently often only possible by private car. In this context, 43 percent gave the reason of insufficient availability and 39 percent the too high costs of the sharing offer. The planned concept provides for an in-house fleet of vehicles, which will provide the residents of the hall of residence with reliable and flexible means of transport, including electrically powered cars.

The above-mentioned reasons are minimized by the concept, which provides for financing and stationing close to the location. 64 per cent are prepared to pay a monthly contribution to be able to use them.

[8]https://fahrradklima-test.adfc.de/fileadmin/BV/FKT/Download-Material/Ergebnisse_2020/Rankingliste_FKT_2020.pdf

9.3 Conception

To develop a well-founded concept of mobility, there where elicited 4 different mobility.

The distances travelled by different means of transport as well as the total energy demand and mean value (type 1 - 4) of all person types are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Description Type 1

- low semester, studies at the Campus In the city center
- Attends lectures regularly, concentrates on studies
- Does not go to work while studying, but works during the semester break
- In my free time I often go to parties or other events to get to know people.
- Uses public transportations and carsharing for activities
- Travels to parents' house at weekends (via long-distance train and own car)

Description Type 2

- Higher semester, studies at the Campus In the city center
- Does not attend all lectures or attends them regularly
- Has a part-time job/work-study job ("regularly")
- Uses public transport or a bike/car-sharing service for leisure activities
- Due to longer study time, more socially integrated/ more often on the road (leisure time) but less frequent trips home at weekends

Description Type 3

- low semester, does not study at the Campus In the city center
- attends lectures regularly, concentrates on studies
- Do not yet have a working student or part-time job
- Uses public transport or a bike-sharing service for leisure activities
- travels home every second weekend

Description Type 4

- Higher semester, does not study at the place of residence (e.g.: University of Hohenheim/PH Ludwigsburg)
- Does not attend all lectures (irregularly)
- Has a part-time job/work-study job alongside studies (regularly)
- Due to longer study time, more socially involved/frequently out and about (leisure time)
- More likely to own a car
- Less frequent trips home (own car)

9.3.1 Pedestrians

The mobility concept for pedestrian traffic was developed taking into account the general conditions and the development of pedestrian traffic in the traffic development concept of the city of Stuttgart, as well as the findings of the survey and the types of people developed.

Walking in the city center area

For short distances, walking is often the fastest way to get around. Since the newly built campus is to be located very centrally in Stuttgart's city center, many of a student's destinations are in the immediate vicinity. Many journeys are therefore made on foot. Distances are covered on foot every day, but only short distances of less than 5.00 km.

Travelling longer distances with pedestrian alternatives

To cover longer distances in the mobility concept of pedestrian traffic, we have investigated and identified different alternatives of pedestrian traffic, such as:

- E-Board
- SEGWAY
- E-Scooter
- Possibilities to facilitate luggage transport in combination with walking.

These are becoming increasingly important in our society. Quickly bridging short distances, e.g. in big cities, is becoming increasingly important. Sharing services are also very popular here.

The conclusion to be drawn from this is that there is still some room for optimization around mobility regarding pedestrians. The implementation is not always easy but should be tackled with the necessary commitment to burden our climate and our environment less than in the past years and decades.

9.3.2 Public transport

Student Stop

To increase the attractiveness of public transport for the planned hall of residence, we have envisaged two focal points for the mobility concept. The first part of the concept deals with the installation of a campus-owned bus stop, which optimizes the connection of the University to the public transport network. In Stuttgart, this network is regulated by the “Verkehrsverbund Stuttgart (VVS)”. In addition to rail transport, there are also several bus routes available. A closer connection via rail transport would be utopian from a financial point of view alone, as the city railway runs underground in this area with a high longitudinal gradient and the distance between the underground stop “Börsenplatz” and the overground stop Berliner Platz is already relatively small. The installation of a bus stop seems to make more sense here because it can be built in the immediate vicinity of the campus with less effort.

To make the new stop preferably efficient it will be placed directly on the campus between building 3 and 4, like shown on picture 11. To make the stop efficient for students the frequency will be adopted to the timetables of lecture. Table 1 shows the frequency of departures that are concentrated on the morning hours for the arrival and in the afternoon for departure of the students.

Days of the week	Frequency
Monday to Friday	07:30 to 09:00 and 15:00 to 17:00: 7-minute cycle 09:00 to 15:00 and 17:00 to 22:00: 15-minute cycle
Saturday + Sunday	No departures of student optimized bus line

Table 3: Frequency of departures (students stop)

SSB-Flex Shuttle

The Stuttgarter Straßenbahn AG (SSB) offers a shuttle bus that can be booked independently of the timetable via an smartphone application. During operating hours, the shuttle collects customers at certain points in the Stuttgart city area to take them to public transport connections or directly to certain destinations, like a taxi. Compared to a taxi, the shuttle is significantly less expensive, especially when several people book it together. By introducing the shuttle, the SSB AG intends to make the use of a taxi, Uber or private car in the inner-city area unnecessary for as many groups of people as possible, including students. The shuttle is available from Sunday to Thursday between 18:00 and 02:00 and Friday to Saturday between 18:00 and 04:00. Accordingly, this solution would primarily be effective for the purpose of evening leisure activities.

In the survey, almost half of the respondents were in favor of the use of such an offer. Some of these participants are residents of the Max Kade dormitory, which is only a minute's walk from the HfT. Accordingly, when planning the meeting point, joint use should be envisaged to avoid car traffic and thus save resources. This also transfers to the concept of sharing models.

Regarding the frequency of departures, the offer of SSB-Flex serves a much more variability than conventional public transportations.

9.3.3 Bicycle

The mobility concept for cycling was developed considering the general conditions and developments in cycling in the transport development concept of the city of Stuttgart, as well as the findings of the survey and the types of people developed.

Parking facilities for private bicycles

Many residents use their own bicycles in everyday life. To enable safe parking of private bicycles in front of the hall of residence, sufficient parking spaces must be provided. This can be made possible by a covered and access-restricted area (e.g. fencing with lockable gate).

Restricted access not only provides security against theft and vandalism, but also ensures sufficient capacity during university opening hours. Due to the immediate proximity to the city center campus, there is a risk that publicly accessible parking facilities could be used by other university members during lecture hours, leaving no capacity for residents.

The Administrative Regulation on the Creation of Necessary Parking Spaces (VwV) of the Baden-Württemberg Ministry of Economics stipulates one parking space for every two places in student halls of residence. This number was also found in the survey among residents of student halls of residence near campus (53% use their own bicycles).

Shared use of e-bikes and cargo bikes

According to the survey among residents of student halls of residence near campus, the provision of cargo bikes and e-bikes would meet with interest among just under 40% of residents.

The bikes can also be parked in the access-restricted and covered area. Management of the batteries (charging and lending) can be realized via the emerging mobility hub. A reservation is required for the use of a cargo bike or e-bike. The batteries can be removed accordingly by pin or key chip.

Loading of electric bikes

Another very important part of the mobility concept is the creation of multifunctional furniture for outside, that complies different tasks such as offering space to chill out but also to load electric devices. For example, there can be filled up the batteries of e-bikes. By offering such a place, the barrier of using alternative kind of mobility can be decreased. In the following picture

9.3.4 Cars

Mobility concept for motor vehicles

Considering the framework conditions and the development in automobile traffic of the traffic development concept of the city of Stuttgart, as well as the findings of the survey and the types of persons developed, the mobility concept for automobile traffic was developed.

Vehicle fleet

During the planned residential units on the roof of Building 5 of the Stuttgart University of Applied Sciences, a jointly accessible vehicle fleet for the residents is planned in the concept. This will include a selection of electrically powered means of transport adapted to the number of residents, such as cars, e-bikes or e-load bikes. These are to be financed and maintained by means of subsidies from the state and a mobility contribution from the residents. Whether this is designed as a compulsory rental surcharge or as a bookable offer was not further investigated here. This is an important investigation about the financing plan, but it is beyond the scope of the project described here.

Information and transport terminal

The core idea of the vehicle fleet is an information and allocation terminal, which is physically accessible in the residence itself, but also via app and website. The reservation and allocation of the available vehicles and means of transport is regulated via this terminal. A reward system will be integrated to reward increased group travel and the pooling of activities through discounts or free kilometers, thus reducing individual journeys.

In general, however, travel options via public transport or the use of the bicycles provided in the vehicle fleet are recommended in the first instance. For this purpose, the system should also inform the users about the traffic situation and the weather, for example, in order to suggest the means of transport that are also available when there is a higher risk of traffic jams and the weather is good.

In addition, the bookings are expanded with the already common car-sharing offers. This means that necessary individual journeys can be combined with drivers from outside the building via platforms such as “Blablacar” or SSB-Flex. “Blablacar” offers are more attractive for longer journeys beyond the city area, for example home trips or excursions. For trips within the city with a shorter distance, such as trips home from friends or activity-related trips home, services such as SSB-Flex or Car2Go are more suitable.

Reduction of car traffic on campus

One of the main goals of the mobility concept is to reduce traffic of cars on the campus. Currently there is a big barrier between the buildings caused by the “Kiene-“ and “Breitscheidstraße” which allows cars to pass in both directions with the speed of 50 km/h. There are also no limitations on the size of vehicle. For the concept it’s important to know that the road fulfils two purposes. First it is the access to the parking side next to building 5 which is dedicated to the people working on the University. Second it is an abbreviation that offers a way around the campus without traffic lights.

So, to reduce the traffic and make the campus a lot more accessible and strengthen the connections between different faculties there are two things to do. First the park sides need to be located outside the campus. Therefor the concept uses the already existing parking garage “Hofdienergarage”. So, some of the parking sides are reserved and offered to people who are working at the University. The second step has a lot bigger shift. Thereby the road itself will be made smaller and only for use in one way and with 30km/h. To make it even more safe for the students there will be a crosswalk. In the following picture it’s shown how the street will look like where it strikes that there is a lot more of free space beside the road.

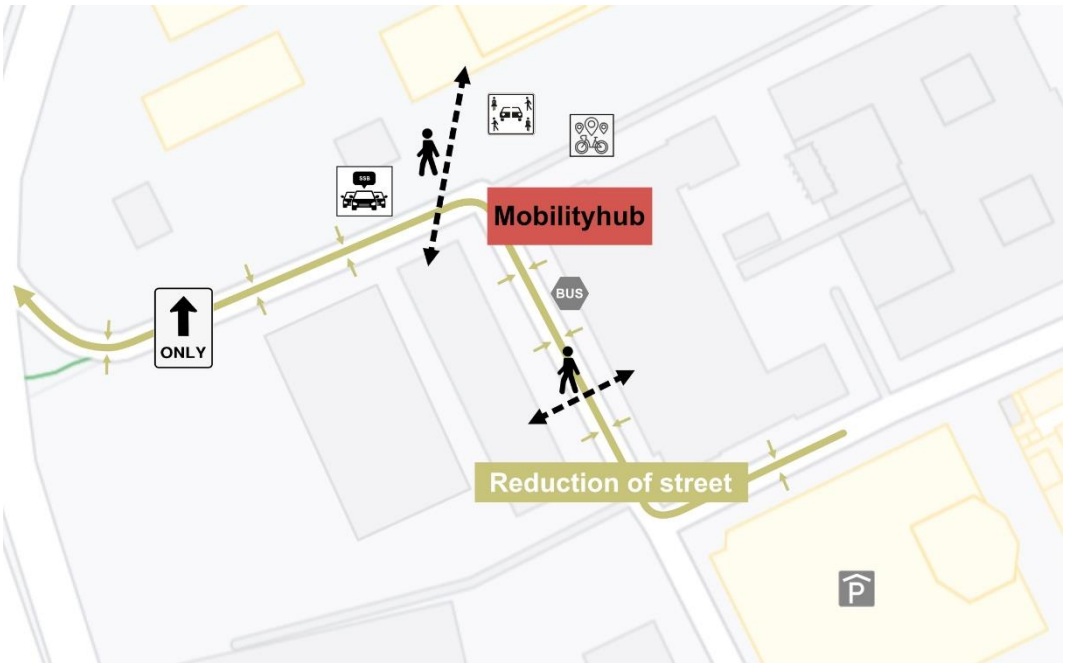


Figure 9.64: Mobility Concept of campus

In the end all roads in the district should be reduced for car traffic, especially seeing that the district is in the city centre. This can be realised like shown in the following figure.

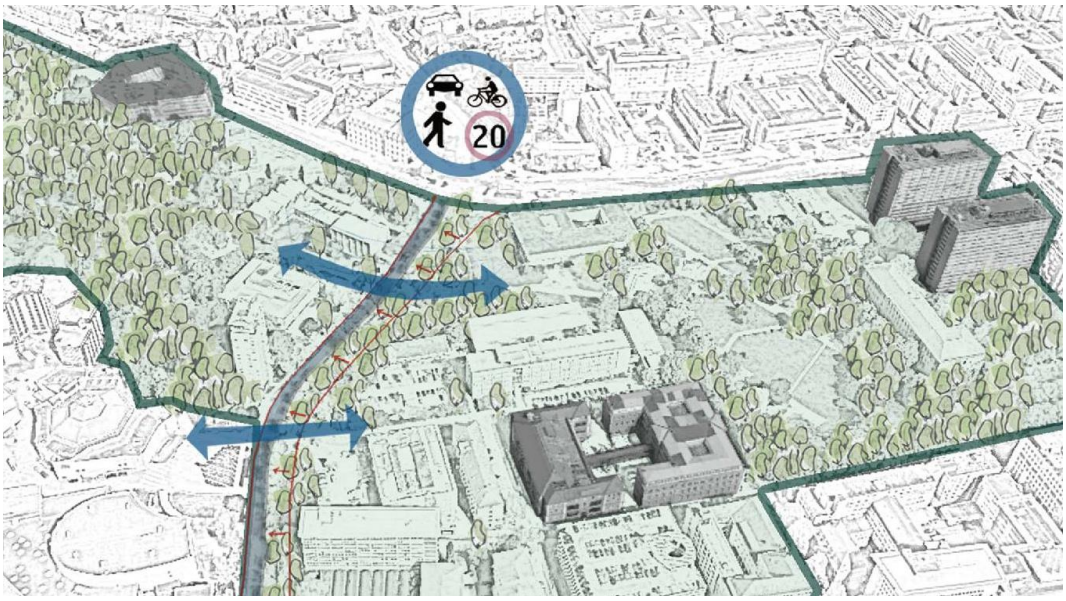


Figure 9.65: Mobility Concept around campus

So, by using those push-factors, people with cars are a lot more comfortable to use the roads next to the campus that are not crossing it. The main vehicles on the road through the campus will be the bus stopping at the bus stop of the University and vehicles like garbage disposal or street-cleaning. The vision for the future is, that the road is only assessable for adjacent owners like the students living in the new student's dorm, public transportations and public infrastructures.

9.3.5 **Persons with reduced mobility**

To improve the mobility of people with disabilities and make it more attractive, the buildings, pathways and public transport stops used by students on campus and in the vicinity of campus were assessed and evaluated according to their barrier-free access and crossability. The results showed that

approximately 80% of the buildings on campus are barrier-free and 65% of them are of sufficiently good quality. Only two out of a total of 14 buildings are not accessible for the mobility impaired. There is still a need for action here to increase the attractiveness for people with limited mobility. One idea would be to equip all necessary doors with an electronic opening mechanism. The following three crossings were considered: 1. Holzgartenstraße, 2. Breitscheidstraße, 3. Schellingstraße. These are all within the prescribed regulations of barrier-free crossings with a kerb of 3cm, but nevertheless wheelchair users and the like still encounter an obstacle when crossing. We have noticed the following points at the crossings that contribute to a better and safer crossing. Crossing 1: By lowering the kerbs to street level in the crossing area, installing floor indicators and an audio system for the visually impaired, the crossing would be easier to pass for the mobility impaired. Crossing 2: The quality of the connection to Bau 5 for the mobility-impaired could be improved by an appropriate extension of the footpath, the lowering of the kerbs and the use of floor indicators. Crossing 3: By lowering the kerbs and providing a level route to the courtyard service garage, installing floor indicators and reducing the amount of stationary traffic in the crossing area, the street space can be made more accessible and safer for people with reduced mobility.

Now to the public transport stops. The entire public transport infrastructure, as well as that around the campus, is barrier-free, so no adaptation is necessary. Stationary traffic has also been assessed near the planned residential units. Parking spaces on the streets and in the courtyard service garage, are all barrier-free accessible, but these are not suitable as permanent parking space for the planned residential units due to the ownership and road space conditions. Consequently, a partial use of the courtyard servants' garage would be appropriate, allowing for sufficient disabled parking spaces. In addition, the construction of disabled parking spaces directly in front of the residential units would be of great advantage.

9.3.6 **Mobility Hub on campus**

What the mobility hub can provide

An initial component of the new mobility concept is the improved connection of the HfT Stuttgart to the local public transport network by means of a campus bus stop. This student stop will be positioned to the west of Building 3 on the adjacent Kienestraße and designed according to Figure 90 b) of RASt 06. The existing parking spaces at the edge of the road on Kienestraße will be omitted.

To improve the mobility concept at the HfT, a so-called "Mobility Hub" is to be created between buildings 1, 3 and 5 of the HfT. This will connect various transport options and thus significantly improve the mobility of the residents of the new student residence. The main focus is on the use of sharing offers and the use of e-vehicles.

An initial component of the new mobility concept is the improved connection of the HfT Stuttgart to the local public transport network by means of a campus bus stop. This student stop will be positioned to the west of Building 3 on the adjacent Kienestraße and designed according to Figure 90 b) of RASt 06. The existing parking spaces at the edge of the road on Kienestraße will be omitted.

Another component of the "Mobility Hub" is the use of bicycles as an important means of transport. For this reason, parking facilities are to be provided for residents' private bicycles as well as sharing facilities for e-bikes and cargo bikes. According to Annex 2 of the VwV Parking Spaces, 20 parking spaces are required for the residents' private bicycles. Additionally there is some more space for 2 cargo bikes

The last component of the traffic concept will be a sharing service for e-cars which consist of two e-cars. For the residents there are two more short term spaces offered. Because of the destruction of the parking lots between the buildings on the campus there is a lot more free space available now. Like shown in picture 11 it will be used to improve the urban climate by creating green space with plants that are evaporating water.

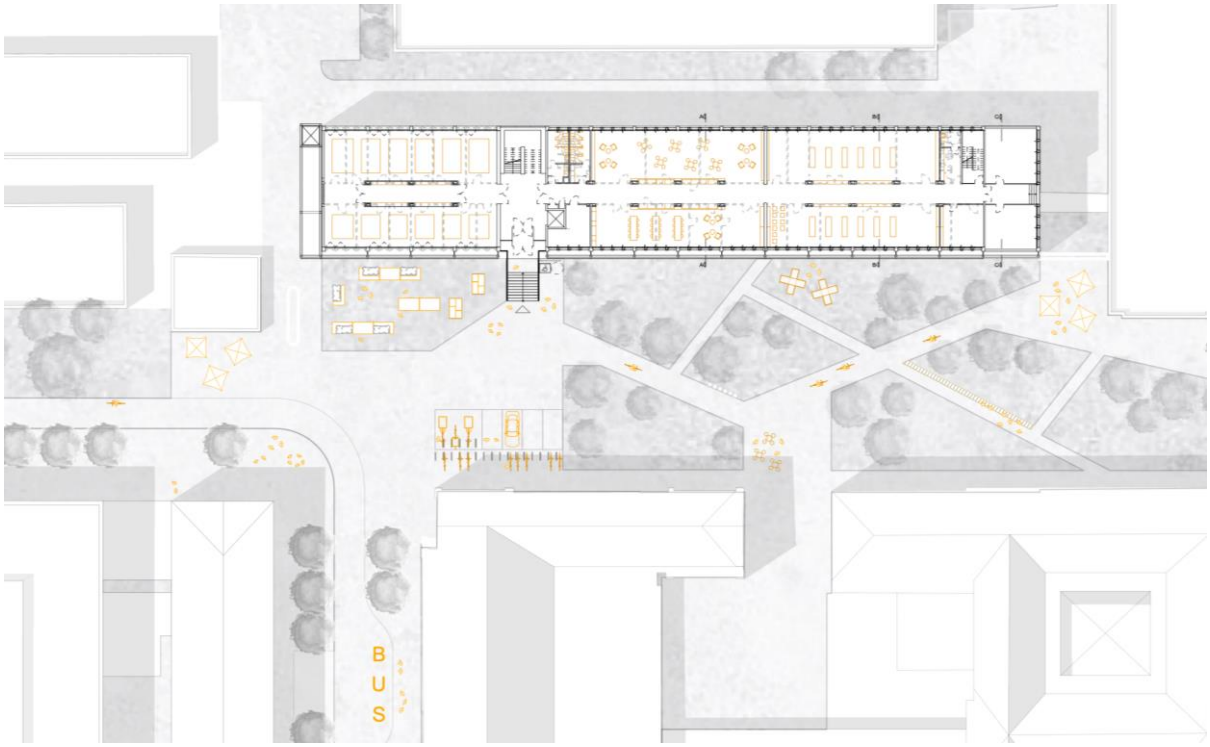


Figure 9.66: Mobility concept at the campus

Smart multifunctional outdoor furniture (SMOF)

The most important move is to create a very high liveability in front of building 5. This can be reached by removing the parking sides and creating free space. But to grade it up there has to be something unique that makes people stay at the place. Therefor we developed the Smart multifunctional outdoor furniture briefly called SMOF and shown in picture 12.

Figure 9.67: Smart multifunctional furniture

Following the final furniture will be described, even if the one shown in the picture is only a prototype.

The furniture is made of different modules so it can be adopted to any situation where it is need. Like you can see on the picture it provides lots of space to linger and chill out after a hard day for example. Because places where you can sit down or hang out pulls people it makes every place a lot more attractive. But the real benefit is the multifunctionality which even gives it the name.

The multifunctionality is founded in the following functions. First it provides the opportunity to load small electric vehicles like pedelecs and e-bikes. Second there is also the possibility to charge other electric devices like smartphones, tablets or ebooks. To make it sustainable and working as a single standing tool there is a solar power cell plus a batterie included in the charging module. The third function of the furniture is plantation, integrated in another module. This supports the surrounding by improving the air quality.

An important point of the furniture is that it can easily be made of recycling material. A construction manual is attached in the appendix (*this will be included in the final version of the mobility report, it's not finished yet).* Additionally, to that the furniture also is not a big technical innovation but it combines many solutions for nowadays challenges and gives a reason to stay at the place in front of the projects building. Therefor it will be placed at a few different places on the campus, shown in the following map.

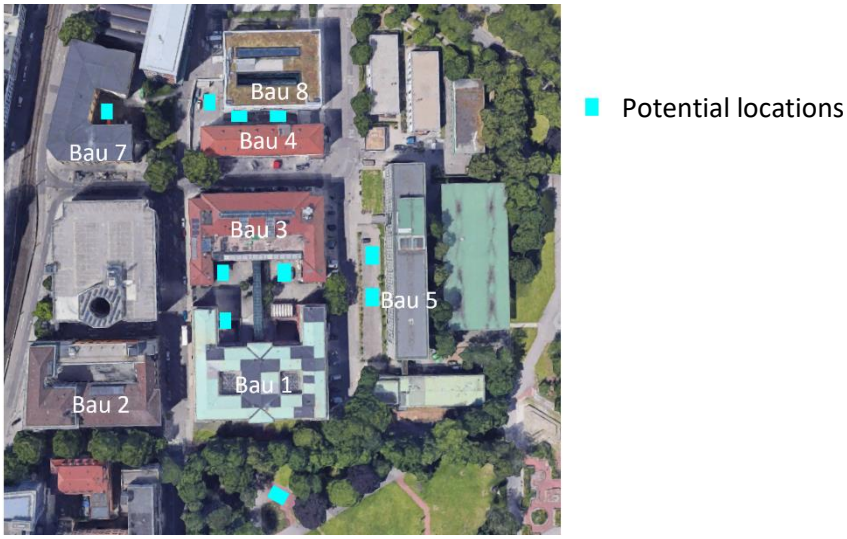


Figure 9.68: Locations of SMOF

So as a conclusion you can say that by the mobility hub we can expect an increase of multimodal transport of the resident students. This means that instead of parking spaces there is a lot of free space with many possibilities to use sharing offers like bikes, pedelecs, cargo bikes, bikes with trailers or cars. Especially the smart multifunctional outdoor furniture make people stay and simplify the use of own pedelecs to go to University a lot. This helps to accomplish the turnaround of the inner-city type of transportation.

9.4 Demand of Energy by Mobility

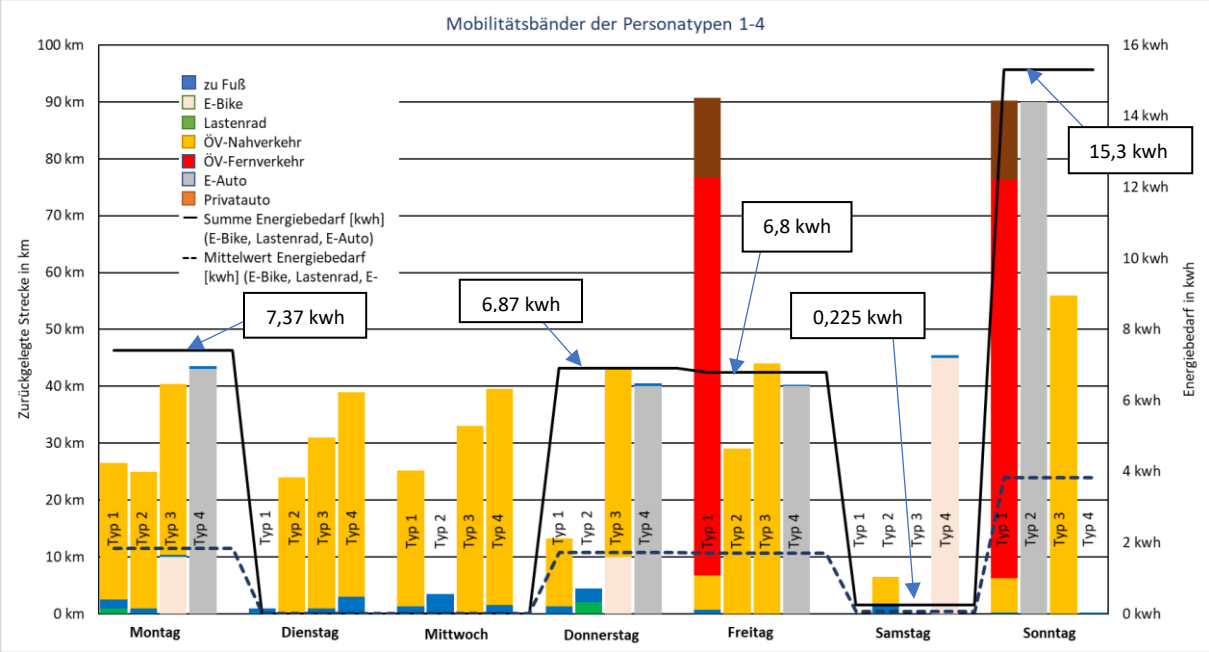


Fig. 9.17: Distances travelled and energy demand

One task was to calculate the energy demand of the respective electrically powered means of transport used by the students living in the additional storey in a typical week. These were then used to create an energy balance so that charging times could be determined. In this regard, the first step was to take the existing electricity demand and yield from a calculated typical week for the planned flats on Building 5. Then it was calculated when the yield is higher than the demand to be able to limit the range from which charging can take place. The electric means of transport and the distance they travelled were taken from the daily bands created from the person types to calculate the energy demand from the consumption of the means of transport. The resulting consumption per day of the week is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Verbrauch in Wh							
Verbrauch insg.	Mo	Di	Mi	Do	Fr	Sa	So
E-Bike	50Wh			50Wh		225Wh	
Lastenrad	10Wh			20Wh			
E-Auto	7310 Wh			6800Wh	6800Wh		15300 Wh
	7370 Wh			6870 Wh	6800 Wh	225 Wh	15300 Wh

Table 1: Demand of Energy

Fehler! Verweisquelle konnte nicht gefunden werden. above shows all four types of persons and the seven means of transport with the respective distances travelled per weekday. The black line shows the total energy demand of all person types and all electric means of transport per weekday. The values for the diagram were taken from the calculation of consumption in the table above. The diagram shows that consumption is about the same on three days of the week, but on Sunday consumption skyrockets. On Tuesday and Wednesday, however, there is no consumption. As a result of the consumption, charging time points were determined in which charging is possible due to the positive energy balance in the flats.

Ladezeitpunkt							
	Mo	Di	Mi	Do	Fr	Sa	So
E-Bike							8:00 (ca.3,0 Stunden)
Lastenrad				17:30 (ca. 30Min)			
E-Auto	15:00 (ca.70Min)				14:30 (ca. 45Min)		

Table 2: Loading electric vehicles

The resulting possible charging times are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. The charging times are not always directly after use, as these are either not necessary or not possible as the energy balance is no longer in the positive range.

This kind of energy management will be an important way in the future when most of our energy comes from inconsistent renewables and must be saved and used at specific times. So thereby the project goes a new way where many consumers and producers become prosumers. This means that everybody can save and hand on energy to the grid, whereby the curve of energy demand can be flatted and fluctuations avoided.

9.5 Part of the mobility Concept shown on HDU

The main factor of the mobility concept is a mobility hub in the centre of the campus where different kind of mobility are used. One of them are pedelecs and e-bikes that must be loaded electrically. In section 3.6. the concept shows a smart multifunctional outdoor furniture (SMOF) that provides space to linger but also the possibility to load electric devices like pedelecs and e-bikes and even smartphones etc. To show this at the HDU one module of this furniture is placed on the solar campus. In picture 13 the position of the furniture is shown just as the position of Information terminals which will be placed to show the concept in general. So, the furniture can already be experienced in its actual function while wating to enter the demonstration Unit of the team coLLab.

Additionally there will be the possibility for the visitors of the SDE21 to have a look on a website that shows the mobility concept. The website will easily be reachable by instructions at the smart furniture and barrier free for smartphones.

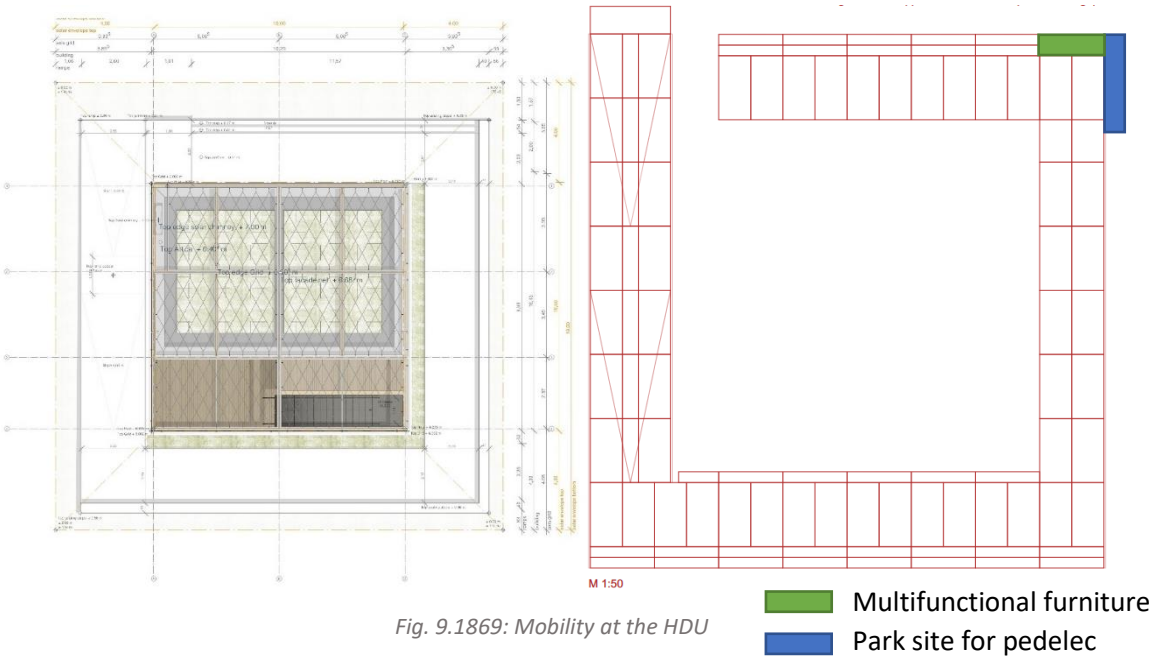


Fig. 9.1869: Mobility at the HDU

To make the mobility more visible there will a pedelec be placed at the furniture combined with a bike-trailer. In figure 17 its shown where the furniture will be placed and where the bike will be. This will also be the vehicle to go for shopping for the cooking challenge.

At the HDU the bike will be placed at a bike stand, next to the multifunctional furniture.

The reason for the decision against a cargo bike was mostly the flexibility. By using a bike-trailer, the pedelec can also be used solitary. On the HDU the options should be shown to the visitors to diversify the kind of mobility. Additionally, the trailer will be foldable like shown in the pictures below.

Fig. 9.1970: Bike-trailer

Additionally, the mobility concept will be shown in the HDU at the exhibition designed by the interior designers. There the information will be described for all visitors in an easy understandable way.

10 DINNER PARTY MENU

coLlab

For the dinner party we will serve a vegan three courses menu. By offering a vegan dinner, many incompatibilities are eliminated, and different lifestyles are united. The goal is to prepare a classic Swabian menu in a vegan alternative. The dinner party consists of 3 courses, appetizer, main course and dessert.

Drinks

To drink, there is water with additives such as lemon, lime, and mint. Apple juice from the Stuttgart region is also served. Moreover, the main course is accompanied by a white wine, which is very traditional in southern Germany.

Fig. 10.1 Example of lamb's lettuce (source: private)

Fig. 10.2 Example of water with flavor (source: private)

Appetizer: Lamb's lettuce

The appetizer will be a light summer lamb's lettuce salad with Alb lentils. Lamb's lettuce is grown mainly in southern Germany and Alb lentils come from the Swabian Alb.

Integrands:

- 400 g Alb Lentils
- 300 g Tomato
- 8 Radish
- 2 Pepper
- 300 g Lamb's lettuce
- 8 Shallots
- 8 Garlic
- 8 tbsp. Mustard
- 16 tbsp. Vinegar
- 10 tbsp. Oil
- Salt and pepper
- Thyme
- Vegetable broth

Preparation

Boil lentils in light vegetable broth for approx. 30 min. and taste whether they are cooked. When cooking, the lentils should be initially covered with broth.

While they are cooking, prepare the salad. To do this, cut tomatoes, radishes, peppers of your choice into small bite-sized pieces or strips. Finely dice the garlic and shallot.

When the liquid has almost boiled away from the lentils towards the end of cooking (there should be some left over for the sauce, otherwise add a little hot water), add the mustard, vinegar and oil. Season heartily with salt and pepper. Mix in thyme and allow to infuse if possible.

Mix with the salad with 2 tbsp. Oil and serve.

Main course: vegan onion tart

Onion cake is a savory cake named after its main topping, onions. The cake is well known in southern Germany, eastern Germany, Switzerland and Alsace. For the onion tart, the recipe is local, the ingredients are not particularly attributable to the Swabian region. Integrands:

Dough:

- 300 g flour
- 1 tsp. salt
- 6 g dry yeast
- 1 Pinch of sugar
- 170 ml water

Topping:

- 700 g onions
- 3 tsp. soy flour
- 6 tsp. water
- 200 g smoked tofu
- 1 tbsp plant oil
- 200 ml vegan cream
- salt
- pepper
- nutmeg
- margarine

Preparation

Mix the yeast, salt, flour and sugar, then add the water and knead into a smooth dough. Cover the dough and let it rise in a warm place for 30 minutes.

In the meantime, peel the onions and cut into rings. Mix the soy flour with the water. Dice the smoked tofu very small and fry in the vegetable oil. Remove from the pan, then fry the onions in the pan until translucent. Pour in the soy cooking cream and the stirred soy flour and allow to thicken. Add the smoked tofu and season with salt, pepper, and nutmeg.

Preheat the oven to 180°C, grease the springform pan (26 cm) with margarine. Roll out the risen dough on a floured work surface, then place in the springform tin and line the base and sides (approx. ¼ high) with it. Spread the tofu and onion mixture on top and bake for approx. 35 minutes.

Fig. 10.3 Example of Onion tart (source: private)

Fig. 10.4 Example of rhubarb crumble (source: private)

Dessert: “Rhubarb crumble”

While eating the main dish, the dessert is baked in the oven. For dessert, a rhubarb crumble is prepared. The rhubarb is available worldwide. Its harvest is at the time of the SolarDecathlon and therefore was chosen as a dessert.

Integrands:

- 1200 g Rhubarb
- 240 g flour
- 240 g tender oatmeal
- 280 ml baking oil
- 200 g sugar
- 20 g vanilla sugar
- 2 pinch of salt
- vegan vanilla ice cream

Preparation

Clean rhubarb stems, remove woody parts and cut into bite-sized pieces. Spread the rhubarb pieces on the bottom of the baking dish. If desired, sprinkle some sugar or a sugar alternative over the rhubarb pieces.

Make a compact dough from the remaining ingredients. Crumble the dough over the rhubarb pieces in crumbles about the size of a walnut.

Bake the crumble on the middle shelf at 200 °C top/bottom heat for about 30 minutes.

Nutritional information

	Salad	Onion tart	Crumble	**Total**	Nutrient daily portion
		(per piece)			
Energy [kcal]	142,1	219	644,4	**1.005,5**	50,3 %
Protein [g]	9	12,7	7,8	**29,5**	59,0 %
Fat [g]	1,5	7,1	37,1	**45,7**	65,3 %
Carbohydrates [g]	22	29,1	68,6	**119,7**	46,1 %
Salt [g]	0,16	2,6	0,12	**2,88**	48,0 %
Dietary fiber [g]	9,9	82	7,5	**99,4**	331,3 %

Cost

Salad:	19,60 €
Onion tart	6,50 €
Crumble	14,80 €
Drinks	15,50 €
Total	56,40 €

Energy demand

The energy consumption for the Party Dinner menu is divided into the consumption of the stove and the oven. On the stove, the lentils are cooked, and the tofu and onions are browned. This requires an energy amount of 259 Wh plus 166.5 Wh, which is 425.5 Wh. 1333 Wh is needed for the onion pie in the oven and 1333 Wh again for the crumble.

11 CONTEST WEEK TASK'S PLANNING

coLlab

In the following table, the main tasks and events are mentioned, which are to be performed, assisted or attended by the team member. It is important to note that tasks are distributed according to the respective focus of the team members, as well as the legally required working time. Since it is not yet completely clear which students will actually be present during the competition phase next year, and more students will certainly have to be acquired, this table only represents the current excerpt.

Deliverable No.	D#5
Team ID	HFT
University/ City	Stuttgart

Note: For the activities highlighted in pink, not every Team is scheduled to do the activity on that day. The exact details of which Team is responsible for which task/activity at which time will be announced at a later date. However, a person responsible for these tasks/activities should be appointed.

Activities/Roles	Responsibles Name of the Team Member 1	Name of the Team Member 2	Name of the Team Member 3	Name of the Team Member 4
11.06.2022	**Saturday**			
on site registration	All Team Members			
welcome ceremony	All Team Members			
health and safety training	All Team Members			
20.05. - 03.06.2022	**Assembly Phase**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
assembly	All Team Members			
Faculty Advisor	Jan Cremers			
Project Manager	Sebastian Baier	Annabell Gronau		
Health and Safety Team Coordinator	Albert Stöcker	Sebastian Baier	Lukas Fischer	
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
Electrical Engineer	Sigfried Baumgartner			
Structural Engineer	Steffen Feirabend			
Site Operations Coordinators	Sebastian Baier	Lukas Fischer		
contact water delivery + removal	Jonas Stave	Volkmar Bleicher	Svenja Herb	Tobias Schätzle
notify appropriate inspector	Annabell Gronau	Clarissa Werner		
contact instrumentation	Jonas Stave			
04. - 06.06.2022	**Saturday-Monday**			
contact for blower door test	Saskia Huttenlocher	Svenja Herb	Volkmar Bleicher	
07. - 09.06.2022	**Tuesday-Thursday**			
performance gap evaluation	Bianca Hettinger	Caroline Scherer		
10.06.2022	**Friday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
opening ceremony	All Team Members			
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
VIP public tours	Jan Cremers	Annabell Gronau	Sebastian Baier	
jury visits CESA	Lisa Wunn	Luisa Claus	Annika Hinterholzinger	
speed peer review	Alessia Gruber	Benjamin Huber	Konrad Löchner	Lukas Möller
11.06.2022	**Saturday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
public tours	Annika Kötzel	Annika Elsner	Katharina König	Judith Leppert
jury visits CESA	Lisa Wunn	Luisa Claus	Annika Hinterholzinger	
12.06.2022	**Sunday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
puplic tours	Annika Kötzel	Annika Elsner	Katharina König	Judith Leppert
jury visits CESA	Lisa Wunn	Luisa Claus	Annika Hinterholzinger	
award ceremony (CESA)	All Team Members			
OOC award ceremony (Mirke Choice)	All Team Members			
13.06.2022	**Monday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
privileged feed-in	Jonas Stave			
contact for sound insulation test	Sophia Agorastos	Clemens Müller		
washing	Alessia Gruber			
drying	Anne Häusle			
dish washing	Benjamin Hueber			
oven	Clarissa Werner			
cooking	Judith Rosemeier			
home electronics	Konrad löchner			
hot water draws	Lisa Wunn			
beverages delivery	Luisa Claus			

Activities/Roles	Responsibles Name of the Team Member 1	Name of the Team Member 2	Name of the Team Member 3	Name of the Team Member 4
beverages delivery	Luisa Claus			
food retrieval	Lukas Möller			
control interior & exterior lighting	Marco Dippon			
14.06.2022	**Tuesday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
demand side management	Jonas Stave	Svenja Herb		
jury visits Affordability & Viability	Konrad Löchner	Elias Schwemin	Lukas Möller	
contact for sound insulation test	Sophia Agorastos	Clemens Müller		
washing	Alessia Gruber			
drying	Anne Häusle			
dish washing	Benjamin Hueber			
oven	Clarissa Werner			
cooking	Judith Rosemeier			
home electronics	Konrad löchner			
hot water draws	Lisa Wunn			
beverages delivery	Luisa Claus			
dinner hosts	Maximilian Eisele	Annika Kötzel	Yannik Zelenka	Clarissa Werner
dinner visitors	Luisa Claus	Benjamin Hueber	Lisa Wunn	Frederik Heck
user friedliness	Robin Fuchs			
beverages delivery	Luisa Claus			
dinner shopping	Lukas Fischer	Annabell Gronau		
food retrieval	Lukas Möller			
control interior & exterior lighting	Marco Dippon			
15.06.2022	**Wednesday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
jury visits Engineering & Construction	Svenja Herb	Jonas Stave	Tobias Schätzle	Robin Fuchs
jury visits Affordability & Viability	Konrad Löchner	Elias Schwemin	Lukas Möller	
contact for sound insulation test	Sophia Agorastos	Clemens Müller		
washing	Alessia Gruber			
drying	Anne Häusle			
dish washing	Benjamin Hueber			
oven	Clarissa Werner			
cooking	Judith Rosemeier			
home electronics	Konrad löchner			
hot water draws	Lisa Wunn			
dinner hosts	Maximilian Eisele			
dinner visitors	Luisa Claus			
user friedliness	Robin Fuchs			
beverages delivery	Luisa Claus			
dinner shopping	Lukas Fischer			
food retrieval	Lukas Möller			
control interior & exterior lighting	Marco Dippon			
16.06.2022	**Thursday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
public tours	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
jury visits Engineering & Construction	Svenja Herb	Jonas Stave	Tobias Schätzle	Robin Fuchs
jury visits Sustainability	Judith Rosemeier	Sophia Agorastos	Elias Schwemin	
washing	Tizian Thum			
drying	Annika Kötzel			
dish washing	Annika Elsner			
oven	Judtih Leppert			
cooking	Katharina König			
home electronics	Frederik Heck			
hot water draws	Saskia Huttenlocher			
award ceremony (Affordability & Viability)	All Team Members			
OOC award ceremony (Social Housing)	All Team Members			
control interior & exterior lighting	Bianca Hettinger			
17.06.2022	**Friday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Yannik Zelenka
contact water delivery + removal	Jonas Stave	Svenja Herb		
jury visits Sustainability	Judith Rosemeier	Sophia Agorastos	Elias Schwemin	
dish washing	Annika Elsner			
oven	Judtih Leppert			
cooking	Katharina König			
hot water draws	Frederik Heck			
beverages delivery	Saskia Huttenlocher			
food retrieval	Lukas Möller			
award ceremony (Engineering & Construction)	All Team Members			
OOC award ceremony (Ventilation, Solar Systems)	All Team Members			
control interior & exterior lighting	Bianca Hettinger			
18.06.2022	**Saturday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Yannik Zelenka
dish washing	Annika Elsner			
oven	Judtih Leppert			
cooking	Katharina König			
hot water draws	Frederik Heck			
award ceremony (Sustainability)	All Team Members			
OOC award ceremony (Craft)	All Team Members			
control interior & exterior lighting	Bianca Hettinger			
19.06.2022	**Sunday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Yannik Zelenka
dish washing	Annika Elsner			
oven	Judtih Leppert			
cooking	Katharina König			
hot water draws	Frederik Heck			
OOC award ceremony (Timber Construction)	All Team Members			
control interior & exterior lighting	Bianca Hettinger			
20.06.2022	**Monday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
privileged feed-in	Jonas Stave			
contact for sound insulation test	Sophia Agorastos			
washing	Annabell Gronau			
drying	Lukas Fischer			
dish washing	Annika Elsner			
oven	Judtih Leppert			
cooking	Katharina König			
home electronics	Sebastian Baier			
hot water draws	Frederik Heck			
beverages delivery	Lukas Möller			
food retrieval	Benjamin Hueber			
control interior & exterior lighting	Bianca Hettinger			

Activities/Roles	Responsibles Name of the Team Member 1	Name of the Team Member 2	Name of the Team Member 3	Name of the Team Member 4
21.06.2022	**Tuesday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Robin Fuchs	Tobias Schätzle	Julia Gessner	Sophia Agorastos
demand side management	Jonas Stave	Svenja Herb		
contact for sound insulation test	Sophia Agorastos	Bianca Hettinger		
washing	Svenja Herb			
drying	Judith Rosemeier			
dish washing	Tizian Thum			
oven	Annika Kötzel			
cooking	Annika Elsner			
home electronics	Judtih Leppert			
hot water draws	Katharina König			
dinner hosts	Frederik Heck			
dinner visitors	Saskia Huttenlocher			
user friedliness	Lukas Möller			
jury visits Urban Mobility	Benjamin Hueber	Jonas Stave	Annika Kötzel	Annabell Gronau
dinner shopping	Lukas Fischer			
food retrieval	Annabell Gronau			
control interior & exterior lighting	Bianca Hettinger			
22.06.2022	**Wednesday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
public tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Annika Kötzel
jury visits Architecture	Yannika Zelenka	Clarissa Werner	Katharina König	Judtih Leppert
washing	Annabell Gronau			
drying	Frederik Heck			
dish washing	Carmen Giehl			
oven	Konrad Löchner			
cooking	Lukas Möller			
home electronics	Tobias Schätzle			
hot water draws	Tizian Thum			
jury visits Urban Mobility	Benjamin Hueber	Jonas Stave	Annika Kötzel	Annabell Gronau
award ceremony (Energy | Comfort | Functioning)	All Team Members			
OOC award ceremony (BIM)	All Team Members			
23.06.2022	**Thursday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Annika Kötzel
jury visits Architecture	Yannika Zelenka	Clarissa Werner	Katharina König	Judtih Leppert
award ceremony (Urban Mobility)	All Team Members			
OOC award ceremony (Mobility)	All Team Members			
24.06.2022	**Friday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Annika Kötzel
award ceremony (Architecture | Innovation | Final)	All Team Members			
25.06.2022	**Saturday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Annika Kötzel
OOC award ceremony (Interior Architecture)	All Team Members			
OOC award ceremony (Lighting)	All Team Members			
26.06.2022	**Sunday**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
Teams Safety Officers	Anne Häusle	Yannik Zelenka	Judith Rosemeier	Carmen Giehl
puplic tours	Lisa Wunn	Luisa Claus	Clarissa Werner	Annika Kötzel
OOC award ceremony (People's Choice)	All Team Members			
28.06. - 03.07.2022	**Disassembly Phase**			
team/organiser meeting	Sebastian Baier	Jonas Stave	Lukas Fischer	Annabell Gronau
disassembly	All Team Members			
Faculty Advisor	Jan Cremers			
Project Manager	Sebastian Baier	Annabell Gronau		
Health and Safety Team Coordinator	Albert Stöcker	Sebastian Baier	Lukas Fischer	
Teams Safety Officers	Jonas Stave	Annabell Gronau		
Electrical Engineer	Sigfried Baumgartner			
Structural Engineer	Steffen Feirabend			
Site Operations Coordinators	Sebastian Baier	Lukas Fischer		
contact water delivery + removal	Jonas Stave	Volkmar Bleicher	Svenja Herb	Tobias Schätzle
notify appropriate inspector	Annabell Gronau	Clarissa Werner		
contact instrumentation	Jonas Stave			

12 COST ESTIMATION AND PROJECT FINANCIAL SUMMARY

coLlab

12.1 Fund-raising plan

All costs associated with the planning manufacturing and construction of the Demonstration Unit are estimated to be around 1.35 Mio €. A cost estimate, based on DIN276 second level cost groups (KGR), was undertaken by students for the whole timber roof extension. The estimated costs where in turn broken down to match the demonstration unit's dimensions. We identified two major cost groups that needed to be calculated in more detail to account for various HDU specific details. The first cost group is the high-current systems (KGR 440), these include the own power supply systems (OPV modules) where the HDU planning differs from the extension's. Our student teams currently perform a variety of own works, most of which can be categorized in the cost group of exterior walls and vertical construction (KGR330), which we accounted for in the price cost proposal. Please find supportive tables in the Appendix "Cost estimation and project financial summary".

Personnel costs, transportation and accommodation during the competition period are funded by state support from the Federal Ministry of Economics and Technology (BMWi) as well as the Ministry for Rural Areas and Consumer Protection Baden Württemberg (MLR). The total support sum of about 750.000 € is sufficient to cover all the cost mentioned above.

We identified Baufritz, an innovative wood-module manufacturer, as a key sponsor early during our planning process. Baufritz is willing to construct most of the buildings shell as well as doing the finishing works and a few electrical and plumbing installations. The remaining components such as the OPV-facade or photovoltaic panels are obtained through a mix of donations in kind or bought. The remaining funds needed are made available by various donations or sponsoring partners. A few other key sponsors, who already issued their interest for a partnership with a letter of intent, are Amor (Manufacturer of OPV Modules) and Karl Stahl (Manufacturer of the stell netting for the OPV-facade).

Furthermore, we need assistants with various specific planning services, such as the fire protection concept or the photovoltaic systems planning. We intended to afford theses service providers through sponsoring or donations. A few companies are already supporting us with their knowledge even though the sponsoring contracts are not yet final.

The fund-raising plan was developed together with the university's rectorate and financial department. To comply with German tax laws, we must differentiate between donations as well as active and passive sponsoring. We intend not to engage in any kind of active sponsoring, because the obtained funds or components would have to be taxed by the university. The resulting fundraising procedure is visualised in the following schematic.

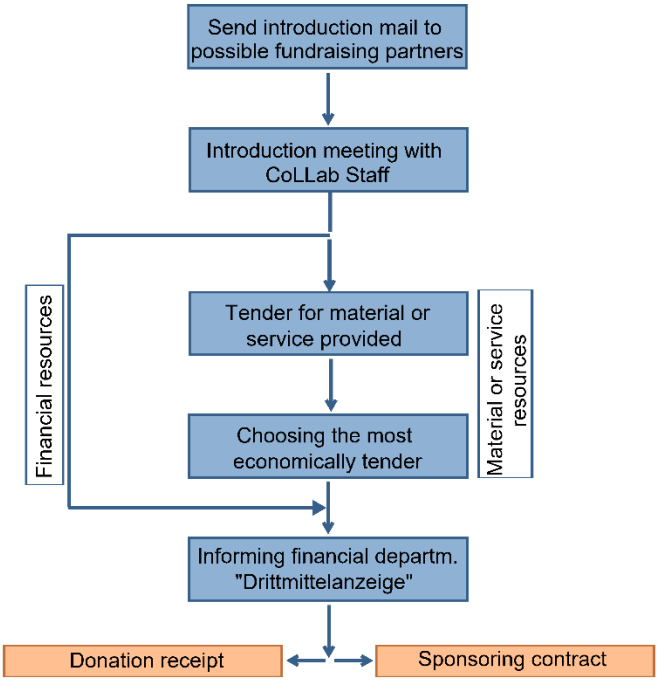


Fig.12.71: Schematic of coLLab's fundraising procedure

Sponsoring partners will get a variety of benefits in exchange for their support. To mention a few:

- Adding the Company Logo on our Webpage
- Naming the Supporter ad public presentations
- Access to our newsletter
- Adding the Company Logo on the building sign

12.2 Comments on the Price-Cost-Proposal.

The adjunctive Price-Cost-Proposal Excel sheet contains further information about the proposed project costs and income details. The costs calculated for direct materials include the labour needed to manufacture and install the components in our demonstration unit. The proportionate labour parts cannot be evaluated separately. Potential fund-raising partners, who are not yet finalised, are not considered for the income details at this time.

The labour overhead cost for our student teams and professors, who incorporate the SDE21 as part of their regular studies, are not considered in the price cost proposal. Only our granted students and direct labour for the manufacturing are considered demonstration united related personnel costs. These are funded by the BMWi donation respectively considered as a (time) donation from our fellow students.

Based on the current estimates we are well within the range to fund the construction of the demonstration unit. Noted should be that some donations, especially the BMWi funding, can only be used to fund specific expanses. Furthermore, not all sponsoring services can be valued in exact monetary terms, which is why the huge contribution from Baufritz to date is only an estimate. We monitor our incomes and expanses carefully to account for any variations.

13 SITE OPERATIONS PLAN

coLlab

13.1 General data

For deliverable #6 our main goal was to specify the Time Schedule and the elementation concept of our HDU more closely. Our focus was primarily on the identification of dependencies and the hour-based elaboration of the elementation tasks. We did this mainly in collaboration with our different Student Teams and the company “Bau-Fritz” which is our main sponsor, but also involved other potential sponsors like “Stahlbau Süßen”, “Carl Stahl” and “Armor” for the OPV-façade.

In parallel, we further worked on the logistics on the SDE21 Solar Campus as well as our lot plan and the further development of the Site Operations Chart based on the actual status of the elementation concept. The elementation was finalized in the course of the last weeks. At the moment, we are working on the coordination of the dates with our collaboration partners. However, the elaboration of the Schedule with the exact Time slots, is currently a work in progress, and we are trying to show a work status that is as up-to-date as possible.

Furthermore, in the last few weeks we have dealt with the machinery and personnel requirements for the individual work steps, which is currently being worked on further. In the coming weeks, we will further elaborate on this planning in order to be able to make more precise statements about team compositions and machine requirements for the Deliverables 7.

13.2 Site Operations Coordinators

Our Site Operations Team consist of the coordinators Mr Sebastian Baier M.A. and Mrs Alessia Gruber B.E. The Team will manage the site operations during the construction and dismantling phases. Mr Baier & Mrs Gruber brings sufficient experience in this area and are very familiar with the processes involved in the construction of pavilions of this kind.

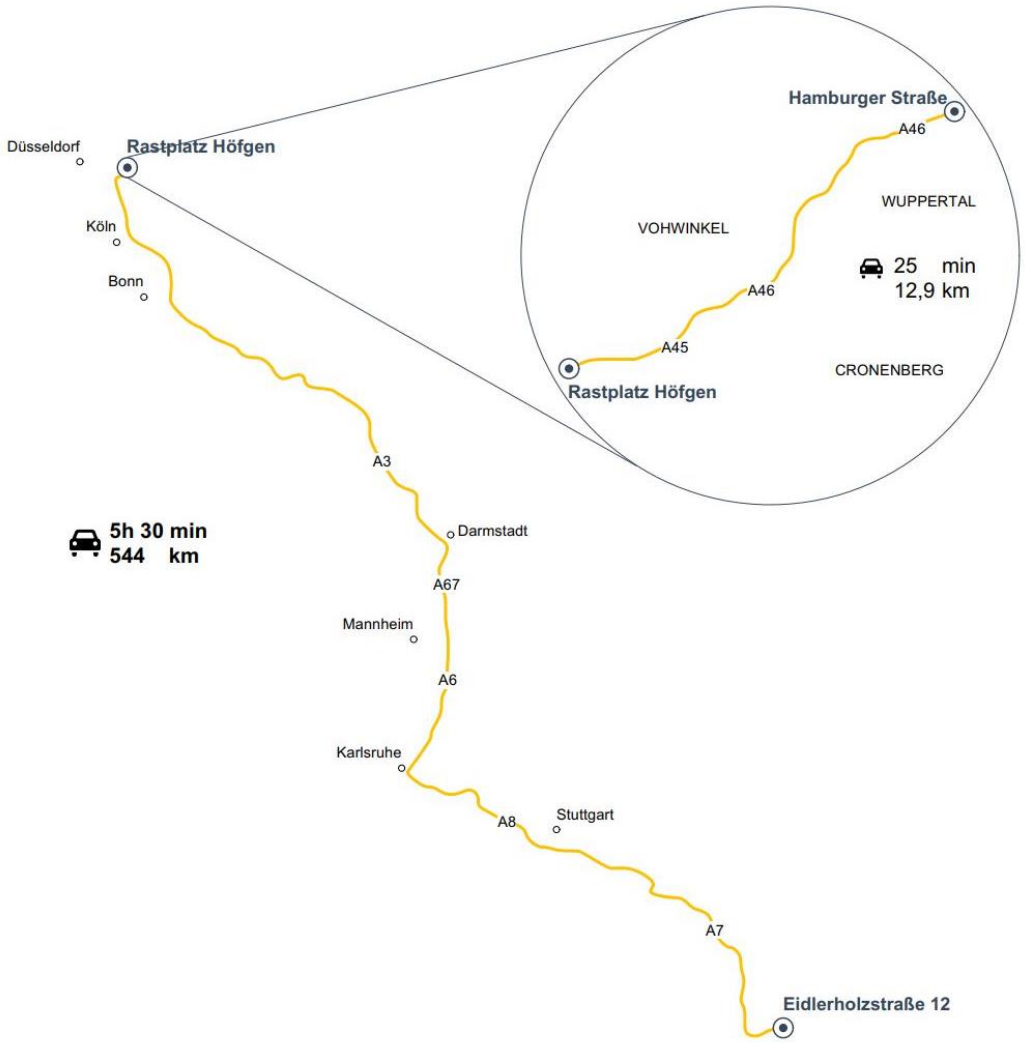
13.3 Logistic outside of SDE21 Solar Campus

13.3.1 Trucks route

Based on the competition rules, we divided the truck routing into three parts: the routing from the company area of “Bau-Fritz” in Erkheim to the “Rastplatz Höfgen”, the routing from “Rastplatz Höfgen” to SDE 21 Solar Campus and the routing on the campus area itself. Based on this, we calculated an approximate transport time to our lot on the campus (see figure 1 and SDE Solar Campus drawings SO-101).

Truck travel time	Duration	Route	Notes
Truck loading Erkheim	1h		
Erkheim – Rastplatz Höfgen	9,5 h	544 km	Incl. break
Waiting time Rastplatz Höfgen	0,5 h		
Rastplatz Höfgen - Wuppertal	0,25 h	14 km	
Entrance Solar Campus	0,25 h	< 1 km	
Unload and exit Solar Campus	2 h	< 1 km	
Sum	13, 5 h	560 km	

Table 72: Calculation of transport time (average speed 65 km/h, breaks 45 minutes every 4,5 h (1 h for calculation))



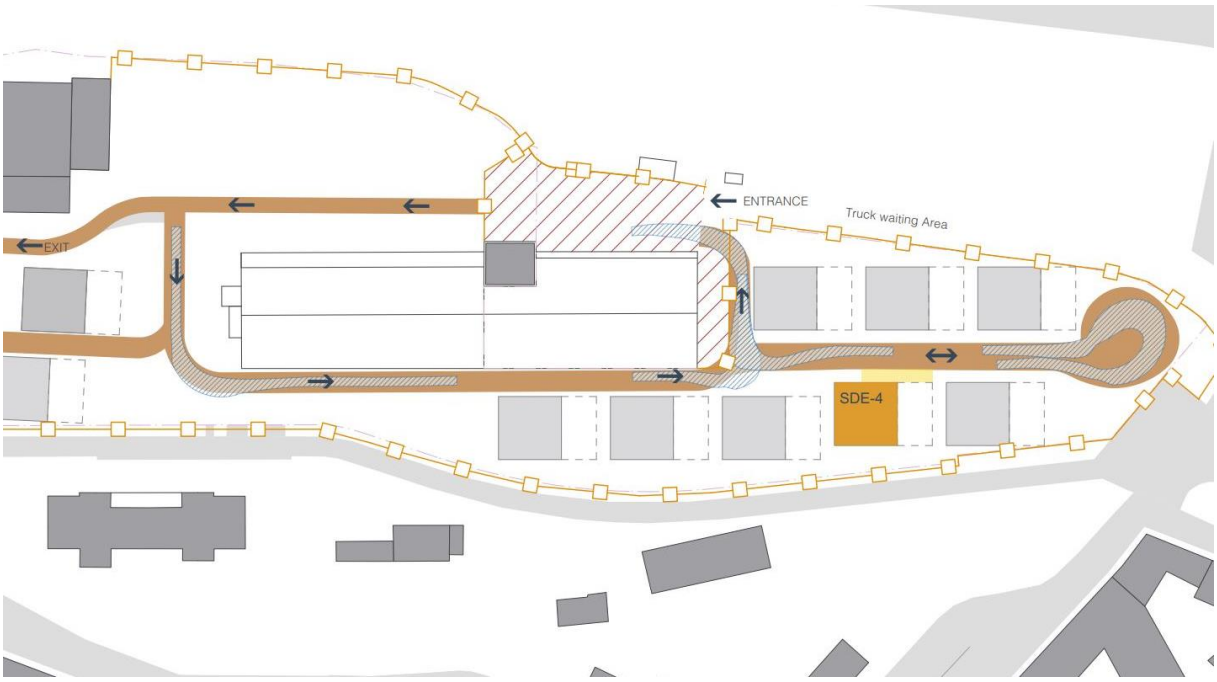
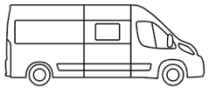
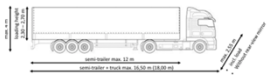
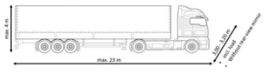


Fig. 13.73 and 13. 2: Routing in- and outside SDE21 Solar Campus and calculation of transport time

13.3.2 Trucks specifications and shipments

In consultation with “Bau-Fritz” and the competition rules we already evaluated, which kinds of vehicles we might use for the transport to Wuppertal (see figure 3). We are trying to use mainly semi-trailer trucks and vans for our main components and want to avoid the use of special transports. However, as the final elementation and therefore the size of our construction elements is not completely sure, we cannot exclude this for now. As you can see in our Assembly & Disassembly Chart, we are currently calculating with seventeen truckloads for the main parts of our HDU. This is an estimation based on the status of our elementation concept and may still vary.

	Van	Truck (Semitrailor tractor)	Special transport
			
Turning Radius:	12 - 16 m	> 25m (varies)	>> 25 m (Varies
Total weight:	< 3,5 t	< 40t	< 22t
Vehicle weight:	2,0 - 3,0 t	> 13 t	varies
Max. load weight:	0,5 - 1,5 t	< 27 t	varies
Max. lenght :		16,5m	22,0 m
Max. width:		2,55 m	3,0 m (With Approval)
Max. height:		4,0 m	4,0 m
EU-directive:		96/53/EG	Approval §70 StVZO, §29 section 3 StVO

Notes:
The given information are guidelines from the SDE21-Transport_V2.0_02_11_21 Dokument.
Total mass = vehicle weight + max. load weight

Fig. 13.3: Overview vehicles

13.4 Logistic on SDE21 Solar Campus

13.4.1 Infrastructures

In our lot plan you can see the current planning for the infrastructure on the lot (construction pit, unloading zone, storage area, crane, façade scaffolding, area for power distributor, waste container, see lot plan SO-102). Please note that the final distribution of our building elements to the trucks has not yet been completed. Depending on the exact weight and position of the individual elements on the trucks, we may have to move the mobile crane closer to the building and the unloading area of the trucks. As soon as the final position is known, we will let you know.

13.4.2 Construction working teams

To ensure a smoother setup, we decided to define expert groups. For this purpose, we have determined the required groups and the number of helpers for the respective work phases of the schedule. The teams will be formed from the respective experts. After that, the carpenters and joiners are distributed among the teams. The remaining places are then filled with the helpers.

In this way, the helpers are informed at an early stage about the tasks for which they are assigned and can prepare for their activities. The process of allocation will take place in the next few weeks. The groups will also be assigned a main person who will be in charge of the team.

The groups look as follows:

Teams:	Task	Discription	Helpers
Site management	Unloading	The teams assist with unloading and take care of the logistics of the trucks. They also inform the site operation team if delays occur.	4 People
Foundations	Foundations & Grid support	The team takes care of the slab foundations, as well as the column foundations. Positioning as well as construction of the grid help.	4 People
OPV	OPV facade & wiring	The team takes care of the wiring of the OPV facade	4 People
Baufritz	Assistant Team	The team supports the company Baufritz in the installation of the HDU. This includes: Mounting and assembly of the modules, as well as the grid and the frames	6 People
Building Constuction	Control	The team supports in structural issues and in the execution of the foundations. + Inspection & control	2 People
Springer	Springer	The team supports the other teams of experts when there is a need. + Target/actual control, communication and documentation.	2-3 People
Cooling	Cooling	The team takes care of the assembly, installation and commissioning of the cooling system.	4 People
Technician	Supply & waste water, electrical, technical room	The team takes care of the installation of supply and sewage. Furthermore, the technician team takes care of the electrics.	2 People
Facade	Unloading & Angle	Unloading and corrdination of the OPV facade. Assembly of the angles.	2 People
Facade	Adjusting the facade	Adjustment of the facade during installation and mounting of the grid. Gladly from the Baufritz support team.	2 People
Scaffold	Support scaffolder	Carrying and unloading of scaffolding parts. Support of the executing company.	3-4 People
Plant troughs	Building, positioning and planting the troughs	The team takes care of the construction, positioning and planting of the plum troughs. As well as support teams, if necessary, in the green roof	4 People
Interior			
Expansion HDU - floor	Assembly of the floor elements & floor	Assembly of the floor elements & laying the floor.	4 People
Expansion HDU - Walls & Ceilings	Assembly of walls and ceiling cladding	Assembly, cutting the ceilings and wall coverings.	6 People oder 2X 4
Rotary body & furniture	Assembly of the rotating body & furniture	*Interior architecture of rotating body on the ground floor, as well as rotating body and tasting station on the upper floor	4-6 People
Electricians outside	Wiring, connection, batteries, technical room		2 People
Electricians inside	Wiring and connection - modules, lighting, etc.		2 People
Workshop team	Devices, saws, woodwork, welders	The workshop team takes care of the cutting of the interior and takes care of the equipment issue and management of the magazine.	4 People
Fine tuning	The finishing touch - HDU interior design	Attach model, foil cuts, etc.	4 People
Unloading	Unloading of trucks and material logistics	Takes care of the material logistics as well as when unloading the trucks. Adjustment of the elements.	2 People

13.4.3 Phases description

Our phases drawing finalized since the last deliverable. The basic construction concept of our HDU based on prefabricated elements for walls, slabs, elevator and staircases, the grid, the façade and the exterior ramp still remains.

The respective phases were further elaborated and defined in the last weeks. We were able to determine the final elements for Deliverables #6. This has already been discussed and approved with “Bau-Fritz”. Now we are in close contact with the remaining companies in order to determine the timelines of the respective work phases.

13.4.4 Waste management

As in deliverable #4 already mentioned, the basis of our waste management concept is the 5S-concept (derived from the German words “Sortieren, Systematisieren, Säubern, Standardisieren, Selbstdisziplin”). According to this guideline we will further elaborate our waste management system. Spaces for waste containers are already kept clear in our lot plan (see lot plan SO-102).

We have decided to rent three 770 liter trash containers. In order to be able to divide the accumulating waste of the construction site into paper, plastic and wood.

13.5 Assembly/ Disassembly schedules

In the attached Site Operation Excel Sheet, you will find the assembly and disassembly phases as well as the elementing steps of the HDU. The phases have been simplified and partially summarized. The current schedule is based on a studio planning.

The individual phases are examined for machine and personnel requirements, as well as for health and safety aspects.

SOLAR DECATHLON EUROPE 2021/22 - ASSEMBLY CHART

Namenfeld

Deliverable No.	D#6
Team ID	HFT
University/ City	Stuttgart

T1	Trucks (truck deliveries; fill in T1, T2, T3, ...)	Number of Trucks (in total)	47,0
C	Crane (40t)	Crane hours 40t (in total)	92,5
C	Crane (100t)	Crane hours 100t (in total)	1,5
H	Telehandler	Telehandler hours (in total)	0,0
F	Forklift	Forklift hours (in total)	29,0
S	Scissor Lift	Scissor Lift hours (in total)	11,5
W	Hydraulic Winch	Hydraulic Winch hours (in total)	0,0

Opening Hours in assembly period: 7:00 - 23:00 h

team ID	Day	Date	Equipment	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00
HFT	Day 1	20/05/2022	Trucks																			T1	T1	T2	T2												
			Crane (40t)																			C	C	C	C	C	C										
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift																																		
			Hydraulic Winch																																		
	Day 2	21/05/2022	Trucks						T3	T3	T3																										
			Crane (40t)								C	C	C																								
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift																																		
			Hydraulic Winch																																		
	Day 3	22/05/2022	Trucks								T4	T4	T4																								
			Crane (40t)										C	C	C																						
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift																																		
			Hydraulic Winch																																		
	Day 4	23/05/2022	Trucks		T5	T5	T5										T6	T6	T6						T7	T7	T7										
			Crane (40t)			C	C	C	C	C	C	C	C	C	C		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift																																		
			Hydraulic Winch																																		
	Day 5	24/05/2022	Trucks		T8	T8	T8										T9	T9	T9																		
			Crane (40t)			C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C											
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift																																		
			Hydraulic Winch																																		
	Day 6	25/05/2022	Trucks		T10	T10	T11	T11																													
			Crane (40t)			C	C	C					C	C	C	C			C	C	C	C	C	C	C						C	C	C				
			Crane (100t)																																		
			Telehandler																																		
			Forklift				F	F	F	F																											
			Scissor Lift						S	S	S	S																									
			Hydraulic Winch																																		
	Day 7	26/05/2022	Trucks		T12	T12	T12																														
			Crane (40t)		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		
			Crane (100t)																																		
			Telehandler																																		
			Forklift				F	F	F	F																											
			Scissor Lift																																		
			Hydraulic Winch																																		
	Day 8	27/05/2022	Trucks		T13	T13	T13								T14	T14	T14																				
			Crane (40t)		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C														
			Crane (100t)																																		
			Telehandler																																		
			Forklift						F	F					F	F																					
			Scissor Lift								S	S	S	S									S	S	S	S											
			Hydraulic Winch																																		
	Day 9	28/05/2022	Trucks		T15	T15	T15																														
			Crane (40t)																																		
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift				S	S										S	S																		
			Hydraulic Winch																																		
	Day 10	29/05/2022	Trucks		T16	T16	T16																														
			Crane (40t)																																		
			Crane (100t)																																		
			Telehandler																																		
			Forklift																																		
			Scissor Lift				S	S										S	S																		
			Hydraulic Winch																																		
	Day 11	30/05/2022	Trucks		T17	T17	T17																														
			Crane (40t)		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C									
			Crane (100t)																																		
			Telehandler																																		

13.6 Equipment Requirement Chart

As you can see in the corresponding table, we have further elaborated and refined the equipment table compared to Del #5. At the current state of planning, we assume that we will only use the 40t crane. Furthermore, we have decided to rent an electric forklift as well as a scissor lift to reduce the crane time.

Smaller equipment such as trolleys, site lighting and saws have been estimated. The final listing of all equipment will be finalized in the upcoming weeks, in consultation with the university workshop.

Equipment such as hammers and cordless screwdrivers, etc. will probably be sourced from the university. The final stand will be delivered in the next Deliverables.

SOLAR DECATHLON EUROPE 2021/22 - EQUIPMENT REQUIREMENT CHART

Deliverable No.	D#6
Team ID	HFT
University/ City	Stuttgart

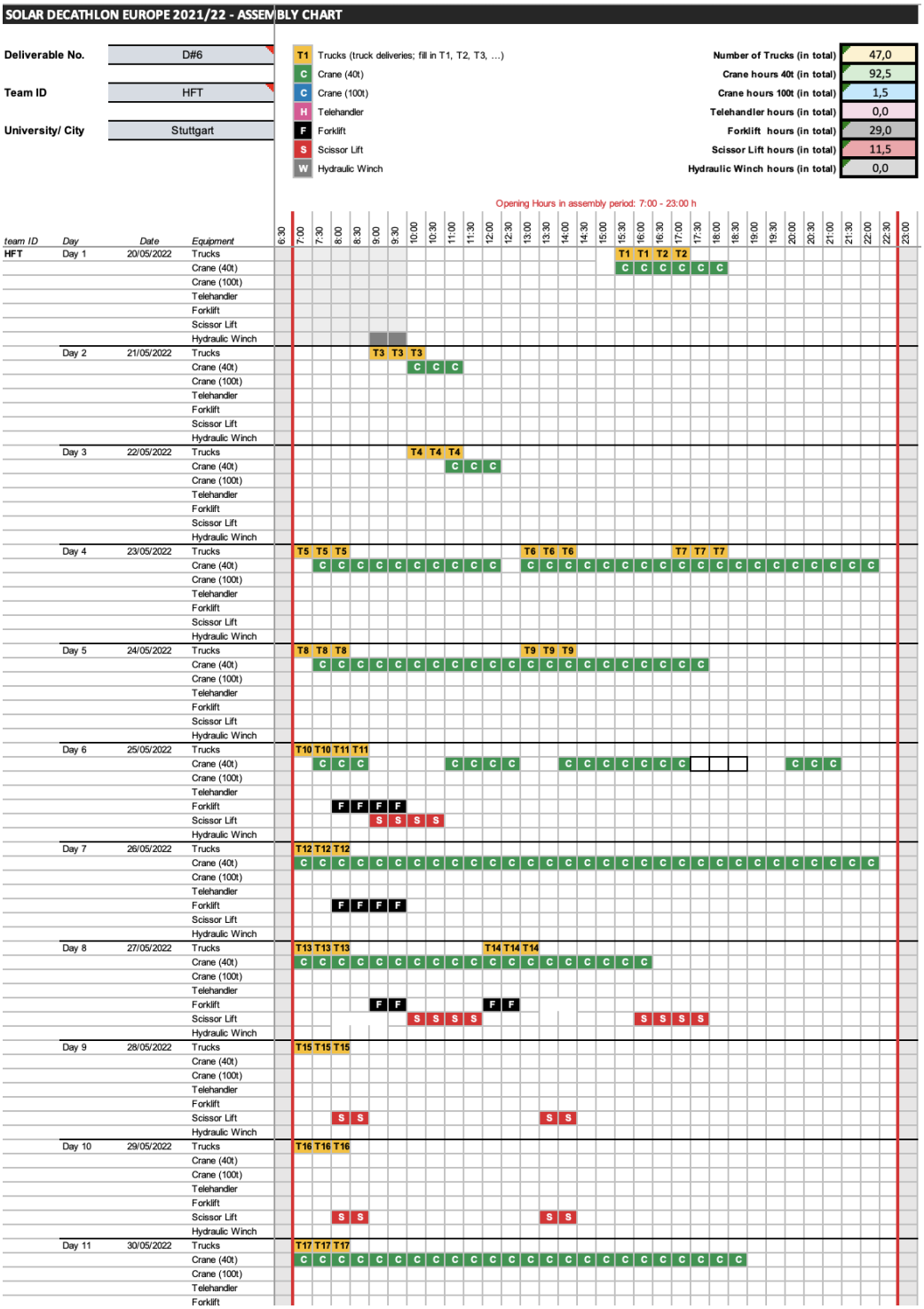
Pos	*Description*	*Price / Unit*	*Unit*	*Quantity*	*TOTAL**
1	Mobile crane (40t)	171,86 €	hour	92,5	15.897,05 €
2	Electric forklift	178,15 €	day	29	5.166,35 €
3	Telehandler	478,33 €	day	0	- €
4	Hydraulic winch	214,20 €	day	0	- €
5	Scissor lift	133,78 €	day	11,5	1.538,47 €
6	Transport wagon	28,29 €	day	5	141,45 €
7	Pallet truck	34,21 €	day	3	102,63 €
8	Cold light lamp	8,21 €	day	20	164,20 €
9	LED illuminated balloon	86,22 €	day	12	1.034,64 €
10	Stepladder	20,53 €	day	20	410,60 €
11	Single ladder	19,34 €	day	4	77,36 €
12	Mobile scaffold (3m)	24,26 €	day	2	48,52 €
13	Ladder-lift	142,28 €	day	3	426,84 €
14	Winch	86,56 €	day	0	- €
15	Waste containers	11,42 €	day	10	114,20 €
16	Hand truck / Barrow	20,17 €	day	3	60,51 €
17	Work trestles	5,71 €	day	3	17,13 €
18	Pavillion	42,84 €	day	0	- €
19	Construction disk saw	69,19 €	day	6	415,14 €
20	Table saw / Chop saw	69,19 €	day	6	415,14 €
21	Hand-held circular saw	35,25 €	day	0	- €
22	Electric ripsaw	58,75 €	day	0	- €
23	Reciprocating saw	31,53 €	day	0	- €
24	Jigsaw	16,66 €	day	4	66,64 €
25	Drill hammer	23,81 €	day	0	- €
26	Cordless screwdriver	48,08 €	day	0	- €

Fig. 13.4: Excerpt chart "Equipment Requirement"

13.7 Assembly & Disassembly Chart

In this table we estimated the number of trucks, their approximate time of arrival as well as the probably needed timeframe for the crane use.

On the one hand, the details were worked out in dialog with the company "Bau-Fritz", on the other hand, the details result from the hour-based schedule. Figures 5 & 6 are excerpts from the Excel spreadsheet (SDE- Site Operation, Sheet: Assembly and Disassembly).



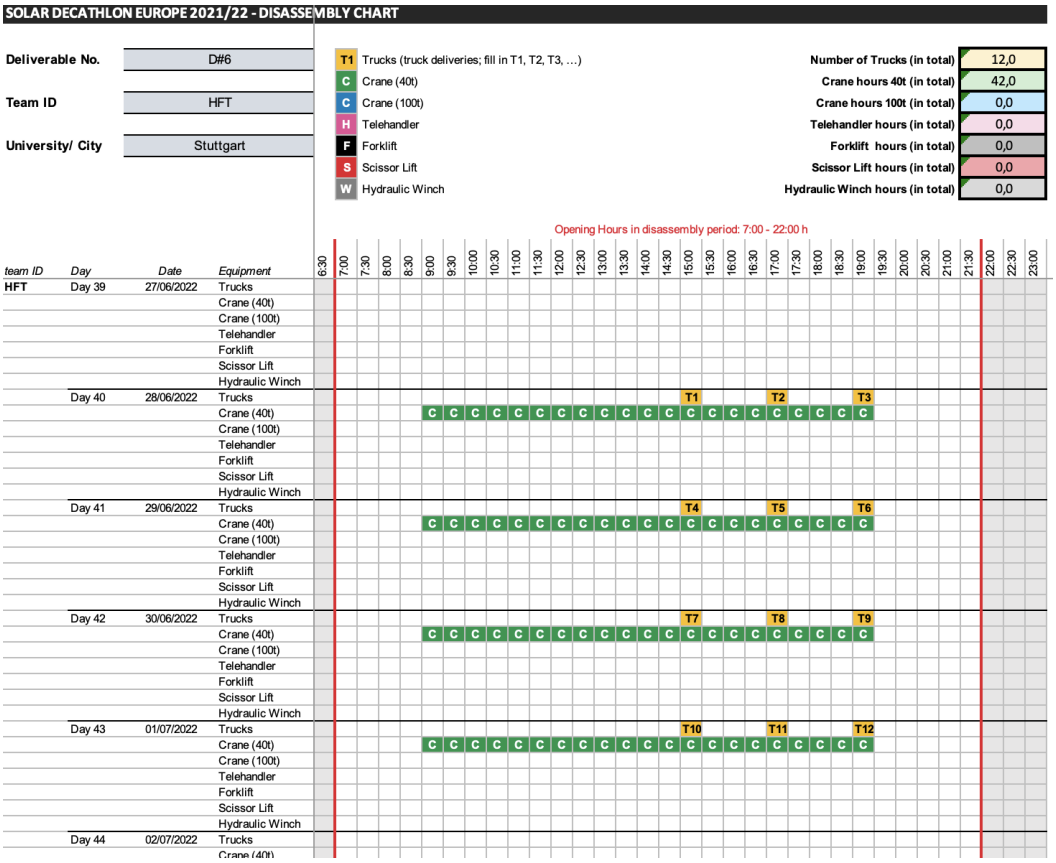


Fig. 13.5 and 13.6: Excerpt "Assembly & Disassembly Chart"

13.8 **Site Operations Chart**

Based on our current elementation concept and together with our partners we figured out a time schedule for the assembly and disassembly of our HDU (see figure 7 and 8 and table "Site Operations Chart" in the site operations excel-file). The assembly basically consists of a phase for preparing the site (i.e. measuring, levelling, foundations, etc.), the assembly of the prefabricated timber elements, the mounting of the OPV-façade as well as the interior and technical finish. Each of these larger steps consists of several smaller ones that are noted in detail in the Site Operations Chart. After the assembly of the timber elements, the mounting of the OPV-façade as well as the interior works are taking place at the same time. For the disassembly of the HDU we arranged this process vice versa with more working steps being implemented at the same time. The timetable for the trucks arrival as well as for the use of the crane is based on the contents of the Site Operations Chart.

SOLAR DECATHLON EUROPE 2021/22 - SITE OPERATIONS CHART

Deliverable No.	D#6
Team ID	HFT
University/ City	Stuttgart

Assembly period

team ID	Pos.	Description	Start Date	End Date	Duration (in days)	Day 0 (19/05/2022)	Day 1 (20/05/2022)	Day 2 (21/05/2022)	Day 3 (22/05/2022)	Day 4 (23/05/2022)	Day 5 (24/05/2022)	Day 6 (25/05/2022)	Day 7 (26/05/2022)	Day 8 (27/05/2022)	Day 9 (28/05/2022)	Day 10 (29/05/2022)	Day 11 (30/05/2022)	Day 12 (31/05/2022)	Day 13 (01/06/2022)	Day 14 (02/06/2022)
coLLab_HFT	1	Measuring and levelling	20/05/2022	20/05/2022	1															
	2	Earthworks	20/05/2022	20/05/2022	1															
	3	Building/Construction site facilities -	20/05/2022	20/05/2022	1															
	4	Connection site power supply	20/05/2022	20/05/2022	1															
	5	Scaffolding erection	21/05/2022	21/05/2022	1															
	6	Foundations	22/05/2022	22/05/2022	1															
	7	Insertion drain pipes	22/05/2022	22/05/2022	1															
	8	Ground slab EG	23/05/2022	23/05/2022	1															
	9	Wall_1_EG	23/05/2022	23/05/2022	1															
	10	Wall_2_EG	23/05/2022	23/05/2022	1															
	11	Wall_3_EG	23/05/2022	23/05/2022	1															
	12	Wall_4_EG	23/05/2022	23/05/2022	1															
	13	Wall_5_EG	23/05/2022	23/05/2022	1															
	14	Wall_6_EG	23/05/2022	23/05/2022	1															
	15	Kitchen module_EG	23/05/2022	23/05/2022	1															
	16	Bathroom module _EG	23/05/2022	23/05/2022	1															
	17	Ceiling tile_EG	23/05/2022	23/05/2022	1															
	18	Wall_7_OG	24/05/2022	24/05/2022	1															
	19	Wall_8_OG	24/05/2022	24/05/2022	1															
	20	Wall_9_OG	24/05/2022	24/05/2022	1															
	21	Wall_10_OG	24/05/2022	24/05/2022	1															
	22	Wall_11_OG	24/05/2022	24/05/2022	1															
	23	Solar chimney_OG	24/05/2022	24/05/2022	1															
	24	Bed module_OG	24/05/2022	24/05/2022	1															
	25	Celing panel_OG	24/05/2022	24/05/2022	1															
	26	Solar chimney roof	24/05/2022	24/05/2022	1															
	27	Roofing_DG	24/05/2022	24/05/2022	1															
	28	Green Roof_DG	24/05/2022	24/05/2022	1															
	29	Grid_Foundation_colume_feet	25/05/2022	25/05/2022	1															
	30	Grid_Base & Colume_ EG	25/05/2022	25/05/2022	1															
	31	Grid_Base & Colume_ OG	25/05/2022	25/05/2022	1															
	32	Exterior Staircase	25/05/2022	25/05/2022	1															
	33	Exterior lighting	25/05/2022	25/05/2022	1															
	34	Assembly OPV-facade-elements	26/05/2022	27/05/2022	2															
	35	Assembly OPV-modules & Facade_wiring	26/05/2022	27/05/2022	2															
	36	Ramp construktion	30/05/2022	30/05/2022	1															
	37	Exterior installation	30/05/2022	30/05/2022	1															
	38	Plant troughts construction & insertion	29/05/2022	30/05/2022	2															
	39	Facade greening	30/05/2022	30/05/2022	1															
	40	**Interior design**																		
	41	EG_Wall covering	25/05/2022	25/05/2022	1															
	42	EG_ceiling_covering	25/05/2022	25/05/2022	1															
	43	EG_Floor_covering	26/05/2022	26/05/2022	1															
	44	EG_Electricity	26/05/2022	26/05/2022	1															
	45	EG_Truned body_Furniture	27/05/2022	27/05/2022	1															
	46	EG_interior fitting	27/05/2022	28/05/2022	1															
	47	EG_technical room	28/05/2022	28/05/2022	1															
	48	EG_connecting modules	29/05/2022	29/05/2022	1															
	49	OG_Wall covering	26/05/2022	26/05/2022	1															
	50	OG_ceiling_covering	26/05/2022	26/05/2022	1															
	51	OG_Floor_covering	27/05/2022	27/05/2022	1															
	52	OG_Electricity	27/05/2022	27/05/2022	1															
	53	OG_Truned body_Furniture	28/05/2022	28/05/2022	1															
	54	OG_interior fitting	28/05/2022	29/05/2022	2															
	55	OG_technical room	30/05/2022	30/05/2022	1															
	56	OG_connecting modules	29/05/2022	30/05/2022	2															
	57	Stairlift	31/05/2022	31/05/2022	2															
	58	Installation & connecting devices	30/05/2022	31/05/2022	1															
	59	Monitoring and test operation	30/05/2022	02/06/2022	4															
	60	Remaining work	01/06/2022	02/06/2022	2															
	61	Construktion cleaning	02/06/2022	03/06/2022	1															
	62	Final inspection	02/06/2022	03/06/2022	1															

team ID	Pos.	Description	Start Date	End Date	Duration (in days)	Day 38 (26/06/2022)	Day 39 (27/06/2022)	Day 40 (28/06/2022)	Day 41 (29/06/2022)	Day 42 (30/06/2022)	Day 43 (01/07/2022)	Day 44 (02/07/2022)	Day 45 (03/07/2022)	Day 46 (04/07/2022)
coLLab_HFT	1	Removal ramp scaffolding	27/06/2022	27/06/2022	1									
	2	Removal facade-greenery and greenery-trays	27/06/2022	27/06/2022	1									
	3	Setup facade scaffolding	28/06/2022	28/06/2022	1									
	4	Disassembly OPV-facade-modules	29/06/2022	29/06/2022	1									
	5	Disassembly grid and exterior area	29/06/2022	30/06/2022	2									
	6	Disassembly exhibition furniture	27/06/2022	27/06/2022	1									
	7	Disassembly rotary corpuses	27/06/2022	27/06/2022	1									
	8	Disconnection from campus-grid	27/06/2022	27/06/2022	1									
	9	Disassembly technical facilities	27/06/2022	29/06/2022	2									
	10	Disconnection timber-structure-modules	28/06/2022	29/06/2022	2									
	11	Disassembly roof covering	30/06/2022	30/06/2022	1									
	12	Disassembly ceiling slab above first floor	30/06/2022	30/06/2022	1									
	13	Disassembly floor construction first floor	30/06/2022	30/06/2022	1									
	14	Disassembly walls first floor	30/06/2022	30/06/2022	1									
	15	Disassembly ceiling slab above ground floor	01/07/2022	01/07/2022	1									
	16	Disassembly bathroom-/ kitchen-/ bed-module	01/07/2022	01/07/2022	1									
	17	Disassembly hot water tank	01/07/2022	01/07/2022	1									
	18	Disassembly floor construction ground floor	01/07/2022	01/07/2022	1									
	19	Disassembly walls ground floor	01/07/2022	01/07/2022	1									
	20	Disassembly floor slab	01/07/2022	01/07/2022	1									
	21	Removal facade scaffolding	02/07/2022	02/07/2022	1									
	22	Removal drain pipes	02/07/2022	02/07/2022	1									
	23	Removal tanks	02/07/2022	02/07/2022	1									
	24	Removal foundations and ground preparation	02/07/2022	02/07/2022	1									
	25	Remaining work	02/07/2022	03/07/2022	1									

Fig. 13.7 and13.8: Excerpt "Site Operations Chart"

14 HS REPORT AND DOCUMENTATION

coLlab

14.1 Health & Safety Checklist

Legal Contents	Location in the report or in drawings
Name and address of SDE21, HS Coordinator, Prevention authorities, Team	14.2.2
Number of workers	14.6.3
Contact information of the Site Operations Coordinator	14.2.2
Description of works	14.5.1
First aid procedure	14.13.1
Name and number of first aid certificated worker	14.2.4-14.2.5
Description of the Team's first aid kit	14.13.2
Description of hygiene conditions (toilet, changing room, restroom,…)	14.11
Detailed description of operation modes	14.5.3
Risk assessment – risks generated by other	14.8.2
Risk assessment – risks generated by environment	14.8.2
Risk assessment – risks generated on other	14.8.2
Risk assessment – self-generated risks	14.8.2
Procedures to adapt collective protection	14.9

14.2 General Data of the Project

14.2.1 Aim of the Health and Safety Plan

With the help of an occupational safety plan, it should be ensured that all persons and team members involved in the construction and project are informed about possible hazards as well as risks. Comprehensive training of all persons is extremely important for this. This can prevent injuries and accidents to individuals, which also jeopardize the course of the project. Furthermore, it also serves as an occupational health and safety guideline, which provides the team members with information on which protective equipment is to be worn for the corresponding activities. This health and safety plan must be constantly accessible to everyone on the construction site and posted in relevant places

14.2.2 Health and Safety Coordinator/ Officers and workers

The HS Coordinator of Team coLLab is an architect with a lot of experience in construction. The coordinator is a trained SiGeKo. The safety and health coordinator (SiGeKo) is responsible for safety and health protection on construction sites. The appointment of the coordinator has been regulated in the Construction Site Ordinance (BaustellV) since 1998. This measure will assist with the implementation of safety measures during site activities and will ensure that the work will be performed according to the labour law.

During the construction phase, there will be two shifts. One before and after lunch. During each shift, the HS Coordinator and SO Coordinator will be on site. In addition, a Foreman of our partner company Baufritz will be present to help with the construction of the module. Meanwhile the HS Coordinator of

our team is taking part at daily briefings of SDE Organisation, at least one of the six Team Safety Officers will be on site, looking out for the workers to ensure that safety measures and protection is being be worn. HS Coordinator is responsible for the operation of each of the team member during assembly and disassembly. Therefor it is mandatory that each team member (currently 27listed) and contracted staff of universities and partner companies (currently around 30 in total) is working according to the present Health and Safety Plan of the HFT and respect the rules and procedures implemented by the team and the SDE organization. Moreover, in each shift it is likely possible that professional staff will be helping throughout the process. The extended list of the team members can be found in the HS Specific Terms and Conditions Document.

Contact SDE21-22 Name: Bergische Universität Wuppertal, Fakultät für Architektur und Bauingenieurwesen Adress: Pauluskirchstraße 7 42285 Wuppertal Tel.: 0202 439 4510 Mail: sde21sek@uni-wuppertal.de	**Contact HFT Team Stuttgart:** Name: Stuttgart University of applied Sciences (Hochschule für Technik Stuttgart) Adress: Schellingstraße 24 70174 Stuttgart Telefax: +49 711 8926-2666 Mail: www.hft-stuttgart.de www.coLLab.hft-stuttgart.de
Contact HS Coordinator of the HFT Stuttgart: Name: Albert Stöcker Adress: Schellingstraße 24 70174 Stuttgart Telephone: +49 711 8926 2598 Mail: albert.stoecker@hft-stuttgart.de	**Contact Faculty Advisor:** Name: Jan Cremers Adress: Schellingstraße 24 70174 Stuttgart Telephone: +49 711 8926-2620 Mail: jan.cremers@hft-stuttgart,de
Contact Emergency telephone codes in Germany: Emergency/Police: 110 Ambulance/Fire Department: 112	**Contact SO Coordinator:** Name: Sebastian Baier Adress: Schellingstraße 24 70174 Stuttgart Telephone: +49 1525 7260037 Mail: sebastian.baier@hft-stuttgart.de
Contact Student Team Leader: Name: Yannik Zelenka Adress: Schellingstraße 24 70174 Stuttgart Mail: 01zeya1mar@hft-stuttgart.de	**Contact Electrical Engineer:** Name: Siegfried Baumgartner Adress: Schellingstraße 24 70174 Stuttgart Mail: siegfried.baumgartner@baumgartner-gmbh.de
Contact Project Architect: Name: Clarissa Werner Adress: Schellingstraße 24 70174 Stuttgart Mail: clarissa.werner@hft-stuttgart.de	

14.2.3 Construction Site

There will be three different Constructions sites for assembly and disassembly. On each site, a HS Coordinator will be present.

Construction Site 1) Workshop HFT: Breitscheidstraße 5, 70174 Stuttgart

Construction Site 2) Baufritz factory: Alpenweg 25, 87746 Erkheim

Construction Site 3) Solar Campus: Mirker Str. 48, 42105 Wuppertal

14.2.4 General distribution on site

All of the people in table below can provide first aid. * First aid training will take place in April. Documentation Certificate will provided on request.

Name	Position	Contact details	Email
* Sebsatian Baier	SO Coordinator, HS Team Safety Officer #1	01525 7260037	sebastian.baier@hft-stuttgart.de
* Jonas Stave	HS Team Safety Officer #2	01522 3353470	jonas.stave@hft-stuttgart.de
* Annabell Gronau	HS Team Safety Officer #3	0176 84684737	annabell.gronau@hft-stuttgart.de
* Lukas Fischer	HS Team Safety Officer #4	0160 6961624	lukas.fischer@hft-stuttgart.de
* Clarissa Werner	HS Team Safety Officer #5	0173 3457043	clarissa.werner@hft-stuttgart.de
* Alesia Gruber	HS Team Safety Officer #6	0176 63467763	81gral1bbi@hft-stuttgart.de
* Albert Stöcker	HS Coordinator	0711 8926 2598	albert.stoecker@hft-stuttgart.de
…	…	…	..

14.2.5 Certificates

The Health and Safety Coordinator, as well as the Team Safety Officers will be in charge of the safety measures observance and are therefore preventive resources. For this reason, they will act as together with the HS Coordinator as Emergency Response Officers, together with the second SO Coordinator provided by our construction partners. The first step for the Health and Safety Team Officers is that they will be trained and certified with the first aid standard certificate. First aiders must be trained and further trained by authorised persons - §26 Para. 2 DGUV Regulation 1 "Principles of Prevention". This will enable them to provide first aid procedures in case of accidents, contain/extinguish fires or other emergency situations, raise the alarm and coordinate an evacuation procedure from the site, in case it is needed. The training will take place in April and is structured by 9 units and will last one day. Certification will documented and will be provided on request.

People with first aid certificate in the team:

• Sebastian Baier • Jonas Stave • Annabell Gronau • Lukas Fischer • Clarissa Werner • Alesia Gruber

• Albert Stöcker

All team Members of the coLLab team will be engaged in construction. This will ensure that the person is not suffering from any contagious disease and is in good physical and mental health. A copy of the medical statement of each team member is handed in. In addition, a G25 examination is requested from persons with driving, steering or monitoring activities as part of the medical statement.

Current listed as drivers are:

• Judith leppert (fork lifter) • Lukas Fischer (HFT van)

• Contracted Staff of partner companies (person yet unknown)

14.3 Health and Safety Plan Objectives

The health and safety plan falls under the legislation of occupational health and safety. The objective of the plan is to guarantee as much safety on the working site as possible. Therefore every work step is planned always to have Health&Safety of the workers in mind. Safety in all relevant areas is necessary for a successful competition.

Relevant regulations for this in Germany include the Working Hours Act, environmental legislation and the European directives on occupational health and safety. All of these laws apply to the entire coLLab construction site.

The following points of our safety plan must be observed:

1 Adherence to all health and safety related topics prescribed by the SDE organizers.

2 Detailed instructions for the assembly and disassembly of the demonstration unit

3 Creation of a health and safety plan manual (this must always be made available on the site)

4 Detailed instructions on the behavior of all persons in the event of Emergency and Accident (first aid, evacuation, etc.)

5 Reduction of risks through preventive measures (protection, analysis, measures etc.)

All persons involved in the construction of the demonstration unit must be informed and trained throughout this plan.

During the construction works in SDE21/22 Solar Campus. It must include set-up and dismantling, maintenance during the competition week and vehicle access and exit to the Solar Campus. Furthermore, the aim is not only to avoid incidents, but also to keep the site litter free and to separate the collected waste.

14.4 Instruction Concept Including Contents

The instruction concept stipulates that a generally valid training regarding all health and safety aspects is to be carried out for each team member and for each third person. This must always be done before entering the construction area. The content of this is the aspects relevant to safety in the previous point. In addition to this training, specialist training on individual construction areas will be necessary for specialist personnel and specialist groups. The further procedure in this regard will be described subsequently.

Training statements are submitted before the start of work in Wuppertal and the Team members will have successfully completed specific disciplines trainings:

- First aid (Scheduled on April)
- Briefing on the construction site procedure (Scheduled on beginning of May)
- Specific training on the work units (Scheduled on beginning of May)
- Risks and preventive measures (Scheduled on beginning of May)
- Use of protective equipment (Scheduled before construction start in Wuppertal)
- Use of machines used on the construction site (Scheduled before construction start)
- Individual training of specific tasks (Scheduled on site)

The Training Statement of Team Members will be documented with the *SDE21_HS_Training-Statement_V1.0_02_11_21.pdf*.

14.5 Conditions of the site where construction will take place and interesting data related to the prevention of risks during the construction process:

The construction of the demonstration unit will last from May 20, 2022 to June 02, 2022. The construction site will be Solar Campus at Mirker Bahnhof in Wuppertal, Germany. In order to ensure safety during the construction phase for all parties involved, a stringent implementation of the safety and health plan is essential during this period. Therefore, this plan will reduce risks related to the realization of the project until its construction. All different parties and persons on the construction site are clearly required to adhere to the prerequisites of the safety plan. The safety plan takes into account the workers on the construction site, the visitors during the competition phase as well as other third parties approaching the construction site or the finished demonstration unit.

We from the coLLab team have a clear opinion of that all partners and students who are on the competition site need special protection on the construction site. Because of this, we will actively address all health, safety and environmental issues as a priority of all activities that will take place. In this sense, the health and safety plan focuses especially on maintaining a safe workplace on the construction site. This will be done by meeting the health and safety obligations under the applicable laws and regulations, but also by working consciously and in a preventive manner.

Therefore, the safety and health officers are responsible for the implementation of the safety and health plan. When presenting the plan, the coordinators will demonstrate the importance of implementing the measures outlined. The site supervisors, the safety and health coordinator will monitor the compliance with the safety measures on a daily basis and will re-sharpen them if necessary.

Specifically, the Safety and Health Coordinator must address the following issues and monitor compliance:

- Suitability of all workers and employers for their respective assigned tasks.
- Adherence to infection control during the construction process related to COVID19, This involves monitoring and adhering to spacing, testing, masking requirements, etc.
- Ensuring suitable and fully comprehensive protective equipment for all employees on the construction site
- Prior to the start of construction, conduct further training with e-learning.
- Detailed site organization
- Instruction of all employees on how to behave in the event of an emergency or fire on the construction site
- Organization of the removal of waste and/or the clean leaving of the construction site after each work shift
- Permanent maintenance and coordination of the contact of the head of health and safety of the SDE organizers.

It is also important to note that all regulations and protocols must be followed during the construction of the demonstration unit as well as during the dismantling of the unit after the competition.

14.5.1 Constructive process

During this time, all safety regulations must be followed to a high degree. Before each shift, the "coLLab" team will give a briefing to all participants on what construction processes are required during this phase, what will be concrete risks and how to deal with risks. Subsequently, the wearing of the appropriate protective equipment will be checked separately for each team member. This control is to be confirmed before the start of the shift. Observance of these rules as well as wearing the relevant protective equipment is necessary to be able to avoid accidents and to be able to work healthily and safely.

Site preparation

In addition to the daily safety briefing before each construction shift, a health and safety training session is held for all site employees before the start of the entire construction process. Here, detailed information will be distributed in small groups on milestones; the construction process; shift assignments; safety regulations and necessary safety equipment.

Another prerequisite for the construction process is the establishment of a storage room for tools as well as safety equipment. The required tools must be returned to the storage room after each shift. The reason for this is to ensure an orderly and tidy site environment to prevent unnecessary accidents and risks. Furthermore, the return is necessary to check the complete functionality of the tool in order to issue only faultless material to the employees. Another necessity of the storage room is the possibility of temporary storage of protective work equipment for all employees. If during a shift an employee's protective equipment breaks, a direct replacement must be available. This requires storage directly at the construction site.

Other relevant measures during the construction process are, on the one hand, the erection of a construction fence around the assigned crane area and, on the other hand, the installation of temporary staircases as well as the installation of safety scaffolding to ensure safety during work on the façade of the HDU. The installation of a construction fence around the crane and storage area is necessary to keep unauthorized persons away from the preparation area to ensure the safety of third parties, as well as using the right exits to enter the site, in order to avoid any possible accidents. Proper installation of fencing, scaffolding and stairs must be verified and confirmed by the safety coordinator. Furthermore, workers who are on the roof or at a height of more than 2.5 meters on the scaffolding must be provided with safety harnesses.

With regard to the installation of lines (especially electrical connections), urgent attention must be paid to safe and proper installation. In case of improper routing or installation, there is a risk of falling, danger of falling or electrical charging of the external facade.

Assembly

1. Unload and assembly of building equipment and site preparation (2Days)

2. Unload, storage, preparation and assembly of the scaffolding façade (1Day)

3. Unload, storage and assembly of timber construction (foundation, modules, grid) (4Days)

4. Unload, storage and assembly of interior components in housing unit and exhibition area (6 Days)

5. Unload, storage and assembly of OPV-façade and façade greenery (3Days)

6. Unload and assembly of technical installation (6Days)

7. Disassembly and loading of scaffolding façade and assembly of scaffolding ramp/platform (part of work unit 2) (1Day)

At the beginning of the construction process, the ground condition must be checked and repaired if necessary. Any fall hazards must be removed. Subsequently, the foundations are attached by crane. Hard hats and other safety equipment must be worn during this process. Furthermore, care must be taken to ensure that as few people as possible in order to provide the greatest possible protection against any falling parts walk on the area. Afterwards, wastewater pipes and containers are installed. Care must be taken to ensure that the piping is connected properly. If the connection is incorrect, there is a risk of uncontrolled loss of liquids.

The facade scaffold can then be erected in preparation for the assembly of the HDU exterior components. It is forbidden to climb on an incomplete scaffold and must be completed by authorised

personnel to ensure safety and the prevention of falling from height. In contrast to the fall protection of the assembly scaffold and the corresponding safety equipment, there is a risk of improper fastening of the individual components, which may subsequently contribute to the collapse of the scaffold. Then, the facade elements must be attached together with the solar chimney. Because these elements are quite slippery and easy to brake, team members must always take time to get a good grip on each panel before attaching it. The employees of the executing carpentry company will be ostensibly responsible for the installation of these. The reason for this is the lack of specialized training for most students. A scissor lift may need to be used as well for support. Despite skilled personnel, the use of a scissor harness and fork lifters is mandatory here.

In addition, care must be taken during the entire construction process to ensure that no one is in the crane's danger zone. With this the H&S Officer will has to make sure that no one is moving or working again under the range of the crane. As for the interior part, there are several things to keep in mind. Attached to this, the interior modules are inserted into the HDU and the hot water tank is installed. The installation of the ceilings, the exterior and interior wall elements of the upper floor and the roof elements has the same requirements as the installation of the exterior wall elements. When installing the exterior facade, care must be taken to ensure that the large-format components are all installed and secured with a precise fit. Due to the accuracy of fit, care must be taken here to ensure that no limbs are jammed. To ensure full concentration and safety, there must always be a break of at least 15 minutes after 2 hours of work, suitable protective clothing like long sleeves and trousers must be worn and the workers must be supplied with sufficient fluids.

At the same time, the interior work takes place. Here the individual furniture modules are brought in as well as the connection of technical plants is accomplished. This must always be checked by the appropriate specialist personnel. The occupational safety officer must always ensure that there are never too many people in one room or place at the same time. Appropriate aids for assembly must also be used. Head protection must be worn to prevent impacts to the head area. Ladders and other equipment must be properly erected and secured. The operating instructions must be taken into account.

For the technical installations, such as the connection of the metal façade, which is covered with a metal mesh filled with organic photovoltaics (OPV façade). Here, the connection must be made by an authorised person – our Electrical Engineer.

Maintenance

It is important to mention, that during the competition there will be no possibility for maintenance or access on the roof. With the final installation of the metal facade on the roof, it is not possible to move elements from that point on. Because of the lack of safely, we deny the access. In order for the OPV-modules to perform as best as possible and look clean, they can be cleaned on a daily basis with water. To do it in a safe way, either scaffolding or a scissor lift can be used or a telescope wiper. Also, the house needs to stay clean and tidy so during the exhibition phase team members will have to clean it at the end of every day.

Disassembly

The same safety regulations must be observed urgently for dismantling after the competition. The disassembly will take place in the same units, but in the opposite order.

1. Disassembly and loading of scaffolding ramp/platform and assembly of scaffolding façade (part of work unit 2) (1Day)

2. Disassembly and loading of technical installation (6Days)

3. Disassembly and loading of OPV-façade (3Days)

4. Disassembly and loading of interior components in living unit and exhibition area (6Days)

5. Disassembly and loading of timber construction (grid, modules, foundation) (4Days)

6. Disassembly and loading of the scaffolding façade (1Day)

7. Disassembly and loading of building equipment and reinstating of previous site condition (2Days)

Tools must be used properly and no one must step under them when removing parts, especially from the ceiling. All small parts must be taken out of the house and stored in a safe place. The parts must not be stored on the floor of the house or on the terrace, as they may block the paths and cause accidents. The individual modules can be taken out and lifted back onto the trucks. The terrace must be dismantled so that access to the house is always safe and there is a railing on each side. The exterior elements and the interior walls and doors must also be moved with the right machinery. Also at this stage, no people are allowed to be under the crane or work, and the health and safety officer must ensure that the procedure is carried out safely. Last but not least, the area must be cleaned again after the dismantling is completed.

14.5.2 Type and characteristics of the materials and elements

All finished ordered components as well as all manufactured components have to pass a guaranteed quality assurance. In order to achieve reliable evaluations, standardized control and test procedures are carried out on the components. A repetition of these checks is also necessary on the Solar Campus. This must ensure that the building materials and components have not suffered any damage even after transport. The following quality aspects are tested:

- Quality system
- Quality process
- Quality of the product
- Quality of delivery and aftercare

The qualities are checked according to the following aspects: The surfaces of the components must be in perfect condition visually as well as haptically. The large components must have the planned dimensions and tolerances before and after transport. It must also be ensured that the fits for intermediate elements and connecting pieces continue to fit properly. Checking the product specifications for proper use of the materials as well as proper installation of the various products.

The various materials and components must have the following properties:

- All structural elements must comply with fire conditions. In addition, fire and smoking is absolutely prohibited on the construction site. As a safety measure, any new person or supplier entering the demonstration unit premises must first be informed of the regulations that apply on the construction site.
- All materials must bear the CE mark to ensure their safe use.
- In the event of a rainstorm, to avoid flooding, a regular inspection of all drainage holes is necessary.
- Small metal parts should be properly placed to prevent injury.
- All floor slabs, outside ramps and outside stepping boards must be covered with anti-slip materials.

Most used materials: wood, glass in doors and windows, steel, aluminum and plastics and façade greenery. Furthermore, we will use oversize-chip-boards, screws, mask band, compositions, Frame chip insulation HOIZ and different material. We also need elements, which are already stuck together

as for example the wooden exterior facade. Gasoline will be stored for generator and fork lift. This is highly non-compostable and therefore it will be stored in a safe petrol can and in small quantity. It will be placed in the container, thus it is shaded and secured. The same will be ensured for clear lacquer spray cans to repair possible scratches on the metal frame. Out of this we don't use any dangerous substances.

14.5.3 **Site description**

The location of the construction site is almost directly at the eastern entrance of the Solar Campus in Wuppertal. In the foremost sense, it is a matter of protecting third parties during the construction and dismantling phases as well as protecting them during the competition period. The risk of third parties being injured or causing damage on the construction site should be kept as low as possible. The most important measure to avoid such eventualities is the fencing of the entire Solar Campus site. To the south of the HDU, a divided pedestrian and cycle path passes by, so the barrier through the site is necessary for safety reasons. There is a green area between the path and our building plot. The smallest distance between our lot and the public road is a more or less 10m. However, we will indeed have fences on our lot, to avoid rolling or moving stored items, which could endanger people and environment. The construction site will have one main access. Through the main access located to the north, all persons will have access to the construction site after verification of the access permit. In addition, requirements are set for all persons who gain access to the site. Signs will be located next to the entrance in order to raise awareness of the possible risk and to point out the protective measures to be taken.

On the construction site there will be a preparation area and an area for loading and unloading to the north. We also have a storage area right next to the preparation area and around the HDU for storing interior components and smaller items. On the preparation area we will attach the final components to the metal façade before it is connected to the rest of the units' structure. On the preparation area we will fold out a membrane that will absorb small pieces of waste. This membrane will be removed after assembly so that we can ensure a clean and safe floor during construction. Furthermore, there will be a supply line in the east, for drinking, power supply and a container for equipment and staff. Waste areas will be located in the far north to allow for quick disposal. In work units 1-5, a crane will be positioned in the south. During work unit 5, the crane will no longer be needed once the last OPV facade has reached its position and only manageable interior components need to be installed.

- The health and safety regulations must be known. If this has not yet been done, a re-training of these must take place before entering the premises. This is to be ensured by the health and safety representative or by the site coordinator.

- Each person who enters and remains on the site must sign and/or carry a confirmation of access.

- A check of the protective equipment of the person entering is necessary.

- Loading and unloading of materials and construction materials is only possible after prior confirmation by the construction site coordinator.

- It is mandatory to carry protective clothing, sunscreen and your own water bottle. In addition, at least one medical protective mask against COVID must be carried and worn indoors to protect against infection.

14.5.4 **Climate description**

The climate in this place is mild as well as generally warm and temperate. Wuppertal is a city with a considerable amount of rainfall. Even in the driest month, a lot of rain falls. The summer in Wuppertal usually starts in June with an annual average temperature from 20.1 to 21.9°C. Over the course of a

year, the precipitation adds up to 1162 mm. Even though the coLLab team is very familiar with the climatic conditions in Germany, some factors have to be considered. Since the construction and dismantling period will take place in the summer months about 9,4h sunlight per day can be expected. Especially during midday, the sun can be quite intense. Therefore, shading will be provided for the team members on the lot. Rain showers can also occur at intervals. In view of these circumstances, health and safety officers must respond to the climatic conditions. Measures such as a steady supply of fluids, appropriate variations in clothing, especially wearing hard hats, long light sleeves and long trousers, as well as sunscreen and sufficient breaks must be included. In addition, constant monitoring of weather conditions in Wuppertal is necessary in order to be able to react accordingly at short notice. The health and safety coordinator must be aware of any risks due to changes in weather conditions up to extreme climate impacts (heavy rain, exposure to environmental heat etc.). Strong winds can make working at heights particularly dangerous or cause crane instability. Rainfall can cause slickness on surfaces, increasing the risk of injury. High temperatures can cause worker headaches and other health problems.

	Januar	Februar	März	April	Mai	Juni	Juli	August	Septem-ber	Oktober	Novem-ber	Dezember
ø. Temperatur (°C)	1.8	2.2	5.1	9.2	13.1	16.1	18	17.5	14.4	10.5	6	2.9
Min. Temperatur (°C)	-0.3	-0.5	1.5	4.7	8.7	11.7	13.9	13.6	10.9	7.8	3.9	0.9
Max. Temperatur (°C)	4	5.1	8.8	13.4	17.1	20.1	21.9	21.3	18	13.5	8.3	4.9
Niederschlag (mm)	110	89	90	72	83	95	111	106	93	95	101	117
Luftfeuchtigkeit(%)	86%	83%	78%	70%	70%	71%	72%	74%	78%	81%	88%	87%
Regentage (Tg.)	12	10	11	10	10	10	12	12	10	10	11	12
Sonnenstd. (Std.)	2.9	3.9	5.4	7.9	8.8	9.4	9.5	8.5	6.6	4.9	3.4	2.7

Fig.14.1: Climate chart of Wuppertal during the year (source:climate-data.org)

14.5.5 Accesses and paths for vehicles

As already communicated by the SDE 21>>22 organizers, during the construction period the Solar Campus will be closed for other access from outside by third parties. Only authorized persons and suppliers with appropriate protective equipment and permits may enter the site. If vehicles enter the construction site, they must follow the safety regulations applicable on the Solar Campus. The vehicles will be guided through the Solar Campus by an authorized person from the moment they enter the site until they reach their destination. The corresponding person of the coLLab team is also equipped with a safety vest and thus clearly recognizable. It is their task to ensure a safe journey through the Solar Campus to their own construction site. In order to avoid possible accidents, it must be ensured that the vehicles move at a maximum of walking speed. In addition, the trucks need to be guided on the Solar Campus as followed: One person must walk in front of the truck; Another person must walk behind the truck. These two people will have to: Establish the maximum speed of the vehicles; direct the movements of the truck; avoid the accidents with people, with the rest of vehicles and/or with the different elements of SDE21/22 Solar Campus. Before entering the Solar Campus, the vehicle owners are informed about all regulations as well as the exact loading place at their own construction site. It is particularly important that the team ensures that no unnecessary materials and tools are in the path of travel. The trucks have to be unloaded after 90minutes and leave the solar campus area throughout the signposted exit.

14.5.6 Determining factors for the house placing

The demonstration facility of the coLLab team will have the entrance for the public tours on the north side. In addition to the better accessibility and attractive development possibility from the square, the safety aspect was also taken into account in the decision-making process, which ensures safe and guided evacuation in emergencies. In addition, this lends itself on the one hand for the reason that the

south façade can be shown more freedom of the building directly towards the path. The main reason, however, is a safety aspect. The sufficient open space on the south side of the property leads to a greater safety factor for third parties. This can prevent risks and accidents.

14.5.7 Overlaps with the affected services and other activities of the environment, able to cause risks during the construction

In direct neighborhood to the construction site of the team coLLab are on the right hand the team X4S as well as on the left hand the team deeplyHigh. Here the restrictions of the individual construction fields which were determined by the SDE 21>>22 organizers are to be considered. Furthermore, there should be a constant coordination with the respective teams regarding the arrival and departure of delivery vehicles as well as the use of cranes. This is particularly important to minimize the risk of injury to third parties in the vicinity of the construction site. Crane work shall only take place on the property and shall not encroach on neighboring lots or the open space to the south. In addition, the teams' properties and the intermediate areas must be respected, which means that they may not be used as intermediate storage areas. They also serve as a safety area during the construction phase. However, this should be able to be ensured through constant communication from the health and safety coordinators. If particularly noisy work is being carried out on the demonstration unit, it is essential that the surrounding teams are informed. Otherwise, there is a risk of hearing damage to third parties. Moreover, security problems can be caused due to the great number of people on the building site at the same time. As mentioned before, there is a pedestrian and bicycle path in the south passing by. A wide green strip and a perimeter fence around the Solar Campus prevent unauthorized access by third parties and protect the public zone from danger. Nevertheless, special attention is required.

14.5.8 Planned activities

Project development, prefabrication to HFT, construction and dismantling, betting period.

Five basic work phases for risk prevention have been defined. The first work phase is the overall project development and project management. Here, the most detailed and realistic work possible must be ensured in order to quickly identify risks in the project process and minimize them if possible. Furthermore, the coLLab team at the HFT Stuttgart holds several workshops for the construction of individual components of the demonstration unit. Here, a timely schedule is to be ensured in order to avoid possible overlaps. In addition, all persons participating in a corresponding workshop must be made aware of the occupational health and safety guidelines and safety regulations. Compliance with these is to be constantly monitored by the health and safety representative. Other critical phases are the construction period and the dismantling period of the demonstration unit. The risks during the construction periods have already been explained in the process. As the time windows for the respective phases are defined by the SDE organizers, it must be ensured that these can be adhered to. If there is a risk of non-compliance, the health and safety coordinator and the site manager must take appropriate action. This is particularly necessary during the construction phase, as otherwise participation in the competition cannot be guaranteed.

A Work-Units		B Tasks		C Agents
Break down to WORK-UNITS		Identify TASKS in each work unit		Identify the AGENTS
Work Unit	Name of Work Unit	Task Number	Name of the task	Name of the agents
Assembly Phase				
Work Unit 1	Building site equipment	Task 1	Building site equipment - transport	HS-coordinator, SO-coordinator, workers, truck, load
		Task 2	Building site equipment - unloading and storage	HS-coordinator, SO-coordinator, workers, truck

Fig.14.2: Excerpt risk analysis excel file, columns A to D

To conclude, our planned activities can be divided into the project phases "Project development", "Prefabrication HFT", "Assembly", “Transport”, "Disassembly" and "Competition". We then subdivided each of the project phases into individual work units, which combine larger work packages with related content. Within these work units, there are individual tasks that represent the measures they contain (see figure 1 and risk analysis excel file, columns A to D).

14.5.9 Trades whose intervention is affected by the risk’s prevention

Each of the individual trades is affected by a specific risk prevention. It is important that, without exception, every person who is on the construction site undergoes safety training in the process. This safety training will deal with all general safety regulations. After completing this training, specific specialized groups will be formed. Depending on the area of responsibility on the construction site, individual safety training will take place here once again. The following trades will be trained in particular:

- Timber construction; The construction and erection of the building structure requires a crane as well as scaffolding. All workers in this trade must be informed about possible dangers.

- Suppliers; Special guidelines apply on the Solar Campus. All drivers must be informed in detail about these regulations.

- OPV- Metal-facade; *(Explanation: The metal façades are enclosed in large square tubular profile frames covered with a stainless steel mesh. The resulting lozenges are clad in advance with organic polycarbonate photovoltaic (OPV) panels. The finished frames are delivered to the construction site and then fitted with the final angles for assembly on the grid).* The facade components are very large and heavy. All risks to be considered and requirements of the assembly must be known in the process.

- Interior fittings; The interior fittings consist of large and heavy elements the assembly of these must be known and thought through. Furthermore, the connection of electrical components and other installations must be clarified. Only verified persons may carry out these installations.

- Scaffold erection; The scaffold may only be erected by qualified personnel. They must be informed about all risks and regulations.

In addition, it must be noted that only persons who have completed a trade-specific training are allowed to work in this field of activity.

Meeting name	PositionFrequency/When/Where/Minutes	Attendees
Brief Meeting	Every day Before start working. Construction site 15 minutes	H&S Coordinator Construction Manager Site Operations Manager Team Safety Officers Team members Contracted staff and professionals
General H&S Team Training	Once May Construction site 2 hours	H&S Coordinator Construction Manager Site Operations Manager Team Safety Officers Team members Contracted staff
Special Training	On a regular basis.	H&S Coordinator

	When a new supplier or a group of people enter the site for the first time. Construction site 10 minutes	Construction Manager Site Operations Manager Team Safety Officers Team members (specialized groups)
Individual Training	Once Construction site 30min	H&S Coordinator Site Operations Manager Team Safety Officers Team members (individual for specific tasks)
H&S general meeting for all SDE Teams	Daily meeting	H&S Coordinator H&S Officials of SDE organization

Fig.14.3: Meetings related to Health and Safety

14.5.10 Auxiliary resources planned for the construction

The coLLab team will use a variety of tools for the construction. First and foremost, the facade scaffolding is a particularly important tool for ensuring safety standards. Furthermore, a storage for tools as well as safety clothing and safety equipment will be installed at the construction site. For late-night work, lighting will be installed around the construction site to ensure adequate illumination of the area. A fire extinguisher and a first aid kit (First aid kit MT-CD industry standard, with wall bracket) are also made available to the construction site and must be accommodated in such a way that, on the one hand, each employee is aware of the exact location and can be available within the shortest possible time. Drinking water will be signposted and located, so that each team member has access to it. A large number of small tools can be found in the storage area. All small tools must be constantly checked for functionality and safety as well as grip strength. All team members must be instructed in the proper use of all tools.

PPE	**Where/ when required**
Safety Boots	Entire site / Continuous
Safety clothing (long trousers, long light sleeves)	Entire site / Continuous
Safety gloves	Entire site / Continuous
Hard hat	Entire site / Continuous
Ear protection	When using loud and heavily vibrating tools or in close proximity
Reflecting Vest	Entire site / Continuous
Safety Mask	Covid-19 requirements, When in contact with substances that have a strong odor and when using a tool that produces flying fragments or particles
Safety glasses	Entire site / Continuous
Safety harness (Scaffolding, incl. falls arrest)	When working on height (f.e. On the roof, on the scissor lift)

Fig.14.4: Safety gear

14.5.11 Machinery planned for the construction

Different machines are needed for the assembly and disassembly. Team coLLab requires a crane, a scissor lift, a forklift and a truck for transport. Before using these machines, it must be ensured that they have a current inspection sticker as well as comply with the conditions of the SDE organizers. The Health and Safety Coordinator must constantly monitor the proper use of these machines. In addition, it must be ensured that they are only operated by persons who have received the appropriate instruction and are authorized to use them. The forklift truck and the crane may only be used in the areas marked for this purpose. This is particularly important to avoid the risk of accidents. In addition, a stable stand must be ensured in order to avoid possible tipping. Smaller machinery will be used during construction process. All machinery have a CE branding.

Big machinery:	**Smaller machinery:**
Crane	Hoover
Scissor lift	Cable drum & extension cable
Fork lift	Trestles
Truck	Screw clamps
Van	Hammers
Crane	Drilling machine
Scissor lift	Building site radio - 2 pieces
Fork lift	Cordless screwdriver
Truck	Flex: Wood & Metal

14.5.12 Construction site installations

It should be noted that water supply as well as power supply is always on site. However, these must be installed in such a way that there is no risk of injury to team members. Lines in the open areas must be clearly visually marked. Before shoring individual lines, they must be inspected for service life and suitability. In addition, it must be ensured that the water supply is functioning properly and that the existing water is free of contamination. As for the electrical supply, electrical cables need to be checked thoroughly prior to construction but also during construction. Ageing of cables may cause damages, such as cracking, which can reduce their service life and suitability. Also, cables can be attacked by rodents, so they have to be checked on a daily basis.

List of site installation:

- Scaffolding with fall protection
- Lighting - Mushrooms and structural steel
- Ladders for indoor installation
- Shading (Pavillon)
- Drinking (fresh water)
- Waste containers
- First aid kit
- Fire extinguisher
- Container for staff and tools
- Waterways
- Membrane for laying

The waste is to be separated into the following areas: plastic, residual waste and organic waste. In addition, non-recyclable materials will be disposed of separately and properly. Waste bins are sorted and disposed of in the area marked for waste, which will be cleared at least once a day.

14.5.13 Characteristics Table for the stocks

The tool stocks are, as already mentioned in the process, stored in a specially designated storage area. For materials that are needed for the construction of the demonstration unit, a separate material store will be created. Strict attention must be paid to proper storage for the respective material. In addition, the removal of materials and tools should be controlled to ensure order on the construction site. Both warehouses must be permanently tidy and clean in order to keep the risk of injury to a minimum. No special chemicals will be stored at the Team coLLab construction site. It it woth mentioned here that the only chemicals used dring construction are clearcoat spray cans and roof sealants. An appropriate PPE will be used (safety masks) while performing the task and even throughout the operation depending on the Covid19 situation. The container for stored spray cans, smaller tools and machinery will be locked against unauthorized access during night. Storage area will be partly surrounded by a fence to insure the stored load is being kept away from the escape routes and supply chain in the east.

14.6 Activities for Risks Prevention

As already described in the process, a large number of different measures are carried out to ensure 'risk prevention. This includes primarily all different training and instruction measures of all persons involved in the construction of the demonstration unit. Furthermore, a detailed planning of the construction process as a precaution for accident prevention will play a significant role. A constantly neat and clean construction site will further reduce the risk of accidents due to tripping or the like. An independent definition of guidelines and requirements as well as the observance of official guidelines must be considered essential. For the safety of our workers, we have personal safety equipment like hard hats, safety goggles, safety vests, ear protection, safety gloves, safety vests, safety shoes, safety clothes and safety masks. For more information see annexed Safety Equipment List.

14.6.1 Construction plan: determination of work effective timing

To ensure the smoothest as well as safest construction process, the development of an effective schedule of the various works and milestones on the demonstration unit is particularly necessary for risk prevention. In this context, it is important to ensure that sufficient safety margins are included for unforeseen increases in working hours. In this way, overlaps of individual trades that increase the risk of accidents can be avoided at best. The health and safety coordinator and the construction site coordinator must coordinate their activities on a regular basis and, if necessary, make adjustments. This would be possible by swapping shifts of individual trades. We will work in 2 Shifts of 8h maximum up to 10h in specific cases. The first shift starts at 07:00 am in the early morning and lasts until lunch at 12:30 p.m. With an hour of break the workers of the first shift continue working until the late midday. The second shift overlaps 30min with the prior shift to inform the following team members about the state of progress and upcoming tasks. The first part of the second shift takes lasts about 6h. A dinner break will be taken, in order to ensure a safe and concentrated work conditions. The second shift stops latest at 11p.m. All shifts will have a 15min break every 2h and a lunch break of minimum 30minutes. There will be 11h of rest time between shifts of a worker. The labour time of each member will be registered. In order to do that, we will have a list on a laptop in form of a daily construction records. The observance of the breaks is controlled. The HS Coordinator and two Safety Team Officers will attend to each shift.

Time [h]	07	08	09	10	11	12	12:30	13:30	14	15	16	17	18	19	20	21	22
Team shift 1	15 min brief-ing		first half 5,5h				1h break	second half 2,5h		end of shift		latest end					
Team shift 2						15m in brie fing				first half 5h		1h break	Sec ond half 3h		end of shift		latest end

Fig.14.5: Time schedule related to determination of work effective timing

14.6.2 Overlaps and incompatibilities in the construction

With our assembling-steps there are almost no incompatibilities of the construction because of the high prefabricated modules and will mostly be directly assembled to the rest of the structure. Nevertheless, there will be overlapping works. Overlapping work units are described below and prevention measures are outlined to ensure that tasks do not interfere with each other through coordination:

Before the start of construction, it must also be ensured that the substrate is fixed and ready prepared. Otherwise, accidents may result with the use of machinery.

Before assembling the individual wall and ceiling components, it is essential to ensure that the facade scaffolding has already been erected; otherwise the risk of injury and accidents will be greatly increased. In addition, it must be ensured that there will be no overlaps between the assembly of the interior finishing elements and the ceiling elements.

Extreme care must be taken in coordinating the work units running at the same time. The construction schedule shows that work on the outer façade, i.e. the OPV façade, which is mounted on the grid, and work on the inside of the HDU are quite possible. In the process, parts that are assembled by crane can pose a significant potential hazard to people walking around. The work areas are divided into outside and inside work, which is why workers hardly get in each other's way and disturb each other. In work unit 4, most of the work is done on the outside on the roof, west, south and east sides. The north side has no metal facade on the grid. This means that the north side is freely accessible and safe for work unit 5, which can be carried out independently of the façade. This mainly involves the installation of wall cladding and exhibition materials and components. Installation and electronic connections are also carried out within the HDU. Once the final façade element is assembled, the crane is dismantled and the OPV façade is connected.

During all work phases, cleaning work takes place in between or at the same time, but this does not pose a danger as each worker follows the appropriate instructions.

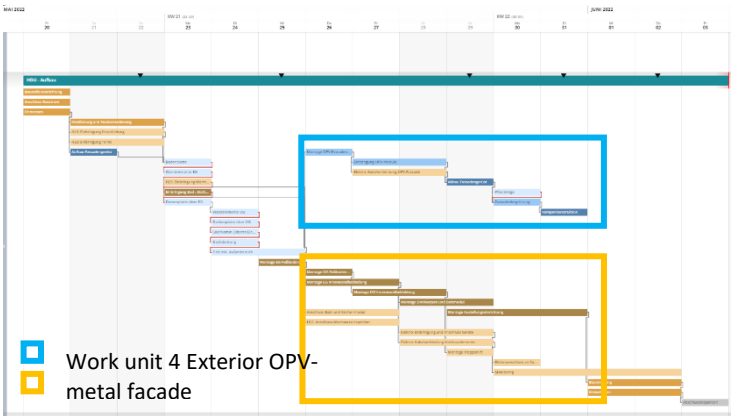


Fig.14.6: Scheduling of overlapping work units of interior and exterior façade construction.

14.6.3 Number of Team members taking part in the construction

The coLLab team is currently working on the extent to which a certain number of students and team members can be released for the set-up, competition and dismantling phases. Currently, in addition to the faculty supervisor, HS and SO coordinator, 6 contracted staff members from the university represent the team safety officers, 21 team members (students and professors) are listed who will participate in the set-up and dismantling of the demonstration unit. In addition, approximately 30 contracted staff from partner companies will be assisting us with the construction. It should be taken into account that in the first few weeks about 5 people from the carpentry company and 1-2 days

about 5 people from a scaffolding company will be on site. Due to the two-shift operation on the construction site, approx. 10-15 team members per shift will be busy with the construction of the demonstration unit. The detailed list can be found in the Excel Specific Term & Condition Documentation. A highly simplified list is provided in the appendix. There will be a limited amount of people from partner companies visiting the HDU and construction process, but not taking part at any construction task. As every Team member, visitors have to wear individual protection like safety boots, -hard hats and vests as well. They also have to sign the consruction Site Ordinance, which describes the safety demands. To avoid confusion they are being briefed about instructions concerning the working procedures. Those visitors are namely listed under contracted staff and other team members of the extended list of the Team Specification Document.

14.6.4 **Contracting planned**

Planned contract conclusions for the construction phase are currently planned for the following companies: The control of the regulations and prerequisites must be carried out by the health and safety coordinator.

The partner company *Bau-Fritz GmbH&Co. KG* will support the coLLab team in the construction of the demonstration unit as well as in the assembly of the facade components. Contractually, a certain number of persons is to be assigned for the period in Wuppertal. In addition, safety training for all persons involved will be mandatory. Furthermore, the company is to provide assistance for machines and trucks. The company has to ensure and prove that these comply with the general requirements and safety regulations and that the respective vehicle drivers can prove their suitability for the equipment. The stairlift will be installed by the company *LiftTech*, which is another partner of the coLLab Team. The company *Helix Pflanzen GmbH* is sponsoring our vertical facade greenery, as well as the roof greenery cassettes. They will infiltrate the plants of the façade greenery into the metal mesh of the OPV-Metal façade. Another Partner is *Schuster Innenausbau* from Salach, which assist us with the interior construction. The Scaffolding for the exterior façade will be *Karl Stüben Gerüstbau GmbH* from Wuppertal. They will help and instruct us with the assembly. Another Scaffolding company Podestbau Kleu will build up the platform/ ramp. For reasons of occupational health and safety as well as protection of use, a specialized company that is very familiar with scaffolding is absolutely necessary in order to avoid accidents and risks. It must also be ensured for this company that all persons entering the site have completed appropriate training and are familiar with the safety regulations. Least but not last the transport is taking over several logistic companies. To mention two, Baufritz and *Wackler* from Göppingen.

14.7 **Critical work phases for risks prevention**

Load/ unload tasks:

The high danger zone will be separated from the rest of the working site. The team members have to wear safety helmets, safety shoes, safety gloves, reflecting vests and long sleeves and trousers. Extreme care must be taken to avoid falling objects when lifting with a crane or forklift truck. When unloading occurs, the crane will be completely locked. The crane are will be surrounded by fences or bands, which are dependent to hold people away from the locked area. The aim in this phase is to have as few persons as possible working around the danger zone.

When operating on the electricity and technical installation, the power has to be turned off as well as the necessity of grounding the electrical system. The authorized person - Siegfried Baumgartner as our Electrical Engineer, will do the operation.

Exterior work:

Because of the narrow and difficult place, the assembling of the solar chimney hast to be done with high carefulness. The Scaffolding is placed in front of it. Nevertheless there is a high risk of colliding of the solar chimney components with the scaffolding. This would have a domino effect of risks such as strong vibrations and instability of the structure, which could endanger the surrounding environment. For this reason unnecessary team members have to stop their work on the other side of the scaffolding or and superfluous people for assistance have to get off the scaffolding. The load will be properly secured on the crane and will be guided by ropes handling and directing it to its final position. Due to the high prefabrication modules the chimney will be assembled in two elements, which will interlock with each other when stocking them on top of each other. This will ensure a safe and quick positioning. Safety protection hast to be worn at any time, especially wearing reflecting vest to be seen by the banksman. The SO Coordinator has to provide guidance because of the high risk of bruises and getting trapped between component and scaffolding, which leads us to the next critical work phase. The previous mentioned risks preventions also apply to the coordination and assembly of timber construction. Great care must be taken when assembling large walls and ceiling components. The precautions for the solar chimney also apply to the coordination of the modules. For this reason, the scaffolding of the facade moves outwards to the open space with the finished assembly of the actual housing unit. The different phases of the scaffolding are emphasized in the assembly sketches.

During the construction of the facades scaffolding, it is forbidden to climb or enter the incomplete structure. Only authorized and clear instructed team members and contracted staff is allowed to assemble. Railings are preventing the risk of falling of the scaffolding. There are two entry/exits envisaged. Jumping off and running on the structure is prohibited. In respect to the amount of risk of and its impacts on fatal injuries, a special attention has to be taken into account of HS Coordinator and Safety Team Officers. Especially hard hats and safety boots have to be worn.

When assembling the OPV-metal-façade there is hast to be a high attention to the overlapping work units with the interior tasks. As soon as the OPV-façade on the roof is being mounted, the scaffolding of the façade is being disassembled and the crane will no longer be needed. When transporting the cane from site an increased mindfulness is needed while dismantling. This will be ensured for example by a restricted area for unauthorized personnel, given instruction and guidance from the HS and CO Coordinator and PPE for preventive protection. Since the Scaffolding is removed, a wooden construction must be erected for the temporary safe entry and exit of the unit until the Scaffolding of the final platform and ramp has been assembled.

Interior work phases:

Special care must be taken when working inside the unit. When assembling vertical and horizontal panels, possible fall hazards are to be prevented with preventive measures for fall protection by means of safety straps or railing devices. When installing ceiling cladding, beware of falling chips, dust or the possibility of impact from objects at head height. Take appropriate precautions before team members start the task. This requires clear instructions and the wearing of helmets, safety goggles and safety shoes as well as protective clothing. Gloves have to be taken off when operating with rotating machines and tools. Ladders are necessary to carry out work at higher levels. The dangers should not be underestimated. Proper positioning must be ensured and a second person regarding the operating instructions must secure the ladder.

If there are special action, we will let our neighbors know for example in case of loud noises. In order to minimize risks in critical phases of work, all team members are informed about the upcoming tasks in morning briefings before work begins. The aim is to better coordinate overlapping work phases and to alert those who need special attention. In addition, the special groups for the individual work units are trained in advance and prepared for the possible preventive measures to avert and prevent hazards. With a trained team, we are confident that risk minimization and prevention are feasible and that members will follow instructions and preventive measures will be effective.

14.8 Risks identification and efficacy evaluation of the adopted protections

The various relevant risks and the evaluation of the effectiveness of the protective measures to be taken are described below. In the health and safety sketches, the exact areas in which work with particular risk is carried out are marked.

14.8.1 Location and identification of the areas where the works involving special risks will be developed

In the very north of our site the arrival of transport is located and with it the **unloading and loading zone**. The reasons for the numerous accidents during loading and unloading are that the work is carried out in close spatial proximity or the driving personnel use industrial trucks of the loading or unloading company without sufficient instruction. Accidents involving forklift trucks are among the most frequent and sometimes serious accidents. People are often hit by forklift trucks or hit by falling loads. Making sure that drivers stay out of the danger zone prevents such accidents. Coordination is particularly important in situations where drivers are supervising the loading or are already making preparations for securing the load during loading.

There will be a **preparation zone** on the construction site, where there will be lots of dangers, because a lot of people and components will remain there. When the crane will rotate loads above this area, nobody is allowed to stay there. The **crane area** will be locked. An example of this is the clear definition of the location for the crane and its restricted zone for unauthorized personnel. It is essential to ensure that the corresponding crane locations are compacted. This is based on various instruction videos on the proper handling of this topic. The protective zone to be maintained ensures that no unauthorized persons are in the danger zone of the crane. This minimizes the risk of accidents and injuries.

Within the **construction area**, risks also arise from the work equipment to be used (accidents due to electricity, heat, compressed air or because of dangerous tools such as saws). Hazardous substances, scients and dusts can also endanger health. The same applies to paints, bitumen and mortar, among other things. A wide variety of hazards and stresses can occur on the construction site, for example due to: constantly changing workplaces and working conditions, working at great heights, working in the direct vicinity of equipment and machinery, the presence of noise, dust and vibrations, hazardous substances contained in building materials or working in wet, hot, cold or draughty conditions. Limited room for maneuver and monotonous work processes can increase the risk potential just as much as constantly exceeding one's capacity. Lifting and carrying instructions must be observed. It is precisely the multitude of hazards and stresses that make it indispensable to take the necessary measures for the safety and health of employees at an early stage.

The biggest dangers lurking in the **storage area** are probably: physical strain from lifting and carrying too heavy and too many parts, from moving machines such as the crane, objects falling or rolling away insecurely stowed away. Contact with dangerous substances or small and sharp objects. Lack of knowledge and training in safety at work. There is also an increased risk of slipping, tripping and falling accidents. It is essential to keep the storage areas tidy and clean to prevent certain components and tools from falling.

Besides the storage area, other particularly relevant areas with a special risk are the **scaffold areas**. In these areas of the scaffold surfaces, care must be taken to prevent the scaffold from being knocked over or damaged by construction machinery. In case of improper handling, erection of scaffolds in strong winds, there is a risk of falling from scaffolds and mobile working platforms. In principle, during assembly and dismantling and during work on the scaffold, the structure should be properly erected from the outset in order to minimize the risks. This should be done by specially trained personnel and supervision by other persons for early hazard identification. During work on the scaffold, utensils, materials and other objects may only be placed in the marked areas. Storage of these objects on the safety scaffold, for example, is not permitted. In addition, the working areas must be easily accessible.

Accordingly, accesses and escape routes must not be blocked. The materials should be positioned in such a way that it is possible to walk easily over the entire scaffold. If several workers are working on the scaffold at the same time, they must be staggered. This means that there is no other worker either below or above the craftsman. This prevents the skilled worker below from being injured by falling objects.

14.8.2 **Risks identification and efficacy evaluation of the adopted protections**

In case of hazards, the work or machinery has to be immediately **stopped**, especially in case of accident. Lack of clarity or unsafe behaviour is corrected and straightened out by clarifying the given instructions and daily briefings. Those **organisational measures** prevent and reduce risks to a minimum before work units with their tasks have started. Technical Measures will be used not only to protect the team members from possible dangers, but also to ensure a safe and solid workplace. Finally the individuals personal protection equipment such as: safety hard hats, - glasses, - vests, - ear protection, -gloves and – clothes (long sleeves and trousers) will have a great effectiveness on preventing and diminish injuries and possible accidents. Each team member will keep a copy of the evacuation plan with him or her in case of an emergency. A further evaluation of a detailed listed risks is being emphasized:

S = Temporary stop of work and machinery; O = Organisational measures; T = Technical measures; P = Individual Protection measures

Risk assessment – risks generated by other

Risk of unsecured unsafely stored objects/load that could slide away and hurt surrounded people; S: Stop working; O: proper load securing acc. to legal requirements, clear instructions, team briefing, wearing safety shoes

Risk due to laser beam or UV-radiation; O: surrounded team members should be informed when starting using the laser, operating instruction and worker briefing before starting the task, pointing at people and looking directly into the laser point is forbidden; P: The risk of injuring the eyes is being reduced by using safety glasses with UV-Protection.

Trapped by turned over machines or vehicles; signs will show, that you have to pay attention to the surrounding; operating instructions, guidance and other safety measures for drivers and operators

Vehicle collisions with persons on site (e.g. driving reverse); S: Stop; O: Drivers with appropriate licensing, anticipatory driving, speed restrictions, warning sound during maneuvering, person in back and front of the vehicle, guidance; P: Wearing reflected jackets minimizes the risk of fatal injuries; Signs

Vehicle collisions with e.g. temporary stored objects on site and other collision on track; S: Stop; O: Drivers with appropriate licensing, anticipatory driving, speed restrictions, warning sound during maneuvering, person in back and front of the vehicle, guidance according to rule 51 will reduce the possible risk to a minimum; P: Wearing reflected jackets; Signs

Risk due to vibration caused by tools and machinery; S: Stop; P: wearing hearing-, glove protection, long sleeves and trousers

Fall of objects because of collapse; all team members wearing safety helmets at all times

Fall of objects because of manipulation; unauthorized people are not allowed to enter the site

Risk due to uncoordinated on-site-layout; There won't be any differences because of the approval of the SDE Officials

Fire; we have a fire extinguisher in the staff container and three inside the HDU.

Exposure to harmful substances (e.g. remaining on objects- accidently rubbing touched chemicals in eyes or skin); S: Stop; O: there will not be any harmful substances on the site, except Lacquer spray can and bitumen membranes, the cans will be stored safely and shadowed in the material container and will be locked during night; previous work briefing, accurate instructions, P: wearing protection googles, long sleeves and trousers and safety gloves, regularly washing hands will help

Risk due to narrow loading zone; S: Stop; T: rearrange truck; O: guidance, a marked loading zone has being set by the SDE Officials regarding the on-site layout.

Risk of overheating, undercooling or lack of security requirements (e.g. defective air conditioning, no life-belts, etc.); S: Stop, T: Regular maintenance and service of the vehicles, tools and devices according to the regulations, P: wearing long sleeves and trousers

Stepping on objects; the workers have to wear safety shoes and the construction site has to be cleaned permanently; stored material only in designated areas.

Risk assessment – risks generated by environment

Risk due to metal, wood dust remaining surfaces; O: operating instructions; T: use of dust extraction devices; P: last wearing face masks and protection googles

Corona-virus infection; O: Worker briefing, adequate hygienic concept, wearing masks; P: vaccinations

Exposure to solar radiation; There will be enough sunscreen and water in or next to the staff container

Explosion; There won't be any explosion substances on site

Accidents caused by living beings; the team members need to wear safety clothes as long sleeves and trousers

Dangers due to darkness and poor visibility e.g. at night; there will be spotlights on the construction site in order of there being enough light all over the construction site

Flying fragments or particles; the workers need to wear safety goggles and helmets

Risk assessment – risks generated on other

Risks due to ergonomic and organisational deficiencies of the work system; S: Stop; O: Worker briefing, clear instructions and early stage of communication

Working with contracted staff: instruction problems; O: Worker briefing, company declaration of appropriately trained staff

Working under unwanted pressure; Include buffers, time management and route calculation

Adverse effects of extreme weather conditions; S: Stop, O: adjust driving/construction to the weather conditions (e.g. heat or heavy rain or wind), long light sleeves and trousers, reflective rain jackets, shading pavilions and fresh drinking water on site

Risk due to falling objects from the crane/ carrying aids; S: Stop; O: Load paths not over traffic areas, secure loading, guidance, warning signs; P: wearing reflecting jackets, safety helmets have to be worn at all times. If a helmet cannot countervail against the falling object, the area will be locked by hoarding

Exposure to extreme environmental temperatures inside the semi-finished housing unit and outside; O: fresh drinking water on site, Sunscreen and shading pavilion; P: regularly water intake, helmets and long light sleeves and trousers.

Risk due to letting go of components; S: Stop; O: working teams, worker briefing, carrying aids as (e.g. lifts, rolling supports, cranes, helping hands while assembling); P: Safety gloves and shoes, helmets

Risk assessment – self-generated risks

Carrying too heavy or too much at a time; O: working teams, worker briefing, carrying aids as (e.g. lifts, rolling supports, cranes, helping hands to carry); P: Safety shoes, helmets and gloves will protect from possible injuries.

Risk of falling from height (scaffolding); S: Stop; T: proper scaffolding securing acc. to legal requirements, O: there won't be any unsecured building edges, gabs will be covered by boards; P: wearing helmets and long sleeves and trousers and safety shoes

Non traumatic pathologies; smaller injuries will be medicated until the worker can continue working without any restriction

Fall, tripping or slipping of persons at different heights as well as ground level; O: always a clean and tidy construction site; properly stored and secured material and components will avoid the risk, step by step movements and no jumping, use handrails and mindfulness; P: hard hats will have a strap so that they do not fly off when falling. Wearing safety shoes. It is recommended to wear long sleeves and trousers to minimize the effected injuries.

Headache and lack of concentration due to dehydration; S: Stop; O: Receive some fresh air by opening windows (,when being inside), risk can be avoided with a lunch- and smaller breaks in-between, schedule of work shifts; P: Regular water intake, food in SDE cafeteria

Risk due to overtiredness and overexertion causing human mistakes; O: Adherence of work and production procedures, working hours and their interaction (e.g. timetables, rota services...) (11h break between shifts, min. 30min lunch break), No operation of mechanical devices will help to reduce dangers;

Incorrect use of machinery and tools; S: Stop machinery; O: Machine operators with appropriate licensing and clear given operating instructions; P: Wear necessary PPE

Trapped by or between objects; O: Previous organisational worker briefing, Stop ,always use security measures (e.g. belts securing the load), wearing working shoes, helmets and gloves, reflecting jackets

Risk of electrical hazards (e.g. electric shock due to damaged cables); S: Stop, O: Check functionality and regular maintenance of the electronics; T: disconnect or turn off the power while working on electronics, only authorized team members grounding and installing electric systems, should not happen because the system starts working power after it's completely installed.; P: Safety clothes

Risk of cutting yourself due to sharp-edged material; O: Having edges already smoothed round in fabrication, handling instructions, P: use protection gloves, long sleeves and pants

Risk of getting hair caught in machinery tools or between material; S: Stop; O:worker briefing, all team members with long hair using hair band or hair tie

Blisters on the skin (e.g. hands) through vibration of used devices and routine movements; O: work shifts schedule, humid hand cream in breaks in between; P: wearing protective gloves, long sleeves and pants

14.9 **Collective protections to use**

Collective protective measures are the generally applicable measures for the protection of team members, external specialist personnel and third parties. The following are considered general protective measures:

- The definition of specific areas of use
- Instruction in the general protective measures
- Instructions in case of emergency

- Signposting about the labour risks
- prohibition of fire and smoking on the entire construction site
- Control of installations by qualified personnel
- Compliance with the Working Hours Act
- Order and cleanliness on the construction site
- First aid station
- Construction schedule with risk management
- Protective fence around the entire construction site SDE Solar campus and areas that are exposed to risk on site and to protect the property from burglary and vandalism
- Fall protection of the scaffold areas
- Marking of laid installation lines
- Continuous monitoring of weather conditions
- Machine operation only by authorized skilled personnel
- Checking of water quality for contamination
- Provision of storage areas for tools and materials
- Shading pavilion
- Spotlights for light working conditions
- Briefings and specific trainings for the different work units and tasks on the daily agenda

Each of these generally applicable protective measures must be checked and ensured by the health and safety coordinator and the site management. The collective Protections have to be used according to the operating instructions for work equipment, work procedures and hazardous or biological substances. These Instructions are written in German, so that they are understandable to the Team members. The instructions are attached to the Annex.

14.10 Individual protection resources to use

In addition to the generally applicable protective measures, each person on the construction site must also observe appropriate safety measures and wear protective clothing. In addition, protective equipment must be provided by the health and safety coordinator. The collective Protections have to be used according to the operating instructions for personal protection equipment. These Instructions are written in German, so that they are understandable to the Team members and are attached to the Annex.

- Safety shoes high ankle of at least grade S3 must be worn at all times.
- Protective work clothing such as long work pants and long light sleeves must be worn.
- Protective gloves must be worn when working with heavy, pointed or sharp-edged components.
- A luminous safety vest must be worn at all times when working outdoors
- In the event of strong sunlight, the skin must be protected with sunscreen
- A safety helmet is to be worn at all times
- Bring your own water bottle when entering the construction site.
- Safety goggles must be worn if necessary
- When working on the scaffolding or on the roof, a safety belt must be worn to prevent falls.
- In appropriate weather conditions, rain jackets or warm jackets must be worn to protect against hypothermia.
- The specified distances from hazardous areas must be observed at all times.
- The breaks according to the Working Hours Protection Act are to be observed
- PPE provided for visitors an third parties entering the site

There will be a storage area for all protective clothing and supplies. The Health and Safety Coordinator will supervise the issuance of materials and shall ensure that all specified safety measures are followed.

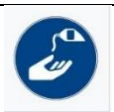
Detailed information about the technical specification of the used products for the PPE provided by the Safety Equipment List in the Annex.

14.10.1 Signposting of the risks according to DIN EN ISO 7010

We are planning to attach the following signposting on our site, to alert team members and third parties to potential risks and safety precautions. :

Sign	Name	Location of Sign
	First aid kit	First aid area, staff container, van
	Emergency exit (to the left/ right)	Along emergency exit routes
	Assembly point	Assembly point
	Emergency telephone	Staff container
	Fresh drinking water	Near the container
	Fire extinguisher	Position of fire extinguisher inside the HDU, the staff container and car
	No entry - for authorized persons only!	Entrance of construction site
	No open flame; fire, open source of ignition and smoking prohibited.	Entrance of construction site
	Use of the incomplete scaffold prohibited	Construction site during scaffolding tasks
	General danger	Entrance of construction site
	Warning of electrical voltage	Construction site in case of risk of electrical loads
	Warning of obstacles on the ground	Entrance of construction site
	Warning of danger of falling	Construction site in case of risk of falling (scaffolding)
	Warning of danger of slipping	Construction site in case of slippery surfaces

	Warning against falling objects	Entrance of construction site
	Warning of obstacles in the head area	Entrance of the HDU, in case of interior works
	Warning against flammable substances	Construction site, material container
	Risk of pending loads	Entrance of construction site
	Warning against industrial trucks	Entrance of construction site
	Laser beam warning	Construction site
	General commandment	Construction site when raise of awareness is needed
	Ground necessary	Construction site
	Use of head protection	Entrance of construction site
	Use of reflecting vests	Entrance of construction site
	Use of hand protection	Construction site
	Use of foot protection	Entrance of construction site
	Use of masks	Entrance of construction site
	Use of safety goggles if necessary	Entrance of construction site
	Use of ear protection if necessary	Entrance of construction site
	Use of working uniform	Construction site

	Hand washing	Construction site
	Use of skin protection	Construction site
	Keep this place litter free	Entrance of construction site

14.11 Safe working procedures of every Team member

Each team member must comply with and observe the safe work procedures described in the procedure. In addition, each team member is responsible for working on the construction site only if they are mentally and physically uninjured. This inertness must also be checked by the health and safety coordinator and is stated by the medical statement of each team member on site. The Documentation will be provided by the *SDE21_HS_Medical-Statement_V1.0_02_11_21.pdf*. Due to the current high demand for doctors, it is difficult to get appointments. Therefore, missing documents will be submitted later. The list of participants also shows which participants have already submitted their statements.

No one is allowed to enter the construction site without the appropriate personal protective equipment (PPE). Anyone not wearing the appropriate PPE will be asked to leave the site and may not return until they are wearing the appropriate PPE.

Prior to the start of construction work, all staff must attend health and safety training. These trainings are designed to provide sufficient knowledge to work with safety precautions. Work training is also provided to familiarize workers with the use of tools and equipment and to learn how the installation process works. The Health and Safety Team Coordinator and designees are responsible for meeting the requirements of the plan, but all team members also have this responsibility. All team members must agree to the terms of the HS Plan and therefore abide by them throughout the process.

Smoking is not permitted on site. Anyone seen smoking will be asked to put out their cigarette immediately. The coLLab team is prohibited from taking drugs or alcohol for non-medical reasons on site. Anyone found to be under the influence of drugs or alcohol will be immediately removed from the site and suspended from duty.

As far as hygiene conditions are concerned, all construction sites are ventilated, lit and kept in constant cleanliness. For antibacterial prevention against the COVID-19 pandemic, disinfection dispensers are placed at the entrance and at the staff container. FFP2 masks must be worn when working indoors at a distance of less than 1.5 meters. The staff container will only be used as a rest and meeting room where fresh drinking water will be provided for each staff member. There will be no toilets on site and no places for lunch or dinner. Both will be provided by the SDE organization.

14.12 Machinery and auxiliary resources

A description of the machines and tools required for the assembly and disassembly of the demonstration unit can already be found under items 14.5.10 and 14.5.11. At the current stage, no further resources are planned. However the construction schedule and Building Equipment List, as well as the Number of Team members can be slightly changed. If so, we will update the health and safety plan immediately to the SDE organizers. The machinery and auxiliary resources have to be used

according to the operating instructions for machinery and work equipment. These Instructions are written in German, so that they are understandable to the Team members. The instructions are attached to the Annex. The team members will be trained in appliance and safety with the tools and used machinery – demonstrated by the HS Coordinator or Safety Team Officers and will be experienced prior assembly on the construction site. Most tools are already familiar to the team members because of the many pre fabrication workshops at the university. Nevertheless, there will be trainings before starting on the construction site.

14.13 Planned Measures in case of accident

The following decribes the procedures during or after an accident. The information will be available furing the assembly and disassembly phase as well as during the competition phase to all team members. The procedures and information will be communicated to all members and can be seen in a first aid manual.

An waterproof mobile signpost is being kept visible inside the lot near the staff container, which informs about the procedure in case of emergency or accident and evacuation path. Moreover Infrmation about the route to the closest health centre, Procedure to follow in case of accident Emergency phones, assurance ID, etc. is being pointed out. A copy of the evacuation plan will always be kept with the individual team member.

14.13.1 First aids

Different procedures are established based on the severity of the injury. A minor injury is identified (such as cuts or bruises): the H&S Coordniator selects another person to accompany the injured person to the medical center. The medical center is then notified by phone of the accident and the arrival of the two people. At the medical center, the injured person is treated and informed about the treatment options and the further procedure (whether work can be resumed or not). After the treatment the escort accompanies the injured person back to the construction site or to the accommodation.

Furthermore, there are the following surrounding pharmacies:

- Panda pharmacy - Hainstraße 15-17 - 42109 Wuppertal
- Pharmacy am Berg - Bergstraße 5-9 - 42105 Wuppertal
- Pharmacy emergency service (Sundays and public holidays): www.aponet.de/apotheke/notdienstsuche (Postcode 42105 for location Solar Campus)

If a serious injury is identified where the victim can no longer walk, first aid must be given.

First, ensure that no other accident occurs. Take in the whole picture. Then, the accident site must be observed to avoid further risks (choking hazards, electrical hazards, falling objects, fire outbreak, etc.).

After assessing the accident, you should, if necessary, get yourself to safety, others and also the victim. The victim should only be moved in an emergency, e.g. to protect him or her from further danger.

Then the SDE first responders are notified that an accident has occurred. A first responder arrives on the scene and is responsible for the following actions upon arrival: making the emergency call, notifying the SDE organization. The German emergency phone numbers are: 110 Police; 112 Fire brigades / ambulance.

If the accident occurs outside of the first responders' working hours, the H&S Coordinator must be notified. He/she will alert the SDE organization and stop all work. The SDE team member is responsible for making the emergency call.

If the team itself must make an emergency call because appropriate persons cannot be reached or the accident occurs outside working hours, the following information must be provided: Where did the accident happen? (Alte Glaserei - Juliusstraße 12 - 42105 Wuppertal), What happened? (fire, injury, electrical accident,...); How many injured? What visible injuries or appearances (wounds, respiratory arrest, ...) The emergency call should not be terminated by the caller, as possible queries may arise. In addition, the emergency center will give instructions on what to do next.

Once the accident site has been secured and the emergency services have been alerted, first aid is given as follows.

Only the person who feels confident to render first aid should do so. Otherwise, the person stays with the victim and calls another person for help.

The victim must first be examined: Check for responsiveness and breathing: If there are multiple victims, try to help first and foremost those who need your first aid most. Check if the injured person is still breathing regularly. If the person is no longer breathing regularly, the resuscitation as the next first aid measure must begin. To do this, the victim must lie on his or her back in front of you.

In many public places, there is an AED device marked green and white. There are specific instructions on what to do for chest compressions. If the injured person is breathing but bleeding heavily, try to stop the bleeding with a pressure bandage as another first aid measure. It is best if the injured person lies on the floor. Use disposable gloves from the first aid kit to protect against infection. When applying a pressure bandage as a first aid measure, you first place a sterile pad on the wound, which you fix with the bandage. By adding a pressure pad (such as another trough), you can contain the bleeding somewhat.

If the injured person is still breathing but unconscious, place him or her in the recovery position. This allows the airways to remain clear.

After these first aid measures, keep checking breathing. It is a vital function for the victim. Help injured persons not to lose their own warmth, preferably by covering them with a rescue blanket. The silver side of the blanket should face inward to reflect the bodies own heat.

Also stroke unconscious people over the head. This lets them know that someone cares for them and that they are not alone.

Until professional help arrives, care for people who are in shock, possibly by holding them, listening to them, and making them feel safe.

HS Coordinator hast to report to the SDE21/22 Organization and write into the medical first aid book about the used registered materials.

14.13.2 **First aids bag**

On the construction site with a size of approx. 30 persons there must be 1 small first aid kit according to DIN 13157 and one large first aid kit according to DIN 13169. There should be 3 trained first aiders available for these 30 persons. These first-aid kits are kept in the storage area on the lot and checked regularly and after use for completeness. An first aid kit MT-CD Industry Standard green will be used with the following content:

• First aid manual	• Acetaminophen and ibuprofen
• Table of contents	• Adhesive tape
• Adhesive plaster 500 cm x 2.5 cm, coil with outer protection	• Elastic bandage
• Quick wound dressing 10 cm x 6 cm	• Sterile gauze

• Finger tip bandages 5 cm x 4 cm	• Antiseptic wipes
• Finger bandages 12 cm x 2 cm	• Soap
• Plaster strips 7.2 cm x 1.9 cm	• Antibiotic cream (triple-antibiotic ointment)
• Plaster strips 7.2 cm x 2.5 cm	• Antiseptic solution (like hydrogen peroxide)
• Dressing pack DIN 13151 - K	• Hydrocortisone cream (1%)
• Dressing pack DIN 13151 - M	• Tweezers
• Dressing pack DIN 13151 - G	• Safety pins
• Dressing cloth DIN 13152 - A, 60 cm x 80 cm	• Disposable instant cold packs
• Fixation bandage DIN 61634 - FB 6	• Calamine lotion
• Fixation bandage DIN 61634 - FB 8	• Alcohol wipes or ethanyl alcohol
• Rescue blanket at least 210 cm x 160 cm	• Thermometer
• Compress (100 ± 5) mm x (100 ± 5) mm	• Foil bag
• Eye compress	• Non-woven cloth
• Immediate cold compress at least 200 cm²	• Wet wipe for cleaning uninjured skin
• Triangular cloth DIN 13168 - D	• First aid brochure/instructions for first aid
• First-aid box scissors DIN 58279 - B 190	• Face masks, at least type 1, according to DIN EN 14683
• Medical gloves for single use (at least 2 pairs)	

Fig.14.7: First aid kit items DIN 13157 DGUV

14.13.3 **Preventive medicine**

Preventive medicine will be used when discomfort occurs or to prevent discomfort. For example, painkillers can be taken for headaches or other minor aches and pains. With regard to the time of year in which the competition takes place, it is essential to ensure adequate protection from the sun. This includes regular application of sunscreen to areas of the skin that will be exposed to the sun. This must be ensured by the H&S Coordinator on a regular basis. Some out of many examples are mentioned below:

- A conventional cold: medicine drops for throat-pain, enough tissues, antipyrectic mediciin
- Dry nose: herbal or seawater nasal spray
- Sunburn/ sunstroke: high-level sunscreen for all members during the competition, hats or caps, cold packs in a cool bag near or at the working site
- Insect bites: if necessary a lotion against the itching and for prevention an anti-insect spray
- Dehydration: enough bottle of drinking water, fresh water on site
- Sickness/ stomach flu: medicine
- Voltaren (painkilling gel) and other pain relievers
- Disinfection spray, germicide

A package leaflet accompanies finished medicinal products and contains the information important for the consumer, mainly the purpose and use of the medicinal product, as well as the frequency and type of side effects. This information must be taken into account before use.

14.13.4 Accident victim evacuation

After the emergency call is made and first aid is administered, evacuation follows in some severe cases. At this point, the SDE organization should already be informed and the rescue service should be on its way. The SDE organization is responsible for getting emergency personnel to the scene. SDE personnel evacuate all emergency areas marked on the Solar Campus. The team itself secures the workstations. To do this, all machines, compressors, etc. should be turned off and made sure that there is no danger. The H&S Coordinator ensures that the entire team leaves the site and is evacuated. The team will assemble in the emergency areas and will not be allowed to leave during the alarm without direction from the SDE organization. The H&S Coordinator is responsible for ensuring that all team members are in the emergency area and no one is missing. The SDE organization will then inform about the further procedure and initiate further measures if necessary.

14.14 Risks identification for works on construction-site

Our risk identification is based on the tasks that we have defined for the work units in the individual project phases. For each task, the corresponding main risks were identified and assessed in terms of probability of occurrence and severity of potential impact. Subsequently, solution measures were identified for each risk and their effect on the classification of the respective risk was assessed (see figure 2 and risk analysis excel file, columns E to R).

D Risks							E Measures					
Identify the RISKS							Develop MEASURES					
Risk Number	Brief description/ listing of the risks	Probability of the risk	Consequence of the risk: L	G	Mo	Risk qualification without measures	Solution Number	Brief description/ listing of the solution	Determined precaution: CP	IP	S	Risk qualification with measures
Risk 1a	Inadequate load securing	Possible			x	Intolerable risk	Solution 1a	Proper load securing acc. to legal requirements	x			Tolerable risk
Risk 1b	Vehicle collisions with persons (on site)	Possible			x	Intolerable risk	Solution 1b	Drivers with appropriate licensing, speed restrictions, warning sound during maneouvring, instructor for maneouvring	x			Tolerable risk
Risk 1c	Vehicle collisions with still objects (on site)	Possible	x			Moderate risk	Solution 1c	Drivers with appropriate licensing, speed restrictions, warning sound during maneouvring, instructor for maneouvring	x			Tolerable risk
Risk 1d	Other kinds of vehicle collisions (on track)	Possible		x		Important risk	Solution 1d	Drivers with appropriate licensing	x			Tolerable risk
Risk 2a	Carrying too heavy loads	Certain	x			Moderate risk	Solution 2a	Working teams, worker briefing, carrying aids	x	x		Trivial risk
Risk 2b	Getting knocked by objects	Possible		x		Important risk	Solution 2b	Worker briefing, wearing helmets, warning signs	x	x		Tolerable risk
Risk 2c	Risk of slipping	Possible	x			Moderate risk	Solution 2c	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
Risk 2d	Stepping on objects	Possible		x		Important risk	Solution 2d	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
Risk 3a	Incorrect use of machinery and tools	Possible		x		Important risk	Solution 3a	Machine operators with appropriate licensing, instructors	x	x		Tolerable risk
Risk 3b	Exposure to electric connections	Possible			x	Intolerable risk	Solution 3b	Workers with appropriate training, warnings signs	x	x		Tolerable risk
Risk 4a	Carrying too heavy loads	Certain	x			Moderate risk	Solution 4a	Working teams, worker briefing, carrying aids	x	x		Trivial risk
Risk 4b	Getting knocked by objects	Possible		x		Important risk	Solution 4b	Worker briefing, wearing helmets, warning signs	x	x		Tolerable risk
Risk 4c	Risk of slipping	Possible	x			Moderate risk	Solution 4c	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
Risk 4d	Stepping on objects	Possible		x		Important risk	Solution 4d	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
...												
Risk 1a	Inadequate load securing	Possible			x	Intolerable risk	Solution 1a	Proper load securing acc. to legal requirements	x			Tolerable risk
Risk 1b	Vehicle collisions with persons (on site)	Possible			x	Intolerable risk	Solution 1b	Drivers with appropriate licensing, speed restrictions, warning sound during maneouvring, instructor for maneouvring	x			Tolerable risk
Risk 1c	Vehicle collisions with still objects (on site)	Possible	x			Moderate risk	Solution 1c	Drivers with appropriate licensing, speed restrictions, warning sound during maneouvring, instructor for maneouvring	x			Tolerable risk
Risk 1d	Other kinds of vehicle collisions (on track)	Possible		x		Important risk	Solution 1d	Drivers with appropriate licensing	x			Tolerable risk
Risk 1e	Working with contracted staff: Instruction problems	Possible	x			Moderate risk	Solution 1e	Worker briefing, company declaration of appropriately trained staff	x	x		Tolerable risk
Risk 2a	Carrying too heavy loads	Certain	x			Moderate risk	Solution 2a	Working teams, worker briefing, carrying aids	x	x		Trivial risk
Risk 2b	Getting knocked by objects	Possible		x		Important risk	Solution 2b	Worker briefing, wearing helmets, warning signs	x	x		Tolerable risk
Risk 2c	Risk of slipping	Possible	x			Moderate risk	Solution 2c	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
Risk 2d	Stepping on objects	Possible		x		Important risk	Solution 2d	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
Risk 2e	Working with contracted staff: Instruction problems	Possible	x			Moderate risk	Solution 2e	Worker briefing, company declaration of appropriately trained staff	x	x		Tolerable risk
Risk 3a	Carrying too heavy loads	Certain	x			Moderate risk	Solution 3a	Working teams, worker briefing, carrying aids	x	x		Trivial risk
Risk 3b	Getting knocked by objects	Possible		x		Important risk	Solution 3b	Worker briefing, wearing helmets, warning signs	x	x		Tolerable risk
Risk 3c	Risk of slipping	Possible	x			Moderate risk	Solution 3c	Worker briefing, wearing working shoes, warning signs	x	x		Tolerable risk
Risk 3d	Risk of falling	Possible		x		Important risk	Solution 3d	Working briefing, fall protections (e.g. scaffolding)	x	x		Tolerable risk
Risk 3e	Fall of objects	Possible		x		Important risk	Solution 3e	Worker briefing, wearing helmets, warning signs	x	x		Tolerable risk
Risk 3f	Exposure to extreme environmental temperatures	Possible		x		Important risk	Solution 3f	Worker briefing, adequate working breaks, sun protection, drinking water, additional shading	x	x		Tolerable risk
Risk 3g	Working with contracted staff: Instruction problems	Possible	x			Moderate risk	Solution 3g	Worker briefing, company declaration of appropriately trained staff	x	x		Tolerable risk

Fig. 14.8: Excerpt risk analysis excel file, columns E to R

14.15 Useful plans and information for works

Plans that are necessary for a safe conduct of the construction works are the health and safety plan, the emergency evacuation plan as well as all relevant planning documents for the assembly and disassembly of the HDU. The coordination plan shows the proper evacuation in all phases of work. The assembly sketches provide a solid overview of the different work units and tasks to be done. Useful information about an extended list regarding the construction and time schedule will be attached to the annex. This gives information about when, how long the tasks will be done and how many team members will take part.

14.16 Adopted system for the level of health and safety control during works

For health and safety, control during the working time our health and safety officer or his representation will be present on the lot. So we can guarantee a permanent supervision of our working

teams during the working time. He will be the contact person in case of queries and will initiate appropriate countermeasures in case of problems.

14.17 Formation and information about health and safety

Formation and information about health and safety is carried our via the working briefings taking place prior to each working unit. Besides, we are going to signpost relevant plans like the escape routes, the health and safety plan and the emergency evacuation plan on central point of our construction lot.

There will be visits from sponsors and professors of the university during the construction process. They are not involved in the construction process and will only get a picture of the progress that has been made. They will also be present frequently during the final competition phase. As they are not actively involved in the construction, we do not issue a medical statement. The reason for this is that they are more of an observer and do not have any authority in giving instructions to the team members on site. A camera team will certainly follow and document the construction phase. All visitors are treated the same as the members team, which is why they are also equipped with personal safety measures such as hard hats and safety vests. Most of the professors work and teach in the field of architecture, civil and climate engineering, so most will bring their own safety shoes. If this is not the case, they will be provided with a pair that are stocked in the staff container. Each of them have to be informed about possible risks, which could occur on site. A detailed list of visitors can be found in the excel sheet HS Specific Terms & Conditions Documentation. Currently, in addition to 8 professors, 7 representatives of the sponsors and partner companies are listed.

Training statements are submitted before the start of work in Wuppertal and the participants will have successfully completed specific disciplines trainings: The Training Statement of Team Members will be documented with the *SDE21_HS_Training-Statement_V1.0_02_11_21.pdf*.

- First aid (Scheduled beginning of May)
- Briefing on the construction site procedure (Scheduled on beginning of May)
- Specific training on the work units (Scheduled on beginning of May)
- Risks and preventive measures (Scheduled on beginning of May)
- Use of protective equipment (Scheduled before construction start in Wuppertal)
- Use of machines used on the construction site (Scheduled before construction start)
- Individual training of specific tasks (Scheduled on site)
- Emergency training

14.18 Emergency evacuation plan during the assembly and disassembly periods

As part of our emergency evacuation plan, the goal is to facilitate the quickest possible evacuation of everyone on the property. The first thing to consider is whether these people are inside or outside the HDU, or on the temporary facade scaffolding. The evacuation of persons inside the HDU should be carried out via the escape routes declared in the fire protection concept and communicated to the persons beforehand. The evacuation of the facade scaffolding must be carried out via the individual scaffolding accesses until the ground surface is reached. The site is then cleared in the direction of the access road. Any injured persons can be taken or admitted to one of the nearby hospitals, for example the Bethesda Clinic. The contents described are included in our evacuation plan. This plan will be visibly attached to a central location on the building site. (see evacuation plan HS-20).

There will be an emergency training prior to the final phase of the Competition, including a visit to the H+S centre on the solar campus (in order to familiarise all Team members with the fastest way to get there) in accordance with the insurance instructions.

As stated, the Evacuation Plan will be kept visible inside the lot by a waterproof mobile signpost during assembly, the final phase of the Competition and disassembly. A copy of the evacuation plan is kept by every team member during their work shift.

15 DETAILED WATER BUDGET

coLlab

The water demand of our HDU consists on the one hand of the tasks in the house functioning contest, as well as cleaning and on the other hand of the demand for the irrigation of plants and our adiabatic cooling and dry mist system. The following table shows the demand of each of these tasks:

Type	Daily Demand [l]	
Hot Water Draw	50	l / draw
Dish Washing	9.5	l / cycle
Clothes Washing	44	l / cycle
Dinner Party	15	l/ dinner
Dry-Myst System	10	l/h
Adiabtic Cooling	5	l/d
Cleaning / Other	20	l/d
Irrigation (Kiwis)	80 to 100	l/d

Based on this data a schedule for the competition period was developed, and the dimensions of the tanks were chosen. The following diagram shows the daily water demand during competition period (bar diagram / left axis) and the fill level of the tanks (line diagram / right axis).

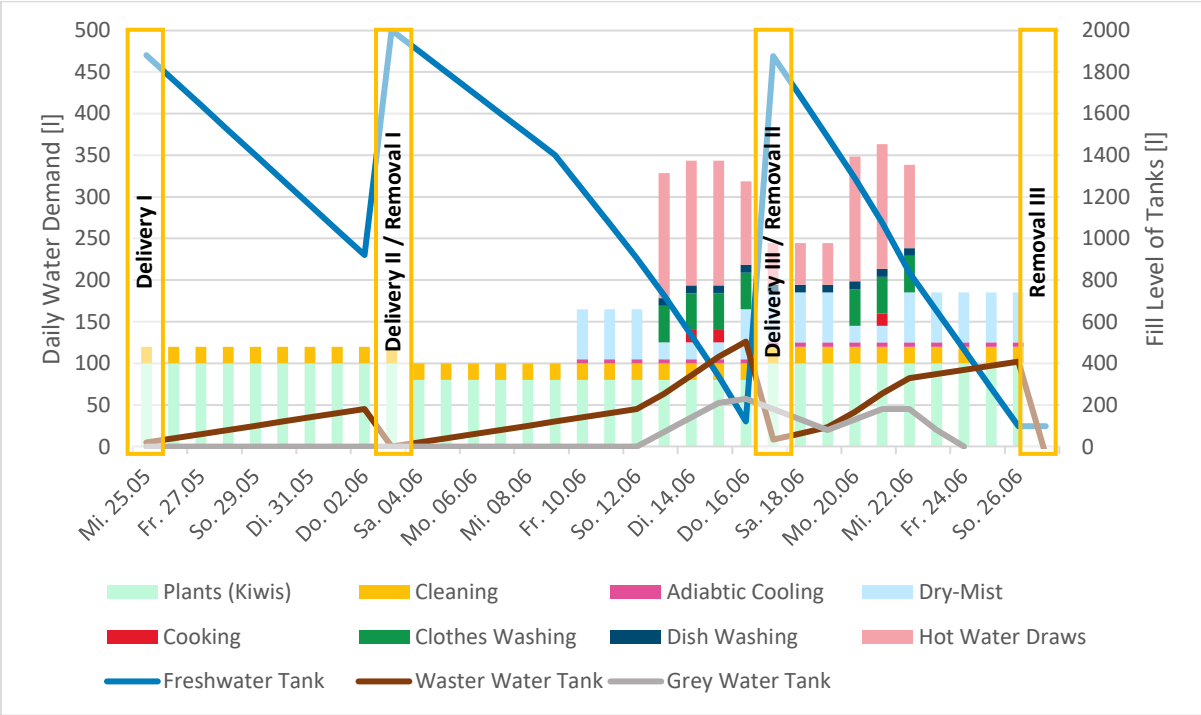


Fig. 15.74: Water Demand and fill level of tanks competition period

This results in the following demand for water deliveries and removals:

Water Delivery / Water Removal				
	Water Delivery I	*Water Delivery II*	*Water Delivery III*	
		Water Removal I	*Water Removal II*	*Water Removal III*
	25. May 2022	***03. June 2022***	***17. June 2022***	***27. June 2022***
Fresh water delivery [litre]	2000	1200	1950	/
Waste water removal [litre]	/	200	500	450

The main water demand results from the irrigation of the facade greenery (kiwi plants) with about 80 to 100 l per day. And also from the use of the adiabatic cooling and dry mist systems. With these three main consumers, the water evaporates completely and no wastewater is produced, therefore the amount of wastewater is considerably less than the amount of fresh water.

In order to reduce the required fresh water quantity, also grey water will be used for irrigation. Only the water of the "hot water draws" from the shower is used as grey water. The bathroom has a separate wastewater line for this purpose and the grey water can thus be used for irrigation without further treatment.

The tank installation will be in the access area in the north of the HDU besides and below our ramp and terrace and can be reached via flexible hoses, as can been seen in the next picture (Cf. PL-3001).

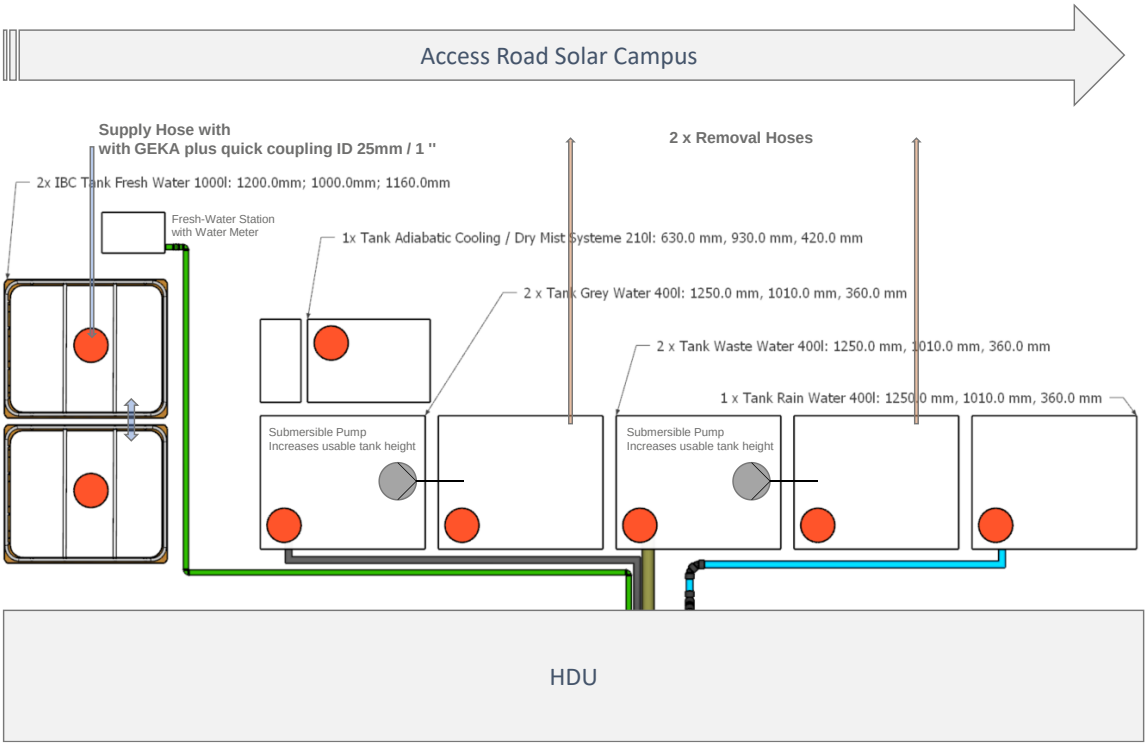


Fig. 15.75: Tank Installations and Access

For Freshwater to 1000l IBC Containers are used. For the waste water and gray water four 400l (2 x 2) tanks are used, each pair inter connected by a pump to increase the usable tank height. For rainwater, another 400 l tank is used under the ramp. In addition, there is a 210 l tank for osmosis water of the adiabatic cooling and dry mist system which is filtered on site by Team coLLab itself. In summary following tanks are used in our system:

Tank overview

Type of tank	*Quantity [#]*	*Volume per tank [litre]*	*Volume total [litre]*
Fresh water tank	2	1000	2000
Waste water tank	2	400	800
Rainwater tank (optional)	1	400	400
Grey water tank (optional)	2	400	800
Other water usage (fill in below)			
Osmosis Water (provided by HFT)	1	210	210
Total	8	2410	4210

16 ELECTRICAL & PV DESIGN SYSTEM

coLlab

The basic idea and design implementation of our OPV system is described in the chapter 4.5 Solar System Integration. Briefly summarized, we developed a modular system, that consists of frames with a stainless-steel mesh. The mesh is used to hold OPV (organic photovoltaic) cells. The placement of the cells is determined by parametric simulation depending on the location of the building and is optimized not only for energy production but also for daylight and summer heat protection through shading. The principle of how the individual OPV cells are suspended in the mesh by means of springs can be seen in the following figure.

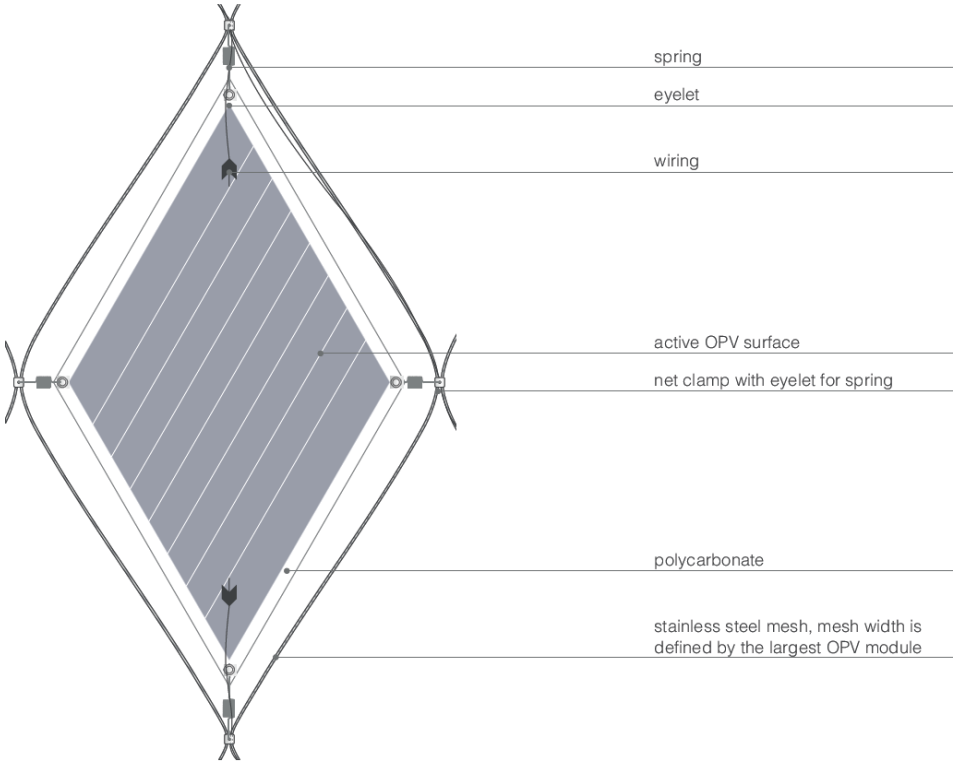


Fig. 16.76: Mounting principle of the OPV cell in the stainless steel mesh

For the HDU our OPV system will be installed on the roof, the south, west, and east façade. The three different sizes of the OPV cells, that will be used in the façade mesh can be seen in the following figure.

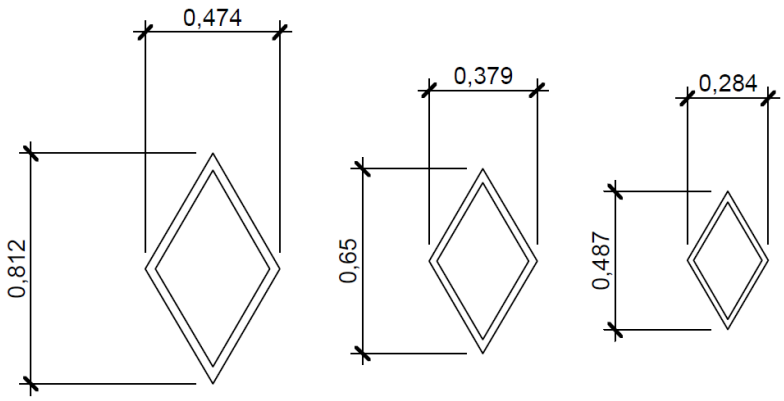


Fig. 16.77: Sizes of OPV cells

The efficiency of the innovative OPV technology is still lower than that of conventional silicon solar cells, at just under 4% today, which results in a specific output of 35 W/m² for the OPV modules. The

electrical characteristics of the three different OPV-Modules are given in the following table (further information can be also found in the corresponding datasheets in the *project specifications*).

Module	PN / Type	Cell area [cm²]	Photoactive area [m²]	Isc [mA]	Impp [mA]	Voc [V]	Vmpp [V]	Power [W]
Large	1150	18.50	0.110	167	120	45.0	32.4	3.9
Medium	1176	9.90	0.059	89	64	45.0	32.4	2.1
Small	1177	5.10	0.031	46	33	45.0	32.4	1.1

Fig. 16.78: electrical characteristics of OPV-Modules

Based on our parametric design and and the simulation methodology developed specifically for this purpose, the allocation of the cells in the façade mesh for the HDU was performed with a target value of 3kWp. The result of this simulation and the distribution and placement of cells for each façade side and the roof are shown in the following picture.

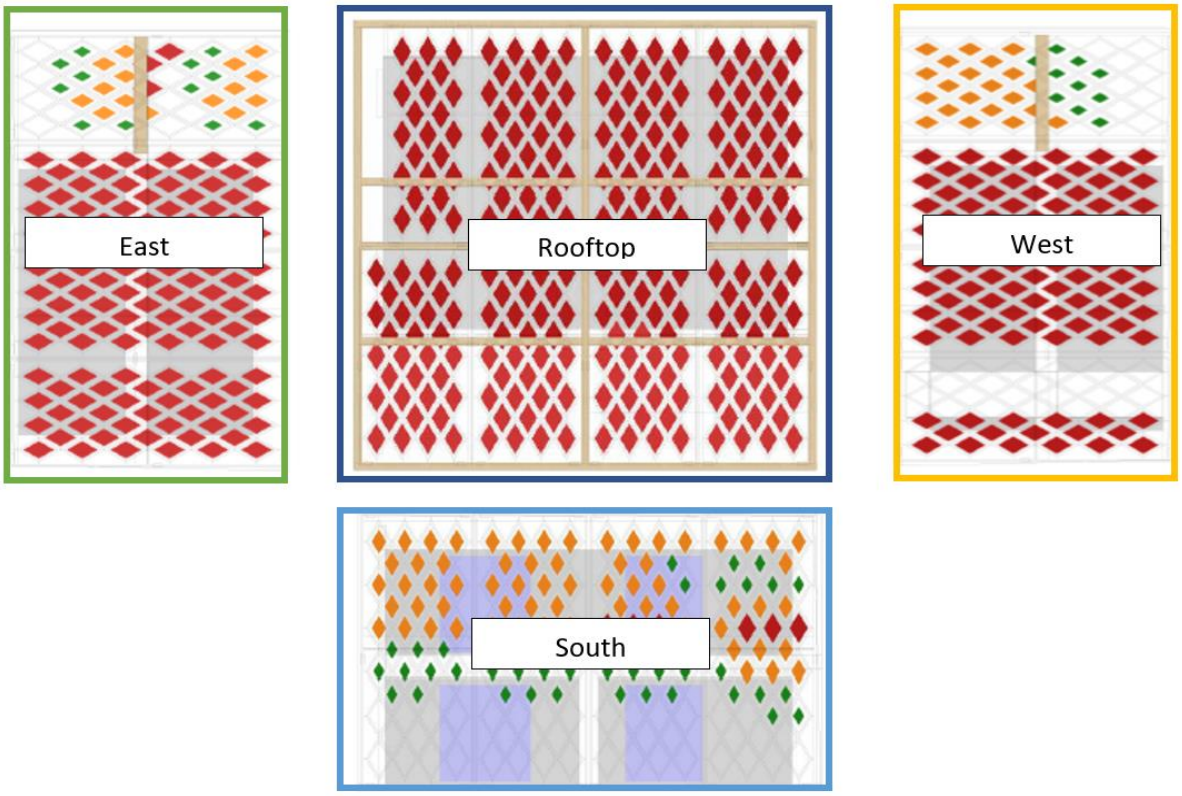


Fig. 16.79: Distribution of OPV cells on the façade (red: large, orange: medium, green: ...

In total, the parametric simulation results in a required number of 633 OPV modules and an active solar area of approx. 60 m². The specific Layout / OPV cell placement for each façade is also shown in the Plans ***PV-00 02 to PV-00 05***.

The number of cells per facade side and the resulting power can also be seen again in the following table. (***Note on simulation results:*** *For the simulation, an efficiency of 4% was used in the design and the active area fraction per module was estimated to be higher. Therefore, in the end, the design target of a power output of* P_{mpp} *= 3 kWp could not be achieved with this OPV allocation. At the end of the chapter, we will briefly discuss this circumstance again*.)

PV-String	Number of Modules			Area [m²]	Power [W]
	Small	Medium	Large		
Roof	-	-	247	27.2	970
South	37	70	6	5.9	210
West	10	21	95	12.0	430
East	12	15	120	14.5	520
Total	***59***	***106***	***468***	***59.6***	***2130***

Fig. 16.5: Number of Modules and Power Output

As can be seen from the DC wiring diagrams (***PV-20 01 to PV-20 16)***, in our system all OPV modules are connected in parallel. For this purpose, the cells which are located above each other in a grid row are first wired in parallel with each other. Then the respective grid rows are combined in parallel per frame via T-connections. The individual frames are then also connected in parallel on each side of the facade via special MC4 connectors, so that the system ends up with four PV strings. The connection types used are listed below.

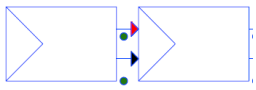
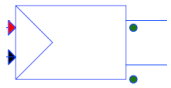
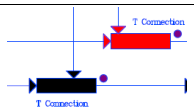
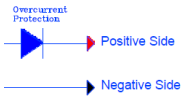
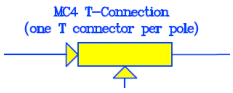
	Connection Point	Type	Connection Symbol (compare PV-20 02 to PV-20 16)
	Between Modules	Buttconnector (DIN 46341, Teil 1) with Heat shrinkable tubing (Protect C)	
	Last Module in Row	TE Connectivity AMP Superseal 1.5 / 2P	
	Module Rows	TE AMP Superseal T-connection 1.5 / 2P	
	Change of Cable Section	Heat shrinkable Buttconnector 1.5 to 6.0 (LAPP)	
	Facade OPV Frame	MC4 connector with integrated diode (overcurrent protection)	
	Between OPV Frames	MC4 solar branch T connector	

Fig. 16.6: Connection Types for DC wiring

The string data resulting from this design and wiring can be taken from the following table. The parallel connection ensures that the maximum voltage in the OPV system is V_{OC} = 45V and therefore the complete system can be operated at Safety Extra Low Voltage level (SELF) and thus comply with protection class III. This means the system carries a low risk of dangerous electrical shock and therefore offers increased safety in the event of contact in a faulty system.

	Impp [A]	Isc [A]	Voc [V]	Vmpp [V]	Pmpp (W)
Roof OPV	29.6	41	45	32.4	960.3
South OPV	6.4	9	45	32.4	208.3
West OPV	13.1	18	45	32.4	423.5
East OPV	15.8	22	45	32.4	510.6

Fig. 16.7: OPV String Data

The PV strings from each façade side and the roof are secured by an PV-Breaker and connected to their own solar charge controller / MPPT. The MPPTs will also be limited to an output power of together 3kWp. The electrical integration of the system can be taken from the following diagram and the plans ***PV-10 01 and PV-30 01***.

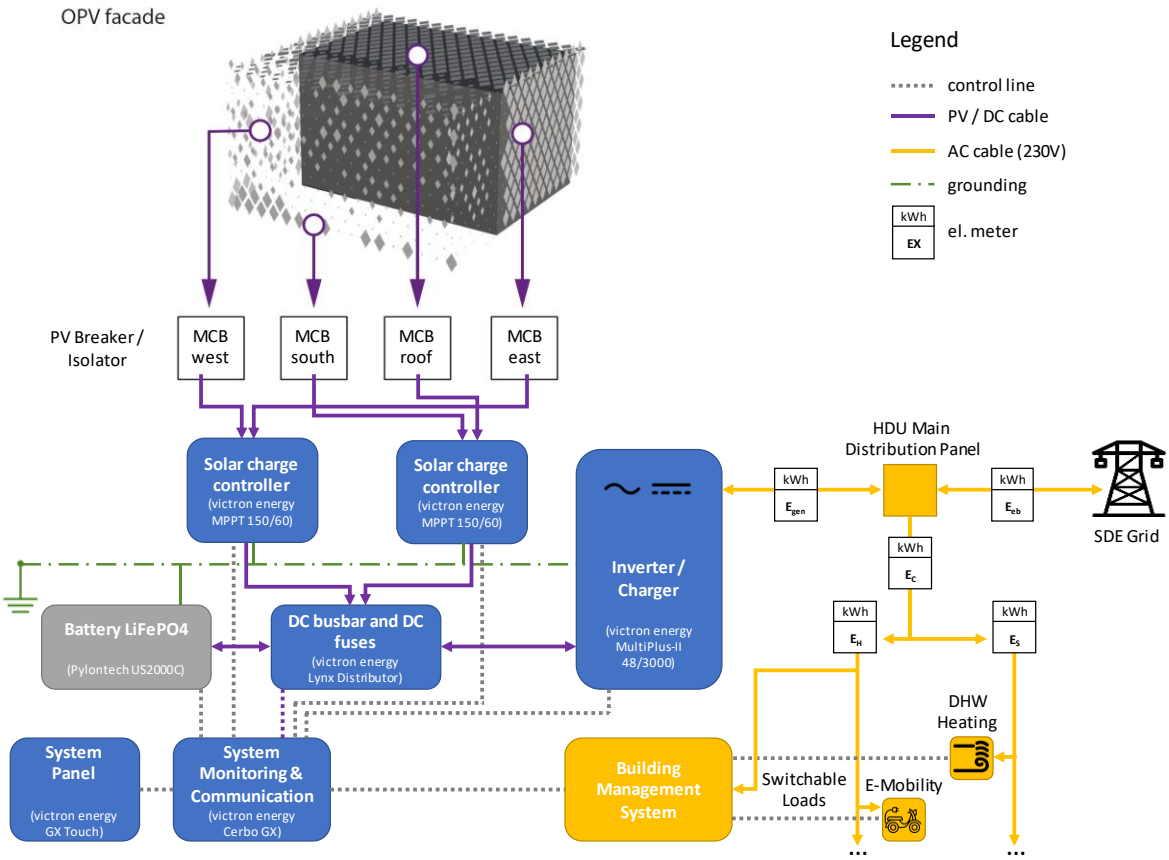


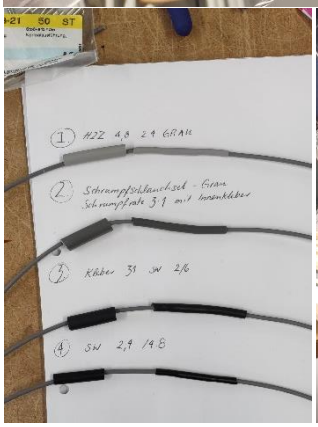
Fig. 16.8: Basic PV-System Layout

The integration of the PV system will mainly be done by components of the manufacturer Victron Energy. The four PV strings are connected via the two solar charge controllers with integrated MPPT (VE MPPT 150/60). A DC busbar (VE Lynx Distributor) connects the MPPTs to the lithium iron phosphate battery with integrated battery management system (Pylontech US2000C) with a capacity of 2.4 kWh and the central inverter (VE MultiPlus-II).

The entire PV system is monitored and operated by a communication and control unit (VE Cerbo GX), which also has a touch panel for operation (VE GX Touch). This control unit is also connected to the Building Management System (BMS - compare Plan **BAS-0001**) via an interface and thus integrated into the overall system of the HDU. Depending on the current PV yield and the state of charge of the battery, the BMS can switch on different loads and thus, for example, switch on the heating rod for heating the domestic hot water when the battery is full and there is a PV surplus (compare Plan **SW-0001**.)

Note: Since, as already indicated, the system target of 3kWp cannot be achieved by the now planned OPV system, and the increase in the number of modules would contradict the parametric design idea, a further adjustment of the PV system is currently being planned. With this redesign the OPV module frame on the roof, which is located next to the solar chimney will be replaced by between three and five "classic" PV modules at this location. These modules are also connected in parallel and integrated into the existing system via a separate charge controller. We will inform the organizer of the final system layout before the start of the competition.

An initial test setup of the OPV-façade has already taken place using a 1-to-1 prototype in the HFT workshops. Different suspension variants and cabling types were also tested. Some impressions of this development work can be seen in the following photos:



16.1 Electric System Design Checklist

Team ID	Team Name	Country
HFT	coLLab	Germany
	University	**Date**
	HFT Stuttgart	23.03.2022

Subject	Element	Required specification or information	Comment	Location PD sheet, PM Page or other documents
General Requirement	Electricity System	Technical products that are used in the House Demonstration Unit (HDU) must provide a safety level equivalent to European standard.	All components are qualified	Project Specifications
		The electrical installations of the HDU must be planned properly by an installation designer and needs to be approved by a professional electrical engineer.	Electrical Engineer: Siegfried Baumgartner (see Statement)	DESIGN APPROVAL
Electrical Grid	Low Voltage Distribution Network	Nominal voltage and frequency in the German Low Voltage distribution networks are: Voltage:400 V/230 V (phase-neutral). Frequency: 50 Hz.>Voltage band: 207 -253 V (normal operating range); >Frequency band: 49.5 -50.5 Hz (normal operating range).	Connection from SDE-Grid to HDU via Main Distribution Panel	EL-0001 EL-1001 EL-3001 EL-5001 (SLD)
		Overvoltage: equal or over 230 + 10% = 253 V; Undervoltage: equal or under 230 –10% = 207 V	Considered	
		Overfrequency: equal or over 50 + 0.5 = 50.5 Hz; Underfrequency: equal or under 50 –0,5 = 49.5 Hz	Considered	
	TN-C-S System	The cable connection of the HDU must be made according to the TN-C-S system, which is used in the German Low-Voltage Grid.	Connection from SDE-Grid / sep. distribution panel (located at the north entrance of the HDU) to HDU via Main Distribution Panel with NYY-J 5x16 mm²	EL-1001 EL-3001 EL-5001 (SLD)

		The TN system (French: terre neutre) is a certain type of implementation of a low-voltage grid in the electrical energy supply. The most important feature is the type of earth connection of this power supply system to the power source.	Considered	
		Colour Code according to the international standard IEC 60446:	Considered	
	Utility Compatibility	The HDU needs to connect to the German Grid. If the Teams home country provides a different voltage, they have to announce this to the SDE21 Organisers.	No other connection planned	EL-1001 EL-5001 (SLD)
		Teams are responsible for the installation of an appropriate transformer, in case their HDU is built for a different voltage. The chosen fabricationneeds to be listed in the equipment listings.	No transformer needed (apart from AC/DC inverter)	EL-1001 EL-5001 (SLD)
		Devices in the house do not necessarily be compatible with the German Grid for the competition phase.	All devices are compatible with the german grid.	
Safty Requirements	Short circuit protection	An automatic Residual Current Device (RCD) for personnel protection against indirect contact is needed.	Each distribution area is extra secured with a RCD	EL-5001 (SLD)
		RCD prevents injuries caused by short circuits.		EL-5001 (SLD)
		A protection against contact of 30 milliamperes must be ensured.	RCD 40A 30mA	EL-5001 (SLD)
		The RCD is mandatory in the fuse box of the HDU.	4 RCDs in Main Disribution Panel	ID-4001 EL-5001 (SLD)
	Earthing	An earthing-system is needed according to IEC 60364-5-54:2011.	Considered	
		Teams must provide equipotential bonding for each washing basin and bathtub and for all household appliances;	Shower tub is connected to equipotential bonding, all Appliances / sockets via TNC-Systeme, Water pipes are made of PE and not metal	ID-4001
		All conductors must be connected on a main equipotential bonding rail;		
		Connection to rod/ strip earth electrodes on the Teams lot	equipotential bonding in technical room of HDU next to Main Disribution Panel will be connected to rod	ID-4001 PV-4001

	which will be prepared by the SDE21 Organisers.		
Receptacles	All receptacles must have a building inspectorate approval. For that a CE marking is required.	Considered / Receptacles from Jung (Type LS 1520 KI) and Berker (Type 941952502) as SCHUKO® socket with contact protection	Project Specifications
	Any receptacles used must be protected with ground a residual current device (RCD). Enclosures provided must be suitable for damp locations (minimum IP44 protection level).	Planned for every receptacles, see above	EL-5001 (SLD)
	Receptacles must be three-poled and have to be equipped with a child safety lock.	see above Jung (Type LS 1520 KI) and Berker (Type 941952502)	Project Specifications
	If a power connection is provided in the kitchen, it must be fused separately.	Fuses for Kitchen : - Washing Machine - Dishwasher - Refrigerator/Freezer - Oven - Stove - Other Appliances (countertop sockets)	EL-5001 (SLD)
	For the heating test, a three-phase current socket (equipped for 5 kW) must be available in the house.	Considered	EL-0001 EL-3001 EL-5001 (SLD)
High Curren Power Connection	If there is a high current power connection (fixed connection) for the oven in the kitchen, it must be fused separately.	Considered	EL-3001 EL-5001 (SLD)
	Any other device with an output greater than 3.5 kW must also have a fixed connection.	No other devices with 3.5 kW planned	
Exterior and Interior Lighting	In house tour areas, light fittings must provide a minimum illumination level of 20 lux for exterior path and traffic areas, and a minimum of 100 lux in average for interior areas. A minimum of 1 lux for all areas is required.	Considered	EL-4001 EL-4002
	Colour temperature of luminaires should be warm white (2700K-3000K) with a colour rendition Ra >80. Coloured lighting is prohibited in outdoor areas.	Considered	Project Specifications
	The exterior and interior lighting design should minimize light pollution (“dark sky”).	Considered (Luminaires with downward radiation (angle 25°) and additional glare frame provided.)	EL-4001 EL-4002
	Houses which have no or only inadequate external lighting on their lot, will be closed during evening hours.		

Technical Requirements	Electricity Meter	Teams must provide an installation space for standardized electricity meters in the HDU. Four metering devices with separate wiring are expected to be installed in the HDU (sub-distribution, battery, PV and consumer meters). Dimensions and exact specifications will be provided on the SDE21 WAT.	Considered HDU Monitoring – Panel Space in Technical Room (3 Meters) Next to Main Distribution Panel (2 Meters)	ID-1001 ID-2001 EL-5001 ID-4001
		Installation height: distance of meter niches from the surface of the finished floor (DIN 18013) > Upper edge max. 210 cm; > Lower edge min. 40 cm.	Considered (Height of MP is 160 cm)	ID-2001
		The cables are inserted vertically into the electricity meter from above or below.	Free Space above and below is considred	ID-2001
	Equipment Listings	All electrical equipment must be certified for the European market by complying with European standards and must bear a CE mark.	Considered, All components are qualified	Project Specifications
		All DC to AC utility-interactive inverters must be fully listed to European Standard.	Considered (Inverters / EVGs for LEDs are currently chosen)	Project Specifications
	House Connection	Teams must provide an empty conduit with an outside diameter of 25 mm for the house connection of the HDU.	Empty conduit from the North Side of the HDU, next to the inlet of Fresh-Water and Waste-Water drain	EL-3001 ID-1001

16.2 Photovoltaic Checklist

Team ID	Team Name	Country
HFT	coLLab	Germany
	University	**Date**
	HFT Stuttgart	23.03.2022

Subject	Element	Required specification or information	Comment	Location PD sheet, PM Page or other documents
General Requirement	Photovoltaic System Design	Particular attention should be paid to photovoltaic system design, storage batteries, generators, grounding, conductors for general wiring, flexible cords and cables, and over-current protection devices, respectively.	Considered, general Layout see PM Chapter, Electrical & PV Design Systems Information	EL-00 01 PV-00 01 – 05 PV-10 01 – 04 PV-20 01 – 16 PV-30 01 PV-40 01
		photovoltaic system design		PV-10 01
		storage batteries	Type: Pylontech_US_C_2000_DS	HFT_SWPV_PV-battery_Pylontech_US_C_2000_DS.pdf
		generators	Inverter Type: Victron Energy MultiPlus-II Load Controller: Victron Energy MPPT 150-60	HFT_SWPV_PV-invertert_VE_MultiPlus-II_DS.pdf HFT_SWPV_PV-Solar-charge-controller_VE_MPPT-150-45_DS.pdf
		grounding		PV-40 01
		conductors for general wiring		PV-20 01 - 16
		flexible cords and cables		PV-20 01 - 16
		over-current protection devices	Every OPV frame has separate over-current protection	PV-20 01 - 16
	Regulation Compliance	In order to verify the regulation compliance, Teams must complete and submit these "Photovoltaic Checklist".	Update will also follow before start of competition	
Safety Requirements	Emergency Switch The photovoltaic system shall include	A general emergency switch for DC current must be set up close to photovoltaic system, and remote controlled from electric box of the house, near to the house general circuit breaking system.	Considered. Every String has separate PV-Breaker Box with Isolator	PV-30 01
		The general emergency switch must provide the isolation level	Considered	

	the following protection devices at the utility interface:	required by the German Regulation. This switch will be accessible to the electricity distribution company in order to be able to perform a safe manual disconnection of the photovoltaic system.	Switch is accessible in the Technical Room of the HDU, next to the Monitoring Panel	PV-10 01 PV-30 01 ID-1001 ID-2001
	Earthing	Earthing of the photovoltaic system equipment shall be done without disturbing the earthing of the utility distribution system, ensuring that no defects are transferred to the distribution network. See Rule 50.5 for Ground Penetration limits.	Considered	PV-00 01 PV-40 01
		The photovoltaic system shall guarantee galvanic separation between the Low Voltage distribution network and the photovoltaic system, by means of an isolation transformer (included in or external to the inverters) or by any other means fulfilling the same function, based on state-of-the-art technological development.	Considered, use of Inverter Type: Victron Energy MultiPlus-II	PV-30 01 HFT_SWPV_PV-invertert_VE_MultiPlus-II_DS.pdf
		In this sense, inverters with high-frequency transformers or transformer less inverters are permitted, provided that the inverter(s) manufacturer(s) provides a certificate guaranteeing that the maximum DC current to be fed into the grid is smaller or equal than 0.5% of the nominal output current of the device(s).		
		Teams must include in the project documents certificates of the inverters manufacturers that demonstrate compliance with the galvanic separation requirement as well as with other requirements of the German Regulations mentioned in Rule 50.2 (for example, protections against over/under voltage and frequency).	Inverter Standards: Safety: EN-IEC 60335-1, EN-IEC 60335-2-29, EN-IEC 62109-1, EN-IEC 62109-2 Emission, Immunity: EN 55014-1, EN 55014-2 EN-IEC 61000-3-2, EN-IEC 61000-3-3 IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3	HFT_SWPV_PV-invertert_VE_MultiPlus-II_DS.pdf
	Equipment Listings	Unlisted PV modules may be used in a system with a DC bus voltage of no greater than 60 volts (open circuit) at 0 °C if, and only if, such equipment has been evaluated and approved by the Solar Decathlon Europe 2021 Building Official and Solar Decathlon Europe 2021 electrical inspectors. PV cell and module mounting means are subject to increased scrutiny in	The Modules consist of only one OPV-Cell per Module and are laminated between sheets of polycarbonate. There are three diffrenet sizes of modules/cells. The modules are suspended in the steel mesh of our façade grid by means of springs and wired to each other.	PV-20 01 – 16 PV-Data Sheets: HFT_SWPV_OPV_Large_Mod_1150-202B.pdf

		custom made, unlisted, building-integrated PV applications.	DC bus Voltage is 45Voc and meets the SAFE level (Safety Extra Low Voltage). See also see PM Chapter, Electrical & PV Design Systems Information Similar systems have been installed by our project partners in a few different projects.	HFT_SWPV_OPV_Medium_Mod_1176-201B.pdf HFT_SWPV_OPV_Small_Mod_1177-201B.pdf
		The use of unlisted PV modules and the installation of listed PV modules in an unapproved manner in a system with a DC bus voltage of greater than 60 volts (open-circuit) at 0 °C are prohibited. Listings shall be to European Standards and shall be granted by an approved, accredited testing laboratory (e.g. German TÜV).	Not planned	
		The attachment of PV modules to any material where the PV module is not listed for such an application is prohibited, regardless of the bus voltage.	The mounting system was developed in close consultation with the OPV module manufacturer and has been approved by them.	
Technical Requirements	Grid Interconnection	The Photovoltaic system will be connected to the electricity distribution network following a single-phase configuration (connection to the phase and neutral) or a three-phase configuration for huge systems.	Considered	PV-30 01
		The interface between the Photovoltaic system and the electricity distribution network shall comply with the international standard IEC 61727 – Photovoltaic (PV) systems – Characteristics of the utility interface.	Considered	HFT_SWPV_PV-invertert_VE_MultiPlus-II_DS.pdf
		IEC 61727 regulates the grid interconnection of low-power electricity generation installations Photovoltaic systems up to 100 kW to Low Voltage electricity distribution networks.		
	Inverters	PV DC cables remain at exterior of the house as most as possible, and then enter directly in mechanical room. In the best case, inverters are positioned at exterior, on house roof. In other cases, PV DC cables remain only in mechanical room, in a protected path. This path must resist during 30 minutes to the fire.	The DC-Cables will be connected on the roof near the HDU-Roof inlet and are guided via an installation shaft directly into the technical room.	EL-3001-02 ID-2001
		A circuit breaking system is installed to switch off simultaneously all inverters. This inverters emergency circuit breaking system will be visible,	Considered	PV-3001

	near to house general circuit breaking system, and these two general switches must be identified by quoting: «Warning: presence of tension sources: 1-Distribution grid 2-Photovoltaic panels», in black letter with yellow background. Furthermore, a pictogram representing photovoltaic risk must be indicated at exterior of the house, on mechanical room door.		
Over / under Voltage and Frequency	The photovoltaic system shall disconnect from the utility system (grid) whenever voltage or frequency are outside the specified ranges. To this aim, an automatic switch will be used to guarantee protection against over/under voltage and frequency. This switch can be integrated in the inverter, in which case it shall comply with the German Low Voltage Electric-Technical Regulation.	Considered	PV-3001

Photovoltaic system drawings

• Teams must complete the drawings according to the specifications given below.

• Drawings reference numbers shown below indicate the minimum drawings required for approval. Additional drawings can be included, provided that they respect the corresponding section, for example: for particular details of the complete PV system, new drawings with reference numbers PV-11 to PV-19 can be added. The same applies for details of the DC circuits (new drawings: PV-21 to PV-29), AC circuits (PV-21 to PV-29) and Grounding system (PV-41 to PV-49)

PV-10	**Photovoltaic system: General** This drawing shall be electrical and include the interfaces with the electrical installation of the house and the electricity distribution network	Team SDE	**PV-10 01** **See also EL-00 01** **And PV-30 01**
PV-20	**Photovoltaic system: DC circuits** This drawing shall be electrical and include information about wiring (section, type), protections (current characteristics) and wiring methods of DC circuits	Team SDE	**DC wiring PV-20 01 – 20 16**
PV-30	**Photovoltaic system: AC circuits** This drawing shall be electrical include information about wiring (section, type), protections (current characteristics) and wiring methods of AC circuits	Team SDE	**PV-30 01 (further information will follow before competition start)**
PV-40	**Photovoltaic system: Grounding system** This drawing shall include information about wiring (section, type) and wiring methods of the grounding system, including DC and AC circuits	Team SDE	**PV-40 01**

16.3 Electrical Storage System Checklist

Team ID	Team Name	Country
HFT	coLLab	Germany
	University	**Date**
	HFT Stuttgart	23.03.2022

Subject	Element	Required specification or information	Comment	Location PD sheet, PM Page or other documents
General Requirements	Inverter	The inverter to be used together with the battery bank must be designed for operation in a grid type TN-C-S	Considered, use of Inverter Type: Victron Energy MultiPlus-II	PV-30 01 HFT_SWPV_PV-invertert_VE_MultiPlus-II_DS.pdf
		This characteristic will be properly justified in the corresponding technical document.	The planned capacity of our battery is currently 2.4 kWh	
	Batteries	With respect to the conditions during the competition weeks and the measured Contest the maximal usable storage capacity of the battery bank is 2,5kWh	Type: Pylontech_US_C_2000_DS Capacity of our battery is 2.4 kWh	HFT_SWPV_PV-battery_Pylontech_US_C_2000_DS.pdf

17 PROJECT SPECIFICATIONS

coLlab

The attached documents for the "Project Specifications" contain all data sheets for the materials that we definitely will install in our HDU. Due to our current planning status, the included documents mainly refer to the wood construction and are not completed yet for the other crafts. Corresponding documents for the OPV-façade, the interior construction as well as the technical installations will be added and linked as soon as their execution is definite. Since the "Project Specifications" in our case also form the basis for the "Fire Protection Concept", the corresponding table will only be finalized in this course - of course, we already take into account the respective fire protection classes of the planned materials.

SDE 21_Project Specifications: Architectural Elements

Deliverable No.	D#6
Team ID	HFT
University/ City	Stuttgart

Architectural Elements

Category	Document Name	GuID (BIM)
Category definitions (see Categorization Guideline)	*Team ID_Abbreviation_Product or Material_maufacturer.pdf when used more than once: Team ID_Abbreviation_Product or Material_maufacturer_01.pdf*	*Element ID according to your BIM Model*
01_Construction materials		
CONS *(Construction materials)*	HFT_CONS_Construction timber_Holzbau Deutschland.pdf	
	HFT_CONS_Glued laminated timber_Holzforschung Austria.pdf	
02_Cladding material		
CLAD *(Cladding material)*	HFT_CLAD_Caly paint_Claytec.pdf	
	HFT_CLAD_ESB_elka.pdf	01IvsljAMnIQT0DBJf9W69,
	HFT_CLAD_Gypum fibre board_Fermacell.pdf	
	HFT_CLAD_Rubber flooring_Nora.pdf	
	HFT_CLAD_Smile Plastic_Alba.pdf	
03_Construction boards		
BRD *(Construction boards)*	HFT_BRD_Formwork panel_Doka.pdf	
	HFT_BRD_GFKi_knauf.pdf	1fzQd8TNu3I8w7eZ3OjjWh, 3YCut1JkfbJgtSEiv45Ctp
	HFT_BRD_GKB_knauf.pdf	01IvsljAMnIQT0DBJf9W69, 0R3tC4oE4YIApLI9GYgWQQ, 1A6vxs1lfOIhuKg_qDqHx4, 1MeJNw_G$hIQymfcm9mk9g, 1bCvzIUYskHRH$6PdWG6oV, 2LZNXEr_M8HRAKIjyM2OKQ, 2OpcItVfXaJfwzYLHWepgL, 37$eqXu68XJwdIX0MGCT_x, 3D2T9fFY6NG8_KK9Ua0UTK, 3iwkaLiyydIRGn2FbV6626
	HFT_BRD_Powerpanel_Fermacell.pdf	
	HFT_BRD_Wood fibre board_Sto.pdf	01IvsljAMnIQT0DBJf9W69, 0R3tC4oE4YIApLI9GYgWQQ, 1A6vxs1lfOIhuKg_qDqHx4, 1MeJNw_G$hIQymfcm9mk9g, 1bCvzIUYskHRH$6PdWG6oV, 2LZNXEr_M8HRAKIjyM2OKQ, 2OpcItVfXaJfwzYLHWepgL, 37$eqXu68XJwdIX0MGCT_x, 3D2T9fFY6NG8_KK9Ua0UTK, 3iwkaLiyydIRGn2FbV6626
04_Thermal Insulation		
THI *(Thermal Insulation)*	HFT_THI_EPS_Joma.pdf	3ZUjzvfx0plvKUATwyf_is
	HFT_THI_HOIZ_Baufritz.pdf	01IvsljAMnIQT0DBJf9W69, 0R3tC4oE4YIApLI9GYgWQQ, 1A6vxs1lfOIhuKg_qDqHx4, 1MeJNw_G$hIQymfcm9mk9g, 1bCvzIUYskHRH$6PdWG6oV, 2LZNXEr_M8HRAKIjyM2OKQ, 2OpcItVfXaJfwzYLHWepgL, 37$eqXu68XJwdIX0MGCT_x, 3D2T9fFY6NG8_KK9Ua0UTK, 3iwkaLiyydIRGn2FbV6626
	HFT_THI_Impact sound insulation_Steico.pdf	
	HFT_THI_Thermal insulation_Steico.pdf	
05_Waterproofing		
WPR *(Waterproofing)*	HFT_WPR_DA_Novoproof.pdf	3ZUjzvfx0plvKUATwyf_is
	HFT_WPR_DB+_ProClima.pdf	01IvsljAMnIQT0DBJf9W69, 0R3tC4oE4YIApLI9GYgWQQ, 1A6vxs1lfOIhuKg_qDqHx4, 1MeJNw_G$hIQymfcm9mk9g, 1bCvzIUYskHRH$6PdWG6oV, 2LZNXEr_M8HRAKIjyM2OKQ, 2OpcItVfXaJfwzYLHWepgL, 37$eqXu68XJwdIX0MGCT_x, 3D2T9fFY6NG8_KK9Ua0UTK, 3iwkaLiyydIRGn2FbV6626
	HFT_WPR_Xund-E Elektrosmog-Schutztechnik_Baufritz.pdf	
	HFT_WPR_Vapor barrier_ProClima.pdf	3ZUjzvfx0plvKUATwyf_is

06_Facade materials		
FCD *(Facade materials)*	HFT_FCD_Exterior wall_Baufritz.pdf	
07_Openings		
OPN *(Openings)*		
08_Ceiling and Flooring		
CEFL *(Ceiling and Flooring)*	HFT_CEFL_Mobile Stage_Kleu.pdf	
	HFT_CEFL_Mobile Stage_Kleu_Statement slip resistance.pdf	
09_Furnishing		
FUR *(Furnishing)*	HFT_FUR_Multilayer panel_elka.pdf	
10_Others		
OTH *(Others)*	HFT_OTH_Green roof_Helix.pdf	

SDE 21_Project Specifications: Technical Building Services

Deliverable No.	D#6
Team ID	HFT
University/ City	Stuttgart

Technical Building Services

Category	**Document Name**	**GuID (BIM)**
Category definitions (see Categorization Guideline)	*Team ID_Abbreviation_Product or Material_maufacturer.pdf when used more than once: Team ID_Abbreviation_Product or Material_maufacturer_01.pdf*	*Element ID according to your BIM Model*
01_Elevator		
ELV *(Elevator)*	HFT_ELV_Lifttec_TPL600.pdf	
02_Plumbing		
PL *(Plumbing)*	HFT_PB_fitting_Vola_2471-061A_DS.pdf	
	HFT_PB_fitting_Vola_A34_DS.pdf	
	HFT_PB_fitting_Vola_A83_DS.pdf	
	HFT_PB_fitting_Vola_HV1+30_150_DS.pdf	
	HFT_PB_fitting_Vola_KV1_250_DS.pdf	
	HFT_PB_heatex_Warmduscher.pdf	
	HFT_PB_pipes_90to100_airfit_DS.pdf	
	HFT_PB_pipes_Geberit_FlowFit_DS.pdf	
	HFT_PB_pipes_Geberit_FlowFit_Flyer.pdf	
	HFT_PB_pipes_Geberit_FlowFit_Manual.pdf	
	HFT_PB_pipes_Geberit_SilentPro_DS.pdf	
	HFT_PB_pipes_Geberit_SilentPro_Manual.pdf	
	HFT_PB_showerdrain_Geberit_DS.pdf	
	HFT_PB_showerdrain_Geberit_Manual.pdf	
	HFT_PB_wastewatertank_400l_tanks_direkt.pdf	
	HFT_PB_WC-Icon_Geberit_DS.pdf	
	HFT_PB_WCelement_Geberit_DS.pdf	
03_Electrical		
EL *(Electrical)*	HFT_EL_Fan_Bosch_DS.pdf	
	HFT_EL_lightingbath_Hansen_surfacelight_DS.pdf	
	HFT_EL_lightinginside_XAL_UNICO_Q1_DS.pdf	
	HFT_EL_lightingoutside_LEDLinear_KALYPS_DS.pdf	
	HFT_EL_socket_black_Berker_DS.pdf	
	HFT_EL_socket_enocean_usb_black_Jung_DS.pdf	
	HFT_EL_socket_white_Berker_DS.pdf	
	HFT_EL_weatherstation_Jung.pdf	
	HFT_EL_windowopener_GEZE_slimchain_DS.pdf	
	HFT_EL_windowopener_Hahn_LAH_65-BSY_DS.pdf	

04_HVAC		
HVAC *(HVAC)*	HFT_HVAC_glas_solarchimney.pdf	
	HFT_HVAC_heatpump_Viessmann_Vitocal-060-A_DS.pdf	
05_Fire Protection		
FP *(Fire Protection)*	HFT_FP_Fire protection board_knauf.pdf	
	HFT_FP_smokedet_Jung-pdf	
06_Solar systems and PV		
SWPV *(Solar systems and PV)*	HFT_SWPV_OPV_Amor.pdf	
	HFT_SWPV_OPV_Amor_Datasheet.pdf	
	HFT_SWPV_PV-battery_Pylontech_US_C_2000_DS.pdf	
	HFT_SWPV_PV-busbar_VE_Lynx_Distributor_DS.pdf	
	HFT_SWPV_PV-communication_VE_Cerbo-GX_DS.pdf	
	HFT_SWPV_PV-invertert_VE_MultiPlus-II_DS.pdf	
	HFT_SWPV_PV-Solar-charge-controller_VE_MPPT-150-45_DS.pdf	
07_Appliances		
APPL *(Appliances)*	HFT_APPL_cooktop_Bosch_PIB375FB1E.pdf	
	HFT_APPL_dishwasher_Bosch_SPV6YMX11E.pdf	
	HFT_APPL_dishwasher_Bosch_SPV6YMX11E_EU-Sheet.pdf	
	HFT_APPL_oven_mircowave_Bosch_HMG6764B1.pdf	
	HFT_APPL_refrigerator_Bosch_KIS77ADD0_EU-Sheet.pdf	
	HFT_APPL_refrigerator_Bosch_KIS77ADD0.pdf	
	HFT_APPL_washdryer_Bosch_WKD28542_EU-Sheet.pdf	
	HFT_APPL_washdryer_Bosch_WKD28542.pdf	
08_Vehicles		
VEH *(Vehicles)*	HFT_VEH_EBK_Smart.pdf	
09_Others		
OTH *(Others)*	HFT_OTH_ADC_Pump_Oase.pdf	

18 STRUCTURAL CALCULATIONS

coLlab

With the current deliverable, we can now present the complete static calculation of our HDU. The overall structural analysis consists of the calculations for the timber construction, the OPV façade, the foundation and the ramp construction around our HDU.

Based on an initial pre-dimensioning of the timber construction by our student team, the calculations for the steel construction of the OPV façade were first prepared. This was done by another team of students together with the engineering firm str.ucture. With the load assumptions derived from this, the final dimensioning of the timber construction could then be carried out by our main sponsor, Bau-Fritz. In the last step, the foundation concept of our HDU was finalised and dimensioned. This was also done by a small group of students together with the engineering office Heiner Hartmann. The static calculation of the ramp construction, which encloses our HDU, is a TÜV-certified construction with existing type statics for the floor and railing construction. Since this is a prefabricated modular system, the corresponding calculations were not carried out by us, but were already available from the manufacturer.

Structural Calculation

Title of document	Version	Date	Pages Count
Appendix A – Foundation	DEL#6	23.03.2022	41
Appendix B – Timber Construction	DEL#6	23.03.2022	238
Appendix C - OPV-façade	DEL#6	23.03.2022	40
Appendix D – Exterior Ramp and Handrail	DEL#6	23.03.2022	69

Structural Drawings

Title of drawing	Version	Date	Pages Count
PD - Structural	DEL#6	23.03.2022	30

19 BIBLIOGRAPHY

coLlab

Aktionsplan „Nachhaltig mobil“. [Online] 11. 2020. https://www.stuttgart.de/leben/mobilitaet/nachhaltige-mobilitaet/mobilitaets-konzepte/aktionsplan-nachhaltig-mobil.php.

Aktuelle Fakten zur Photovoltaik in Deutschland. Fraunhofer ISE. 2021.

Armor Groupe: 2019 Annual report Corporate Social Responsibility (03.05.2021): https://www.armor-group.com/sites/default/files/rapport-rse-2019-en-digital-compressed.pdf, page 48, 15:31

Bachelor thesis Optimierung des Entwurfs für den SDE21 für verschieden Standorte anhand von Parametrisierung, winter semester 2020/21, Luisa Claus

Bank, Sebatian. Methodology for the Assessment of the Hot Water. s.l. : ITW – University of Stuttgart, 2012.

Bau-Fritz GmbH & Co. KG (03.05.2021): https://www.baufritz.com/files/downloads/Umwelterkla_rung_2020.pdf, page 32, 12:58

Bau-Fritz GmbH & Co. KG (21.06.2021): https://www.baufritz.com/de/innovation-und-geschichte/auszeichnungen/, 11:36

Bau-Fritz GmbH & Co. KG 01.12.2020: https://www.baufritz.com/de/kontakt-und-beratung/dokument-download/#site; 18:38

Boomforest 27.06.2021: https://boomforest.org/en/pages/miyawaki_method, 12:03

Bundesinstitut für Bau- Stadt- und Raumforschung (2017): Immobilienpreisentwicklungen in Deutschland. Bonn: Bundesamt für Bauwesen und Raumordnung.

Carl Stahl ARC GmbH (03.05.2021): https://www.carlstahl-architektur.com/fileadmin/user_upload/logistik.pdf, page 1, 15:17

Claus, Luisa. Optimierung des Entwurfs für den Solar Decathlon Europe 21 für verschiednene Standorte anhand von Parametrisierung. Stuttgart : s.n., 2021.

Construction of accessible buildings – design principles – part 1: publicly accessible buildings

D-Arch (27.06.2021) https://archive.arch.ethz.ch/bph/Filep/Licht/Licht_Bauwerk/Kennwerte/ReflexionsgradBaumat.html, 15:46

Datasheet Asca Module General Data, OPV Films by Armor

DIN Deutsches Institut für Normung e.V. (2010-10): DIN 18040-1

EnBW Fernwärme. [Online] 2020. [Cited: 08 03 2022.] https://assets.ctfassets.net/upmoejz03x66/2M7Xy6C02AsImaom0qE2S4/aba9ecd8ca796d4e7f4d0d352ff968ad/EnBW-Fernwaerme-Kennzahlen2020.pdf.

Fahrgemeinschaften für Pendler und Reisende. [Online] 9. 10. 2020. https://www.stuttgart.de/leben/mobilitaet/auto/fahrgemeinschaften.php.

forbo (27.06.2021): https://forbo.blob.core.windows.net/forbodocuments/38258/Forbo_Linoleum-Uni_Technische-Daten_201704.pdf, 19:12

Fraunhofer ISE (2020), Aktuelle Fakten zur Photovoltaik in Deutschland, Freiburg

German Sustainable Building Council – DGNB e.V. DGNB System 2018: Kriterienkatalog: page 255 + p 436 + pp 534

Google Maps (21.06.2021): https://www.google.de/maps/place/Erkheim/@48.0430928,10.3240081,8z/data=!4m5!3m4!1s0x479bf641078a25b3:0x8cdf7e3c7a8a64fc!8m2!3d48.037988!4d10.336242?hl=de, 10:25

Gutachterausschuss für die Ermittlung von Grundstückswerten in Stuttgart (2020): Grundstücksmarktbericht 2020 (GMB 2020) – Daten für die Wertermittlung 2020/21

https://mlr.baden-wuerttemberg.de/de/unser-service/publikation/did/bienenweidekatalog-verbesserung-der-bienenweide-und-des-artenschutzes/, 27.06.2021 at 18:36

IEEE 40th Photovoltaic Specialist Conference (PVSC). Cnops, K, et al. Piscataway NJ : s.n., 2014.

Institut für Handelsforschung IFH (Hg.) (2015c): Studie „Vitale Innerstädte 2014“, Untersuchung des IFH Köln und weiterer Kooperationspartner, Köln.

Integrierte Verkehrsleitzentrale. [Online] 9. 10. 2020. https://www.stuttgart.de/leben/mobilitaet/verkehrsleitzentrale/

Landeshauptstadt Stuttgart. (2013). Verkehrsentwicklungskonzept der Landeshauptstadt Stuttgart.

Marity, David (2017): Verdichtetes Wohnen. Grenzenlose Möglichkeiten des Stahl-Leichtbaus. In: DBZ - Deutsche Bauzeitung (05), zitiert nach: https://www.dbz.de/artikel/dbz_Grenzenlose_Moeglichkeiten_des_Stahl-Leichtbaus_2810957.html

Ministerium für Ländlichen Raum und Verbraucherschutz BW (2019): Bienenweidekatalog. Verbesserung der Bienenweide und des Artenreichtums

Nachhaltig mobil in Stuttgart. [Online] 2017. https://www.stuttgart.de/medien/ibs/web_Aktionsplan-Mobilitaet.pdf.

natureplus database (21.06.2021): https://www.natureplus-database.org/produkte.php, 14:45

Ökobaudat. [Online] 2015. [Cited: 06 03 2022.] https://www.oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=34ad748d-a657-4d69-92ae-c53dd18a0094&version=01.00.074.

Organic Photovoltaics: Where Are We Headed? van der Staaij, F, van Keulen, I and von Hauff, E. s.l. : Wiley, 2021.

Parkraumkonzept Stuttgart. (9. 10. 2020). Von https://www.stuttgart.de/leben/mobilitaet/auto/parkraummanagement/parken-in-stuttgart.php abgerufen

Parkraumkonzept Stuttgart. [Online] 9. 10. 2020. https://www.stuttgart.de/leben/mobilitaet/auto/parkraummanagement/parken-in-stuttgart.php.

Stadtklima Stuttgart. [Online] 9. 10. 2020. https://www.stadtklima-stuttgart.de/index.php?luft_messdaten_feinstaubwerte#.

Stolz, Philippe. Ökobilanz PV-Anlage und Batterie. 2018.

Studierendenwerk Stuttgart Available at https://www.studierendenwerk-stuttgart.de/ [online] (Accessed 13 June 2020)

Tichelmann, Kartsten Ulrich (2019): Deutschlandstudie 2019 - Wohnraumpotenziale in urbanen Lagen - Kurzfassung. Aufstockung und Umnutzung von Nichtwohngebäuden. Darmstadt.

Ultrathin and lightweight organic solar cells with high flexibility. Kaltenbrunner, M, et al. s.l. : Nature Communications, 2012.

VDE Verlag: Errichtung von Photovoltaik-(PV)- Stromversorgungssystemen: https://www.vde-verlag.de/buecher/leseprobe/9783800748006_PROBE_01.pdf, page 144, 16:16

Ward Larson, G. & Shakespeare, R. (1998), Rendering with Radiance: The Art and Science of Lighting Visualization, San Francisco

Weith, Barkmann, Gaasch, Rogga, Strauß, Zscheiler (2021) Sustainable Land Management in a European Context – A Co-Design Approach

20 APPENDIX

coLlab

20.1 Engineering & Construction

Appendix A – Reduction of Energy Demand

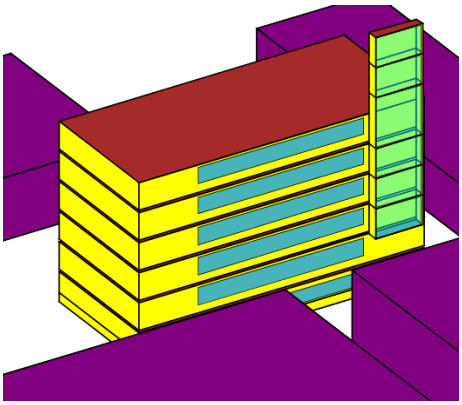
This Part of the Appendix features a description of calculation methods and simulation inputs for the Building Simulations carried out with TRNSYS.

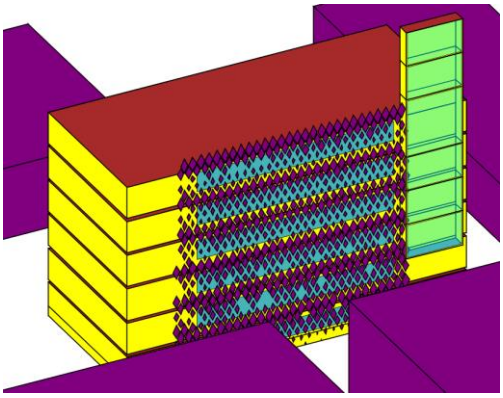
Software used:
The thermal Simulations were conducted with **Trnsys 18** through the simulation studio interface.

Weather data:
The weather data used is provided by the **EnergyPlus**. The location is **Stuttgart**:
Stuttgart 107380 (IWEC)

Existing Building

A reference part of the building was simulated and the results were scaled up:

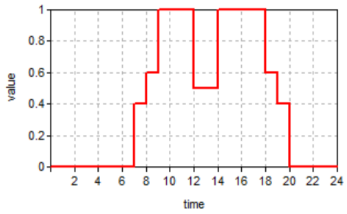




The solar chimney was simulated as a thermal zone in TRNFlow. The shading geometry was later implemented as a shading group.

Internal heat loads and occupants

The simulation inputs for the basis are the following:

Schedule	Time of use: 7:00-20:00 
	Occupancy density: Max. 72 people per floor, distributed by schedule
Internal heat loads	Heat loads persons: 125 W per person
	Heat loads Devices: 100 W per person
	Light: 10 W/m² - daylight controlled
infiltration	1 1/h; hygienic air chnage rate: 30 m^3/pers*h

Envelope Improvements:

Component	**Existing building**	**Refurbished**
External wall	U-value = 2.1 W/m²K	U-value = 0.24 W/m²K
Roof	U-value = 0.43 W/m²K	U-value = 0.24 W/m²K
Floor	U-value = 3.7 W/m²K	U-value = 0.24 W/m²K
Windows	Ug-value = 2.6 W/m²K Frame share 15%	Ug-value = 1.3 W/m²K G=0.74

Ventilation for overheating protection:

Natural ventilation	Control: Day: 25°C/23°C and ΔT 2K/0,5K Night: 23°C/20°C and ΔT 2K/0,5K
Sun protection movable	Regulation: radiation controlled from 140 W/m² to 120 W/m²
	$_{\text{FC-value}}$ = 30

Radiant Ceilings

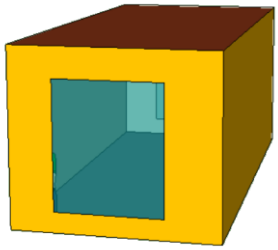
Control	With active layer: Mf: 12 kg/h*m² - VL: between 28°C - 32°C following ambient temperature dependent heating curve
	Weekend setback

Heat Recovery:

Centralized recovery	Effiency: 0.8
Run around coil	Efficiency: 0.6

Additional Story

One module is simulated in 4 different scenarios (upper corner, upper middle, lower corner, lower middle) and the results are scaled up to the whole additional story.

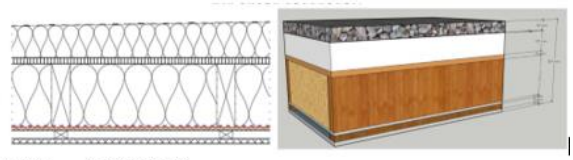


Basic Evaluation of Passive Measures

Basis

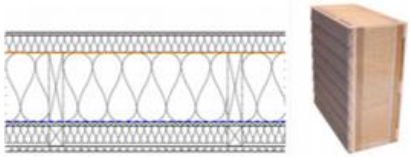
Envelope Build-up (Bau-Fritz GmbH & Co. KG 01.12.2020)

Flat roof



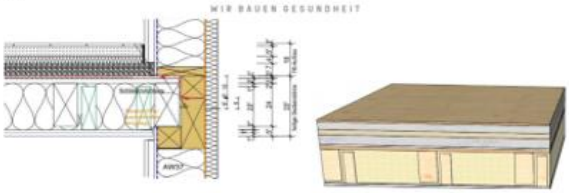
U-Value: 0,12 W/m²K

Wall



U-Value: 0,135 W/m²K

Floor



U-Value: 0,218 W/m²K

Other envelope inputs

thermal bridges	0,1 W/m² (envelope area)
Window U-Value g-Value U frame Frame fraction	 0,8 W/m²K 0,52 1 W/m²K 15%
Infiltration through envelope	0,2 1/h always

Thermal Gains and Losses:

Occupants	75 W/occupant *1 occupants
Schedule	18:00 - 08:00 Uhr; 12:00 – 13:00

Internal loads	3,75 W/m²
Ventilation minimum ventilation	 30m³/h*pers
thermal bridges	0,1 W/m² (envelope area)
Heating	constantly 20°C

PV Overhang

Basis with added overhang (8m)

Ventilation

All optimizations including:

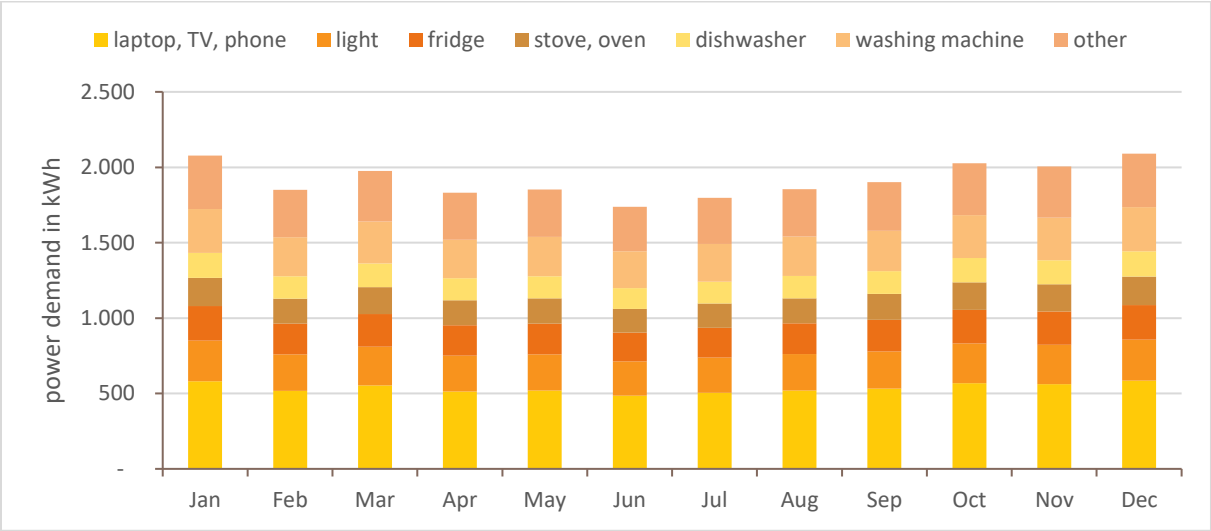
Ventilation minimum ventilation open window when close window when	 at least 30m³/h*pers internal temperature exceeds 25°C and the ambient temperature is lower than the internal temperature internal temperature falls below 21°C

Mass

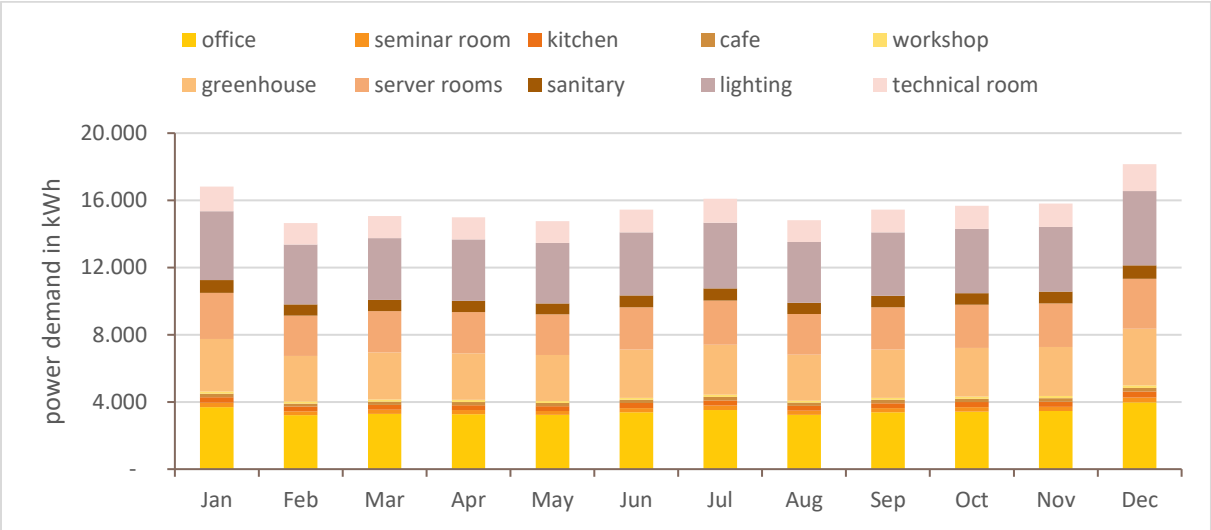
All optimizations including thermal mass as solid wood roof or clay panels on the walls and ceiling (surface)

Appendix B – Final Energy Concept

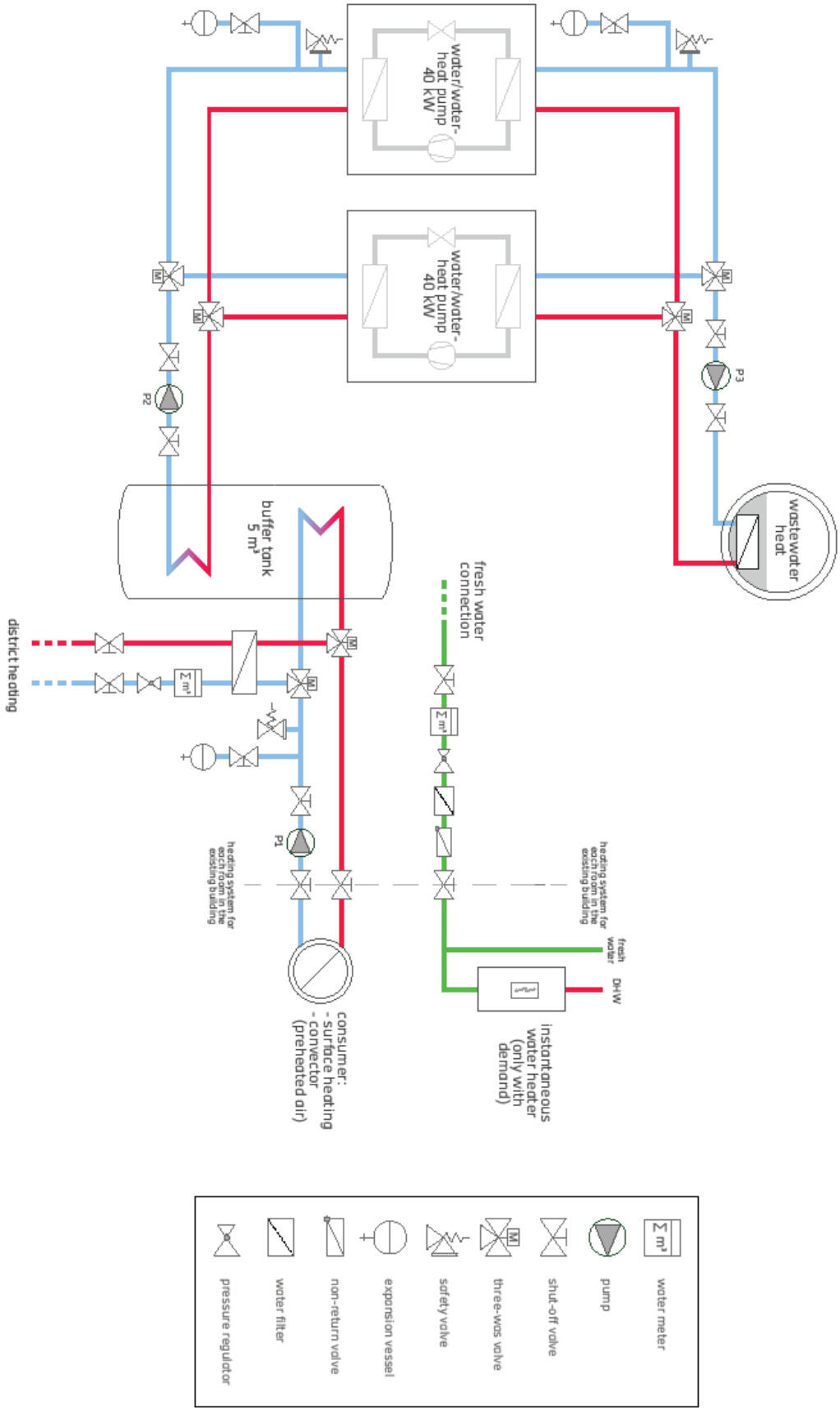
Electrical appliance demand extension



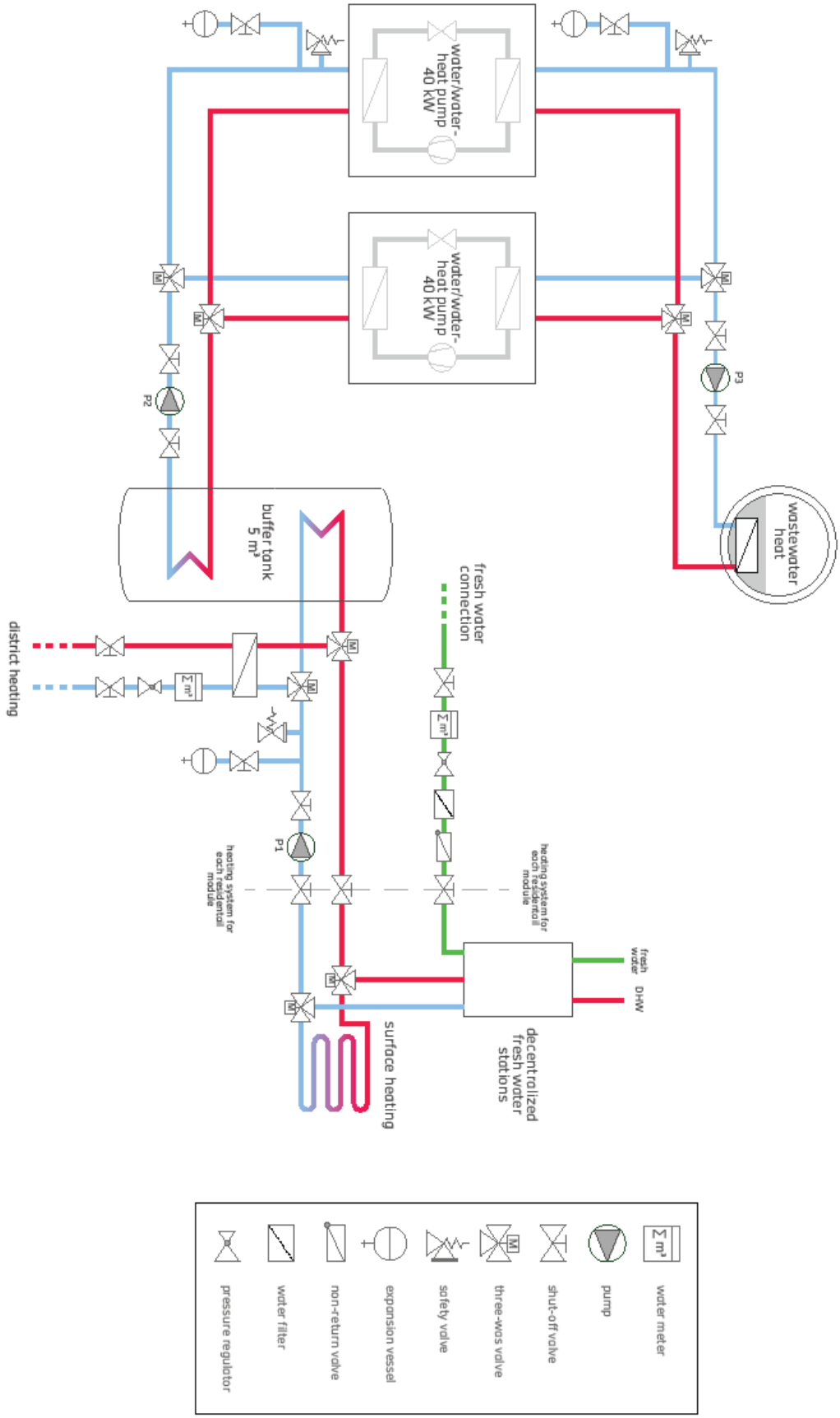
Electrical appliance demand existing building



Heating scheme for DHW in existing building



Heating scheme for DHW in residential building



Appendix C – Measures to Decarbonize Energy supply

This Part of the Appendix features a description of calculation methods and simulation inputs for the system design simulation carried out with TRNSYS.

System Design Simulation

Software used:
The system Simulations were conducted with **Trnsys 18** through the simulation studio interface.

Weather data:
The weather data used is provided by the **EnergyPlus**. The location is **Stuttgart**:
Stuttgart 107380 (IWEC)

Heat Pump Calculation

The heat pump data used for the study is from the brine/water heat pump model Vitocal 300-G, BW/BWS 301.A from Viessmann.

For the calculations, the data set obtained from Viessmann for two brine/water heat pump model Vitocal 300-G, BW/BWS 301.A29, which has a rated power of 37.1 kW, are used. The data is based on a spread of 5K in the secondary circuit and 3 K in the primary circuit. In simplified terms, it is assumed that the temperature to be achieved in the wastewater heat exchanger for the primary flow of the heat pump is constantly 12°C. The temperature on the secondary side was controlled according to the required flow temperature (25 to 35 °C). Since no data was given for a primary circuit temperature of 12 °C, the linear was determined.

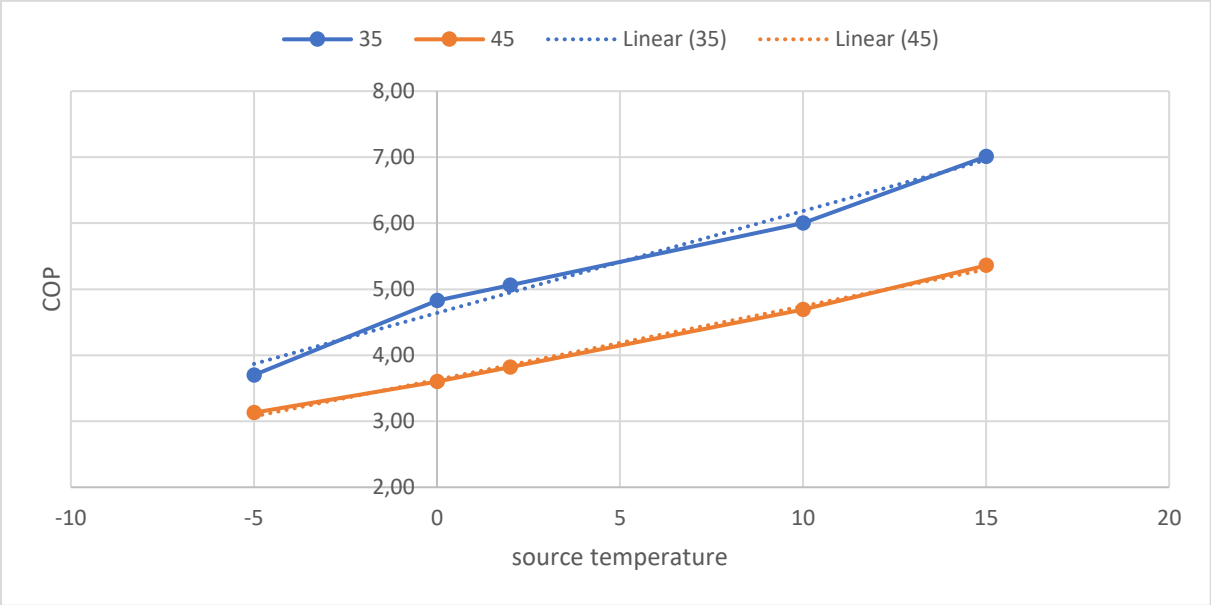
Leistungsdaten

Betriebspunkt	**W**	**°C**			**35**		
	B	**°C**	**-5**	**0**	**2**	**10**	**15**
Heizleistung		kW	25,03	28,80	30,46	37,10	44,18
Kälteleistung		kW	19,33	23,30	24,92	31,40	38,31
Elektr. Leistungsaufnahme		kW	6,97	5,96	6,01	6,20	6,31
Leistungszahl ε (COP)			3,70	4,83	5,06	6,00	7,01

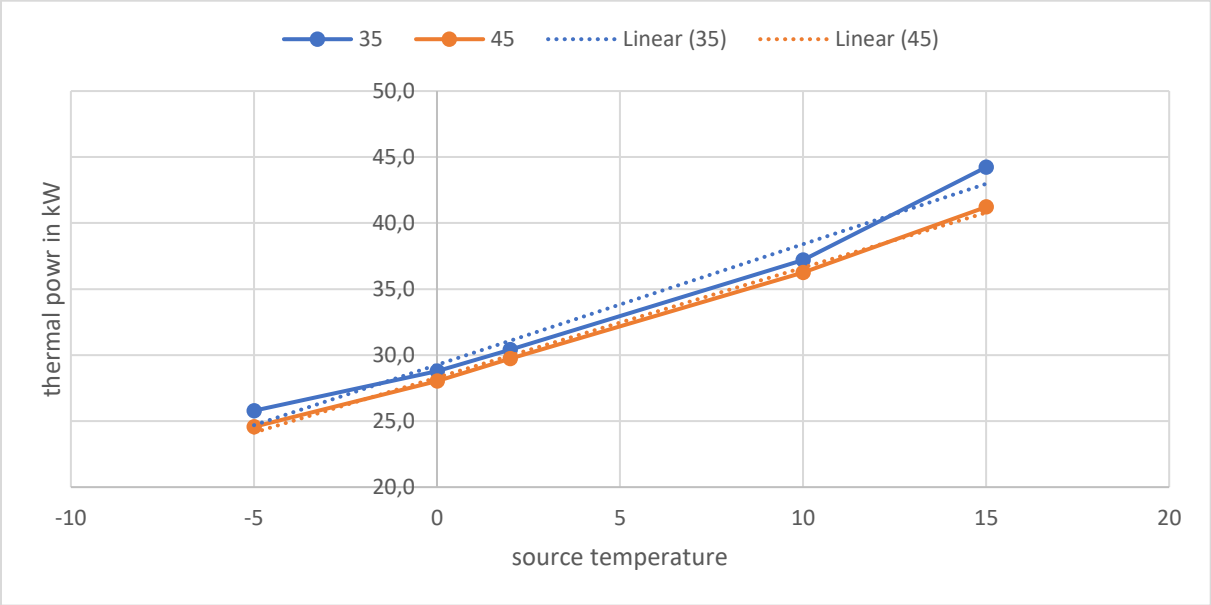
Betriebspunkt	**W**	**°C**			**45**		
	B	**°C**	**-5**	**0**	**2**	**10**	**15**
Heizleistung		kW	24,54	28,04	29,68	36,23	41,21
Kälteleistung		kW	17,24	20,80	22,45	29,05	34,07
Elektr. Leistungsaufnahme		kW	7,85	7,79	7,78	7,73	7,69
Leistungszahl ε (COP)			3,13	3,60	3,82	4,69	5,36

Based on these data, straight-line equations for the heat output and the COP were formed for simplified simulation of the heat pumps as a function of the required flow temperature.

COP = -0.155 * source temperature + 12.00



Thermal power = -0.248 * source temperature + 49.72

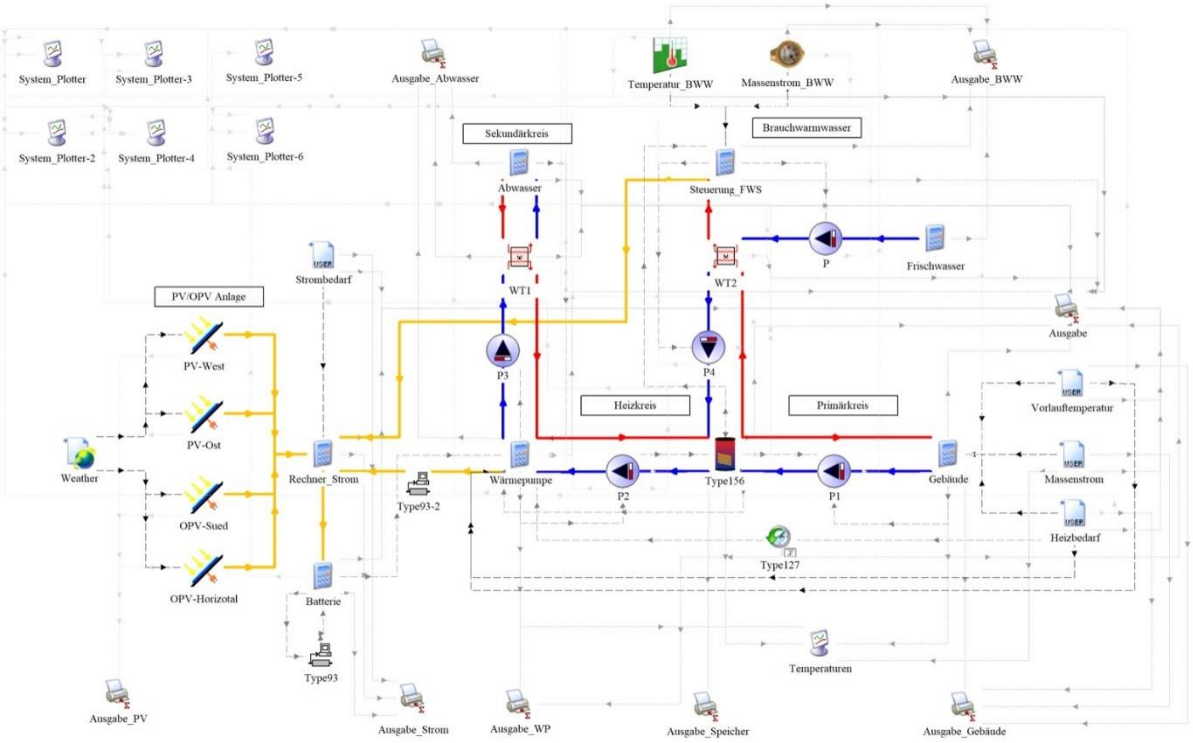


With this data, the corresponding mass flow could be calculated with the following equation

$$\dot{m} = \frac{\dot{Q}}{c \cdot \Delta t} \cdot 3600$$

$\dot{m}$	Massflow in kg/h
$\dot{Q}$	load of the heat pump in kW
c	specific heat capacity in kJ/kgK
Δt	temperature difference in K

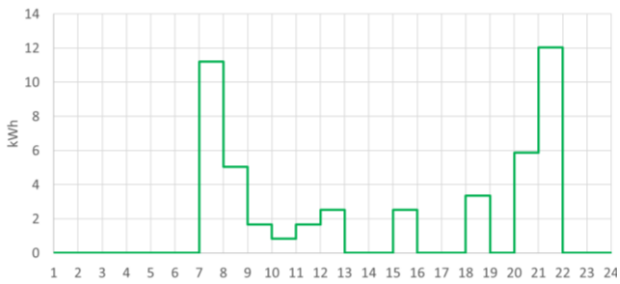
The following figure shows a screenshot of the system simulation in the Simulation Studio:



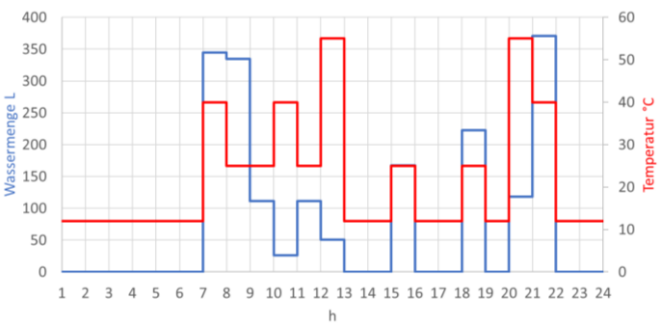
The electric appliance energy demand, the heating energy demand, the supply temperature, as well as the massflow is derived from the building simulation and read into the system simulation using Type 9.

The DHW demand is derived from the “European reference tapping cycles“ (Profile: 3 XL).

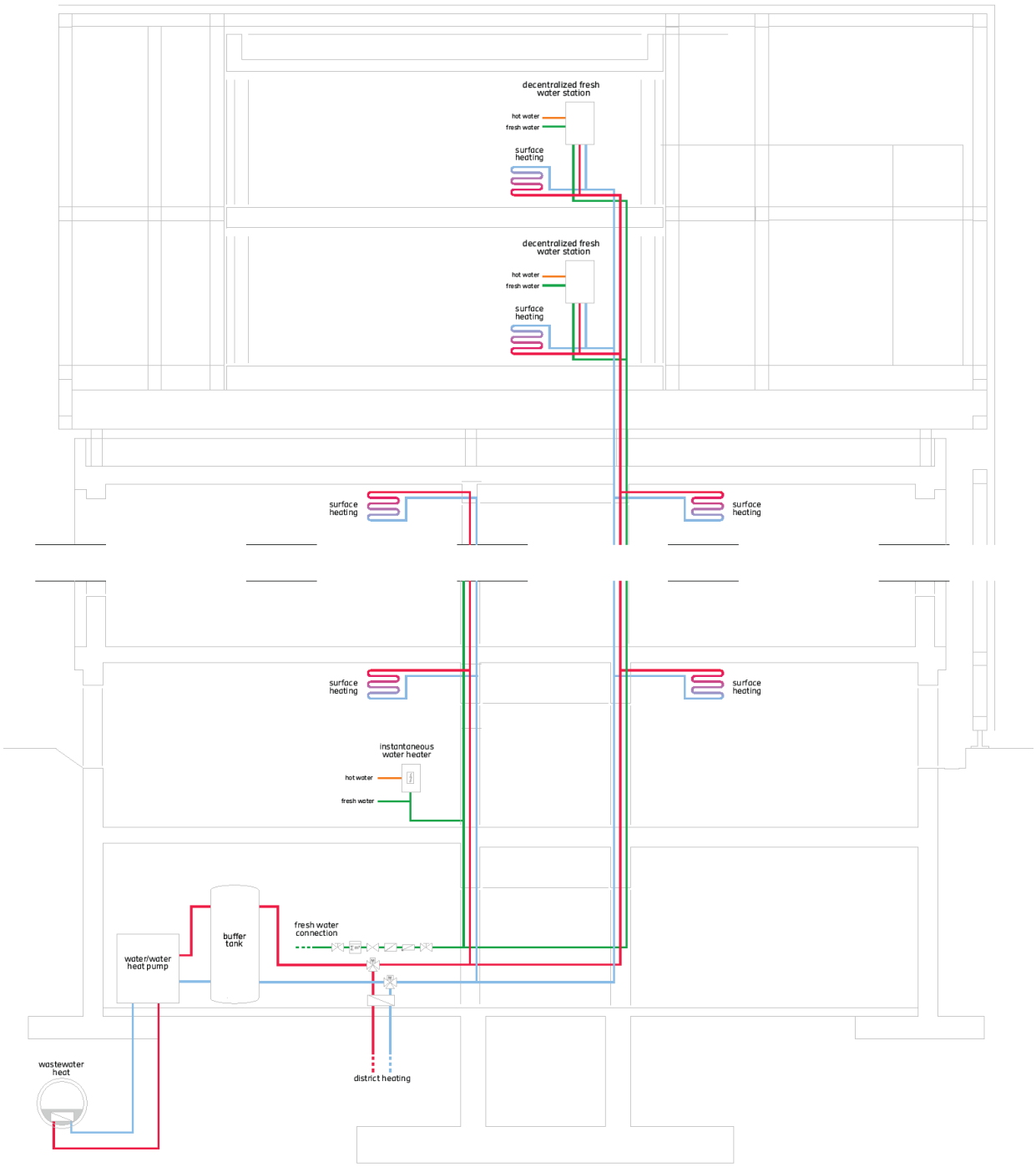
energy:



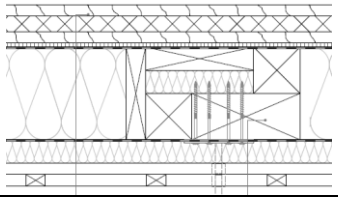
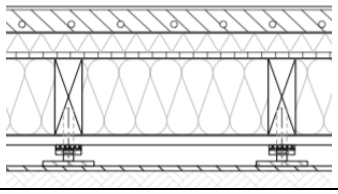
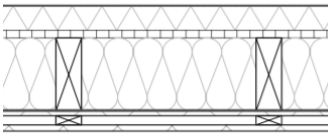
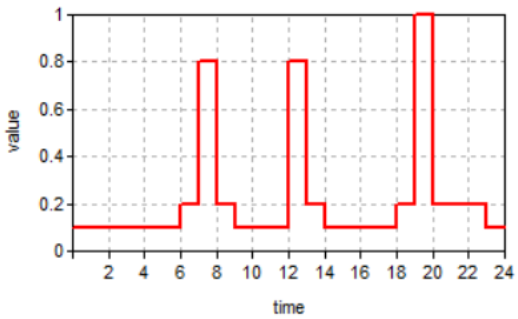
daily water volume and Temperature (used in simulation):

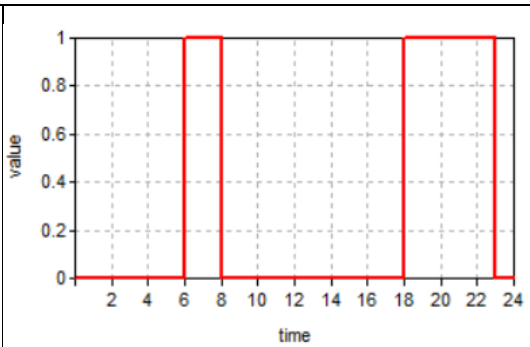


string diagram for DHW

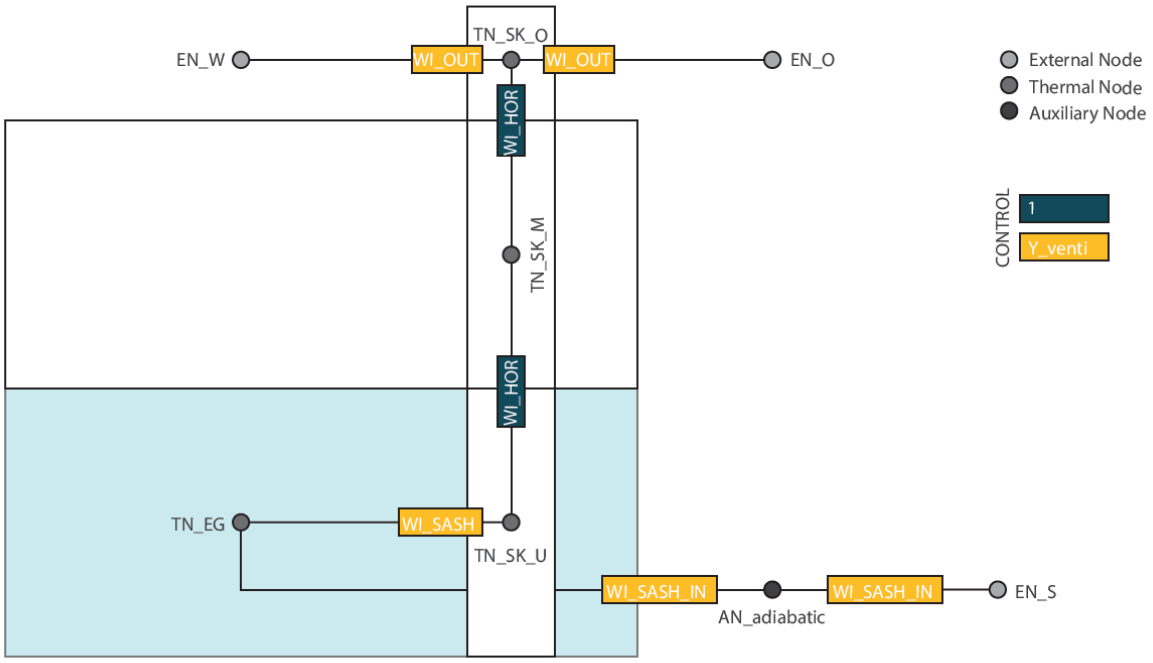


Appendix D – HDU Simulation assumptions

simulation program	Trnsys18 with TrnFlow
weather data	site-related weather data Wuppertal (DWD) 1st may until 21st july
reference area (residential zone EG)	26m²
volume (residential zone EG)	64m³
u-values external wall	0,147 W/m²/K 
u-values external floor	0,152 W/m²/K 
u-values external roof	0,145 W/m²/K 
u-value window	0.71 W/m²/K
g-value window	0.52
Internal gains thermal bridges	0,05 W/m²
schedule person	24 hours & 7 days a week
number of persons	2
internal gains – person	100W per person
schedule equipment	
internal gains – electrical equipment	8 W/m² * schedule equipment

schedule light	
internal gains – light	2,7 W/m² * schedule light
CO_2 concentration outside	400 ppm
CO_2 output per person	16 l/h

TrnFlow Scheme



20.2 Affordability and viability

Appendix A – Calculation of rent

Rental rates student housing

1. Grundwert

Wohnfläche	Baujahr					
	bis 1914	1915 bis 1984	1985 bis 2010	2011 bis April 2020		
Über 25 bis unter 33 m²	12,15	11,79	12,00	12,33		
33 bis unter 40 m²	10,48	10,12	10,33	10,66		
40 bis unter 70 m²	9,64	9,28	9,49	9,82		
70 bis unter 90 m²	9,00	8,64	8,85	9,18		
90 bis unter 115 m²	8,72	8,36	8,57	8,90	Grundwert:	10,66
115 m² und größer	8,74	8,38	8,59	8,92	Grundwert:	12,33

2. Baujahr ab 1998 oder seit 1998 energetisch saniert

Baujahr ab 1998 **oder** umfassende energetische Sanierung seit 1998 Bei energetischer Sanierung wurden Außenwände des Gebäudes gedämmt sowie mind. drei der folgendenden Maßnahmen durchgeführt: - Erneuerung Heizung, - Austausch der Fenster, - Dämmung des Dachs oder der obersten Geschossdecke, - Dämmung des Kellers oder der untersten Geschossdecke	+ 0,37	Zuschlag:	0,37

3. Gebäude- und Wohnungstyp

Penthousewohnung (großzügige Whg. mit Terrasse)	+ 0,96	Zuschlag:	0,96
Einfamilienhaus (freistehend, DHH, RH)	+ 0,42	Zuschlag:	
Hochhaus (mind. 8 Etagen inkl. EG)	- 0,51	Abschlag:	

4. Lage der Immobilie

Mitte 1	+ 0,71	Zuschlag:	
Mitte 2	+ 0,85	Zuschlag:	
Mitte 3	+ 1,76	Zuschlag:	1,76
Filder 1	+ 0,25	Zuschlag:	
Filder 2	+ 0,81	Zuschlag:	
Filder 3	+ 0,94	Zuschlag:	
Neckar 1	+ 0,22	Zuschlag:	
Neckar 2	+ 0,25	Zuschlag:	
Nord 1	0,00		
Nord 2	+ 0,27	Zuschlag:	
Nord 3	+ 0,75	Zuschlag:	

Hinweis : Projektstudie_SS21\Mietspiegel Stuttgart_04.2020.PDF

5. Balkon oder Terrasse

kein Balkon / Terrasse oder kleiner als 3 m²	0,00		
Balkon / Terrasse mit mind. 3 m²	+ 0,26	Zuschlag:	

Hinweis : bei mehreren Balkonen / Terrassen, tatsächliche Gesamt-m² ansetzen

6. Sanitärausstattung und Küche

Dusche mit niedrigem oder bodenebenen Einstieg	+ 0,48	Zuschlag:	0,48
Doppelwaschbecken oder mehrere Einzelwaschbecken (auch in unterschiedlichen Bädern / WC´s)	+ 0,42	Zuschlag:	0,42
Handtuchwärmer	+ 0,58	Zuschlag:	0,58
Offene Küche (keine Kochnische)	+ 0,62	Zuschlag:	

7. Heizung			
keine Heizung, Einzelöfen oder Elektrospeicheröfen	+ 0,58	Zuschlag:	
Etagen- / Zentralheizung mit Heizkörpern	0,00		
Fußbodenheizung	+ 0,70	Zuschlag:	0,7

Hinweis : Heizart auswählen mit der die Whg. überwiegend beheizt wird

8. Haustechnik			
keine zentrale Warmwasserbereitung für Whg. / Gebäude	- 0,27	Abschlag:	
auf Putz verlegte, sichtbare Gas- oder Heizleitungen	- 0,39	Abschlag:	
elektrische Rolläden	+ 0,52	Zuschlag:	0,52

9. Fußboden			
kein vom Vermieter gestellten Boden	- 1,22	Abschlag:	
PVC, Teppich, Linoleum	- 0,94	Abschlag:	
Laminat, Fliesen	+ 0,33	Zuschlag:	0,33
Parkett	+ 0,42	Zuschlag:	

Ortsübliche Vergleichsmiete		Eingeschossig	Zweigeschossig
Grundwert		12,33	10,66
zuzüglich Gesamtsumme Zuschläge		+ 6,12	+ 6,12
abzüglich Gesamtsumme Abschläge		- 0,00	- 0,00
Durchschnittlich ortsübliche Vergleichsmiete		**18,45 €**	**16,78 €**
unterer Spannenwert (1,83)	- 1,83	16,62 €	14,95 €
Durchschnittliche ortsübliche Vergleichsmiete in €/m² Wohnfläche (Übertrag von oben)		18,45 €	16,78 €
oberer Spannenwert (1,81)	+ 1,81	20,26 €	18,59 €
Durchschnittliche Nebenkosten Stuttgart Mitte lt. Mieterverb.:		3,19 €	3,19 €

Areas and calculation of rental income of student housing

Flächen	Geschosse		
	5.OG	6.OG	Summe:
Geschossfläche	1.519,10 m²	1.519,10 m²	**3.038,20 m²**
Fläche Brutto	1.274,71 m²	1.373,45 m²	**2.648,16 m²**
Fläche Netto:	802,68 m²	885,06 m²	**1.687,74 m²**
> Wohnen	453,74 m²	453,74 m²	**907,48 m²**
> Terrasse	348,94 m²	428,32 m²	**777,26 m²**
Verkehrsflächen	316,65 m²	316,65 m²	**633,30 m²**

Anrechenbare Flächen Miete lt. (WoFlV)			
	Anzahl	Flächen	Anrechenbare Fläche
Wohnungen Gesamt	23,00	907,48 m²	**907,48 m²**
Eingeschossig	18,00	*32,41 m²*	**583,38 m²**
Zweigeschossig	5,00	*64,82 m²*	**324,10 m²**
Terasse	0,25	777,26 m²	

Wohnungsmiete pro Monat	
Eingeschossig	597,96 €
Zweigeschossig	1.087,68 €

Hinweis: Flächen lt. Architekten Annika Kötzel

	Eingeschossige Wohnung		
	Durchschnittliche Miete	Obere Spannweite	Untere Spannweite
Mietspiegel lt. Tabelle	18,45 €	20,26 €	16,62 €

	Zweigeschossige Wohnung		
	Durchschnittliche Miete	Obere Spannweite	Untere Spannweite
	16,78 €	18,59 €	14,95 €
Miete Gesamt pro Monat:	16.201,76 €	17.844,30 €	14.541,07 €

Valuation system for commercial real estate

Punktesystem Gewerbeimmobilien

	Punkte:	Gewichtung:
1. Gebäudequalität		
Energetische Sanierung	4	20%
Barrierefreiheit	3	
	3,50	
2. Infrastruktur / Lage		
ÖPNV	4	50%
Lage / Örtliche Umgebung	4	
Verpflegung in naher Umgebung	3	
Stellplätze vorhanden	1	
Ladepunkte für E-Autos	1	
Ladepunkte für E-Bikes	4	
	2,60	
3. Ausstattung		
CAT 7 bis zum Arbeitsplatz	4	30%
Duschen je ME	4	
WC zugehörig zu den ME	4	
Teeküchen bereits vorhanden	4	
Innenverschattung	1	
Außenverschattung	3	
Klimatisierung	4	
Öffenbare Fenster an AP	4	
Fahrradstellplätze in der ME	1	
ZuKo	2	
Verweilflächen pro ME	1	
	2,91	100%
Ergebnis:		2,873

Punkteskala

1	2	3	4
Nicht erfüllt	Nur bedingt erfüllt	Teilweise erfüllt	Voll erfüllt

Bewertungsskala - Grundmiete

Erzielte Punkte	Ab-/ Zuschlag
1,00 - 1,44	-15%
1,45 - 1,89	-10%
1,90 - 2,34	-5%
2,35 - 2,79	0%
2,80 - 3,24	5%
3,25 - 3,69	10%
3,70 - 4,00	15%

Bewertungsskala - Lage innerhalb der Immobilie

UG 1	0,80
EG	1,00
1.OG	1,00
2.OG	1,00
3.OG	1,05
4.OG	1,10

Rental income from commercial real estate

Flächen	Geschosse						
	UG 1	EG	1.OG	2.OG	3.OG	4.OG	Summe:
Nettomietfläche Gesamt	311,75 m²	935,25 m²	935,25 m²	935,25 m²	935,25 m²	935,25 m²	4.988,00 m²
Verkehrsflächen Gesamt							

Anrechenbare Flächen Miete lt. DIN 277

	Grundmiete	Gewichtete Miete	"Mikromiete"	Mietertrag netto	
UG 1	19,50 €	20,48 €	16,38000 €	5.106,47 €	
EG	19,50 €	20,48 €	20,47500 €	19.149,24 €	
1.OG	19,50 €	20,48 €	20,47500 €	19.149,24 €	
2.OG	19,50 €	20,48 €	20,47500 €	19.149,24 €	
3.OG	19,50 €	20,48 €	21,49875 €	20.106,71 €	
4.OG	19,50 €	20,48 €	22,52250 €	21.064,17 €	
				103.725,07 €	1.244.700,84 €

Total rental income

Mietertrag Gesamtgebäude

Miete aus Studentenwohnung

Oben	17.844,30 €
Mitte	**16.201,76 €**
Unten	14.541,07 €

Miete aus Gewerbe

Gewerbemiete Gesamt:	**103.725,07 €**

Miete Gesamt:

Miete Gesamt pro Monat:	**119.926,83 €**
Miete Gesamt pro Jahr:	**1.439.121,95 €**

Hinweis:
> MwSt. muss nicht finanziert werden, wenn man aus der Sicht des Projektentwickler agiert **(Nettomiete)**
> MwSt. muss finanziert werden, wenn man aus der Sicht des Landes agiert **(Bruttomiete)**

Appendix B – Calculation of property value

Income capitalization method according to §§ 17-20 ImmoWertV

Grundstücksfläche	3.643,30 m²	
Überbaufläche	1.379,00 m²	
Geschossfläche BGF	9.875,37 m²	
Umbauterraum BRI	35.147,00 m³	
Stockwerke	2	UG
	6	OG
Nutzfläche Miete Bestand	4.988,00 m²	
Baujahr	1959	
Restnutzungsdauer	30 Jahre	
Bestandsmiete 2018 Netto	10,00 €/m²	
ausgehend des Marktberichtes der Wirtschaftsförderung der Stadt Stuttgart von 2018		
Steigerung auf das Jahr 2021	18,13%	
nach dem Büromarktbericht von Ellwanger und Geiger 2020-2021 S.17		
Bestandsmiete 2021 Netto	11,81 €/m²	
Bodenrichtwert	4.600,00 €/m²	
Verwaltungskosten	3%	des Rohertrages
nach Ertragswert Richtlinie Anlage 1. Nr.2 a)		
Instandhaltungskosten 2015	11,00 €/m² Nutzfläche	
nach Ertragswert Richtlinie Anlage 1. Nr.2 b)		
Instandhaltungskosten 2021	11,77 €/m² Nutzfläche	
Anpassung nach Ertragswert Richtlinie Anlage 1. Nr.3 mit der Preissteigerung des Verbreucherpreisindex		
Verbraucherpreisindex 2015 (2015 = 100)	100	
Verbraucherpreisindex Februar 2021 (2015 = 100)	107	
Mietausfallwagnis	4%	des Rohertrages
nach Ertragswert Richtlinie Anlage 1. Nr.2 c)		
Liegenschaftszinssatz	2,8%	
nach dem Grundstücksmarktbericht 2020 des Gutachterausschusses der Stadt Stuttgart (S.55)		
Barwertfaktor	20,132	
nach § 20 ImmoWertV i.V.m. Anlage 1 zu § 20 ImmoWertV		
Wegerecht	154,35 m²	
Minderung nach Anlage 20 WertR um 15% des Bodenwertes		
Abstandsflächenbaulast	25,00 m²	
Minderung des Bodenrichtwertes in diesem Bereich um 90%		

Calculation of the capitalized earnings value (§§ 17-20 ImmoWertV)

Marktüblicher Rohertrag § 18 (2) ImmoWertV		707.078,93 €
Bewirtschaftungskosten § 19 (2) ImmoWertV		
Verwaltungskosten	-	21.212,37 €
Instandhaltungskosten	-	58.708,76 €
Mietausfallwagnis	-	28.283,16 €
Jährlicher Reinertrag		598.874,64 €
Bodenverzinsungsbetrag	-	469.257,04 €
Reinertrag der baulichen Anlage		129.617,60 €
Ertragswert der baulichen Anlage		**2.609.461,58 €**
Bodenwert		**16.759.180,00 €**
Anpassung an Allg. Wertverhältnisse		
Berücksichtigung objektspezifischer Grundstücksmerkmale		
- Wegerecht	-	2.513.877,00 €
- Abstandsflächenbaulast	-	103.500,00 €
Ertragswert		**16.751.264,58 €**

Asset value method according to §§ 21-23 ImmoWertV

Grundstücksfläche	3.643,30 m²
Überbaufläche	1.379,00 m²
Geschossfläche BGF	9.875,37 m²
Umbauterraum BRI	35.147,00 m³
Stockwerke	2 UG
	6 OG
Nutzfläche Miete Bestand	4.988,00 m²
Baujahr	1959
Restnutzungsdauer	0 Jahre
Normalherstellungskosten 2010	1.840,00 €/m² BGF
Preissteigerung nach Baupreisindex der Bauwirtschaft	35,01%
Regionalfaktor Stuttgart	1,12
Alterswertminderung	100%
Anteil der Rohbaukosten an Kostengruppe 300 und 400 nach Preisindex für die Bauwirtschaft	34,9%
Einsparung an Rohbaukosten	50%
Sachwertfaktor Angenommen	1,0
Wegerecht Minderung nach Anlage 20 WertR um 15% des Bodenwertes	154,35 m²
Abstandsflächenbaulast Minderung des Bodenrichtwertes in diesem Bereich um 90%	25,00 m²

Calculation of the asset value (§§ 21-23 ImmoWertV)

Normalherstellungskosten 2010		1.840,00 €/m² BGF
Preissteigerung nach Baupreisindex für die Bauwirtschaft	35,01%	
Normalherstellungskosten bezogen auf Wertermittlungsstichtag		2.484,18 €/m² BGF
Regionalfaktor Region Stuttgart nach BKI	1,12	
Normalherstellungskosten bezogen auf Wertermittlungsstichtag und Region Stuttgart		2.782,28 €/m² BGF
exkl. Mehrwertsteuer	19%	
Normalherstellungskosten bezogen auf Wertermittlungsstichtag und Region Stuttgart exkl. MwSt.		2.338,05 €/m² BGF
Brutto-Grundfläche	9875,37 m²	
Normalherstellungskosten bezogen auf Wertermittlungsstichtag und Region Stuttgart exkl. MwSt.		23.089.108,83 €
Alterswertminderung	100%	
Normalherstellungskosten bezogen auf Wertermittlungsstichtag und Region Stuttgart inkl. Alterswertminderung exkl. MwSt.		- €
Anteil der Rohbaukosten von KG 300 und 400 nach Preisindex für die Bauwirtschaft	34,90%	
Rohbaukosten		8.058.098,98 €
Einsparung an Rohbaukosten	50,00%	
Angesetzter Wert der baulichen Anlage		**4.029.049,49 €**
Bodenwert		**16.759.180,00 €**
vorläufiger Sachwert		**20.788.229,49 €**
Sachwertfaktor	1,0	
Marktangepasster vorläufiger Sachwert		20.788.229,49 €
Berücksichtigung objektspezifischer Grundstücksmerkmale		
- Wegerecht	-	2.513.877,00 €
- Abstandsflächenbaulast	-	103.500,00 €
Sachwert		**18.170.852,49 €**

Fees for boundary survey and continuation of the real estate cadastre

Bodenrichtwert	4.600,00 €/m²	
Anzahl Ausgangsflurstücke (AF) Flst. 500 = 25.749 m²	1	
Anzahl gebildeter Flurstücke (Flste.) Flst. 500 = ca. 22.106 m² Flst. 500/1 (neu) = ca. 3.643 m²	2	
Anzahl Kleinflächen (KF) bei 2 Flste.	0	KF < 76 m² max. 1 je AF
Anzahl Kleinflächen (KF) bei ≥ 2 Flste.	0	KF für 1. Flst. < 76 m² je AF
Anzahl Kleinflächen (KF) bei ≥ 3 Flste.	0	KF für 2. Flst. bis ∞ Flst. < 76 m² je AF
Anzahl Großflächen (GF)	1	GF > 599 m², bzw. > 525 m² + KF je AF bleibt ein GF unberücksichtigt
Anzahl Grenzpunkte der neuer Grenzen	6	
davon Abzumarken	6	

Bodenwertfaktoren	Faktor		Bodenrichtwert
	1,0	≤	10 €/m²
	1,7	>	10 bis 100 €/m²
	2,3	>	100 bis 300 €/m²
	3,0	>	300 bis 1.000 €/m²
	3,7	>	1.000 €/m²

Gebühr für die Grenzvermessung

Nr. in Anlage zur GebVO-MLR						
Nr. 30.2.1.3	Flurstückszerlegung					
Nr. 30.6.2.1	Ausgangsflurstück	1 x	150,00 €	=	150,00 €
Nr. 30.6.2.2.1	gebildete Flurstücke	2 x	220,00 €	=	440,00 €
Nr. 30.6.2.2.2	Kleinflächenbonus bei Zerl. in 2 Flste. mind. 1 < 76 m²	0 x	- 220,00 €	=	- €
Nr. 30.6.2.2.3	Kleinflächenbonus bei Zerl. In mehr als 2 Flste.				
	1. Flst. < 76 m²	0 x	- 220,00 €	=	- €
	2. und mehr Flst. < 76 m²	0 x	- 110,00 €	=	- €
Nr. 30.6.2.2.4	Großflächenzuschlag	1 x	220,00 €	=	220,00 €
Nr. 30.6.2.3	Grenzpunkte der neuen Grenze	6 x	40,00 €	=	240,00 €
Nr. 30.6.2.5	Abzumarkende Grenzpunkte	6 x	60,00 €	=	360,00 €
Zwischensumme					**1.410,00 €**
Nr. 30.6.3.1	Berücksichtigung des Bodenwertfaktor				
	Zwischensume	x	3,7	=	5.217,00 €
Gebühr für die Grenzvermessung netto					**5.217,00 €**
	Mehrwertsteuer		19%		991,23 €
Gebühr für die Grenzvermessung brutto					**6.208,23 €**

Gebühr für die Fortführung des Liegenschaftskatasters

Nr. 30.3.1.1	Die Gebühr zur Fortführung des Liegenschaftskatasters beträgt 35% der Gebühr für die Grenzvermessung netto.			
	Gebühr für die Grenzvermessung netto	x	35%	1.825,95 €
Gebühr für die Fortführung des Liegenschaftskatasters				**1.825,95 €**

Appendix C – Profitability calculation

Profitability calculation of the overall project

Wirtschaftlichkeitsberechnung gesamtes Projekt

Projekt	**Bau 5 SDE**
Standort	**Stuttgart**
Stand	
	=Eingabefeld

Gebäude 5 - Allgemeine Daten:

Grundstück

Grundstücksfläche	3643 m²		
Zul. GFZ	0	GFZ geplant	0
Zul. GRZ	0	GRZ geplant	0
Zul. Vollgeschosse	0	Vollgeschosse geplant	0

Stellplatznachweis

PKW			Fahrrad	
Stellplätze nach LBO/VwV oder Satzung		0 Stp.	Stellplätze nach LBO/VwV	0 Stp.
ÖPVN-Minderung in %	0%	0 Stp.	Stellplätze geplant	0 Stp.
Stellplätze erforderlich		0 Stp.	Überdeckung/Unterdeckung	0 Stp.
Stellplätze geplant		0 Stp.		
Überdeckung/Unterdeckung		0 Stp.		

Gebäude				Mietflächen	
Geschosse:	BGF	Geschosshöhe	BRI	Mietflächen	Effizienz
6. OG	1373,45 m²	3,03 m	4161,55 m³	453,74 m²	33%
5. OG	1274,71 m²	2,76 m	3518,20 m³	453,74 m²	36%
4. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
3. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
2. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
1. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
EG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
1. UG	1349,76 m²	4,30 m	5803,97 m³	311,75 m²	23%
2. UG	1349,76 m²	3,30 m	4454,21 m³	0,00 m²	0%

Zusammengefasst

Summe oberirdische Geschosse	9544,41 m²
Summe unterirdische Geschosse	2699,52 m²
Summe aller Geschosse	12243,93 m²
Summe Außenanlage	2264,05 m²
Summe Mietflächen	5895,48 m²
Gesamteffizienz	48%

Kostenberechnung nach DIN 276

Kostengruppe 100 - Grundstück	Kostengruppe	Bemerkung			**Berechnung**	
Grundstückswert	110		3643,30 m²	4600,00 €/m²	16.759.180,00 €	16.751.265,00 €
Vermessungsgebühren	121				2.500,00 €	2.500,00 €
Gerichtsgebühren	122		16.751.265,00 €	0,5%	83.756,33 €	83.756,33 €
Noriariatsgebühren	123		16.751.265,00 €	1,0%	167.512,65 €	167.512,65 €
Grunderwerbssteuer	124		16.751.265,00 €	5%	837.563,25 €	837.563,25 €
Umweltgutachten	125				- €	- €
Genehmigungsgebühren	127				7.500,00 €	7.500,00 €
Baulasten/Dienstbarkeiten					- €	- €
Rechtsberatung Grunderwerb					- €	- €
Maklerprovision			16.751.265,00 €	0%	- €	- €
Risikozuschlag/Sonstiges			17.850.097,23 €	1,0%	178.500,97 €	178.500,97 €
Vorsteuer			840.063,25 €	19,0%	159.612,02 €	159.612,02 €
Summe Grundstück	**KG100**					**18.188.210,21 €**

Kostengruppe 200 - Herrichten und Erschließen	Kostengruppe	Bemerkung				
Herrichten	210				70.000,00 €	70.000,00 €
Öffentliche Erschließung	220		0,00 m²	0,00 €/m²	- €	- €
Nichtöffentliche Erschließung	230		0,00 m²	0,00 €/m²	- €	- €
Ausgleichsmaßnahmen und -abgaben	240				471.622,86 €	471.622,86 €
Übergangsmaßnahmen	250		270.627,00 €	18 Monate	81.000,00 €	1.728.627,00 €
Risikozuschlag/Sonstiges			2.270.249,86 €	5%	113.512,49 €	113.512,49 €
Vorsteuer			2.270.249,86 €	19%	431.347,47 €	431.347,47 €
Summe Herrichten und Erschließen	**KG 200**					**2.815.109,83 €**

Kostengruppe 300-400 - Bauwerk - Baukonstruktion - TGA	Kostengruppe	Bemerkung				
Baugrube/Erdbau	310				101.288,81 €	101.288,81 €
Gründung/Unterbau	320				16.411,11 €	16.411,11 €
Außenwände/Vertkiale Baukonstruktionen, außen	330				2.524.270,26 €	2.524.270,26 €
Innenwände/Vertikale Baukonstuktionen, innen	340				840.189,19 €	840.189,19 €
Decken/Horizontale Baukonstruktionen	350				2.314.074,28 €	2.314.074,28 €
Dächer	360				92.290,09 €	92.290,09 €
Baukonstruktive Einbauten	380				- €	- €
Sobstige Maßnahmen für Baukonstruktionen	390				832.937,09 €	832.937,09 €
Abwasser-, Wasser-, Gasanlagen	410				1.335.123,97 €	1.335.123,97 €
Wärmeversorgungsanlagen	420				1.216.063,04 €	1.216.063,04 €
Raumlufttechnische Anlagen	430				4.662,80 €	4.662,80 €
Elektrische Anlagen	440				5.199.026,16 €	5.199.026,16 €
Kommunikations-, Sicherheits-, und informationstechnsiche Anlagen	450				331.599,98 €	331.599,98 €
Förderanlagen	460				165.400,44 €	165.400,44 €
Nutzungsspezifische- und verfahrenstechnische Anlagen	470				655.449,55 €	655.449,55 €
Gebäude- und Anlagenautomation	480				111.675,98 €	111.675,98 €
Sonstige Maßnahmen für technische Anlagen	490				- €	- €
Risikozuschlag/Sonstiges			15.740.462,76 €	3%	472.213,88 €	472.213,88 €
Vorsteuer			15.740.462,76 €	19%	2.990.687,92 €	2.990.687,92 €
Summe Baukonstruktionen	**KG 300-400**					**19.203.364,57 €**

Kostengruppe 500 - Außenanlagen	Kostengruppe	Bemerkung				
Erdbau	510				- €	- €
Gründung/Unterbau	520				- €	- €
Oberbau/Deckschicht	530				2.371,35 €	2.371,35 €
Baukonstruktionen	540				244.254,67 €	244.254,67 €
Technische Anlagen	550				- €	- €
Eibauten in Außenanlagen und Freiflächen	560				- €	- €
Vegetationsflächen	570				22.644,33 €	22.644,33 €
Wasserflächen	580				- €	- €
Sonstige Maßnahmen für Außenanlagen und Freiflächen	590				- €	- €
Risikozuschlag/Sonstiges			269.270,35 €	3%	8.078,11 €	8.078,11 €
Vorsteuer			269.270,35 €	19%	51.161,37 €	51.161,37 €
Summe Außenanlagen	**KG 500**					**328.509,83 €**

Kostengruppe 600 - Ausstattung	Kostengruppe	Bemerkung				
Allgemeine Ausstattung	610				1.010.992,58 €	1.010.992,58 €
Besondere Ausstattung	620				- €	- €

Infromationstechnische Ausstattung	630				346.419,48 €	346.419,48 €
Risikozuschlag/Sonstiges			1.357.412,06 €	5%	67.870,60 €	67.870,60 €
Vorsteuer			1.357.412,06 €	19%	257.908,29 €	257.908,29 €
Summe Ausstattung	**KG 600**					**1.683.190,96 €**

Kostengruppe 700 - Baunebenkosten	Kostengruppe	Bemerkung				
Bauherrenaufgaben	710				381.522,56 €	381.522,56 €
Vorbereitung der Objektplanung	720				10.000,00 €	10.000,00 €
Objektplanung	730				2.587.253,69 €	2.587.253,69 €
Fachplanung	740				2.472.457,16 €	2.472.457,16 €
Künstlerische Leistungen	750				- €	- €
Allgemeine Baukosten	760				332.550,60 €	332.550,60 €
Sonstige Baunebenkosten	790				- €	- €
Risikozuschlag/ Sonstiges			5.783.784,01 €	3%	173.513,52 €	173.513,52 €
Vorsteuer			5.783.784,01 €	19%	1.098.918,96 €	1.098.918,96 €
Summe Baunebenkosten	**KG 700**					**7.056.216,49 €**

Kostengruppe 800 - Finanzierungskosten						
Eigenkapital		20% von GIK		10.178.702,01 €		
Fremdkapital		80% von GIK		40.714.808,02 €		
Finanzierungsnebenkosten	810				2.973.903,32 €	2.973.903,32 €
Fremdkapitalzinsen	820				393.286,37 €	393.286,37 €
Eigenkapitalzinsen	830				98.321,59 €	- €
Bürgschaften	840				491.607,96 €	491.607,96 €
Sonstige Finanzierungskosten	890				- €	- €
Risikozuschlag/ Sonstiges			3.858.797,65 €	3%	115.763,93 €	115.763,93 €
Vorsteuer			3.858.797,65 €	19%	733.171,55 €	733.171,55 €
Summe Finanzierungskosten	**KG 800**					**4.707.733,13 €**

Kostenzusammenstellung					
Summe Grundstück	KG 100		36%		18.188.210,21 €
Summe Herrichten und Erschließen	KG 200		6%		2.815.109,83 €
Summe Baukonstruktionen	KG 300-400		38%		19.203.364,57 €
Summe Außenanlagen	KG 500		1%		326.509,83 €
Summe Ausstattungen	KG 600		3%		1.683.190,96 €
Summe Baunebenkosten	KG 700		14%		7.056.216,49 €
Summe Finanzierungskosten	KG 800		9%		4.707.733,13 €
Vorsteuer				5.722.807,59 €	
Bundesförderungen für effiziente Gebäude					**3.088.825,00 €**
Gesamtkosten					**50.893.510,03 €**

Mieterträge					
Mieter gesamt		**Monatsmiete**	**119.926,83 €**	**Jahresmiete**	**1.439.121,95 €**

Gesamtbetrachtung					
Jahresmiete					**1.439.121,95 €**
Gesamtkosten					**50.893.510,03 €**
Gesamtkosten/Gesamtertrag		**Bruttorendite**	**2,83%**	**Faktor**	**35,36**
Risikozuschlag/Sonstiges		**Faktor**		**2,24%**	**1.139.453,51 €**

Profitability calculation of the refurbishment

Wirtschaftlichkeitsberechnung Sanierung

Projekt	**Bau 5 SDE**
Standort	**Stuttgart**
Stand	
	=Eingabefeld

Gebäude 5 - Allgemeine Daten:

Grundstück

Grundstücksfläche	3643 m²		
Zul. GFZ	0	GFZ geplant	0
Zul. GRZ	0	GRZ geplant	0
Zul. Vollgeschosse	0	Vollgeschosse geplant	0

Stellplatznachweis

PKW			Fahrrad	
Stellplätze nach LBO/VwV oder Satzung	0 Stp.		Stellplätze nach LBO/VwV	0 Stp.
ÖPVN-Minderung in %	0%	0 Stp.	Stellplätze geplant	0 Stp.
Stellplätze erforderlich		0 Stp.	Überdeckung/Unterdeckung	0 Stp.
Stellplätze geplant		0 Stp.		
Überdeckung/Unterdeckung		0 Stp.		

Gebäude				Mietflächen	
Geschosse:	BGF	Geschosshöhe	BRI	Mietflächen	Effizienz
4. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
3. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
2. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
1. OG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
EG	1379,25 m²	3,50 m	4827,38 m³	935,25 m²	68%
1. UG	1349,76 m²	4,30 m	5803,97 m³	311,75 m²	23%
2. UG	1349,76 m²	3,30 m	4454,21 m³		0%

Zusammengefasst

Summe oberirdische Geschosse	6896,25 m²
Summe unterirdische Geschosse	2699,52 m²
Summe aller Geschosse	9595,77 m²
Summe Außenanlage	2263,75 m²
Summe Mietflächen	4988,00 m²
Gesamteffizienz	52%

Kostenberechnung nach DIN 276

Kostengruppe 100 - Grundstück	Kostengruppe	Bemerkung				**Berechnung**
Grundstückswert	110				16.751.265,00 €	16.751.265,00 €
Vermessungsgebühren	121				2.500,00 €	2.500,00 €
Gerichtsgebühren	122				83.756,33 €	83.756,33 €
Norariatsgebühren	123				167.512,65 €	167.512,65 €
Grunderwerbssteuer	124				837.563,25 €	837.563,25 €
Umweltgutachten	125				- €	- €
Genehmigungsgebühren	127				7.500,00 €	7.500,00 €
Baulasten/Dienstbarkeiten					- €	- €
Rechtsberatung Grunderwerb					- €	- €
Maklerprovision					- €	- €
Vorsteuer			840.063,25 €	19%	159.612,02 €	159.612,02 €
Summe Grundstück	**KG 100**					**18.009.709,24 €**

Kostengruppe 200 - Herrichten und Erschließen	Kostengruppe	Bemerkung	Gesamt	€/m²	Fläche Sanierung	
Herrichten	210		70.000,00 €	5,72 €/m²	54.860,16 €	54.860,16 €
Öffentliche Erschließung	220		- €	- €	- €	- €
Nichtöffentliche Erschließung	230		- €	- €	- €	- €
Ausgleichsmaßnahmen und -abgaben	240		471.622,86 €	38,52 €/m²	369.618,62 €	369.618,62 €
Übergangsmaßnahmen	250		1.728.627,00 €	141,18 €/m²	1.354.753,51 €	1.354.753,51 €
Vorsteuer			1.779.232,28 €	19%	338.054,13 €	338.054,13 €
Summe Herrichten und Erschließen	**KG 200**					**2.117.286,41 €**

Kostengruppe 300-400 - Bauwerk - Baukonstruktion - TGA	Kostengruppe	Bemerkung				
Baugrube/Erdbau	310				6.906,20 €	6.906,20 €
Gründung/Unterbau	320				14.556,45 €	14.556,45 €
Außenwände/Vertkjale Baukonstruktionen, außen	330				1.607.640,24 €	1.607.640,24 €
Innenwände/Vertikale Baukonstuktionen, innen	340				609.892,45 €	609.892,45 €
Decken/Horizontale Baukonstruktionen	350				1.720.305,27 €	1.720.305,27 €
Dächer	360				- €	- €
Baukonstruktive Einbauten	380				- €	- €
Sobstige Maßnahmen für Baukonstruktionen	390				674.522,92 €	674.522,92 €
Abwasser-, Wasser-, Gasanlagen	410				1.127.927,41 €	1.127.927,41 €
Wärmeversorgungsanlagen	420				1.005.083,83 €	1.005.083,83 €
Raumlufttechnische Anlagen	430				- €	- €
Elektrische Anlagen	440				1.917.476,59 €	1.917.476,59 €
Kommunikations-, Sicherheits-, und informationstechnsiche Anlagen	450				318.276,55 €	318.276,55 €
Förderanlagen	460				77.601,02 €	77.601,02 €
Nutzungsspezifische- und verfahrenstechnische Anlagen	470				648.062,43 €	648.062,43 €
Gebäude- und Anlagenautomation	480				111.675,98 €	111.675,98 €
Sonstige Maßnahmen für technische Anlagen	490				- €	- €
Vorsteuer			9.839.927,35 €	19%	1.869.586,20 €	1.869.586,20 €
Summe Baukonstruktionen	**KG 300-400**					**11.709.513,55 €**

Kostengruppe 500 - Außenanlagen	Kostengruppe	Bemerkung				
Erdbau	510				- €	- €
Gründung/Unterbau	520				- €	- €
Oberbau/Deckschicht	530				2.371,35 €	2.371,35 €
Baukonstruktionen	540				23.502,00 €	23.502,00 €
Technische Anlagen	550				- €	- €
Eibauten in Außenanlagen und Freiflächen	560				- €	- €
Vegetationsflächen	570				22.115,53 €	22.115,53 €
Wasserflächen	580				- €	- €
Sonstige Maßnahmen für Außenanlagen und Freiflächen	590				- €	- €
Vorsteuer			47.988,89 €	19%	9.117,89 €	9.117,89 €
Summe Außenanlagen	**KG 500**					**57.106,78 €**

Kostengruppe 600 - Ausstattung	Kostengruppe	Bemerkung				
Allgemeine Ausstattung	610				670.213,58 €	670.213,58 €
Besondere Ausstattung	620				- €	- €
Infromationstechnische Ausstattung	630				346.419,48 €	346.419,48 €
sonstige Ausstattung	690				- €	- €
Vorsteuer			1.016.633,06 €	19%	193.160,28 €	193.160,28 €
Summe Ausstattung	**KG 600**					**1.209.793,35 €**

Kostenrgruppe 700 - Baunebenkosten	Kostengruppe	Bemerkung				
Bauherrenaufgaben	710				223.647,61 €	223.647,61 €

Vorbereitung der Objektplanung	720			5.000,00 €	5.000,00 €
Objektplanung	730			1.612.929,21 €	1.612.929,21 €
Fachplanung	740			1.495.002,59 €	1.495.002,59 €
Künstlerische Leistungen	750			- €	- €
Allgemeine Baukosten	760			184.888,48 €	184.888,48 €
Sonstige Baunebenkosten	790			- €	- €
Vorsteuer		3.521.467,89 €	19%	669.078,90 €	669.078,90 €
Summe Baunebenkosten	**KG 700**				**4.190.546,79 €**

Kostenzusammenstellung					
Summe Grundstück	KG 100		48%		18.009.709,24 €
Summe Herrichten und Erschließen	KG 200		6%		2.117.286,41 €
Summe Baukonstruktionen	KG 300-400		31%		11.709.513,55 €
Summe Außenanlagen	KG 500		0%		57.106,78 €
Summe Ausstattungen	KG 600		3%		1.209.793,35 €
Summe Baunebenkosten	KG 700		11%		4.190.546,79 €
Vorsteuer				3.238.609,42 €	
Gesamtkosten					**37.293.956,11 €**

Mieterträge					
Nutzungsart	Miete/pm Stellplatz	Fläche Anzahl	Mietertrag p.M.	Mietertrag p.a.	
	4676,25 m²				
4. OG	22,52 €	935,25 m²	21.064,17 €	252.770,02 €	252.770,02 €
3. OG	21,50 €	935,25 m²	20.106,71 €	241.280,47 €	241.280,47 €
2. OG	20,48 €	935,25 m²	19.149,24 €	229.790,93 €	229.790,93 €
1. OG	20,48 €	935,25 m²	19.149,24 €	229.790,93 €	229.790,93 €
EG	20,48 €	935,25 m²	19.149,24 €	229.790,93 €	229.790,93 €
1. UG	16,38 €	311,75 m²	5.106,47 €	61.277,58 €	61.277,58 €
2. UG	- €		- €	- €	- €
Stellplätze	- €	0 Stp.	- €	- €	- €
Mieter gesamt		**Monatsmiete**	**103.725,07 €**	**Jahresmiete**	**1.244.700,84 €**

Gesamtbetrachtung				
Jahresmiete				**1.244.700,84 €**
Gesamtkosten				**37.293.956,11 €**
Gesamtkosten/Gesamtertrag	**Bruttorrendite**	**3,34%**	**Faktor**	**29,96**

Profitability calculation of the extension

Wirtschaftlichkeitsberechnung Aufstockung

Projekt	**Bau 5 SDE**
Standort	**Stuttgart**
Stand	
	=EIngabefeld

Gebäude 5 - Allgemeine Daten:

Grundstück

Grundstücksfläche	3643 m²		
Zul. GFZ	0	GFZ geplant	0
Zul. GRZ	0	GRZ geplant	0
Zul. Vollgeschosse	0	Vollgeschosse geplant	0

Stellplatznachweis

PKW			Fahrrad	
Stellplätze nach LBO/VwV oder Satzung		0 Stp.	Stellplätze nach LBO/VwV	0 Stp.
ÖPVN-Minderung in %	0%	0 Stp.	Stellplätze geplant	0 Stp.
Stellplätze erforderlich		0 Stp.	Überdeckung/Unterdeckung	0 Stp.
Stellplätze geplant		0 Stp.		
Überdeckung/Unterdeckung		0 Stp.		

Gebäude					Mietflächen	
Geschosse:	BGF	Geschosshöhe	BRI	Mietfläche Wohnung	Mietflächengesamt	Effizienz
6. OG (Wohnungen und Terrrassen)	1373,45 m²	3,03 m	4161,55 m³	453,74	453,74 m²	33%
5. OG (Wohnungen und Terrassen)	1274,71 m²	2,76 m	3518,20 m³	453,74	453,74 m²	36%
Zusatzliche Flächenausweisung						
Terrasse 6.OG	0,00 m²					
Terrasse 5.OG	0,00 m²					
Verkehrsflächen 6.OG	316,65 m²					
Verkehrsflächen 5.OG	316,65 m²					

Zusammengefasst

Summe oberirdische Geschosse	2648,16 m²
Summe Mietflächen	907,48 m²
Gesamteffizienz	34%

Kostenberechnung nach DIN 276 — **Berechnung**

Kostengruppe 100 - Grundstück	Kostengruppe	Bemerkung	Gesamt	€/m²	Fläche Aufstockung	
Grundstückswert						
Vermessungsgebühren						
Gerichtsgebühren						
Norariatsgebühren						
Grunderwerbssteuer						
Umweltgutachten						
Genehmigungsgebühren						
Baulasten/Dienstbarkeiten						
Rechtsberatung Grunderwerb						
Maklerprovision						
Risikozuschlag/Sonstiges						
Vorsteuer						
Summe Grundstück	**KG100**					**- €**

Kostengruppe 200 - Herrichten und Erschließen	Kostengruppe	Bemerkung	Gesamt	€/m²	Fläche Aufstockung	
Herrichten	210		70.000,00 €	5,72 €	15.139,84 €	15.139,84 €
Öffentliche Erschließung	220		- €	- €	- €	- €
Nichtöffentliche Erschließung	230		- €	- €	- €	- €
Ausgleichsmaßnahmen und -abgaben	240		471.622,86 €	38,52 €	102.004,24 €	102.004,24 €
Übergangsmaßnahmen	250		1.728.627,00 €	141,18 €	373.873,49 €	373.873,49 €
Vorsteuer			491.017,58 €	19%	93.293,34 €	93.293,34 €
Summe Herrichten und Erschließen	**KG 200**					**584.310,92 €**

Kostengruppe 300-400 - Bauwerk - Baukonstruktion - TGA	Kostengruppe	Bemerkung				
Baugrube/Erdbau	310				182,61 €	182,61 €
Gründung/Unterbau	320				1.854,66 €	1.854,66 €
Außenwände/Vertkiale Baukonstruktionen, außen	330				829.204,73 €	829.204,73 €
Innenwände/Vertikale Baukonstuktionen, innen	340				215.573,22 €	215.573,22 €
Decken/Horizontale Baukonstruktionen	350				520.211,99 €	520.211,99 €
Dächer	360				81.448,53 €	81.448,53 €
Baukonstruktive Einbauten	380				- €	- €
Sobstige Maßnahmen für Baukonstruktionen	390				150.993,38 €	150.993,38 €
Abwasser-, Wasser-, Gasanlagen	410				194.596,56 €	194.596,56 €
Wärmeversorgungsanlagen	420				198.688,38 €	198.688,38 €
Raumlufttechnische Anlagen	430				- €	- €
Elektrische Anlagen	440				3.144.394,60 €	3.144.394,60 €
Kommunikations-, Sicherheits-, und informationstechnsiche Anlagen	450				12.727,47 €	12.727,47 €
Förderanlagen	460				47.874,07 €	47.874,07 €
Nutzungsspezifische- und verfahrenstechnische Anlagen	470				1.867,12 €	1.867,12 €
Gebäude- und Anlagenautomation	480				- €	- €
Sonstige Maßnahmen für technische Anlagen	490				- €	- €
Vorsteuer			5.399.617,32 €	19%	1.025.927,29 €	1.025.927,29 €
Summe Baukonstruktionen	**KG 300-400**					**6.425.544,61 €**

Kostengruppe 500 - Außenanlagen	Kostengruppe	Bemerkung				
Erdbau	510				- €	- €
Gründung/Unterbau	520				- €	- €
Oberbau/Deckschicht	530				- €	- €
Baukonstruktionen	540				191.480,89 €	191.480,89 €
Technische Anlagen	550				- €	- €
Eibauten in Außenanlagen und Freiflächen	560				- €	- €
Vegetationsflächen	570				- €	- €
Wasserflächen	580				- €	- €
Sonstige Maßnahmen für Außenanlagen und Freiflächen	590				- €	- €
Vorsteuer			191.480,89 €	19%	36.381,37 €	36.381,37 €
Summe Außenanlagen	**KG 500**					**227.862,26 €**

Kostengruppe 600 - Ausstattung	Kostengruppe	Bemerkung				
Allgemeine Ausstattung	610				299.650,50 €	299.650,50 €
Besondere Ausstattung	620				- €	- €
Infromationstechnische Ausstattung	630				- €	- €
Vorsteuer			299.650,50 €	19%	56.933,60 €	56.933,60 €
Summe Ausstattung	**KG 600**					**356.584,10 €**

Kostenrgruppe 700 - Baunebenkosten	Kostengruppe	Bemerkung

Bauherrenaufgaben	710			154.797,49 €	154.797,49 €
Vorbereitung der Objektplanung	720			5.000,00 €	5.000,00 €
Objektplanung	730			887.377,10 €	887.377,10 €
Fachplanung	740			889.669,31 €	889.669,31 €
Künstlerische Leistungen	750			- €	- €
Allgemeine Baukosten	760			132.720,71 €	132.720,71 €
Sonstige Baunebenkosten	790			- €	- €
Vorsteuer		2.069.564,61 €	19%	393.217,28 €	393.217,28 €
Summe Baunebenkosten	**KG 700**				**2.462.781,89 €**

Kostenzusammenstellung				
Summe Grundstück	KG 100	0%		- €
Summe Herrichten und Erschließen	KG 200	6%		584.310,92 €
Summe Baukonstruktionen	KG 300-400	64%		6.425.544,61 €
Summe Außenanlagen	KG 500	2%		227.862,26 €
Summe Ausstattungen	KG 600	4%		356.584,10 €
Summe Baunebenkosten	KG 700	24%		2.462.781,89 €
Vorsteuer			1.605.752,87 €	
Gesamtkosten				**10.057.083,77 €**

Mieterträge					
Nutzungsart		Miete/pm Stellplatz	Fläche Anzahl	Mietertrag p.M.	Mietertrag p.a.
Fläche Gesamt	**907,48 m²**				
Terrassen Gesamt	**0,00 m²**				
Wohnung Eingeschossig		18,45 €	583,38 m²	10.763,36 €	129.160,33 €
Anteil Terrassen		0%	0,00 m²		
Wohnungen Zweigeschossig		16,78 €	324,10 m²	5.438,40 €	65.260,78 €
Anteil Terrassen		0%	0,00 m²		
Keller		- €		- €	- €
Stellplätze		- €	0 Stp.	- €	- €
Mieter gesamt			**Monatsmiete**	**16.201,76 €**	**Jahresmiete** **194.421,11 €**

Gesamtbetrachtung			
Jahresmiete			**194.421,11 €**
Gesamtkosten			**10.057.083,77 €**
Gesamtkosten/Gesamtertrag	**Bruttorrendite**	**1,93%**	**Faktor** **51,73**

Appendix D – Calculation of federal funding

Federer funding of energy efficient buildings (BEG)

Wohngebäude	Annahmen		Förderung
Anzahl an Wohnungen:	23		3.088.825,00 €
Kosten je Wohnung:	150.000,00 €		
Anteil EEG am Wärmebedarf:			
Kosten Energiefachplanung:	8.500,00 €		
Kosten Nachhaltigkeitszertifizierung:	5.000,00 €		
Nichtwohngebäude			
Nettogrundfläche:	7541 m²	*Gesamtfläche nach Aufstellung der Klimaing.*	
Förderung 2.000€/m², max. 30 Mio. €	7.541.000,00 €	*Annahme: 1.000€/m²*	
Anteil EEG am Wärmebedarf:			
Kosten Nachhaltigkeitszertifizierung:	15.000,00 €		

BEG Förderung - Wohngebäude - Neubau

Effizienzhaus	Tilgungszuschuss/Wohneinheit	Förderung
Effizienzhaus 40 Plus	25 % von max. 150.000€ / WE	862.500,00 €
Effizienzhaus 40	20 % von max. 120.000€ / WE	552.000,00 €
Effizienzhaus 40 + EEG-Klasse oder Nachhaltigkeitszertifikat	22,5 % von max. 150.000€ / WE	776.250,00 €
Effizienzhaus 55	15 % von max. 120.000€ / WE	414.000,00 €
Effizienzhaus 55 + EEG-Klasse oder Nachhaltigkeitszertifikat	17,5 % von max. 150.000€ / WE	603.750,00 €

Wohngebäude - Erzieltes Effizienzgebäude

Effizienzhaus 55 + EEG-Klasse oder Nachhaltigkeitszertifikat

Erzielte Förderung 603.750,00 €

BEG Förderung - Wohngebäude - Baubegleitung

Geförderte Kosten

bis zu 4.000€ je Wohnung zu 50%, maximal 40.000 € zu 50%

Wohngebäude - Baubegleitung

Erzielte Förderung 4.250,00 €

BEG Förderung - Wohngebäude - Nachhaltigkeitszertifizierung QNB

Geförderte Kosten

Kosten bis max. 40.000 € zu 50%

Wohngebäude - Nachhaltigkeitszertifizierung

Erzielte Förderung 2.500,00 €

BEG Förderung - Nichtwohngebäude - Sanierung von bestehenden Immobilien

Effizienzhaus	Tilgungszuschuss in %	Förderung
Effizienzhaus 40	45,0%	3.393.450,00 €
Effizienzhaus 40 + EEG-Klasse oder Nachhaltigkeitszertifikat	50,0%	3.770.500,00 €
Effizienzhaus 55	40,0%	3.016.400,00 €
Effizienzhaus 55 + EEG-Klasse oder Nachhaltigkeitszertifikat	45,0%	3.393.450,00 €
Effizienzhaus 70	35,0%	2.639.350,00 €
Effizienzhaus 70 + EEG-Klasse oder Nachhaltigkeitszertifikat	40,0%	3.016.400,00 €
Effizienzhaus 100	27,5%	2.073.775,00 €
Effizienzhaus 100 + EEG-Klasse oder Nachhaltigkeitszertifikat	32,5%	2.450.825,00 €

Nichtwohngebäude - Erzieltes Effizienzgebäude

Effizienzhaus 100 + EEG-Klasse oder Nachhaltigkeitszertifikat

Erzielte Förderung 2.450.825,00 €

BEG Förderung - Nichtwohngebäude - Baubegleitung

Geförderte Kosten

10 €/m² Nettogrundfläche, max. 40.000 € zu 50%

Nichtwohngebäude - Baubegleitung

Erzielte Förderung 20.000,00 €

BEG Förderung - Nichtwohngebäude - Nachhaltigkeitszertifizierung QNB

Geförderte Kosten

Kosten bis max. 40.000 € zu 50%

Nichtwohngebäude - Nachhaltigkeitszertifizierung

Erzielte Förderung 7.500,00 €

Appendix E – Calculation of cash flow analysis

Cash flow analysis

Anlage 27 - Chash-Flow-Analyse

Chash-Flow-Analyse		
Herstellungskosten		
Summe KG 100	18.188.210,21 €	
Summe KG 200	2.815.109,83 €	
Summe KG 300/400	19.203.364,57 €	
Summe KG 500	328.509,83 €	
Summe KG 600	1.683.190,96 €	
Summe KG 700	7.056.216,49 €	
Summe KG 800	4.707.733,13 €	
Bundesförderung für effiziente Gebäude	- 3.088.825,00 €	
Vorsteuer	5.722.807,59 €	
Gesamtinvestitionskosten	**50.893.510,03 €**	
Finanzierung		
Gesamtinvestment	50.893.510,03 €	
Grundstück	18.188.210,21 €	
Finanzierung	4.707.733,13 €	
Zwischensumme Grundstück und Finanzierung	**22.895.943,35 €**	
Prozentualer Anteil von Gesamtinvestitionskosten	45%	
Konditionen der Finanzierung		
EK	20%	10.178.702,01 €
FK	80%	40.714.808,02 €
Summe	100%	50.893.510,03 €

Finanzierungsberechnung FK	Kommentar		0	1	2	3	4	5	6	7	8	9	10	11	12
Zins (Zinsbindung 10 Jahre)	Ab 10 Jahre - Annahmen	1%	407.148,08 €	407.148,08 €	394.933,64 €	382.597,05 €	370.137,10 €	357.552,55 €	344.842,15 €	332.004,65 €	319.038,77 €	305.943,23 €	292.716,74 €	279.357,99 €	265.865,64 €
Tilgung		3%	1.221.444,24 €	1.221.444,24 €	1.233.658,68 €	1.245.995,27 €	1.258.455,22 €	1.271.039,77 €	1.283.750,17 €	1.296.587,67 €	1.309.553,55 €	1.322.649,09 €	1.335.875,58 €	1.349.234,33 €	1.362.726,68 €
Restschuld			40.714.808,02 €	39.493.363,78 €	38.259.705,10 €	37.013.709,83 €	35.755.254,60 €	34.484.214,83 €	33.200.464,66 €	31.903.876,98 €	30.594.323,43 €	29.271.674,35 €	27.935.798,77 €	26.586.564,44 €	25.223.837,76 €
FinanzierungskostenJahr - Annuität			1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €
Mieteinnahmen Gewerbe															
Gesamtmiete				1.244.700,84 €	1.244.700,84 €	1.244.700,84 €	1.244.700,84 €	1.244.700,84 €	1.244.700,84 €	1.263.371,356 €	1.263.371,356 €	1.263.371,356 €	1.282.321,93 €	1.282.321,93 €	1.282.321,93 €
Mietanpassung ab Jahr 3 alle 3 Jahre um 1,5 %							101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%
MieteinnahmenJahr				1.244.700,84 €	1.244.700,84 €	1.244.700,84 €	1.263.371,36 €	1.263.371,36 €	1.263.371,36 €	1.282.321,93 €	1.282.321,93 €	1.282.321,93 €	1.301.556,76 €	1.301.556,76 €	1.301.556,76 €
Mieteinnahmen Studentenwohnen															
Gesamtmiete				194.421,11 €	194.421,11 €	194.421,11 €	194.421,11 €	194.421,11 €	194.421,11 €	197.337,42 €	197.337,42 €	197.337,42 €	200.297,49 €	200.297,49 €	200.297,49 €
Mietanpassung ab Jahr 3 alle 3 Jahre um 1,5 %							101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%
MieteinnahmenJahr				194.421,11 €	194.421,11 €	194.421,11 €	197.337,42 €	197.337,42 €	197.337,42 €	200.297,49 €	200.297,49 €	200.297,49 €	203.301,95 €	203.301,95 €	203.301,95 €
Miete gesamt:				**1.439.121,95 €**	**1.439.121,95 €**	**1.439.121,95 €**	**1.460.708,78 €**	**1.460.708,78 €**	**1.460.708,78 €**	**1.482.619,41 €**	**1.482.619,41 €**	**1.482.619,41 €**	**1.504.858,70 €**	**1.504.858,70 €**	**1.504.858,70 €**
Betriebskosten															
Hausverwaltungskosten		2,5% der Mieteinnahmen		35.978,05 €	35.978,05 €	35.978,05 €	36.517,72 €	36.517,72 €	36.517,72 €	37.065,49 €	37.065,49 €	37.065,49 €	37.621,47 €	37.621,47 €	37.621,47 €
Nicht umlegbare Kosten (Verwaltung, Abrechnung, ...)		1,5% der Mieteinnahmen		21.586,83 €	21.586,83 €	21.586,83 €	21.910,63 €	21.910,63 €	21.910,63 €	22.239,29 €	22.239,29 €	22.239,29 €	22.572,88 €	22.572,88 €	22.572,88 €
Leerstandsrisiko		1,5% der Mieteinnahmen		21.586,83 €	21.586,83 €	21.586,83 €	21.910,63 €	21.910,63 €	21.910,63 €	22.239,29 €	22.239,29 €	22.239,29 €	22.572,88 €	22.572,88 €	22.572,88 €
Laufende Instandhaltungen		1,5% der Mieteinnahmen		21.586,83 €	21.586,83 €	21.586,83 €	21.910,63 €	21.910,63 €	21.910,63 €	22.239,29 €	22.239,29 €	22.239,29 €	22.572,88 €	22.572,88 €	22.572,88 €
Betriebskosten/Jahr				**100.738,54 €**	**100.738,54 €**	**100.738,54 €**	**102.249,61 €**	**102.249,61 €**	**102.249,61 €**	**103.783,36 €**	**103.783,36 €**	**103.783,36 €**	**105.340,11 €**	**105.340,11 €**	**105.340,11 €**
Ergebnis															
Ergebnis (Mieteinnahmen - Betriebskosten)				1.338.383,42 €	1.338.383,42 €	1.338.383,42 €	1.358.459,17 €	1.358.459,17 €	1.358.459,17 €	1.378.836,05 €	1.378.836,05 €	1.378.836,05 €	1.399.518,59 €	1.399.518,59 €	1.399.518,59 €
Internes Ergebnis (Mieteinnahmen - Betriebskosten - Annuität)				- 290.208,91 €	- 290.208,91 €	- 290.208,91 €	- 270.133,15 €	- 270.133,15 €	- 270.133,15 €	- 249.756,27 €	- 249.756,27 €	- 249.756,27 €	- 229.073,73 €	- 229.073,73 €	- 229.073,73 €
Rendite (Eigenkapital und Tilgung)				**9%**	**9%**	**9%**	**10%**	**10%**	**10%**	**10%**	**10%**	**11%**	**11%**	**11%**	**11%**

Jahre	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Zins (Zinsbindung 10 Jahre)	252.238,38 €	238.474,84 €	224.573,66 €	210.533,48 €	196.352,89 €	182.030,49 €	167.564,88 €	152.954,60 €	138.198,22 €	123.294,28 €	108.241,30 €	93.037,79 €	77.682,25 €	62.173,15 €	46.508,95 €	30.688,12 €	14.709,08 €
Tilgung	1.376.353,94 €	1.390.117,48 €	1.404.018,66 €	1.418.058,84 €	1.432.239,43 €	1.446.561,83 €	1.461.027,45 €	1.475.637,72 €	1.490.394,10 €	1.505.298,04 €	1.520.351,02 €	1.535.554,53 €	1.550.910,07 €	1.566.419,17 €	1.582.083,37 €	1.597.904,20 €	1.613.883,24 €
Restschuld	23.847.483,82 €	22.457.366,33 €	21.053.347,68 €	19.635.288,83 €	18.203.049,40 €	16.756.487,57 €	15.295.460,13 €	13.819.822,41 €	12.329.428,31 €	10.824.130,27 €	9.303.779,25 €	7.768.224,73 €	6.217.314,65 €	4.650.895,48 €	3.068.812,11 €	1.470.907,91 €	- 142.975,33 €
FinanzierungskostenJahr - Annuität	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €	1.628.592,32 €
Mieteinnahmen Gewerbe																	
Gesamtmiete	1.301.556,76 €	1.301.556,76 €	1.301.556,76 €	1.321.080,11 €	1.321.080,11 €	1.321.080,11 €	1.340.896,31 €	1.340.896,31 €	1.340.896,31 €	1.361.009,75 €	1.361.009,75 €	1.361.009,75 €	1.381.424,90 €	1.381.424,90 €	1.381.424,90 €	1.402.146,27 €	1.402.146,27 €
Mietanpassung ab Jahr 3 alle 3 Jahre um 1,5 %	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%
MieteinnahmenJahr	1.321.080,11 €	1.321.080,11 €	1.321.080,11 €	1.340.896,31 €	1.340.896,31 €	1.340.896,31 €	1.361.009,75 €	1.361.009,75 €	1.361.009,75 €	1.381.424,90 €	1.381.424,90 €	1.381.424,90 €	1.402.146,27 €	1.402.146,27 €	1.402.146,27 €	1.423.178,47 €	1.423.178,47 €
Mieteinnahmen Studentenwohnen																	
Gesamtmiete	203.301,95 €	203.301,95 €	203.301,95 €	206.351,48 €	206.351,48 €	206.351,48 €	209.446,75 €	209.446,75 €	209.446,75 €	212.588,45 €	212.588,45 €	212.588,45 €	215.777,28 €	215.777,28 €	215.777,28 €	219.013,94 €	219.013,94 €
Mietanpassung ab Jahr 3 alle 3 Jahre um 1,5 %	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%	101,5%
MieteinnahmenJahr	206.351,48 €	206.351,48 €	206.351,48 €	209.446,75 €	209.446,75 €	209.446,75 €	212.588,45 €	212.588,45 €	212.588,45 €	215.777,28 €	215.777,28 €	215.777,28 €	219.013,94 €	219.013,94 €	219.013,94 €	222.299,15 €	222.299,15 €
Miete gesamt:	**1.527.431,58 €**	**1.527.431,58 €**	**1.527.431,58 €**	**1.550.343,06 €**	**1.550.343,06 €**	**1.550.343,06 €**	**1.573.598,20 €**	**1.573.598,20 €**	**1.573.598,20 €**	**1.597.202,18 €**	**1.597.202,18 €**	**1.597.202,18 €**	**1.621.160,21 €**	**1.621.160,21 €**	**1.621.160,21 €**	**1.645.477,61 €**	**1.645.477,61 €**
Betriebskosten																	
Hausverwaltungskosten	38.185,79 €	38.185,79 €	38.185,79 €	38.758,58 €	38.758,58 €	38.758,58 €	39.339,96 €	39.339,96 €	39.339,96 €	39.930,05 €	39.930,05 €	39.930,05 €	40.529,01 €	40.529,01 €	40.529,01 €	41.136,94 €	41.136,94 €
Nicht umlegbare Kosten (Verwaltung, Abrechnung, ...)	22.911,47 €	22.911,47 €	22.911,47 €	23.255,15 €	23.255,15 €	23.255,15 €	23.603,97 €	23.603,97 €	23.603,97 €	23.958,03 €	23.958,03 €	23.958,03 €	24.317,40 €	24.317,40 €	24.317,40 €	24.682,16 €	24.682,16 €
Leerstandsrisiko	22.911,47 €	22.911,47 €	22.911,47 €	23.255,15 €	23.255,15 €	23.255,15 €	23.603,97 €	23.603,97 €	23.603,97 €	23.958,03 €	23.958,03 €	23.958,03 €	24.317,40 €	24.317,40 €	24.317,40 €	24.682,16 €	24.682,16 €
Laufende Instandhaltungen	22.911,47 €	22.911,47 €	22.911,47 €	23.255,15 €	23.255,15 €	23.255,15 €	23.603,97 €	23.603,97 €	23.603,97 €	23.958,03 €	23.958,03 €	23.958,03 €	24.317,40 €	24.317,40 €	24.317,40 €	24.682,16 €	24.682,16 €
Betriebskosten/Jahr	**106.920,21 €**	**106.920,21 €**	**106.920,21 €**	**108.524,01 €**	**108.524,01 €**	**108.524,01 €**	**110.151,87 €**	**110.151,87 €**	**110.151,87 €**	**111.804,15 €**	**111.804,15 €**	**111.804,15 €**	**113.481,21 €**	**113.481,21 €**	**113.481,21 €**	**115.183,43 €**	**115.183,43 €**
Ergebnis																	
Ergebnis (Mieteinnahmen - Betriebskosten)	1.420.511,37 €	1.420.511,37 €	1.420.511,37 €	1.441.819,04 €	1.441.819,04 €	1.441.819,04 €	1.463.446,33 €	1.463.446,33 €	1.463.446,33 €	1.485.398,02 €	1.485.398,02 €	1.485.398,02 €	1.507.679,00 €	1.507.679,00 €	1.507.679,00 €	1.530.294,18 €	1.530.294,18 €
Internes Ergebnis (Mieteinnahmen - Betriebskosten - Annuität)	- 208.080,95 €	- 208.080,95 €	- 208.080,95 €	- 186.773,28 €	- 186.773,28 €	- 186.773,28 €	- 165.145,99 €	- 165.145,99 €	- 165.145,99 €	- 143.194,30 €	- 143.194,30 €	- 143.194,30 €	- 120.913,33 €	- 120.913,33 €	- 120.913,33 €	- 98.298,14 €	- 98.298,14 €
Rendite (Eigenkapital und Tilgung)	**11%**	**12%**	**12%**	**12%**	**12%**	**12%**	**13%**	**13%**	**13%**	**13%**	**14%**	**14%**	**14%**	**14%**	**14%**	**15%**	**15%**

Appendix F – Calculation of capitalized value

Net present value calculation

Kapitalwertberechnung

Gesamtinvestition netto	42.767.655,48 €
Annahme Kalkulationszinsfuß	3,00%

Jahr	Ausgaben	Einnahmen	Periodenüberschuss	Abzinsung	Kapitalwert	kum. Kapitalwert
0	42.767.655,48 €		-42.767.655,48 €	1	-42.767.655,48 €	-42.767.655,48 €
1	100.738,54 €	1.439.121,95 €	1.338.383,42 €	0,970873786	1.299.401,37 €	-41.468.254,11 €
2	100.738,54 €	1.439.121,95 €	1.338.383,42 €	0,942595909	1.261.554,73 €	-40.206.699,38 €
3	100.738,54 €	1.439.121,95 €	1.338.383,42 €	0,915141659	1.224.810,42 €	-38.981.888,96 €
4	102.249,61 €	1.460.708,78 €	1.358.459,17 €	0,888487048	1.206.973,37 €	-37.774.915,58 €
5	102.249,61 €	1.460.708,78 €	1.358.459,17 €	0,862608784	1.171.818,81 €	-36.603.096,77 €
6	102.249,61 €	1.460.708,78 €	1.358.459,17 €	0,837484257	1.137.688,17 €	-35.465.408,61 €
7	103.783,36 €	1.482.619,41 €	1.378.836,05 €	0,813091511	1.121.119,89 €	-34.344.288,72 €
8	103.783,36 €	1.482.619,41 €	1.378.836,05 €	0,789409234	1.088.465,91 €	-33.255.822,80 €
9	103.783,36 €	1.482.619,41 €	1.378.836,05 €	0,766416732	1.056.763,02 €	-32.199.059,78 €
10	105.340,11 €	1.504.858,70 €	1.399.518,59 €	0,744093915	1.041.373,27 €	-31.157.686,51 €
11	105.340,11 €	1.504.858,70 €	1.399.518,59 €	0,722421277	1.011.042,01 €	-30.146.644,50 €
12	105.340,11 €	1.504.858,70 €	1.399.518,59 €	0,70137988	981.594,18 €	-29.165.050,32 €
13	106.920,21 €	1.527.431,58 €	1.420.511,37 €	0,68095134	967.299,12 €	-28.197.751,19 €
14	106.920,21 €	1.527.431,58 €	1.420.511,37 €	0,661117806	939.125,36 €	-27.258.625,83 €
15	106.920,21 €	1.527.431,58 €	1.420.511,37 €	0,641861947	911.772,20 €	-26.346.853,64 €
16	108.524,01 €	1.550.343,06 €	1.441.819,04 €	0,623166939	898.493,96 €	-25.448.359,67 €
17	108.524,01 €	1.550.343,06 €	1.441.819,04 €	0,605016446	872.324,23 €	-24.576.035,44 €
18	108.524,01 €	1.550.343,06 €	1.441.819,04 €	0,587394608	846.916,73 €	-23.729.118,71 €
19	110.151,87 €	1.573.598,20 €	1.463.446,33 €	0,570286027	834.582,99 €	-22.894.535,72 €
20	110.151,87 €	1.573.598,20 €	1.463.446,33 €	0,553675754	810.274,75 €	-22.084.260,97 €
21	110.151,87 €	1.573.598,20 €	1.463.446,33 €	0,537549276	786.674,51 €	-21.297.586,45 €
22	111.804,15 €	1.597.202,18 €	1.485.398,02 €	0,521892501	775.218,09 €	-20.522.368,36 €
23	111.804,15 €	1.597.202,18 €	1.485.398,02 €	0,506691748	752.638,92 €	-19.769.729,44 €
24	111.804,15 €	1.597.202,18 €	1.485.398,02 €	0,491933736	730.717,40 €	-19.039.012,04 €
25	113.481,21 €	1.621.160,21 €	1.507.679,00 €	0,477605569	720.075,88 €	-18.318.936,15 €
26	113.481,21 €	1.621.160,21 €	1.507.679,00 €	0,463694727	699.102,80 €	-17.619.833,35 €
27	113.481,21 €	1.621.160,21 €	1.507.679,00 €	0,450189056	678.740,58 €	-16.941.092,77 €
28	115.183,43 €	1.645.477,61 €	1.530.294,18 €	0,437076753	668.856,01 €	-16.272.236,76 €
29	115.183,43 €	1.645.477,61 €	1.530.294,18 €	0,424346362	649.374,77 €	-15.622.861,99 €
30	115.183,43 €	1.645.477,61 €	1.530.294,18 €	0,41198676	630.460,94 €	-14.992.401,05 €
31	116.911,18 €	1.670.159,78 €	1.553.248,59 €	0,399987145	621.279,47 €	-14.371.121,58 €
32	116.911,18 €	1.670.159,78 €	1.553.248,59 €	0,388337034	603.183,95 €	-13.767.937,63 €
33	116.911,18 €	1.670.159,78 €	1.553.248,59 €	0,377026247	585.615,49 €	-13.182.322,14 €
34	118.664,85 €	1.695.212,17 €	1.576.547,32 €	0,3660449	577.087,11 €	-12.605.235,03 €
35	118.664,85 €	1.695.212,17 €	1.576.547,32 €	0,355383398	560.278,74 €	-12.044.956,29 €
36	118.664,85 €	1.695.212,17 €	1.576.547,32 €	0,345032425	543.959,95 €	-11.500.996,34 €
37	120.444,82 €	1.720.640,36 €	1.600.195,53 €	0,334982937	536.038,20 €	-10.964.958,15 €
38	120.444,82 €	1.720.640,36 €	1.600.195,53 €	0,325226152	520.425,44 €	-10.444.532,71 €
39	120.444,82 €	1.720.640,36 €	1.600.195,53 €	0,315753546	505.267,41 €	-9.939.265,30 €
40	122.251,50 €	1.746.449,96 €	1.624.198,46 €	0,306556841	497.909,15 €	-9.441.356,15 €
41	122.251,50 €	1.746.449,96 €	1.624.198,46 €	0,297628001	483.406,94 €	-8.957.949,20 €
42	122.251,50 €	1.746.449,96 €	1.624.198,46 €	0,288959224	469.327,13 €	-8.488.622,08 €
43	124.085,27 €	1.772.646,71 €	1.648.561,44 €	0,280542936	462.492,27 €	-8.026.129,81 €
44	124.085,27 €	1.772.646,71 €	1.648.561,44 €	0,272371782	449.021,62 €	-7.577.108,19 €
45	124.085,27 €	1.772.646,71 €	1.648.561,44 €	0,264438624	435.943,32 €	-7.141.164,87 €
46	125.946,55 €	1.799.236,41 €	1.673.289,86 €	0,256736528	429.594,63 €	-6.711.570,24 €
47	125.946,55 €	1.799.236,41 €	1.673.289,86 €	0,249258765	417.082,16 €	-6.294.488,08 €
48	125.946,55 €	1.799.236,41 €	1.673.289,86 €	0,241998801	404.934,14 €	-5.889.553,94 €
49	127.835,75 €	1.826.224,96 €	1.698.389,21 €	0,234950292	399.037,04 €	-5.490.516,90 €
50	127.835,75 €	1.826.224,96 €	1.698.389,21 €	0,22810708	387.414,60 €	-5.103.102,29 €
51	127.835,75 €	1.826.224,96 €	1.698.389,21 €	0,221463184	376.130,68 €	-4.726.971,61 €
52	129.753,28 €	1.853.618,33 €	1.723.865,05 €	0,2150128	370.653,05 €	-4.356.318,56 €
53	129.753,28 €	1.853.618,33 €	1.723.865,05 €	0,208750292	359.857,33 €	-3.996.461,23 €
54	129.753,28 €	1.853.618,33 €	1.723.865,05 €	0,202670186	349.376,05 €	-3.647.085,18 €
55	131.699,58 €	1.881.422,61 €	1.749.723,02 €	0,196767171	344.288,05 €	-3.302.797,13 €
56	131.699,58 €	1.881.422,61 €	1.749.723,02 €	0,191036088	334.260,24 €	-2.968.536,89 €
57	131.699,58 €	1.881.422,61 €	1.749.723,02 €	0,18547193	324.524,51 €	-2.644.012,38 €
58	133.675,08 €	1.909.643,95 €	1.775.968,87 €	0,180069835	319.798,42 €	-2.324.213,96 €
59	133.675,08 €	1.909.643,95 €	1.775.968,87 €	0,174825083	310.483,90 €	-2.013.730,05 €
60	133.675,08 €	1.909.643,95 €	1.775.968,87 €	0,16973309	301.440,68 €	-1.712.289,37 €
61	135.680,20 €	1.938.288,61 €	1.802.608,40 €	0,164789408	297.050,77 €	-1.415.238,60 €
62	135.680,20 €	1.938.288,61 €	1.802.608,40 €	0,159989716	288.398,81 €	-1.126.839,79 €
63	135.680,20 €	1.938.288,61 €	1.802.608,40 €	0,155329822	279.998,84 €	-846.840,95 €
64	137.715,41 €	1.967.362,93 €	1.829.647,53 €	0,150805652	275.921,19 €	-570.919,76 €
65	137.715,41 €	1.967.362,93 €	1.829.647,53 €	0,146413254	267.884,65 €	-303.035,11 €
66	137.715,41 €	1.967.362,93 €	1.829.647,53 €	0,142148791	260.082,18 €	-42.952,93 €
67	139.781,14 €	1.996.873,38 €	1.857.092,24 €	0,138008535	256.294,58 €	213.341,65 €

68	139.781,14 €	1.996.873,38 €	1.857.092,24 €	0,133988869	248.829,69 €	462.171,34 €
69	139.781,14 €	1.996.873,38 €	1.857.092,24 €	0,13008628	241.582,22 €	703.753,56 €
70	141.877,85 €	2.026.826,48 €	1.884.948,63 €	0,126297359	238.064,03 €	941.817,60 €
71	141.877,85 €	2.026.826,48 €	1.884.948,63 €	0,122618796	231.130,13 €	1.172.947,73 €
72	141.877,85 €	2.026.826,48 €	1.884.948,63 €	0,119047374	224.398,18 €	1.397.345,91 €
73	144.006,02 €	2.057.228,88 €	1.913.222,86 €	0,115579975	221.130,25 €	1.618.476,16 €
74	144.006,02 €	2.057.228,88 €	1.913.222,86 €	0,112213568	214.689,56 €	1.833.165,73 €
75	144.006,02 €	2.057.228,88 €	1.913.222,86 €	0,108945212	208.436,47 €	2.041.602,19 €
76	146.166,11 €	2.088.087,31 €	1.941.921,20 €	0,10577205	205.400,99 €	2.247.003,18 €
77	146.166,11 €	2.088.087,31 €	1.941.921,20 €	0,102691311	199.418,43 €	2.446.421,61 €
78	146.166,11 €	2.088.087,31 €	1.941.921,20 €	0,099700302	193.610,13 €	2.640.031,74 €
79	148.358,60 €	2.119.408,62 €	1.971.050,02 €	0,09679641	190.790,56 €	2.830.822,31 €
80	148.358,60 €	2.119.408,62 €	1.971.050,02 €	0,093977097	185.233,56 €	3.016.055,87 €
81	148.358,60 €	2.119.408,62 €	1.971.050,02 €	0,0912399	179.838,41 €	3.195.894,27 €
82	150.583,98 €	2.151.199,75 €	2.000.615,77 €	0,088582427	177.219,40 €	3.373.113,67 €
83	150.583,98 €	2.151.199,75 €	2.000.615,77 €	0,086002356	172.057,67 €	3.545.171,34 €
84	150.583,98 €	2.151.199,75 €	2.000.615,77 €	0,083497433	167.046,28 €	3.712.217,62 €
85	152.842,74 €	2.183.467,75 €	2.030.625,00 €	0,081065469	164.613,57 €	3.876.831,19 €
86	152.842,74 €	2.183.467,75 €	2.030.625,00 €	0,078704339	159.819,00 €	4.036.650,19 €
87	152.842,74 €	2.183.467,75 €	2.030.625,00 €	0,07641198	155.164,08 €	4.191.814,27 €
88	155.135,38 €	2.216.219,76 €	2.061.084,38 €	0,074186388	152.904,41 €	4.344.718,67 €
89	155.135,38 €	2.216.219,76 €	2.061.084,38 €	0,072025619	148.450,88 €	4.493.169,55 €
90	155.135,38 €	2.216.219,76 €	2.061.084,38 €	0,069927786	144.127,07 €	4.637.296,62 €
91	157.462,41 €	2.249.463,06 €	2.092.000,64 €	0,067891054	142.028,13 €	4.779.324,74 €
92	157.462,41 €	2.249.463,06 €	2.092.000,64 €	0,065913645	137.891,39 €	4.917.216,13 €
93	157.462,41 €	2.249.463,06 €	2.092.000,64 €	0,06399383	133.875,13 €	5.051.091,27 €
94	159.824,35 €	2.283.205,00 €	2.123.380,65 €	0,062129932	131.925,50 €	5.183.016,76 €
95	159.824,35 €	2.283.205,00 €	2.123.380,65 €	0,060320322	128.083,01 €	5.311.099,77 €
96	159.824,35 €	2.283.205,00 €	2.123.380,65 €	0,05856342	124.352,43 €	5.435.452,20 €
97	162.221,72 €	2.317.453,08 €	2.155.231,36 €	0,056857689	122.541,47 €	5.557.993,67 €
98	162.221,72 €	2.317.453,08 €	2.155.231,36 €	0,05520164	118.972,31 €	5.676.965,98 €
99	162.221,72 €	2.317.453,08 €	2.155.231,36 €	0,053593825	115.507,09 €	5.792.473,07 €
100	164.655,04 €	2.352.214,87 €	2.187.559,83 €	0,05203284	113.824,95 €	5.906.298,02 €

20.3 CESA

Appendix A: List of participating subjects

Obligatory Subject „MAKE“	BA KlimaEngineering 4 & MA Architektur
Period	Wintersemester 2019/20
Supervisor	Prof. Petersen, Prof. Schlaier, Prof. Kretzer
Goal	Preliminary designs of extensions with student housing (Building 5&6)
Consultation	Gebäude- & Denkmalpflege GDP2
Participants	Marco Dippon, Jonathan Scheider, Noah Blessing, Clarissa Werner, Alissia Herbrand, Daniel Klaus, Clemens Müller, Jan Tondera, Jana Lais, Oliver Hoefner, Christopher Piontek, Chris Philipp, Sören Hueneborg, Daniel Waibel, Benjamin Schuler, Kilian Merz, Karolin Diettrich, Laura Dürholz, Evelyn Göckler, Julian Harter, Venus Fatah, Tobias Schätzle, Michael Walther, Julia Krieger, Rizkiyah Rizkyah, Sophia Agorastos, Janick Hörmann, Daniel Mesch, Janine Singer, Joshua Blachetta, Martin Scheffold, Markus Brunner

Obligatory Subject „ Building and monument conservation GDP2“	BA KlimaEngineering 6
Period	Wintersemester 2019/20
Supervisor	Prof. Binder, Waggershauser, Leiser
Goal	Renovation concepts (Building 5&6)
Consultation	MAKE
Participants	Till Helmus, Beate Kleinewefers, Fabian Puttrus, Philipp Widmaier, Patrick Bosch, Lukas Fischer, Michael Bährle, Sophia Stettner, Nicolas Stephan, Svenja Herb, Luisa Claus, Benjamin Hueber, Moritz Sambeth, Daniel Merz, Judith Rosemeier, Stefan Finkbeiner, David Steeb, Sven Dietterle

Optional Subject „SDE21 – construction and design“	open
Period	Summersemester 2020
Supervisor	Prof. Schlaier
Basis	Results MAKE and GDP2
Goal	Development of a draft for the Solar Decathlon (Design and Building Challenge) from the results of MAKE and GDP2; almost finished draft; MA 1:200
Consultation	Wood construction seminar and SIM5, project structural engineering, furniture design
Participants	Till Helmus, Luisa Claus, Stefan Finkbeiner, Evelyn Goeckler, Kilian Merz, Chris Philipp, Jan Tondera, Clarissa Werner

Optional Subject „ Wood construction seminar “	open
Period	Summersemester 2020
Supervisor	Prof. Bleicher, Prof. Löffler
Basis	Results MAKE and GDP2

Goal	Detailed planning of building physics and building services engineering
Consultation	SDE21 – construction and design
Participants	Martin Abt, Johanna Alt, Michael Bährle, Markus Brunner, Nikolaj Cinciala, Freddi Dengler, Sven Dietterle, Stefan Finkbeiner, Chiara Firrincieli, Julian Harter, Steffen Heinz, Till Helmus, Jonas Emilio Hillberger, Janick Hörmann, Rafael Lettieri, Daniel Mesch, Daniel Müller Heiduk, Rizkiyah Rizkiyah, Mario Schmid, Roman Stegmüller, Sophia Stettner, Bettina Strobel, Stefan Tolksdorf

Optional Subject „Simulation Tools SIM5“	open
Period	Summersemester 2020
Supervisor	Prof. Bleicher
Basis	Results MAKE and GDP2
Goal	Simulation of the design and optimization for thermal/daylight requirements, simulation of active technology
Consultation	SDE21 – construction and design, Solar heating and cooling, Wood construction seminar
Participants	Svenja Herb, Luisa Claus, Fabian Puttrus, Till Helmus, Sebastian Auderer

Optional Subject „Solar Heating and Cooling”	open
Period	Summersemester 2020
Supervisor	Prof. Jakob
Basis	Results MAKE and GDP2
Goal	Development of a concept for active building services engineering
Consultation	SDE21 – construction and design, Simulation tools, Wood construction seminar
Participants	David Steeb, Stefan Finkbeiner, Benjamin Hueber, Svenja Herb, Daniel Klaus, Daniel Merz, Moritz Sambeth, Jeremias Bayer, Anja Seuchz-Wirth, Christoph Jooß, Sven Dietterle

Compulsory Subject "furniture design”	BA Innenarchitektur
Period	Summersemester 2020
Supervisor	Prof. Betha
Basis	Results MAKE und GDP2
Goal	Development of different approaches to interior quality, interior design
Consultation	SDE21 – construction and design
Participants	Elena Ponkina, Lea Proß, Leonie Philipp, Nadine Braunschweiler, Laura Kühme, Janina Kuhn, Malin Hoppe, Hanna Hänig, Charlotte Brühl, Olesja Zergiebel, Alexander Philipp, Leander Deppe, Silas Lehmann, Nico Lachner,Valerie Fürst, Nicole Neumüller, Nathalie Schneider, Julia Sokolov, Elisabeth Wassermann, Christina Breinich, Annika Maier, Carmen Schick, Katharina Wagner, Miriam Zimmermann, Breinich, Franka Bogner, JuliaSchwierz, KathrinPittroff, Lisa Stegmeyer, Pauline

	Wintermann, Diana Heiland, Lisa Maahsen, Tolga Guecueyeter, Julia Aruanno, Anne Augsten, Annemarie Vogel, Fabian Kaa, Dominik Kschul, Laura Schlobach, Amy Smith, Jule Dörr, Hanna Leiber, Annemarie Ruhland, Theresa Weigand, Jasmin Zimmermann

Compulsory subject „Construction“	BA Bauingenieurwesen
Period	Summersemester 2020
Supervisor	Prof. Betha
Basis	Results MAKE und GDP2
Goal	Development of a structural concept
Consultation	SDE21 – construction and design
Participants	

Optional Subject „BIM“	open
Period	Summersemester 2020
Supervisor	Prof. Sondermann
Basis	Design “MAKE Project”
Goal	Creation of a 3D model of the design
Consultation	SDE21 – construction and design
Participants	

Compulsory subject "lighting engineering”	BA Bauphysik
Period	Summersemester 2020
Supervisor	Prof. Beck
Basis	Design "MAKE Project
Goal	Daylight simulation, artificial light illumination
Consultation	SDE21 – construction and design, SIM5
Participants	

Optional Subject „Mobility Concept“	BA Bauingenieurwesen, BA Infrastrukturmanagement
Period	Summersemester 2020
Supervisor	Prof. Gaspers
Basis	Design “MAKE Project”
Goal	Creation of mobility concept
Consultation	SDE21 – construction and design
Participants	Julian Hegele, Alexander Spiegele, Fabian Schweizer, Michael Frisch, Noah Götz, Stefan Holzwarth, Monika Kraus, Andreas Franz, Semih Cavusoglu, Madleine Bode

Optional subject “Profitability calculation”	MA General Management
Period	Summersemester 2020
Supervisor	Prof. Hauer
Basis	Design "MAKE Project

Goal	Profitability calculation
Consultation	Core team
Participants	Julian Hegele, Alexander Spiegele, Fabian Schweizer, Michael Frisch, Noah Götz, Stefan Holzwarth, Monika Kraus, Andreas Franz, Semih Cavusoglu

Optional subject "Financing Model"	BA Betriebswirtschaft
Period	Summersemester 2020
Supervisor	Prof. Popovic, Elias Schwemin
Basis	Design "MAKE Project
Goal	Creation of financing model, business models
Consultation	Core team
Participants	

Optional subject "economic efficiency analysis"	BA Wirtschaftsingenieurwesen
Period	Summersemester 2020
Supervisor	Prof. Kindsvater
Basis	Design "MAKE Project
Goal	Profitability assessment, market analysis
Consultation	Core team
Participants	

Optional Subject „HFT goes green SuSe 20"	open
Period	Summersemester 2020
Supervisor	Jonas Stave, Annabell Gronau
Basis	- Communication Strategy DEL#1 - Results "MAKE Project and GDP2
Goal	- Support of the coLLab project with public relations and social media - Development of different facade greening variants - Ecological and economical comparison of different building materials
Consultation	Core team, all other subjects involved
Participants	Luisa Claus, Sophia Stettner, David Steeb, Lukas Fischer, Judith Rosemeier, Sven Dietterle, Fabian Puttrus

Optional Subject „HFT goes green WiSe 20/21"	open
Period	Wintersemester 2020/21
Supervisor	Jonas Stave, Annabell Gronau, Luisa Claus
Basis	- Communication Strategy DEL#1&2 - Results of HFT goes green SuSe 20, Solar Heating and Cooling, GDP2, Urban Mobility
Goal	- Support of the coLLab project with public relation, social media and sustainability communication - Development of an energy concept for a solar chimney

	- Mobility Concept for the HDU
Consultation	Core team, all other subjects involved
Participants	Leon Reinhardt, Leonie Schwarz, Lisa Heckmann, Sarah Krimmel, Moritz Hartwich, Anne Jones, Lisa Wunn, Tobias Schätzle, Nikolai Berges

Compulsory Subject „Technical Design“	MA Architecture
Period	Wintersemester 2020/21
Supervisor	Prof. Schlaier
Basis	Results „SDE21 – construction and design“
Goal	Development of a draft for the Solar Decathlon (Design and Building Challenge); finished draft
Consultation	Core team, all other subjects involved
Participants	Eveline Best, Annika Elsner, Frederik Heck, Katharina Kaißer, Annika Kötzel, Mikhail Kutznetsov, Yannik Zelenka, Judith Leppert, Clarissa Werner

Optional Subject „Technical Concept“	BA KlimaEngineering
Period	Wintersemester 2020/21
Supervisor	Prof. Bleicher
Basis	Results SIM5, Solar Heating and Cooling, GDP2
Goal	Development of a technical concept for the Solar Decathlon (Design and Building Challenge)
Consultation	Technical Design
Participants	Saskia Huttenlocher, Bianca Hettinger, Karolin Diettrich, Tobias Schätzle, Clemens Müller, Marco Dippon, Frank Wetzel, Luisa Claus, Svenja Herb

Compulsory Subject „certification systems“	BA KlimaEngineering
Period	Wintersemester 2020/21
Supervisor	Volker Auch-Schwelk
Basis	Results „SDE21 – construction and design“
Goal	Life cycle assessment, Urban Mining Checklist
Consultation	Technical Design, Technical Concept
Participants	Karolin Dietrich, Clemens Müller, Tobias Schätzle, Marco Dippon, Jonathan Scheider, Janine Singer, Sophia Agorastos Manuel Delesky, Alissia Herbrand, Jana Lais, Laura Dürholz, Venus Fatah, Benjamin Schuler, Daniel Waibel, Noah Blessing Oliver Höfner, Christopher Piontek, Martin Scheffold, Rizkiyah Rizkiyah, Joshua Blachetta

Compulsory Subject „Urban Mobility“	BA Bauingenieurwesen
Period	Wintersemester 2020/21
Supervisor	Prof. Gaspers
Basis	Results SIM5, Solar Heating and Cooling, GDP2

Goal	Creation of Mobility Concept - focus existing building
Consultation	Technical Design, Technical Concept
Participants	Julian Hegele, Alexander Spiegele, Fabian Schweizer, Michael Frisch, Noah Götz, Stefan Holzwarth, Monika Kraus, Andreas Franz, Semih Cavusoglu, Madleine Bode

Compulsory Subject „Urban Mobility 2“	BA Bauingenieurwesen
Period	Summersemester 2021
Supervisor	Prof. Gaspers
Basis	Results of “Urban Mobility”
Goal	Creation of Mobility Concept - focus quarter
Consultation	Technical Design, Technical Concept
Participants	Julian Hegele, Alexander Spiegele, Fabian Schweizer, Michael Frisch, Noah Götz, Stefan Holzwarth, Monika Kraus, Andreas Franz, Semih Cavusoglu

Optional Subject „Implentation planning”	participants of “Technical Design”
Period	Summersemester 2021
Supervisor	Prof. Schlaier
Basis	Results of “Technical Design”
Goal	finished implementation planning of HDU with details
Consultation	core team, Technical Concept
Participants	Eveline Best, Annika Elsner, Frederik Heck, Katharina Kaißer, Annika Kötzel, Mikhail Kutznetsov, Yannik Zelenka, Judith Leppert, Clarissa Werner

Compulsory Subject „Interior design”	MA Interior Design
Period	Summersemester 2021
Supervisor	Prof. Betha
Basis	Results of “Furniture Desgin”
Goal	finished planning with details of the interior design and the public tour
Consultation	core team, Implementation planning, Technical Design
Participants	Elena Ponkina, Lea Proß, Leonie Philipp, Nadine Braunschweiler, Laura Kühme, Janina Kuhn, Malin Hoppe, Hanna Hänig, Charlotte Brühl, Olesja Zergiebel, Alexander Philipp, Leander Deppe, Silas Lehmann, Nico Lachner,Valerie Fürst, Nicole Neumüller, Nathalie Schneider, Julia Sokolov, Elisabeth Wassermann, Christina Breinich, Annika Maier, Carmen Schick, Katharina Wagner, Miriam Zimmermann, Breinich, Franka Bogner, JuliaSchwierz, KathrinPittroff, Lisa Stegmeyer, Pauline Wintermann, Diana Heiland, Lisa Maahsen, Tolga Guecueyeter, Julia Aruanno, Anne Augsten, Annemarie Vogel, Fabian Kaa, Dominik Kschul, Laura Schlobach, Amy Smith, Jule Dörr, Hanna Leiber, Annemarie Ruhland, Theresa Weigand, Jasmin Zimmermann

Compulsory Subject „Structure planning"	BA Bauingenieurwesen
Period	Summersemester 2021
Supervisor	Prof. Hartmann
Basis	Results of "Construction"
Goal	finished planning with constructive details and structural calculations
Consultation	Implementation planning, Technical Design
Participants	

Compulsory Subject „construction costs"	BA Wirtschaftsingenieurwesen Bau und Immobilien
Period	Summersemester 2021
Supervisor	Prof. Kindsvater
Basis	Results of "Technical Design" - finished draft
Goal	building costs calculations and recommendation for adaption
Consultation	Implementation planning, Technical Design
Participants	

Compulsory Subject „Interior design 2"	BA Interior Design
Period	Wintersemester 2021/ 22
Supervisor	Prof. Betha
Basis	Results of "Interior Desgin"
Goal	Execution planning with details of the interior design focus living module
Consultation	core team, Implentation planning, Technical Design
Participants	Hannes Greule, Theresa Kehle, Leona Heinz, Loretta Pittino Franziska Goetschi, Laura Grau, Anna Ude, Laura Schneider, Christin Sarreira Santos, Nele Helfer, Paula Fröhlich Träger, Tea Debeljak, Miriam Ilg, Emilia Linse, Sarah Haas

Optional Subject „Scenography"	Faculty of Architecture & Interior Design
Period	Wintersemester 2021/ 22
Supervisor	Jutta Schädler
Basis	Results of "Interior Desgin"
Goal	Execution planning with details of the interior design focus exhibition modules
Consultation	core team, Implentation planning, Technical Design, Interior Design
Participants	Max Baumann, Franziska Heidt, Raphaela Jahnke, Franziska Kofler, Sarah Krimmel, Lars Roth, Leonie Schillak, Julia Walter, Marie-Christin Wassner, Sophie Weiss, Patricia Weber

Compulsory Subject „Lighting design"	BA Interior Design
Period	Wintersemester 2021/ 22
Supervisor	Sabine Wiesend

Basis	Results of “Interior Desgin”
Goal	Execution planning with details of lighting design
Consultation	core team, Implentation planning, Technical Design,Interior Design
Participants	Hannes Greule, Theresa Kehle, Leona Heinz, Loretta Pittino Franziska Goetschi, Laura Grau, Anna Ude, Laura Schneider, Christin Sarreira Santos, Nele Helfer, Paula Fröhlich Träger, Tea Debeljak, Miriam Ilg, Emilia Linse, Sarah Haas

Appendix B: Visual Identity Manual

Team logo

The team logo is a letter mark logo which shortens the name “collaborative laboratory” to “collab”. The two “L’s” in the middle of the word “collab” become a collective form as the second “L” is turned upside down. This makes the logo memorable and represents the team’s visions in a playful and visual way. Three different versions are available and are used in the following ways:

Coloured

The coloured version of the logo is the team’s main logo. The two different colours, orange and blue, are used to emphasize that the logo is made of two different words: “collaborative laboratory”. It also reinforces the idea of different people working together.

Black & White

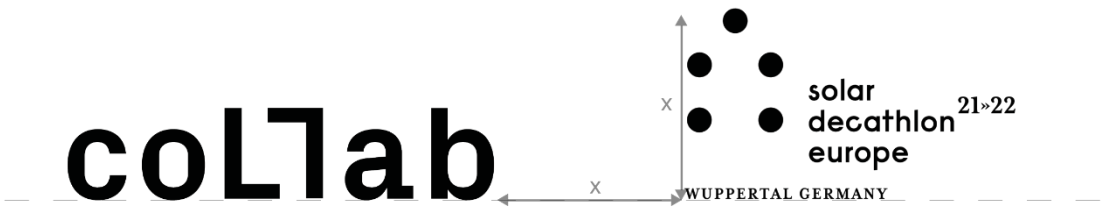
Against a very light background, the logo can be used in only black and against a grey or darker background the logo is used in white.

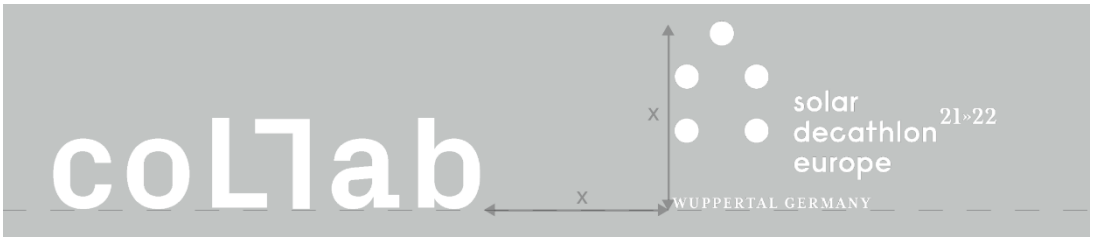
Logo combination

To unify the visual aesthetics of the different logos, the white and black logo variants are preferred. Against a very light background, the logo combination is used in only black and against a grey or darker background the logo combination is used in white.

SDE21 Logo Combination

We have developed two different combination styles to be able to react to the background and context of the particular document (or similar):

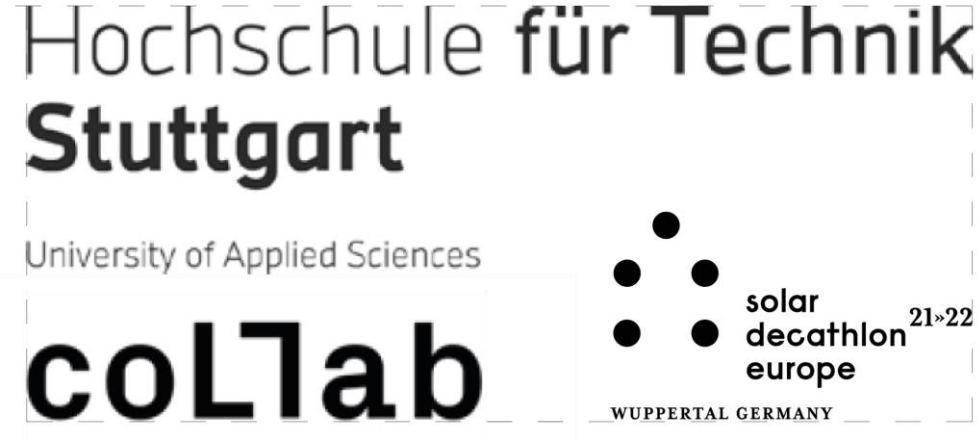




This logo combination is used e.g. for our team uniform:

Supporting institution logo combination

If the supporting institution logo of the “Hochschule für Technik Stuttgart” is to be named, the HFT logo, the team’s logo and the SDE21 logo are all combined. In documents we combine the logos in the following way:



In addition, we have created a logo combination where you can immediately see the focus on our team. This can be used when our team name should be emphasized:

Sponsor logo combination

All the sponsors' logos are presented in a non-hierarchical way. They are arranged in alphabetical order so as not to highlight any one of them and to give them all equal credit. Either the names of the sponsors are listed or the logos are presented in a 4-part grid.

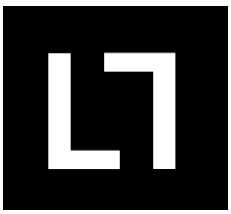
Favicon

An Icon was created to convey the idea of the logo in the shortest possible way. The two mirrored “L’s” of the logo were isolated to form an operative unit. It can be used in the following colours:

Coloured

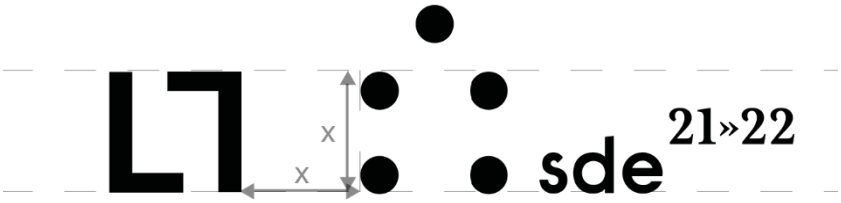
Black & White

Against a very light background, the logo can be used in only black and against a grey or darker background the logo is used in white.



Combination

SDE21 Logo Combination If there is not enough space for the combination of the full logo versions, the favicon and the shortest SDE21 logo can be used. They can either be black or white, depending on the brightness of the background.



Colours

Black, white or one of the following colours are used.

CMYK 81 / 62 / 42 / 36	CMYK 10 / 50 / 100 / 0	CMYK 28 / 19 / 21 / 2
RGB 55 / 72 / 91	RGB 214 / 123 / 20	RGB 191 / 194 / 195

20.3.1 Fonts

PX Grotesk

The font “PX Grotesk” is used for the logo. It would be conceivable to use the font in the future for e.g. quotations or meaningful sentences.

AplusTextRegular

The font “AplusTextRegular” is used for continuous text.

AplusTextBold

The font “AplusTextBold” is used for headings.

Collab-Schrift

The self-made and handwritten font “COLLAB” is used for subtexts and highlights.

Shadows Into Light

The font “Shadows Into Light” is used in Instagram posts.

Calibri

The font “Calibri” is used for reports and documents.

20.3.2 Instagram templates

Templates for Instagram posts have been designed to fasten the process of creating feed but also to achieve a consistent design language on all platforms.

Front post

Four primary layouts are used.

Grey background picture with white cut off lettering.

Photography with orange, white or blue Favicon in different opacities depending on the brightness of the picture.

Blue coloured background with white lettering.

Orange coloured background with white lettering.

Slides

Grey background with white lettering as described:

Layout Instagram overview

Combination of front posts in an alternating order to create a varied feed. The orange and blue colour scheme of the visual identity should be identifiable.

Layout Instagram Story

The “Collab” font and the “Shadows Into Light” font is used in prepared instagram stories.

20.3.3 **Team-Uniform**

Team shirt

For events specified by the SDE 21/22 Organizers the following shirt was created. The colour orange is part of our visual identity and attracts attention through the strong color. The vertical arranged logo combination is used for the team shirt. Team-jackets or long sleeved shirts, if necessary, will contain the same legible logo combination on one side of the wearable item. At the moment, we do not plan to list the sponsors logos on the back of the shirt.

Other items

To raise our profile, we created this bag. The favicon on one side and our team logo on the other side is applied in a large size, making it easy recognizable.

Front *Back*

In addition, we plan to produce more merchandise featuring our logo, such as caps and face masks, to be safe at SDE events while representing our team's visual identity.

Appendix C: Sponsorship Manual

Partner

Sponsoring:

Company/ Institution	Support	Contact team coLLab
Bau-Fritz	Realisation carcass wood construction	Sebastian Baier
Amor Group	Implementation and planning OPV Cells	Jonas Stave
Carl Stahl	Implementation and planning steel-net-construction	Sebastian Baier
Str.ucture	Calculation OPV facade	Sebastian Baier
LWKonzept	Fire Protection Concept	Sebastian Baier
Stahlbau Süßen	Steel frames OPV facade	Sebastian Baier
Bastian	Painting Work steel frames	Sebastian Baier
Exolon Group	Polycarbonate	Jonas Stave
Schuster Innenausbau	Carpenter's work interior	Sebastian Baier
Smile Plastics	Recycled board	Sebastian Baier
Helix	Fassade- and roof greening	Jonas Stave
Schuster Inennausbau	Carpentry work	Sebastian Baier
Stahlbau Süßen	Metal construction work	Sebastian Baier
Nora systems	Floor coverings	Annabell Gronau
XAL	Lamps	Jonas Stave
Infinite Flex	DC-Tape (lighting)	Jonas Stave
VOLA	Fittings interior	Sebastian Baier
LED linear	Lamps	Annabell Gronau
Karl Stüben Gerüstbau	Scaffolding work	Sebastian Baier
Podestbau Kleu	Ramp HDU	Sebastian Baier
Fischer	Carpenter's work	Sebastian Baier
Hahn Lamellen	Windows Solar Chimney	Sebastian Baier
Offgridtec	Building technology	Jonas Stave
Bosch	Kitchen appliances	Jonas Stave
Würth	Screws	Annabell Gronau
Wackler	Haulage	Sebastian Baier
Transsolar	Support energy concept	Jonas Stave
Baumgartner	Calculations OPV	Jonas Stave
ORB. Lichtplanung	Support light planning	Annabell Gronau
Victron Energy	Battery	Jonas Stave
Claytec	Clay paint	Annabell Gronau
Elka	Panel material	Annabell Gronau
Lifttec	Stairlift	Sebastian Baier

Donations:

- BMWi – Wuppertal Start donation
- BMWi
- Knödler-Decker-Foundation
- Metzger Foundation
- Verein der Freunde

Sponsorship/ Foundraising Contact team coLLab:

Sebastian Baier

Sebastian.baier@hft-stuttgart.de

+49 711 8926 2828

Annabell Gronau

Annabell.gronau@hft-stuttgart.de / netzwerk.sde21@hft-stuttgart.de

+49 711 8926 2828

Jonas Stave

Jonas.stave@hft-stuttgart.de

+49 711 8926 2828

Process at HFT

Necessary administrative processes have never existed to this extent at our university before. With our project, we are establishing new structures and taking on a pioneering role in the implementation of large sponsoring and donation cooperations at the university. We are striving to consolidate these processes in the administration and thus pave the way for future projects of this type and scope.

Sponsoring Kit

To request sponsors for a cooperation, a sponsoring kit was created. This includes a standard mail, which briefly informs about the project, a flyer and a sponsoring video. Thus, different forms of information transmission are addressed to ensure that the information reaches the addressee. Furthermore, “how to become a sponsor” sheets were placed in the videos and presentation that we made for different purposes.

Sponsoring Flyer

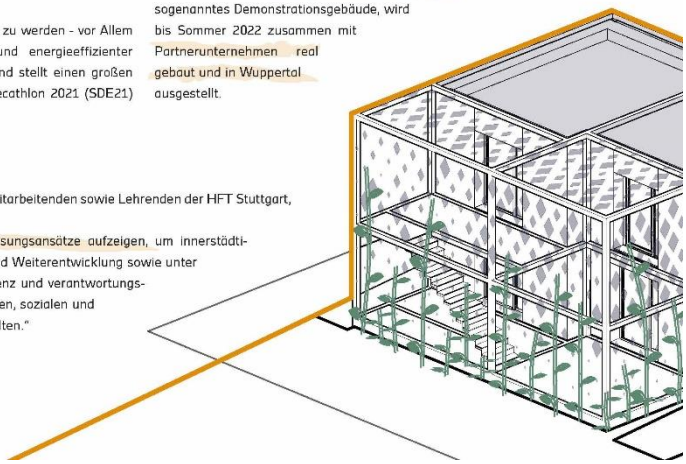
Hoch hinaus mit dem Team „coLLab" der HFT Stuttgart

Gebäudeaufstockung als Lösungsvorschlag zur urbanen Nachverdichtung im Rahmen des internationalen Wettbewerbs Solar Decathlon Europe 2021

Hochschule für Technik Stuttgart
coLlab

Der Gebäudesektor ist für ca. 40% der CO_2-Emissionen in Deutschland verantwortlich, verursacht 52% unseres Müllaufkommens und allein die Baustoffproduktion nimmt 90% der mineralischen, nicht nachwachsenden Rohstoffe in Anspruch.
Zudem stehen wir vor einer weiteren großen Herausforderung: Vor allem in Städten ist Wohnraum so knapp wie noch nie, die Urbanisierung schreitet in großen Schritten voran.
Diesem Bedarf an bezahlbarem Wohnraum gerecht zu werden - vor Allem unter Berücksichtigung ressourcenschonender und energieeffizienter Maßnahmen - ist eine globale Herausforderung und stellt einen großen Anreiz für das Team dar, am Wettbewerb Solar Decathlon 2021 (SDE21) teilzunehmen.

Hohes Übertragungspotential mit der „coLLab"-Lösung
Geplant wird die Aufstockung und Sanierung eines Bestandsgebäudes des Hochschulcampus in der Stadtmitte von Stuttgart unter Berücksichtigung wichtiger Faktoren wie urbane Mobilität, kreislauffähige Konstruktionen, nachhaltige Finanzierungsmodelle und klimaneutrale Gebäudekonzepte. Ein Ausschnitt dieser Planung, ein sogenanntes Demonstrationsgebäude, wird bis Sommer 2022 zusammen mit Partnerunternehmen real gebaut und in Wuppertal ausgestellt.



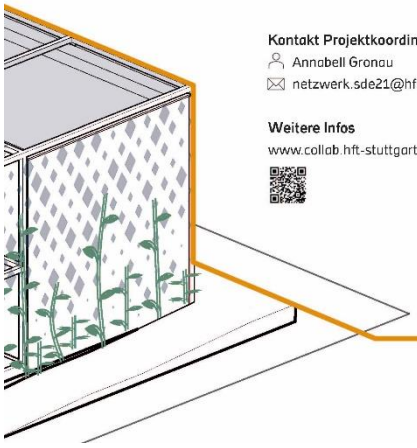
Fragestellung
Das Team „coLLab", bestehend aus Studierenden, Mitarbeitenden sowie Lehrenden der HFT Stuttgart, arbeitet an einer gemeinsamen Fragestellung:
„Wie können wir übertragbare und innovative Lösungsansätze aufzeigen, um innerstädtische Bestandsstrukturen durch Wiederbelebung und Weiterentwicklung sowie unter Berücksichtigung von Nachhaltigkeit, Energieeffizienz und verantwortungsbewussten Ressourcenmanagement zu lebenswerten, sozialen und nachhaltigen Wohn- und Lebensräumen umzugestalten."

Der Wettbewerb
Bereits 2010 erreichte die HFT Stuttgart bei der Teilnahme am Solar Decathlon 2010 in Madrid die Drittplatzierung im Gesamtranking. 2022 findet der Wettbewerb in Wuppertal statt.

- Internationaler Wettbewerb: 18 Hochschulteams messen sich in zehn Disziplinen
- Stärkung des Transfers und interdisziplinäre Zusammenarbeit zwischen Lehre, Forschung und Wirtschaft

Ihre Zusammenarbeit mit „coLLab"

- Unterstützung eines innovativen und zukunftsorientierten Projekts
- Kooperation mit einer der Drittmittel-stärksten HAWs in BW
- Nutzung von regionalen, überregionalen und internationalen Netzwerken und Plattformen
- Beitrag zur Entwicklung der Baubranche hin zur klimaverträglichen und zukunftsfähigen Industrie
- Ihre Unterstützung: Sachspende, Geldspende

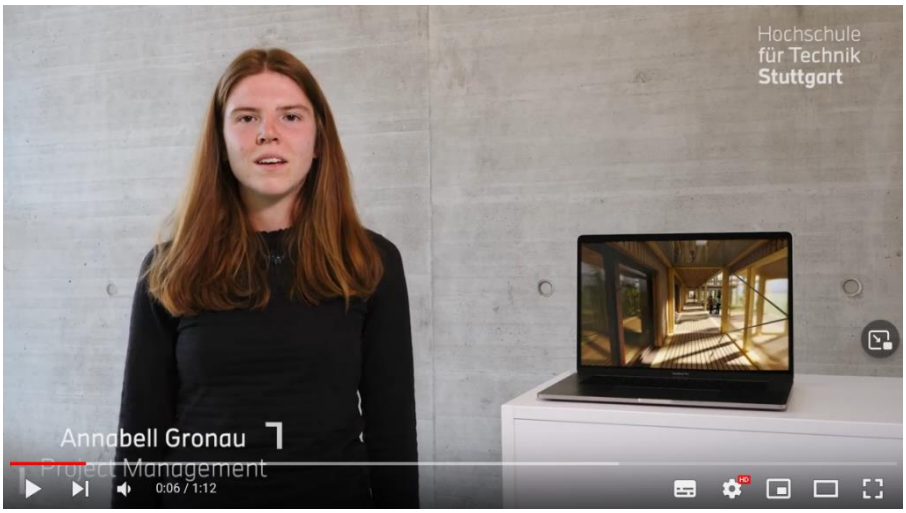


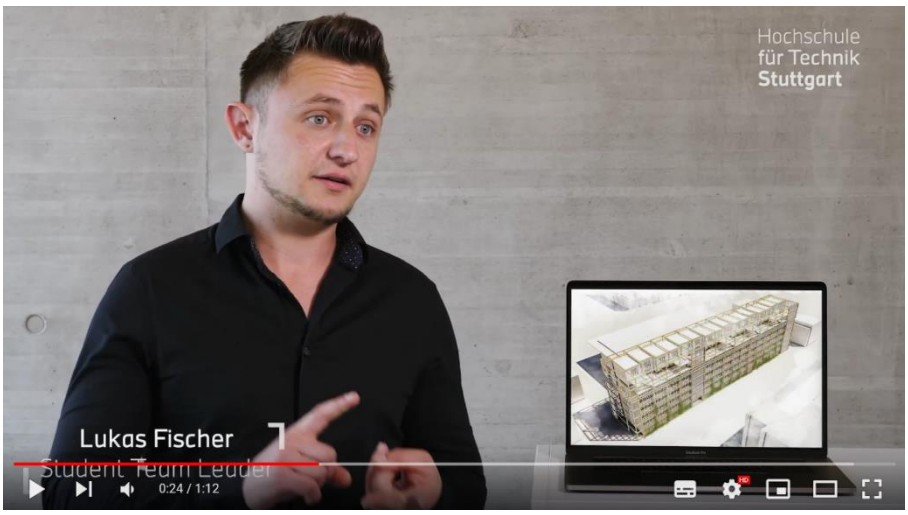
Kontakt Projektkoordination
Annabell Gronau
netzwerk.sde21@hft-stuttgart.de

Weitere Infos
www.collab.hft-stuttgart.de

Sponsoring Video

In order to attract sponsorship partners, a video was made alongside the flyer to show the backing behind the project. It should be noted that this was made during a very restrictive Corona situation.





Appendix D: Public Tour Description

The lot is accessed via a ramp on the north side while the Demonstration Unit is accessed via the terrace also on the north side of the building. If a waiting line occurs, it is led once around the unit to have an impression of the building while waiting.

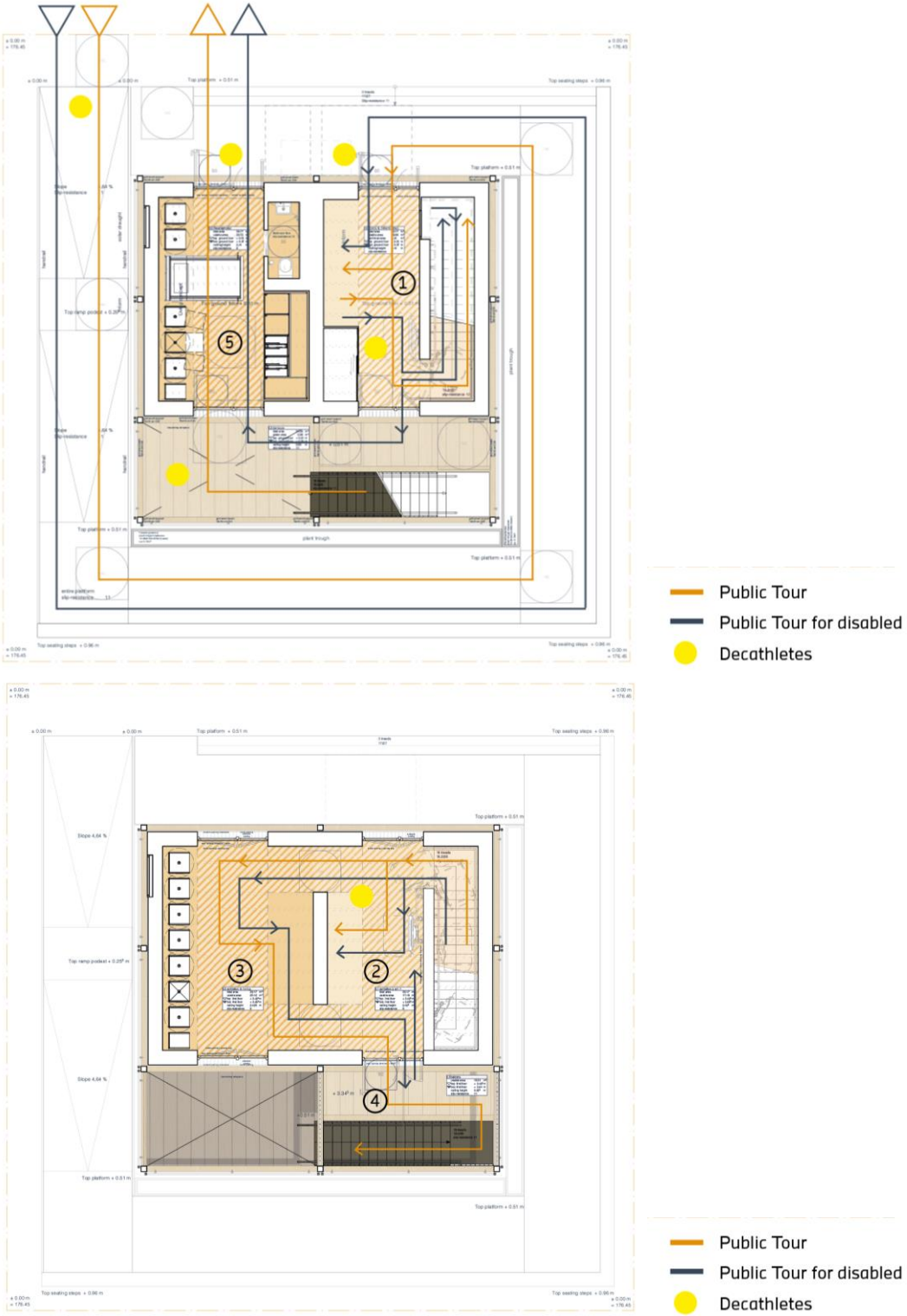


Figure 80: HDU and Public Tour

Also, content is already being conveyed on the façade surfaces, so everyone is encouraged to look at the external appearance of the HDU first. Some parts of the diamond shaped OPV façade are used for

a quiz. The upper modules provide questions for adults while the lower modules take care of children's entertainment (Figure 2). Answers and questions will be written in both english and german language. In general, the informing topics are ranked and communicated from big to small, meaning that in the waiting line area, data of the general situation and the relevance of the topic in relation to the location of Stuttgart is shown.

Figure 2: Quiz provided while waiting in line

The public tour groups, which will be led through the HDU, consist of five to eight visitors. Two groups can be guided at the same time, while every group is led by one Decathlete. The duration of one tour is approximately 30 minutes. The access for disabled people is guaranteed through ramps, a seat elevator, braille, and Decathletes who take care of people who are disabled to ensure that all participants experience the tour equally. Also, it is important to make clear what part of the building is showing the housing concept and what part represents the exhibition. This will be communicated through the separation of the two floors and also through colours, materiality and labelling.

Various target groups are able to get a tour through the HDU. Foreigners and non-German speaking guests can get an English version of the tour while others can join a German guided tour. Information will be provided through pictures, games and trying out furniture and other integrated objects. The tour can have different focuses, for example people without an architectural or technical background can get more general information and basic explanations to understand the concept. Tours for specialists and student groups can offer more detailed explanations and expert knowledge through QR-Codes of the project.

The tour starts outside on the terrace area. The student tour guide provides information about the overall concept and the team. The main elements of the design, like the façade, the solar chimney and the urban mobility concept is described. Furthermore, attention is drawn to the existing open spaces, to the possibilities of using the terrace area and to the visual relationship of the two levels. Before entering the unit, strollers can be parked in front of the door.

Then the group enters the unit and finds itself in the first module (1). Here, special emphasis is placed on the urban situation of Stuttgart. A relief model from the campus is displayed (Figure 3). Buildings where an addition of storey is possible are highlighted. A sound installation with reports of apartment seekers in Stuttgart is being played. The reports will also be visible on the opposite wall as speech bubbles.

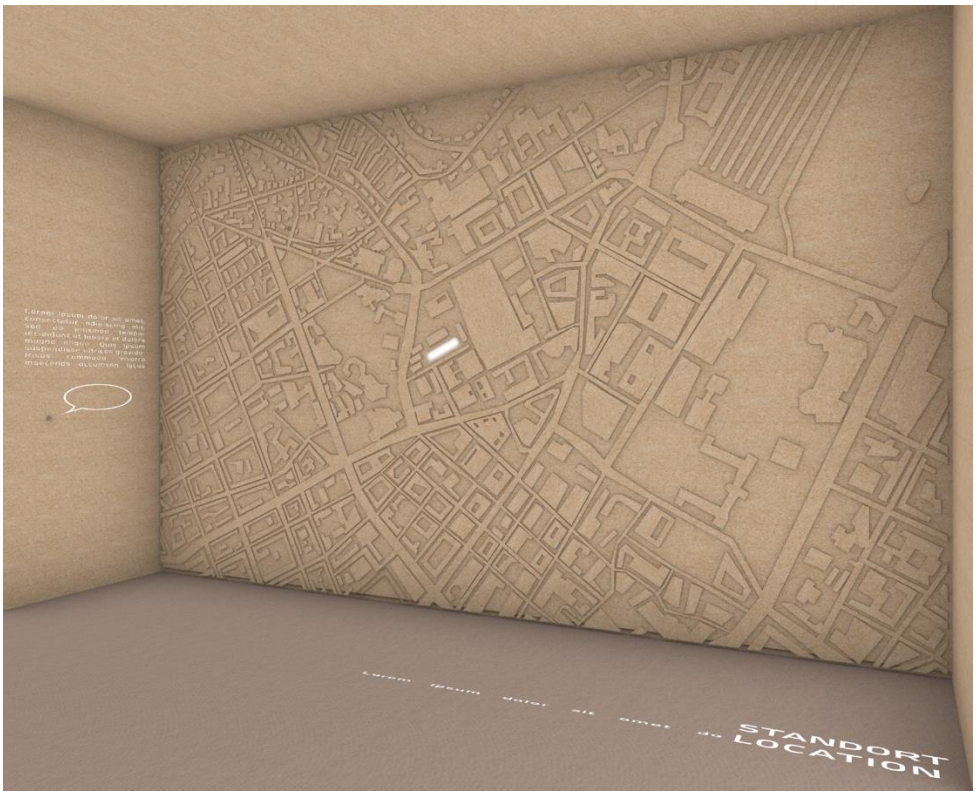


Figure 3: Urban situation relief model

The tour then continues via the inside staircase or via the staircase-lift to the upper floor.

The inside staircase ends with the explanation of the light installation, which forms a seamless transition from wall to ceiling.

The main exhibition room and presentation space (2) covers information of sustainable building in general. A hidden objects game will convey the information in an unusual way, to make this topic easy to understand for everyone (Figure 4) .

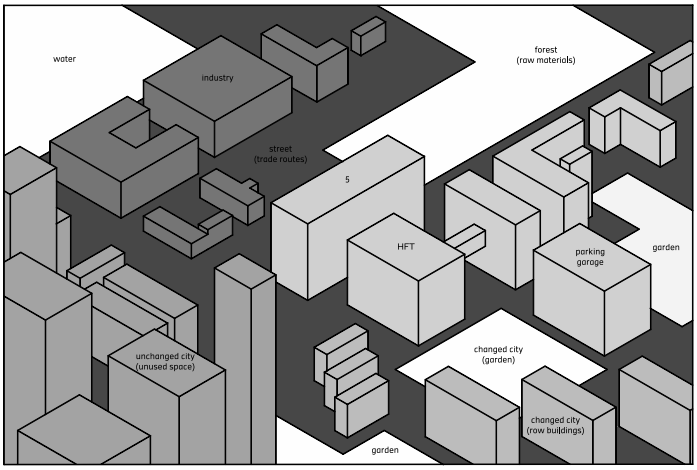


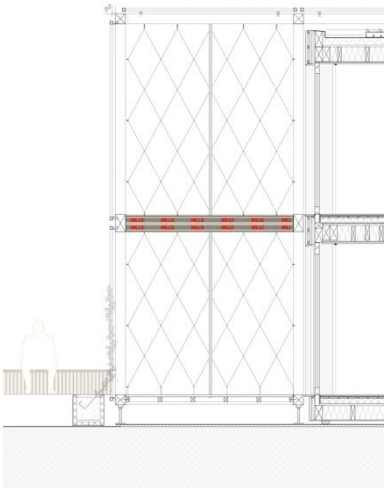
Figure 4: hidden object game (city template)

Then the tour enters the left module of the HDU (3), where the visitor gets a first impression of the actual housing concept. Here, the furnishing elements can be tested, which means the rotating cabinet can be equipped with provided fabric elements and the visitor can try out whether the idea really

works. On the other side of the hands-on furniture, a projection will show a video of how the furniture works to ensure public safety and to explain the interior design concept (Figure 5).

Figure 5: Projection shows a daily routine in a continuous loop

The subject of the HDU is then delved deeper and individual components are presented as detailed sections on a scale of 1:1. This is followed by an exploded model presenting the design challenge to make our building design tangible.



The next stop is the outside terrace area (4), which represents the community space of the building design challenge. Virtual reality glasses are provided by the tour guide. They will show an animation of the community outdoor spaces and will give visitors a sense of how it would be like to live in our addition of storey.

After following the outside staircase down to the ground floor, the group can see the current consumption of the HDU on an LED display panel (Figure 6) before they enters the building again (5) and experiences the grand final of the tour.

Figure 6: LED display panel

The seat-lift on the inside staircase provides a barrier-free access to the ground floor. A responsible Decathlete will help the disabled visitor. The actual housing concept, with its living and dining area as well as the kitchen and bathroom module of the residential unit, is presented. Moveable objects are demonstrated to the visitors and to ensure public safety, only the tour guide will pull out the flexible bed element (Figure 7).

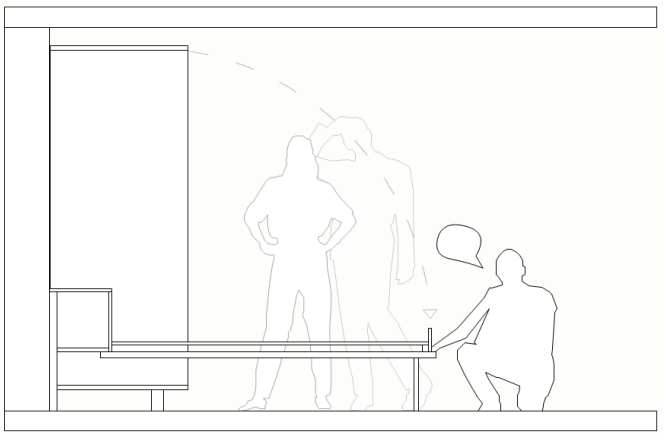


Figure 7: Moveable bed is demonstrated by Decathlete

The tour ends, after leaving the unit, on the north side terrace. Here, final information about the project and sponsors are presented. The lot can be left via seating steps or via a ramp on the north side to get back to the main path.

The development of the tour description is integrated into the curriculum of the interior design course and changes can still be possible.

20.4 Sustainability

Appendix A – Materials

8.1.1 Building parts catalogue

FOUNDATION		
product/material	**material name in the UMI**	**manufacturer**
Nora Fußbodenbelag	Nora Rubber Flooring	Nora
ESB-Platte 30 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Gefachdämmung, Holzfaser STEICOflex 038 (Rahmenkonstruktion ausgedämmt) 50 mm	Wood fibre insulation board (lignin-bonded) *	Steico
Balken kvh (6x8cm) (Rahmenkonstruktion ausgedämmt) 60 mm	Solid wood boards / battens sustainable forestry	Baufritz
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Trittschalldämmung, STEICOthermSD 30mm	Wood fibre insulation board (lignin-bonded) *	Steico
ESB-Platte 25 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Deckenbalken Nadelholz FI/TA C24 8/24 cm	Solid structural timber beams, sustainable forestry	Baufritz
HOIZ-Dämmung	Baufritz HOIZ planed chip insulation	Baufritz
Powerpanel H2O 12 mm	Fiber cement and glass fiber concrete slab	Fermacell
EXTERIOR WALLS		
product/material	**material name in the UMI**	**manufacturer**
Recycling-Schalung 30 mm	Coniferous wood boards / battens sustainable forestry	Team Collab (waste wood from Baufritz)
Lattung 30/50 mm	Solid wood boards / battens sustainable forestry	Baufritz
Lattung 30/50 mm	Solid wood boards / battens sustainable forestry	Baufritz
STO-Holzweichfaserplatte M046 60 mm	Wood fiberboard * proportionally sustainable forestry E1	sto
Xund-E Elektrosmog-Schutztechnik, technisches Papier	Fleece made of cellulose and binder, reinforced with synthetic fibers	Baufritz

Ständer, Nadelholz FI/TA C24; 50/240 mm	Solid wood boards / battens sustainable forestry	Baufritz
HOIZ-Dämmung	Baufritz HOIZ planed chip insulation	Baufritz
Dampfbremspapier	Underlayment, sarking and facade membrane (PE-HD) *	ProClima
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
GKF 12,5 mm	Gypsum plasterboard	Knauf
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
EXTERIOR WALLS_2		
product/material	**material name in the UMI**	**manufacturer**
Fensterrahmen	Window profiles hardwood, lacquered without wood preservatives	
Fensterscheibe	Insulating glazing, clamped	
EXTERIOR WALLS_3		
product/material	**material name in the UMI**	**manufacturer**
BSH Balken	Glued laminated timber, sustainable forestry	Baufritz
Stahlrahmen	Structural steel (rolled sections and heavy plates)	Karl Stahl
INTERIOR WALLS		
product/material	**material name in the UMI**	**manufacturer**
GKF 18 mm	Gypsum plasterboard	Knauf
Ständer Nadelholz C24 120/240 mm, e=31.25 cm	Solid wood boards / battens sustainable forestry	Baufritz
HOIZ-Dämmung	Baufritz HOIZ planed chip insulation	Baufritz
GKF 18 mm	Gypsum plasterboard	Knauf
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
INTERIOR WALLS_2		
product/material	**material name in the UMI**	**manufacturer**
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
GKF 18 mm	Gypsum plasterboard	Knauf

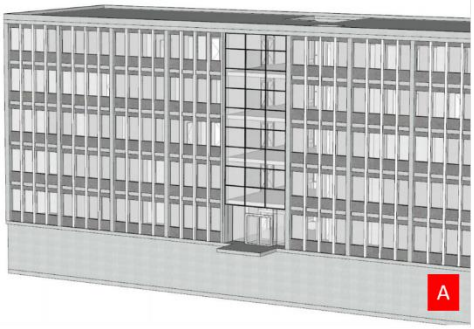
Ständer Nadelholz C24 120/240 mm, e=31.25 cm	Solid wood boards / battens sustainable forestry	Baufritz
HOIZ-Dämmung	Baufritz HOIZ planed chip insulation	Baufritz
GKF 18 mm	Gypsum plasterboard	Knauf
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH

CEILINGS		
product/material	**material name in the UMI**	**manufacturer**
Nora Fußbodenbelag	Nora Rubber Flooring	Nora
ESB-Platte 30 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Gefachdämmung, Holzfaser STEICOflex 038 (Rahmenkonstruktion ausgedämmt) 50 mm	STEICO Wood fibre insulation board	Steico
Balken kvh (6x8cm) (Rahmenkonstruktion ausgedämmt) 60 mm	Solid wood boards / battens sustainable forestry	Baufritz
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Trittschalldämmung, STEICOthermSD 30mm	STEICO Wood fibre insulation board	Steico
ESB-Platte 25 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Xund-E Elektrosmog-Schutztechnik, technisches Papier	Fleece made of cellulose and binder, reinforced with synthetic fibers	Baufritz
Deckenbalken Nadelholz FI/TA C24 70/240 mm, 60 cm Achsmaß	Solid structural timber, sustainable forestry	Baufritz
HOIZ-Dämmung 24 cm (ohne Verdichten)	Baufritz HOIZ planed chip insulation	Baufritz
GKF 18 mm	Gypsum plasterboard	Knauf
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
ROOF		
product/material	**material name in the UMI**	**manufacturer**
Pflanzensubstrat	Planting substrate, system soil *	Helix Gründach-Module
Fleece in den Kunststoffwannen	Protective fleece made of plastic mix, 70% PE/30% PP *	Helix Gründach-Module
Kunststoff-Wannen mit integrierter Drainage	Drainage and water storage element of polypropylene	Helix Gründach-Module
Flachdachfolie: D-A-CH-Lux: DA-PF Abdichtung 1,5 mm lose verlegt	Waterproofing, polyisobutylene	Novoproof DA EPDM-Plane
Dämmung EPS Mindestdeckung 60 mm (mit 2 % Gefälle)	Polystyrene rigid foam (EPS)	Joma/EPS 035 DAA dh

ESB-Platte 25 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH
Balken Nadelholz FI/TA C24 8/24 cm	Solid structural timber, sustainable forestry	Baufritz
HOIZ-Dämmung	Baufritz HOIZ planed chip insulation	Baufritz
Dampfbremse PRO CLIMA INTELLO	Vapor retarder (PE-LD) *	ProClima
Xund-E Elektrosmog-Schutztechnik, technisches Papier	Fleece made of cellulose and binder, reinforced with synthetic fibers	Baufritz
GKF 12,5 mm	Plasterboard, filled and painted	Knauf
ESB-Platte 12 mm	ESB board*, sustainable forestry E1	elka Holzwerke GmbH

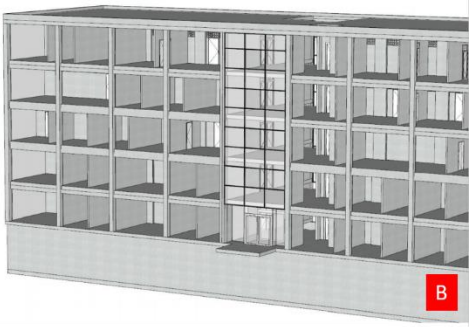
Appendix B – Construction

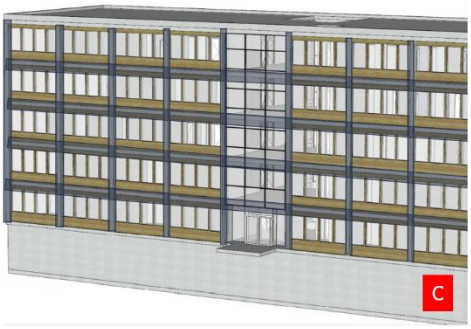
8.1.2 Construction of renovation



A: Status quo of Bau5

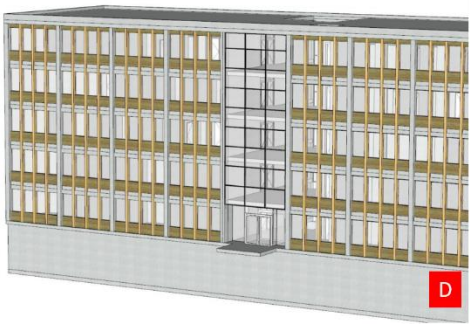
B: Bau5 dismantled

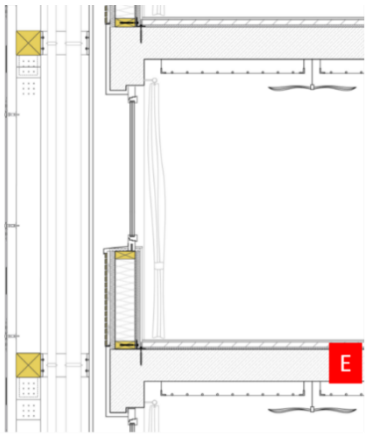




C: Bau5 with new window modules

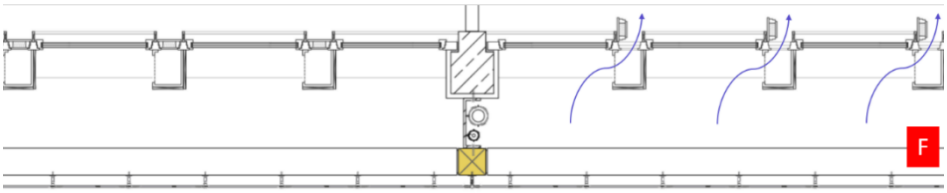
D: Bau5 with new ventilation flaps in column optics





E: Drawing of the side view of the window modules

F: Drawing of the top view of the ventilation flaps



Appendix C – Maintenance

8.1.3 Durability and LCA data of technical building services

component/ type	reference unit	production [kg of CO_2-equivalents (GWP 100a)]	use phase	end-of-life	years [a]	source
Electric installations						
Cables [a)]						
0.75 mm²	100 m² conditioned net floor area	125	0	-	50	1) 5) 6)
Water installations						
Water installation system [b)]						
Steel	100 m² conditioned net floor area	60	0	not incl.	30	3) 4) 5) 6)
Copper	100 m² conditioned net floor area	71	0	not incl.	30	3) 4) 5) 6)
Plastics	100 m² conditioned net floor area	8	0	not incl.	30	3) 4) 5) 6)
Ventilation systems		no ventilation system used → solar chimney				
Centralized with heat exchanger						
steel ducts	100 m² conditioned net floor area	1.845	123	1	50	1)
PE ducts	100 m² conditioned net floor area	1.250	135	1	50	1)
De-centralized						
steel ducts	100 m² conditioned net floor area	3.100	123	1	50	1)
PE ducts	100 m² conditioned net floor area	1.450	135	1	50	1)
Photovoltaics		used OPV → manufacturer data				
Flat-roof						
multi-Si	1 kW_{PEAK} PV module	2.124	not incl.	not incl.	25	1)
single-Si	1 kW_{PEAK} PV module	2.476	not incl.	not incl.	25	1)
Slanted-roof						
multi-Si	1 kW_{PEAK} PV module	1.939	not incl.	not incl.	25	1)
single-Si	1 kW_{PEAK} PV module	2.302	not incl.	not incl.	25	1)
a-Si	1 kW_{PEAK} PV module	1.572	not incl.	not incl.	25	1)
Battery						
lead-acid	1 kWh of storage	52	not incl.	not incl.	25	2)
lithium-ion	1 kWh of storage	169	not incl.	not incl.	25	2)
Solar collectors		no solar collectors used → heat pump				
Collector						
flat-plate	1 m² of collector	114	not incl.	not incl.	25	1)
excavated	1 m² of collector	93	not incl.	not incl.	25	1)
Water tank						
all types	1.000 litre of tank	452	not incl.	not incl.	25	1)
Pumping and installation [c)]						
all types	1 m² of collector	40	not incl.	not incl.	25	2)

Appendix D - Circularity concept

8.1.4 Results of the individual components of the UMI calculation

Appendix E – Carbon footprint of the construction

8.1.5 Calculation of technical building services

	given reference	GWP in kg CO2 eq	frequency of exchange	factor mixed use	reference used	unit		
electrical installation (cables)	100 m²	125	1	1	90	m²	**112,5**	**kg CO2eq**
water installation (plastic)	100 m²	8	2	0,8	90	m²	**11,52**	**kg CO2eq**
water installation (steel)	100 m²	60	2	0,2	90	m²	**21,6**	**kg CO2eq**
PV system (OPV)	3 kWp --> 0,04 kWp/m²	8	2	1	75	m²	**1200**	**kg CO2eq**
battery (LiFePO4)	1 kWh	169	2	1	2,4	kWh	**811,20**	**kg CO2eq**
heat pump	1 unit	219,33	2	1	1	unit	**438,66**	**kg CO2eq**
pump for adiabatic cooling	1 unit	8,5	2	1	1	unit	17	**kg CO2eq**
pump for fresh water supply	1 unit	8,5	2	1	1	unit	17	**kg CO2eq**
pump for waste water	1 unit	8,5	2	1	1	unit	17	**kg CO2eq**
over all result							**2646,48**	**kg CO2eq**
							2,65	**t CO2eq**

result per m² net floor area							**0,03**	**t CO2eq**

Appendix F – Biodiversity

8.2.1.4 Ecologically valuable open spaces with climate-resilient, diverse plant selection

for area 1 on the site plan:

botanical name	common name	bee pasture	edible
Clematis alpina	Clematis	x	-
Clematis viticella	Clematis	x	-
Clematis macropetala	Clematis	x	-
Lonicera caprifolium	Common honeysuckle	x	-
Actinidia kolomikta	Hardy kiwi	-	x
Akebia quinata	Chocolate vine	-	x

For area 2 on the site plan:

botanical name	common name	bee pasture	suitable underneath PV
Alyssum saxatile	Gold dust	x	-
Anthemis tinctoria	Yellow chamomile	x	-
Aubrieta deltoidea	Purple rockcress	x	x
Carlina vulgaris	Carline thistle	x	-
Dianthus deltoides	Maiden pink	x	-
Echium vulgare	Viper’s bugloss	x	-
Euphorbia cyparissias	Cypress spurge	x	-
Origanum vulgare	oregano	x	-
Sedum rupestre	Jenny’s stonecrop	x	x
Sedum acre	Biting stonecrop	x	x
Sedum album	White stonecrop	x	x
Satureja montana	Winter savoury	x	-
Sempervivum arachnoideum	Cobweb houseleek	x	x
Sempervivum tectorum	Common houseleek	x	x
Thymus pulegioides	Large thyme	x	x

For area 3 on the site plan:

botanical name	common name	plant size/type	bee pasture
Acer monspessulanum	French maple	Small tree	-
Amelanchier ovalis	Juneberry	Shrub/small tree	-
Carpinus betulus	Common hornbeam	Small tree	-
Castanea sativa	European chestnut	Big tree	-
Cornus mas	Cornel cherry	Shrub	-
Fraxinus excelsior	Common ash	Big tree	-
Hippophae rhamnoides	Sea buckthorn	Shrub/small tree	-
Pinus sylvestris	Scots pine	Big tree	-
Pyrus pyraster	Wild pear	Big tree	x
Populus alba	White poplar	Big tree	-
Populus tremula	Aspen	Small tree	-
Prunus mahaleb	Perfumed cherry	Small tree	-
Prunus spinosa	Blackthorn	shrub	x
Robinia pseudoacacia	False acacia	Big tree	x
Robinia viscosa	Clammy locust	Big tree	-

Robinia luxurians	Robinia	Small tree	-
Rosa canina	Dog rose	shrub	-
Rosa corymbifera	Rose	shrub	-
Rosa gallica	French rose	shrub	-
Laburnum anagyroides	Common laburnum	Shrub/small tree	-
Viburnum lantana	Viburnum	shrub	-

Big tree: over 10m, small tree: less than 10m

For area 4 on the site plan:

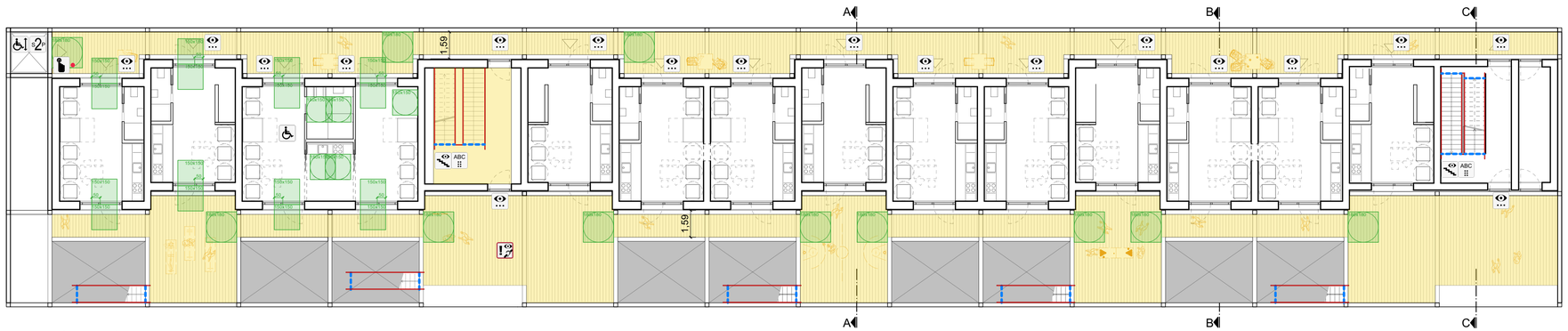
botanical name	**common name**
Anthum graveolens	Dill
Allium sativum	Garlic
Allium schoenoprasum	Chives
Allium ampeloprasum	Leek
Allium fistulosum	Spring onion
Apium graveolens var. Rapaceum	Celery
Beta vulgaris ssp. vulgaris var. conditiva	Beetroot
Brassica oleracea gongylodes	Stem cabbage
Daucus carota ssp. Sativus	Carrot
Eruca vesicaria	Rocket
Foeniculum vulgare	Fennel
Fragaria x ananassa	Strawberry
Ipomoea batatas	Sweet potato / yam
Lactuca sativa var. crispa	Lettuce
Lavandula angustifolia	Lavender
Origanum majorana	Marjoram
Phaseolus vulgaris var. nanus	Bush bean
Petroselinum crispum	Parsley
Spinacia oleracea	Spinach
Thymus vulgaris	Thyme
Tropaeolum minus	Nasturtium
Valerianlella locusta	Field salad

Appendix G – Society

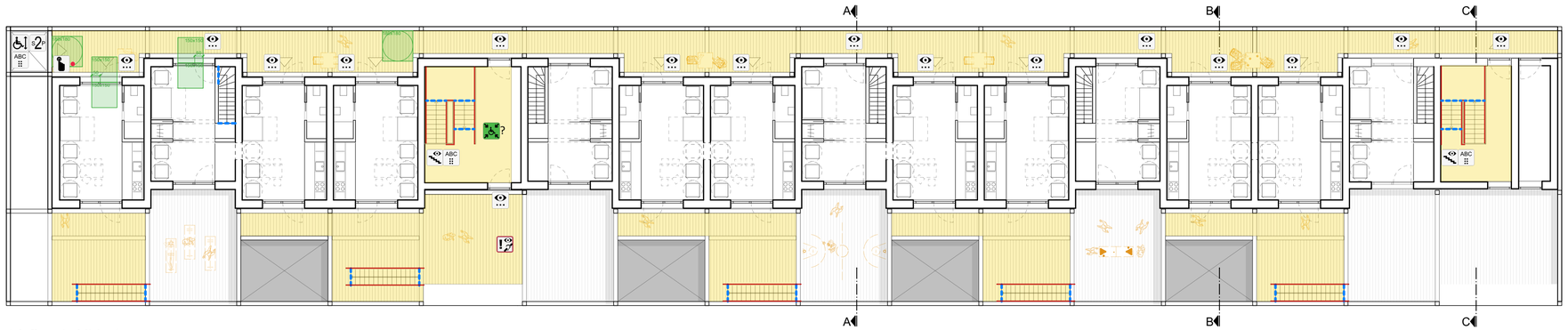
8.2.2.3 Offer of mixed use

8.2.2.9 Accessibility for wheelchair users and people with reduced mobility and for further handicaps

Vectorworks Educational Version



5th floor (addition)

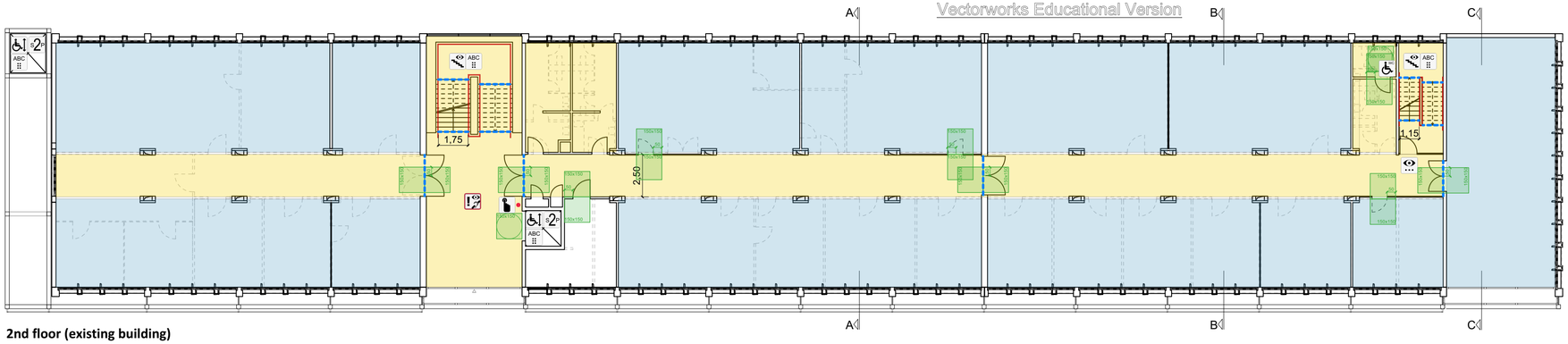


6th floor (addition)

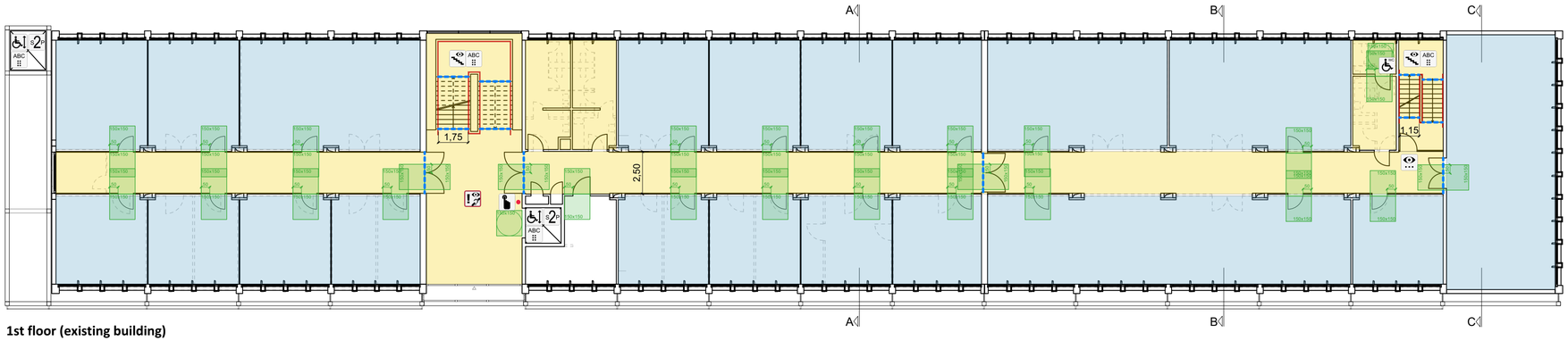
- applicability: public space
- applicability: work/ university space
- deviation from regulations
- 150x150cm: wheelchair turning area; 180x180xm: wheelchair passing area
- turning and moving areas around doors
- barrier-free handrail
- visually (strongly) contrasting safety markings
- barrier-free signs
- barrier-free entrance
- barrier-free elevator
- barrier-free staircase
- barrier-free toilet
- tactile and braille information
- barrier-free control panel
- visually contrasting design
- application of the "two-senses-principle"
- alarm system based on the "two-senses-principle"
- safe short-term waiting area
- automated door opener

Vectorworks Educational Version

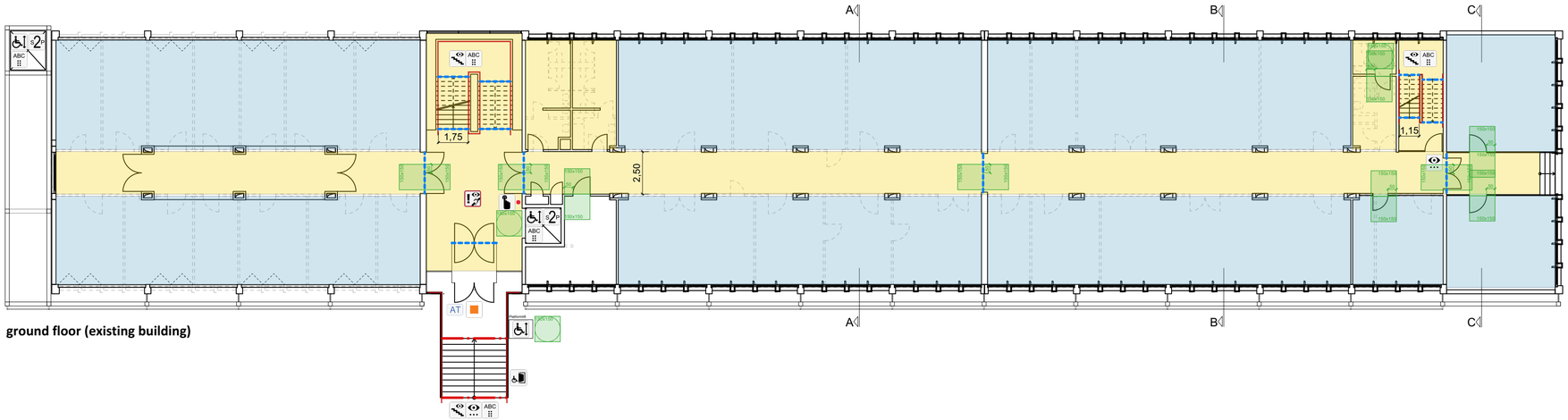
Vectorworks Educational Version



2nd floor (existing building)



1st floor (existing building)



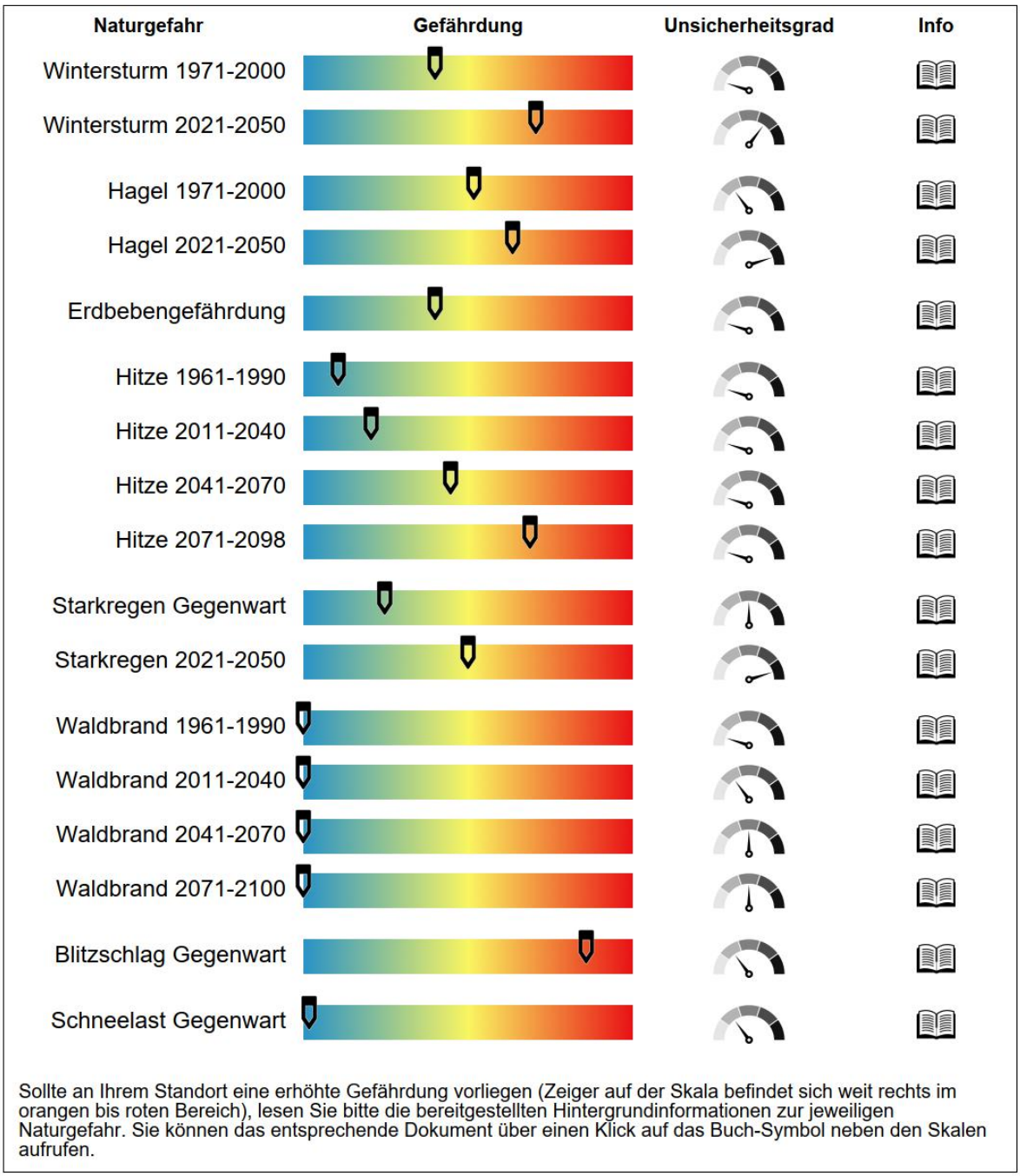
ground floor (existing building)

- applicability: public space
- applicability: work/ university space
- deviation from regulations
- 150x150cm: wheelchair turning area; 180x180xm: wheelchair passing area
- turning and moving areas around doors
- barrier-free handrail
- visually (strongly) contrasting safety markings
- barrier-free signs
- barrier-free entrance
- barrier-free elevator
- barrier-free staircase
- barrier-free toilet
- tactile and braille information
- barrier-free control panel
- visually contrasting design
- application of the "two-senses-principle"
- alarm system based on the "two-senses-principle"
- safe short-term waiting area
- automated door opener

Vectorworks Educational Version

Appendix H – Climate

8.2.3 Risk situation for the design challenges



8.2.3.6 Resilient rainwater runoff

Emergency drainage Extension

Entwässerungs- und Notentwässerungssystem müssen zusammen mindestens das am Gebäudestandort über 5 min zu erwartende Jahrhundertregenereignis ($r_{5,100}$) entwässern können. Das Mindestabflussvermögen wird wie folgt berechnet:

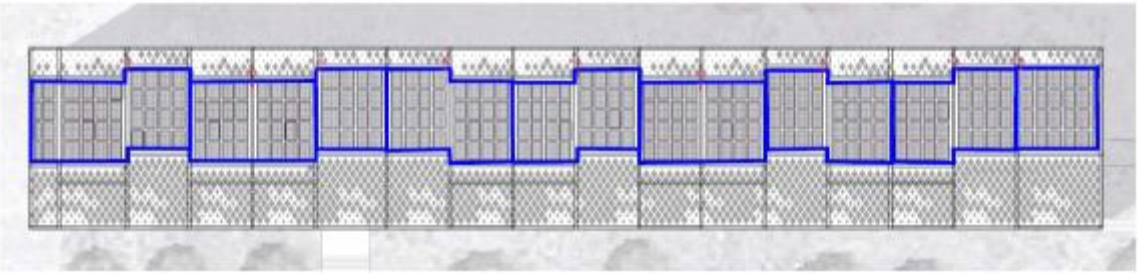
$$Q_{Not} = (r_{(5,100)} - r_{(D,T)} \cdot C) \cdot \frac{A}{10000}$$

Q_{Not} = Mindestabflussvermögen der Notüberläufe in l/s
$r_{(5,100)}$ = Jahrhundertregenspende
$r_{(D,T)}$ = Berechnungsregenspende in l/(s*ha)
C = Abflussbeiwert (siehe auch Abschnitt 4.3.1)
A = wirksame Niederschlagsfläche in m²

Abflussbeiwert C	Art der Fläche
	Wasserundurchlässige Flächen
1,0	Dachflächen
1,0	Rasenflächen
1,0	Rampen
1,0	befestigte Flächen mit Fugenabdichtung
1,0	Schwarzdecken (Asphalt)
1,0	Pflaster mit Fugenvergüsse
8,0	Kiesflächen
8,0	Begrünte Dachflächen für Intensivbegrünung
8,0	Begrünte Dachflächen für Extensivbegrünungen ab 10 cm Aufbaudicke
8,0	Begrünte Dachflächen für Extensivbegrünungen unter 15 cm Aufbaudicke
	Teilundurchlässige und schwach absickernde Flächen, z.B.
8,7	Betonsickerpflaster, in Sand oder Schlacke verlegt, Flächen mit Pflaster
8,8	Flächen mit Pflaster, Fugenanteil > 15%, z.B. 15x15 cm und kleiner
8,0	wassergebundene Flächen
8,0	Kinderspielplätze mit Teilversickerungen
8,0	Kunststoff-Flächen, Kunststoffrasen
8,4	Tennisflächen
8,0	Rasenflächen
	Wasserdurchlässige Flächen ohne oder mit unbedeutender Wasserableitung z.B.
8,0	Parkplätzen und Hofzufahrtsflächen, Schotter- und Schlackenbeläge, Pollblau, auch mit befestigten Flächen, wie
8,0	Gartenwege mit wassergebundener Decke oder
8,0	Einfahrten und Einzelstellplätze mit Rasengittersteinen

$r_{(5,100)}$	858,3	l/(s*ha)	Stuttgart
$r_{(D,T)}$	445,8	l/(s*ha)	Stuttgart
C	0,5	Gravel roof (under PV)	
A	37,24	m²	equivalent to the roof area of one module of the extension
	595,84		(7,6 m*4,9 m)

Roof



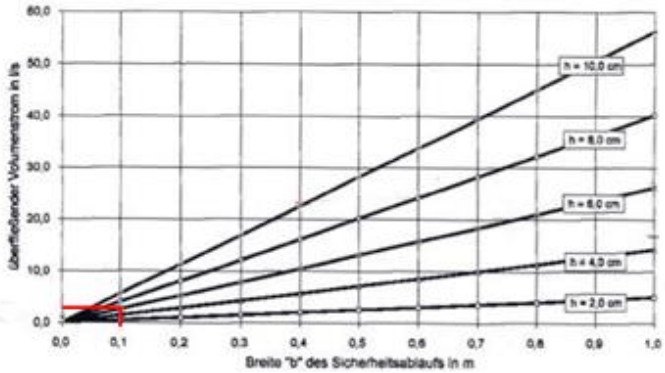
Emergency drainage roof area staircase

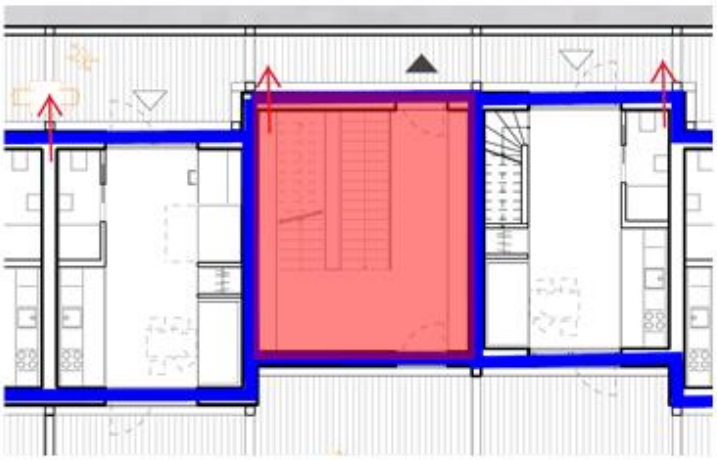
$$Q_{Not} = (r_{(5,100)} - r_{(D,T)} \cdot C) \cdot \frac{A}{10000}$$

$r_{(5,100)}$	858,3	l/(s*ha)
$r_{(D,T)}$	445,8	l/(s*ha)
C	0,5	Gravel roof (under PV)
Breite	6	m
Tiefe	7,6	m
A	45,6	m²

Q_{Not} 2,897424 l/s

Cross-section determination 10 cm x 6 cm Slot size





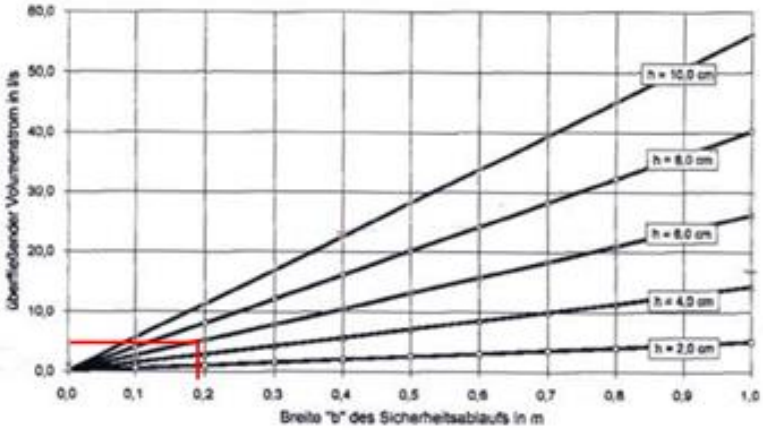
Emergency drainage 2 modules

$$Q_{Not} = (r_{(5,100)} - r_{(D,T)} \cdot C) \cdot \frac{A}{10000}$$

$r_{(5,100)}$	858,3	l/(s*ha)
$r_{(D,T)}$	445,8	l/(s*ha)
C	0,5	Gravel roof (under PV)
Breite	9,8	m
Tiefe	7,6	m
A	74,48	m²

Q_{Not} 4,7324592 l/s

Cross-section determination 18 cm x 6 cm Slot size



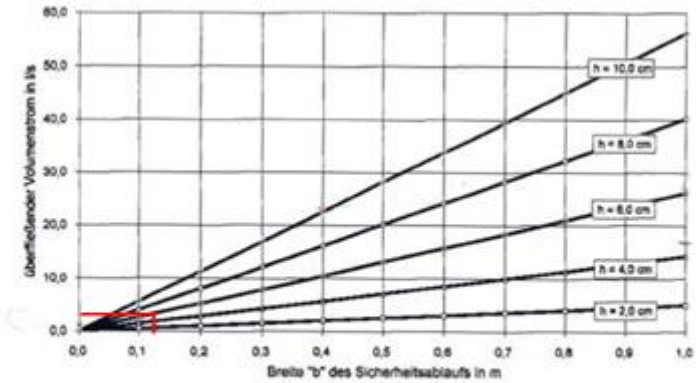
oder

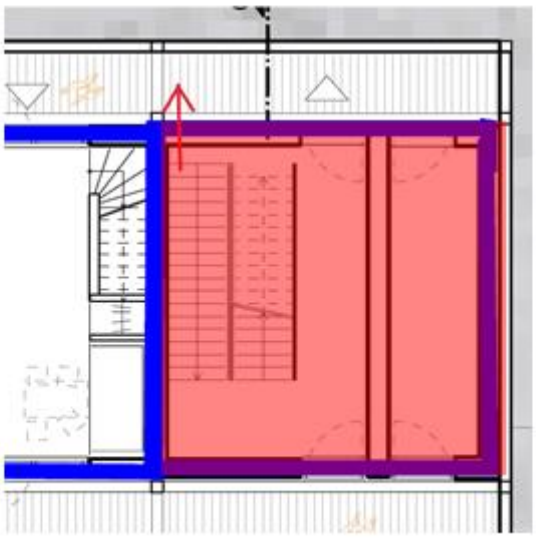
Emergency drainage roof area staircase east with outdoor area

$$Q_{Not} = (r_{(5,100)} - r_{(D,T)} \cdot C) \cdot \frac{A}{10000}$$

$r_{(5,100)}$	858,3	l/(s*ha)
$r_{(D,T)}$	445,8	l/(s*ha)
C	0,5	Gravel roof (under PV)
Breite	7	m
Tiefe	7,6	m
A	53,2	m²
Q_{Not}	3,380328	l/s

Cross-section determination 12 cm x 6 cm Slot size



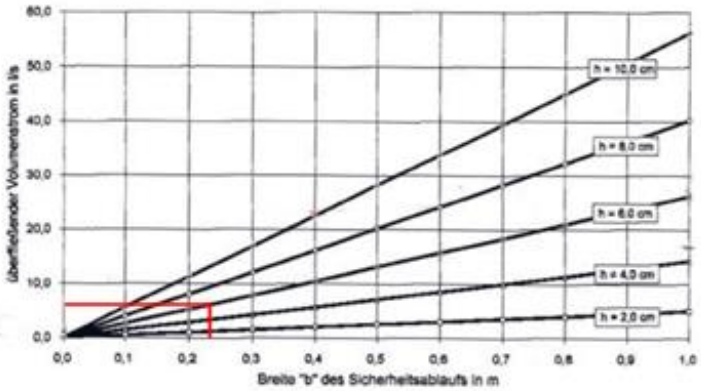


Emergency drainage special case front side west: 2 modules + outdoor area

$$Q_{Not} = (r_{(5,100)} - r_{(D,T)} \cdot C) \cdot \frac{A}{10000}$$

$r_{(5,100)}$	858,3	l/(s*ha)
$r_{(D,T)}$	445,8	l/(s*ha)
C	0,5	Gravel roof (under PV)
Breite	13,6	m
Tiefe	7,6	m
A	103,36	m²
Q_{Not}	6,5674944	l/s

Cross-section determination 24 cm x 6 cm Slot size



Appendix J – Building Material

8.2.5.6 Environmental impact of the building materials

Material	Installation site	Pullants	Detailed pollutants	Project information	Product name	Detection document
Plaster, varnishes, and paints for wood preservation	Facade	Biocides	Diuron, Terbutryn, 2-Oc-tyl-3-isothiazolinon (OIT), Zinkpyrithion, TBTO (Tributylzinnoxid)	Not in use		
Perimeter bitumen membranes	Green roofs	Biocides	herbicide mecoprop	EPDM	Novoproof DA	Manufacturer declaration
Textile	floor coverings	Biocides	Insecticides against moth infestation	Not in use		
Textile	insolation	Biocides	Insecticides against moth infestation	Not in use		
Wood-based panels		Formaldehyde	urea-formaldehyde (UF), melamine-formaldehyde (MF), melamine-urea-formaldehyde (MUF)	Roof construction	Span P5 E1 EN 13986 (EN 312)	natureplus
Mineral wool	insolation	Formaldehyde	Phenol-formaldehyde resin	Not in use		
Fiberglass fleece	Overlays, sheathing, army stripes	Formaldehyde	Urea-formaldehyde (UF)	Not in use		
In-situ/monthly foams		Formaldehyde	Urea-formaldehyde (UF)	Not in use		
EPS/XPS	insolation	SVHC	HBCD	EPS	EPS 035 DAA hd	Manufacturer declaration
Textile	floor coverings	SVHC	DecaBDE, brominated polystyrene, TBBPA	Not in use		
Epoxy resin	coatings, screeds	SVHC	TBBPA	Not in use		
Waterproofing membranes and vapour barriers		SVHC	DecaBDE, brominated polystyrene, propylene dibromostyrene	Vapor barrier	Intello	Manufacturer declaration
unsaturated polyester	Facade, roof and profiled panels	SVHC	TBBPA	Not in use		
Textile	floor coverings	SVHC	Phthalates, bisphenol-A, lead (Pb) and cadmium (Cd), MDA (4,4'-diaminodiphenylmethane)	Not in use		
rubber, linoleum, PVC, etc.	floor coverings	SVHC	Phthalates, bisphenol-A, lead (Pb) and cadmium (Cd), MDA (4,4'-diaminodiphenylmethane).	Rubber	norament 975 LL	Manufacturer declaration
plastic	doors, windows	SVHC	Stabilizers [2-(2H-benzotriazol-2-yl)-4,6-di-tert-pentylphenol and 2-(2H-benzotriazol-2-yl)-4,6-di-tert-butylpheno, tris(nonylphenyl)phosphite].	Not in use		
panels	Roof or facade panels	SVHC	Bisphenol-A	Not in use		
Epoxy resin	screed or-floor coating	SVHC	MDA (4,4'-Diaminodiphenylmethane), Bisphenol-A	Not in use		
Paints, varnishes		SVHC	Solvents [2-ethoxyethanol, 2-methoxyethanol, 2-ethoxyethylaceta], MDA (4,4'-diaminodiphenylmethane), bisphenol-A, lead (Pb) and cadmium (Cd)	Not in use		
Vinyl	wallpaper	SVHC	Phthalate	Not in use		
XPS	insolation	Halogen	Halogen propellants	Not in use		

PIR	insolation	Halogen	Halogen propellants	Not in use		
PUR	insolation	Halogen	Halogen propellants	Not in use		
Building foam		Halogen	Halogen propellants	Not in use		
Hard foam boards	insolation	Halogen	Halogen propellants	Not in use		
Heavy metal	roof, facade	Heavy metal	min. 95 % of roof or facade	Not in use		
Natural stone	Exterior wall cladding	Subsequently applied coatings that are hazardous to water	Permanent graffiti protection, subsequently applied hydrophobic coatings	Not in use		
Coated metal panels	Exterior wall cladding	Subsequently applied coatings that are hazardous to water	Permanent graffiti protection, subsequently applied hydrophobic coatings	Not in use		
Fiber cement panels	Exterior wall cladding	Subsequently applied coatings that are hazardous to water	Permanent graffiti protection, subsequently applied hydrophobic coatings	Not in use		
Fiberglass panels	Exterior wall cladding	Subsequently applied coatings that are hazardous to water	Permanent graffiti protection, subsequently applied hydrophobic coatings	Not in use		
Glass	bathroom	Subsequently applied coatings that are hazardous to water	Subsequently applied hydrophobic coatings	Not in use		
Ceramic	bathroom	Subsequently applied coatings that are hazardous to water	Subsequently applied hydrophobic coatings	Not in use		

NOVOPROOF® DA-K

Für Leichtdachkonstruktionen bei Neubau und Sanierung... ...leicht,

8

Die wirtschaftliche Sofortverlegung der Bahnen auf begehbarer Aufdachdämmung jeglicher Art erfolgt schnell und problemlos durch mechanische Befestigung und/oder teilflächige Verklebung.

Qualität schweißt Vertrauen

Durch die einfache und zuverlässige Verarbeitung von NOVOPROOF® **DA-K** mittels der von uns entwickelten Thermofast® Fügetechnik, ist eine jahrzehntelange Sicherheit von Material und Verarbeitung gewährleistet.
Diese umweltbewusste Schweißmethode ohne Kleber und Lösemittel erlaubt die Verarbeitung von NOVOPROOF® **DA-K** Bahnen bis -10° C, wobei die Schweißparameter gemäß der Verlegeanleitung anzupassen sind.

Leicht und robust

Durch das geringe Gewicht von nur 1,7 kg/m² ist NOVOPROOF® **DA-K** nicht nur leicht zu verlegen, sondern eignet sich insbesondere für die Leichtbauweise von Dächern jeglicher Art.
Die extrem gute Ozon- und UV-Beständigkeit sowie die robusten und dennoch elastischen Eigenschaften von NOVOPROOF® **DA-K** garantieren in allen Klimazonen, von der nördlichen Taiga bis in südliche Wüstengebiete, eine hohe Beständigkeit fast ohne Alterungsprozess.

Es grünt so grün

Eine spätere Erweiterung der Dachfläche ist ebenso möglich wie das Aufbringen einer nachträglichen Begrünung. Denn die herbizidfreie Dichtungsbahn ist wurzelfest.

Rundum dicht

Abdichtungen mit NOVOPROOF® **DA-K** werden komplettiert durch passgenaue Formteile für Dachdurchdringungen, An- und Abschlüsse unterschiedlichster Ausführungen.
Für alle Problemstellungen sind Lösungen möglich. Unsere Mitarbeiter stehen Ihnen mit Rat und Tat zur Seite.

Internationaler Verein für zukunftsfähiges Bauen und Wohnen – natureplus e.V.

ZERTIFIKAT
über die Vergabe des Qualitätszeichens
CERTIFICATE
for the award of the quality label
CERTIFICAT
pour l'attribution du label de qualité

Geprüfte Produkte Tested products Produits testés	**Baufritz Dach-Bauteil**
Hersteller/Vertreiber Manufacturer/Distributer Producteur/Distributeur	**Baufritz GmbH & Co. KG** **D-87746 Erkheim/Allgäu** **Deutschland**
Produktart Type of product Nature du produit	Bauteile in Holzbauweise Building elements in timber construction Éléments constitutifs pour construction en bois
Zertifikatsnummer Number of certificate Numéro de certificat	**2001-1804-006-4**
Prüfumfang Test program Étendue du test	**Umwelt – Gesundheit – Funktion** Produktlebenslinie Laborprüfung (Inhaltsstoffe und Emissionen) Gebrauchstauglichkeit **Environment – Health – Function** Life cycle evaluation Laboratory test (content and emissions) Fitness for use **Environnement – Santé – Fonction** Cycle de vie du produit Test en laboratoire (composants et émissions) Aptitude à l'usage
Prüfergebnis Test result Résultat du test	Das Produkt/die Produkte erfüllt/erfüllen die strengen Anforderungen der natureplus-Vergaberichtlinie RL2001 Bauteile in Holzbauweise The product/the products fulfill/fulfills the stringent requirements of the natureplus awardguidelines RL2001 Building elements in timber construction Le(s) produit(s) mentionné(s) ci-dessus remplit/remplissent les exigences strictes des directives pour l'attribution de contrats de natureplus RL2001 Éléments constitutifs pour construction en bois
Gültigkeit des Zertifikats Validity of certificate Validité du certificat	**April / April / Avril 2023**
Neckargemünd, 2018-4-18	natureplus

Association internationale pour une construction et un habitat durables – natureplus

International Association for Sustainable Building and Living – natureplus

www.natureplus.org

Besser dämmen mit JOMA

Leistungserklärung Nr. LE-DE-17.1-DAA-dh-035

nach Artikel 4 der Bauproduktenverordnung (EU-BauPVO) 305/2011

1	Kenncode des Produkttyps:	EPS 035 DAA dh
2	Verwendungszweck	Wärmedämmstoffe für Gebäude Außendämmung von Dach oder Decke, vor Bewitterung geschützt, Dämmung unter Abdichtungen
3	Handelsname Kontaktanschrift des Herstellers	AirPor® 035 DAA dh JOMA Dämmstoffwerk GmbH, Niederriederstraße 8, 87752 Holzgünz, info@joma.de Herstellwerk: siehe Etikett (BFA-Nr.1494 = Cretzschwitz/Gera ; BFA-Nr. 1498 = Holzgünz)
4	Kontaktanschrift des Bevollmächtigten	Nicht relevant
5	System zur Bewertung und Überprüfung der Leistungsbeständigkeit	System 3
6	Notifizierte Stelle und Konformitätsbescheinigung	Erstprüfung des Produktes (PTD) nach System 3 durch das notifizierte Prüflabor FIW-München, Kennnummer 0751
7	Leistungserklärung bezüglich Europäisch Technischer Bewertung	Nicht relevant
8	Erklärte Leistung	

Wesentliche Merkmale	Eigenschaft	Leistung	Harmonisierte techn. Spezifikation
Wärmedurchlasswiderstand	Wärmedurchlasswiderstand und Wärmeleitfähigkeit	R_D s. Tabelle λ_D = 0,034 W/(mK)	EN 13163: 2012 +A1:2015
	Tabelle: Wärmedurchlasswiderstand in Abhängigkeit von der Dicke		
	Dicke d_N [mm]	R_D [m²K/W]	
	50	1,45	
	60	1,75	
	80	2,35	
	100	2,90	
	120	3,50	
	140	4,10	
	160	4,70	
	180	5,25	
	200	5,85	
	Für andere Dicken können die RD -Werte durch lineare Interpolation oder durch Berechnung nach RD = Dicke / ID ermittelt werden. Die Dicke ist in [mm] anzugeben, RD in der zweiten Nachkommastelle auf 0 oder 5 abzurunden.		
Dauerhaftigkeit des Wärmedurchlasswiderstands unter Einfluss von Wärme, Witterung, Alterung/Abbau	Die Wärmeleitfähigkeit von EPS-Produkten ändert sich nicht mit der Zeit.		
Brandverhalten	RtF - E		
Druckfestigkeit	Druckspannung bei 10% Stauchung	CS(10) 150; ≥ 150 kPa	
Dauerhaftigkeit der Druckfestigkeit unter Einfluss von Alterung/Abbau	Kriechverhalten bei Druckbeanspruchung	NPD	
	Widerstandsfähigkeit gegen Frost-Tau-Beanspruchung	NPD	
	Langzeit-Dickenverringerung	NPD	
Zug-/Biegefestigkeit	Biegefestigkeit	BS 200; ≥ 200 kPa	
	Zugfestigkeit senkrecht zur Plattenebene	NPD	
Wasserdurchlässigkeit	Wasseraufnahme bei kurzzeitigem teilweisen Eintauchen	NPD	
	Langzeitige Wasseraufnahme durch Diffusion	NPD	
Wasserdampfdurchlässigkeit	Wasserdampfdiffusion	NPD	
Trittschallübertragung (für Böden)	Dynamische Steifigkeit	NPD	
	Dicke	NPD	
	Zusammendrückbarkeit	NPD	
Glimmverhalten	Glimmverhalten	NPD	
Freisetzung gefährlicher Stoffe, Abgabe in das Gebäudeinnere	Freisetzung gefährlicher Stoffe	NPD	

NPD: Keine Leistung festgelegt (en: No performance determined)

9 Die Leistung des Produkts gemäß der Nummer 1 entspricht der erklärten Leistung nach Nummer 8. Verantwortlich für die Erstellung dieser Leistungserklärung ist allein der Hersteller gemäß Nummer 3. Unterzeichnet für den Hersteller und im Namen des Herstellers von:

Roland Mang (Geschäftsführer)

Ort und Datum der Ausstellung: Holzgünz 15.01.2017

Herstellerklärung zum Bauprodukt

Flachdachdämmplatte

EPS-Flachdach-Dämmplatte EPS 035 DAA dh

Informationen für Merkmale, die für die Verwendungen in Deutschland wesentlich sind			
Handelsname	***Produktname***		
Wesentliche Merkmale	**Eigenschaft**	**Information**	**geltende Norm, Grundlage**
Qualitätstyp		EPS 035 DAA dh	IVH-Qualitätsrichtlinie
Anwendungstyp	Flachdach - Dämmplatte	DAA dh	DIN 4108-10
Wärmeleitfähigkeit	Bemessungswert	λ; 0,035 W/(mK)	DIN 4108-4
Dimensionen	Länge, Grenzabmessung	L(3); ± 3 mm / m	EN 13163:2012 +A1:2015
	Breite, Grenzabmessung	W(3); ± 3 mm / m	
	Dicke, Grenzabmessung	T(2); ± 2 mm / m	
Rechtwinkligkeit in Längen- und Breitenrichtung	Grenzabmaß für die Rechtwinkligkeit	S(5); ± 5 mm / m	
Ebenheit	Grenzabmaß für die Ebenheit	P(10); ± 10 mm / m	
Dimensionsstabilität	Dimensionsstabilität im Normalklima	DS(N)5; ± 0,5 %	
	Dimensionsstabilität unter definierten Temperatur- und Feuchtebedingungen	NPD	
Verformung	Verformung bei definierter Druck- und Temperaturbelastung	DLT(1)5; ≤ 5 %	
Scherfestigkeit		NPD	
Schermodul		NPD	
Ausgangsstoff (Rohstoff)	Flammschutz	Polymer-FR (frei von HBCD)	IVH-Qualitätsrichtlinie
	Brandverhalten	B1 schwerentflammbar	DIN 4102-1:1998-05 DIN 4102-16:1998-05
	Kennzeichnung, BFA-Rohstoffnummer	2.1001.1	IVH-Qualitätsrichtlinie

INTELLO

Hydrosafe® Hochleistungs-Dampfbremse für faserförmige Matten- und Plattendämmstoffe

Technische Daten

	Stoff
Vlies	Polypropylen
Membran	Polyethylen-Copolymer

Eigenschaft	Regelwerk	Wert
Farbe		weiß-transparent
Flächengewicht	DIN EN 1849-2	85 g/m²
Dicke	DIN EN 1849-2	0,25 mm
Dampfdiffusionswiderstandszahl µ	DIN EN 1931	56.000
sd-Wert	EN 1931	14 m
sd-Wert feuchtevariabel	DIN EN ISO 12572	0,25 - >25 m
Hydrosafe-Wert	DIN 68800-2	2 m
Brandverhalten	EN 13501-1	E
Brandkennziffer (CH)	VKF	5.3
Luftdichtheit	DIN EN 12114	durchgeführt
Höchstzugkraft längs/quer	DIN EN 12311-2	110 N/5 cm / 80 N/5 cm
Dehnung längs/quer	DIN EN 12311-2	40 % / 35 %
Weiterreißwiderstand längs/quer	DIN EN 12310-1	60 N / 60 N
Dauerhaftigkeit nach künstl. Alterung	ETA-18/1146	bestanden
Temperaturbeständigkeit		dauerhaft -40 °C bis +80 °C
Wärmeleitzahl		2,3 W/(m·K)
Materialgarantie, hinterlegt	ZVDH	ja
CE-Kennzeichnung	ETA-18/1146	vorhanden

Anwendung

Einsatz in Dach, Wand, Decke und Boden in außen diffusionsoffenen sowie in diffusionsdichten Konstruktionen z. B. Flach-/Steildächern und Gründächern nach Bemessung.

Lieferformen

Art.-Nr.	GTIN	Länge	Breite	Gefaltet	Inhalt	Gewicht	VE	Gebinde
10077	4026639011985	50 m	3 m		150 m²	14 kg	1	20
10090	4026639011190	50 m	1,5 m		75 m²	7 kg	1	20
10091	4026639011176	20 m	1,5 m		30 m²	3 kg	1	42
12221	4026639122216	50 m	3 m	✓	150 m²	14 kg	1	20

Vorteile

- ✔ Bester Schutz vor Bauschäden und Schimmel, weil feuchtevariabel mit mehr als 100-facher Spreizung
- ✔ Dauerhaft sicher: Funktion amtlich geprüft und bestätigt (ETA-18/1146)
- ✔ Sichere Winterbaustellen durch Hydrosafe®-Funktion
- ✔ Mit allen faserförmigen Matten- und Plattendämmstoffen kombinierbar
- ✔ Einfach zu Verarbeiten: Dimensionsstabil, kein Spleißen oder Weiterreißen
- ✔ Beste Werte im Schadstofftest, Prüfung nach AgBB / ISO 16000 durchgeführt

Die dargestellten Sachverhalte beziehen sich auf den Stand der aktuellen Forschung und der praktischen Erfahrung. Wir behalten uns Änderungen der empfohlenen Konstruktionen und der Verarbeitung sowie die Weiterentwicklung und die damit verbundene Qualitätsänderung der einzelnen Produkte vor. Wir informieren Sie gern über den aktuellen technischen Kenntnisstand zum Zeitpunkt der Verlegung.

Weitere Informationen über die Verarbeitung und Konstruktionsdetails enthalten die pro clima Planungs- und Anwendungsempfehlungen. Bei Fragen erreichen Sie die technische Hotline von pro clima unter 0 62 02 - 27 82.45.

MOLL
baubiologische Produkte GmbH
Rheintalstraße 35 - 43
D-68723 Schwetzingen
Fon: +49 (0) 62 02 - 27 82.0
eMail: info@proclima.de

pro clima®

Version 174012 vom 08.11.2021 | Seite 1

Rahmenbedingungen

pro clima INTELLO soll mit der Folienseite (Beschriftung) zum Verarbeiter hin zeigend verlegt werden. Sie können straff und ohne Durchhang längs und quer zur Tragkonstruktion, z. B. den Sparren, verlegt werden. Bei horizontaler Verlegung (quer zur Tragkonstruktion) ist der Abstand der Tragkonstruktion auf maximal 100 cm begrenzt. Nach der Verlegung muss innenseitig eine quer laufende Lattung im Abstand von max. 50 cm das Gewicht des Dämmstoffs abtragen. Sind bei der Verwendung von matten- und plattenförmigen Dämmstoffen z. B. durch das Dämmstoffgewicht Zugbelastungen auf die Klebebandverbindungen zu erwarten, soll zusätzlich auf der Überlappungsverklebung eine Stützlatte angeordnet werden. Alternativ kann das Klebeband auf der Überlappung zusätzlich mit quer dazu laufenden Klebebandstreifen im Abstand von 30 cm gesichert werden.

Luftdichte Verklebungen können nur auf faltenfrei verlegten Dampfbremsen erreicht werden. Erhöhte Raumluftfeuchtigkeit (z. B. während der Bauphase) durch konsequentes und stetiges Lüften zügig abführen. Gelegentliches Stoßlüften ist nicht ausreichend, um große Mengen baubedingter Feuchtigkeit schnell aus dem Gebäude zu befördern, ggf. Bautrockner aufstellen.

Um Tauwasserbildung zu vermeiden, sollte die luftdichte Verklebung der INTELLO unmittelbar nach Einbau der Wärmedämmung erfolgen. Dies gilt besonders bei Arbeiten im Winter.

ETA
European Technical Approval
ETA – 18 / 1146

ZERTIFIZIERTE KOMPONENTE
Passivhaus Institut

Materialgarantie
hinterlegt beim ZVDH

Schadstoffgeprüft nach AgBB

100X
feuchtevariabel
humidity variable
hygrovariable
s_d 0,25 - >25 m
g-value 1.25 - >125 MN/g
Hydrosafe 2 m

Die dargestellten Sachverhalte beziehen sich auf den Stand der aktuellen Forschung und der praktischen Erfahrung. Wir behalten uns Änderungen der empfohlenen Konstruktionen und der Verarbeitung sowie die Weiterentwicklung und die damit verbundene Qualitätsänderung der einzelnen Produkte vor. Wir informieren Sie gern über den aktuellen technischen Kenntnisstand zum Zeitpunkt der Verlegung.

Weitere Informationen über die Verarbeitung und Konstruktionsdetails enthalten die pro clima Planungs- und Anwendungsempfehlungen. Bei Fragen erreichen Sie die technische Hotline von pro clima unter 0 62 02 - 27 82.45.

MOLL
baubiologische Produkte GmbH
Rheintalstraße 35 - 43
D-68723 Schwetzingen
Fon: +49 (0) 62 02 - 27 82.0
eMail: info@proclima.de

pro clima

Technische Daten

norament® 975 LL, Oberfläche: Hammerschlag

	Prüfnorm	Anforderungen	Gemittelte Prüfwerte der laufenden Produktion
CE-Konformität	**EN 14041**		**Hersteller: nora systems GmbH, D-69469 Weinheim**
DoP-Nr.	EN 14041		0024
Wärmeleitfähigkeit	EN 10456	λ = 0,17 W/(m·K)	Erfüllt
Gleitreibungskoeffizient	EN 13893	DS	Erfüllt
Brandklasse	EN 13501-1	Unverklebt	Bfl-s1

Eigenschaften nach EN 1817

Dicke	EN ISO 24346	Mittelwert ± 0,15 mm nach EN 1817	3,5 mm
Maßbeständigkeit	EN ISO 23999	± 0,4 %	± 0,1 %
Weiterreißwiderstand	ISO 34-1, Verfahren B, Arbeitsweise A	Mittelwert ≥ 20 kN/m	40 kN/m
Beständigkeit gegen Zigarettenglut	EN 1399	Verfahren A (ausgedrückt) ≥ Stufe 4 Verfahren B (brennend) ≥ Stufe 3	Erfüllt
Biegsamkeit	EN ISO 24344, Verfahren A	Domdurchmesser 20 mm, keine Rissbildung	Erfüllt
Härte	ISO 48-4	≥ 75 Shore A nach EN 1817	85 Shore A
Resteindruck	EN ISO 24343	Mittelwert ≤ 0,25 mm bei Dicke ≥ 3,0 mm	0,07 mm
Abriebfestigkeit bei 5 N Auflast	ISO 4649, Verfahren A	≤ 250 mm³	150 mm³
Farbbeständigkeit gegenüber künstlichem Licht	ISO 105-B02, Verfahren 3, Prüfbedingungen 6.1 a)	Mindestens Stufe 6 des Blaumaßstabs; ≥ Stufe 3 des Graumaßstabs	Graumaßstab ≥ Stufe 3 nach ISO 105-A02
Klassifizierung	EN ISO 10874	Gewerblich / Industriell	34 / 43

Zusätzliche technische Eigenschaften

Rutschhemmung	DIN 51130	Gemäß BGR 181	R 9
Trittschallverbesserungsmaß	ISO 10140-3		8 dB
Chemikalieneinwirkung	EN ISO 26987		Beständig in Abhängigkeit von Konzentration und Einwirkzeit*
Elektrische Isolierfähigkeit	EN 1081 R1		> 10^9 Ohm
Elektrostatisches Verhalten beim Begehen	EN 1815		Antistatisch, Aufladung bei Gummisohlen < 2 kV
Stuhlrollenversuch	EN 425		Geeignet bei Verwendung von Stuhlrollen, Typ W, nach EN 12529
Fußbodenheizung	EN 1264-2		Geeignet, max. 35 C°

* Bei verstärkter Einwirkung von Ölen, Fetten, Säuren, Laugen und anderer aggressiver Chemikalien ist Rücksprache erforderlich.

Produktionsbedingte Farbabweichungen sowie technische Veränderungen, die der Verbesserung der Produkte dienen, behalten wir uns vor.

EN 1817: Spezifikation für homogene und heterogene ebene Elastomer-Bodenbeläge

nora® by Interface®

01/2021

20.5 Cost Estimate and Financial Summery

20.5.1 Cost Estimate of the roof extension based on key values from "BKI Kostenplaner 2022" detailed in DIN 276 second cost group.

Comment: The following table was extracted from the submission created by Annika Elsner, Frederik Heck, Annika Kötzel and Judith Leppert.

AUFSTOCKUNG (Roof extension)

Preisbasis: BKI
Kostenplaner 2022
Datum: 30.01.2022

KGR	Gebäudeelement	Menge	Einheit	Einheitspreis [€]	Gesamtpreis [€]
100	**Grundstück**		m² GF		
110	Fläche	nicht relevant	m² GF	-	
200	**Herrichten und Erschließen**		m² GF		
210	Herrichten und Erschließen	nicht relevant	m² GF	-	
220	Öffentliche Erschließung	nicht relevant	m² GF	-	
300	**Bauwerk- Baukonstruktion**		m² BGF		**2.408.075 €**
310	Baugrube	nicht relevant	m³ BGI	-	
320	Gründung	1.342,00	m² GRF	420	563.640 €
330	Außenwände	1.261,00	m² AWF	484	610.324 €
340	Innenwände	792,00	m² IWF	378	299.376 €
350	Decken	695,00	m² DEF	451	313.445 €
360	Dächer	695,00	m² DAF	418	290.510 €
380	Baukonstruktive Einbauten	2.980,00	m² BGF	16	47.680 €
390	Sonstige Baukonst.	2.980,00	m² BGF	95	283.100 €
400	**Technik**		m² BGF		**905.920 €**
410	Abwasser, Wasser, Gas	2.980,00	m² BGF	79	235.420 €
420	Heizung	2.980,00	m² BGF	82	244.360 €
430	Lufttechnische Anlagen	2.980,00	m² BGF	10	29.800 €
440	Starkstromanlagen	2.980,00	m² BGF	79	235.420 €
450	Fernmeldeanlagen	2.980,00	m² BGF	26	77.480 €
460	Förderanlagen	2.980,00	m² BGF	28	83.440 €
470	Nutzungsspezifische Anlagen	2.980,00	m² BGF	23	68.540 €
480	Gebäudeautomation	2.980,00	m² BGF	25	74.500 €
490	Sonstige Technische Anlagen	2.980,00	m² BGF	2	5.960 €
SUMME KGR 300-400			m² BGF		**3.313.995 €**
500	**Außenanlagen**		m² AF		**0 €**
510	Grünfläche	nicht relevant	m² AF	-	
520	Befestigte Fläche	nicht relevant	m² AF	-	
SUMME KGR 300-500			m² BGF		**3.313.995 €**
SUMME KGR 200-700			m² BGF		**4.142.494 €**
600	**Ausstattung**				kein Ansatz
700	**Baunebenkosten** (% von KG 3 bis 5)		25%		**828.499 €**
	Unvorhergesehenes (% von KG 2 bis 7)		10%		**414.249 €**

SUMME KGR 200-700 Bau- und Planungskosten inkl. Unnvorherg.	m² BGF	**4.556.743 €**

* alle Preisangaben in brutto
Regionalfaktor von 13% für den Standort Stuttgart berücksichtigt.

20.5.2 Detailed estimation for the HDU's exterior walls / vertical constructions (KGR 330)

Comment: The following table was created on the basis of real costs wherever possible and include VAT. If cost where not available BKI estimates where used.

KGR		Einheit	Masse	EP	GP
330	**Außenwände/ Vertikale Baukonstruktion**				**150.971,36 €**
331	**Tragende Außenwände**				**- €**
					- €
332	**Nichttragende Außenwände**				
333	**Außenstützen**				**21.494,82 €**
	Holzstützen 16x16 cm inkl. Verbindungselemente (Grid)	Lfm.	275	78,16 €	21.494,82 €
	Holzstütze GL24h liefern	m3	7,04	1.634,90 €	11.509,68 €
	Abbund Konstruktionsholz, Decken	Lfm.	275	31,87 €	8.763,33 €
	Holzschutz	m2	176,3712	6,93 €	1.221,82 €
334	**Außenwandöffnungen**				**34.624,71 €**
	Öffnungen in Außenwänden: Außenwand Holzrahmen	m²	33,6	150,00 €	5.040,00 €
	Schwellenlose Balkontür + Fenster Kombination bxh 1,75*2,4	Stk.	8	3.463,77 €	27.710,12 €
	Absturzsicherung	Stk.	3	624,86 €	1.874,59 €
335	**Außenwandbekleidung außen**	**m2**	**207,5**	**31,00 €**	**6.432,50 €**
	Tägerlattung	m²	207,5	8,00 €	1.660,00 €
	Konterlattung	m²	207,5	8,00 €	1.660,00 €
	vorgehängte Fassadenbekleidung aus Recyclingholz	m²	207,5		3.112,50 €
	Material	m²	207,5	- €	- €
	Arbeitszeit Studenenten	h	800	15,68 €	
	Montage sichtbar	m²	207,5	15,00 €	3.112,50 €
336	**Außenwandbekleidung innen**				**5.187,50 €**
	ESB-Platte 12mm einschichtig	m2	207,5	25,00 €	5.187,50 €
337	**Elementierte Außenwandkonstruktionen**				**40.088,53 €**
	Außenwand Holzrahmenbau Elemente (Baufritz)	m²	207,5	193,20 €	40.088,53 €
338	**Lichtschutz**				**2.715,59 €**
	Innenliegende textil Jalousien	Stk.	8	339,45 €	2.715,59 €
339	**Außenwände, sonstiges**				**48.330,80 €**
	Metallrahmenkonstruktion inkl. Dach	m²	288	58,51 €	16.850,00 €
	Seilnetz inkl. Dach	m²	288	78,82 €	22.700,00 €
	Arbeitszeit Studenten	h	560	15,68 €	8.780,80 €

20.5.3 Detailed estimation for the HDU's high current systems (KGR 440)

Comment: The following table was created on the basis of real cost wherever possible and include VAT. If cost where not available BKI estimates where used.

KGR		Einheit	Masse	EP	GP
440	**Starkstromanlagen**				**65.458,00 €**
441	**Hoch- und Mittelspannungsanlagen**				**0,00 €**
	Kennwert BKI 2019 für Wohnheime indexiert auf Q3 2021	m²BGF	175	0,00 €	0,00 €
442	**Eigenstromversorgungsanlagen**				**46.700,00 €**
	OPV Module (Eigenkostenanteil)	m2	288	150,00 €	43.200,00 €
	Wechselrichter	Stk.	1	3.500,00 €	3.500,00 €
443	**Niederspannungsschaltanlagen**				**0,00 €**
	Kennwert BKI 2019 für Wohnheime indexiert auf Q3 2021	m²BGF	175	0,00 €	0,00 €
444	**Niederspannungsinstallationsanlagen**				**12.656,00 €**
	Kennwert BKI 2019 für Wohnheime indexiert auf Q3 2021	m²BGF	175	72,32 €	12.656,00 €
445	**Beleuchtungsanalgen**				**5.424,00 €**
	Kennwert BKI 2019 für Wohnheime indexiert auf Q3 2021	m²BGF	175	30,99 €	5.424,00 €
446	**Blitzschutz und Erdungsanlagen**				**678,00 €**
	Kennwert BKI 2019 für Wohnheime indexiert auf Q3 2021	m²BGF	175	3,87 €	678,00 €
447	**Fahrleitungssysteme**				**0,00 €**
449	**Starkstromanlagen, sonstiges**				**0,00 €**

20.6 Health and Safety

Appendix A - Technical Specification of the Safety Equipment List

PPE	Item description	Detailed description of the company engelbert-strauss	Image
Safety Ear Protection	3M Peltor hearing protectors for helmet mounting Optimel	Nach DIN EN 352-3:2002. Hearing protectors for light noise exposure, such as in workshops, plumbers or printers. Very comfortable due to the soft padding, even for continuous use. SNR: 26 dB (H: 32 dB / M: 23 dB / L: 15 dB) Helmet adapter for 30 mm intake	
Safety hard hat	Baumeister, 6-point, twist-lock fastener yellow + green (1x)	according to DIN EN 397:2012 Large protective surface due to helmet shape with pulled-down neck section Interior with comfortable webbing good impact absorption due to HDPE technology with leather sweatband adjustable side ventilation rain gutter and chin strap holder adjustable head width from 53 to 61 cm 2x 16 mm ear protectors 6-point interior One-hand twist closure for individual head width adjustment Straps suitable for "Safety helmet, 6-point" and "KWF forestry safety helmet combination professional". for a secure fit of the helmet	
Safety gloggles	e.s. Hill	according to DIN EN 166:2001 / DIN EN 170:2002 anti-fog scratch-resistant coating large field of vision due to completely transparent design 99,9 % UV protection Weight: 25 g	
Safety gloves	Pair of latex knitted gloves Super Grip	EN 388:2016, Mechanical risks, 2242X breathable cotton-polyester coarse knit material non-slip, shrink-roughened and thick latex coating for a secure grip even in wet conditions Fields of application: ideal e.g. for gardening, carpenters, roofers, in metal	

		processing or in the building trade Length: approx. 24 cm	
	+ pair of Split Leather Gloves Cooper	EN 388:2016, Mechanical risks, 3143X High quality materials only selected, high quality materials are used for the production of the gloves first class workmanship due to the high quality material mix and workmanship these gloves are particularly robust and durable best possible protection reinforcement of the fingertips and the index finger provide additional protection at work highest comfort due to the excellent fit the glove fits perfectly to the hand and offers highest wearing comfort made of ox split leather of the highest quality hard-wearing and supple excellent fit reinforced fingertips, index finger and seams palm lined with cotton back of hand in grey cotton canvas Cuffs with reflectors Applications: for heavy, long activities in the construction industry Length: approx. 27 cm	
Safety Shoes	STONEKIT S3 safety high boots Bob	EN ISO 20345:2011 S3 with steel toe cap and steel sole Upper made of water-repellent, full-grain smooth leather, extremely easy to clean breathable inner lining Perforated, removable insole with antibacterial textile surface anti-slip and abrasion-resistant PUR sole according to SRC, antistatic, fuel-resistant and heat-resistant up to approx. 120 °C extremely soft padded tongue Shaft edge padding	
Safety Vest	STONEKIT high-visibility waistcoat Basic	according to DIN EN ISO 20471:2013 class 2 Practical pull-on high-visibility waistcoats with Velcro fastener universal size	

Safety cloths	Waistband trousers e.s.concrete light + e.s. Longsleeve cotton	Long sleeve made from combed, high-quality cotton double seams at collar, shoulders and armholes long-lasting colour brilliance Only 170 g/m² fabric weight - but full twill power! Pleasantly light, robust and flexible thanks to a particularly hard-wearing twill composition with stretch content, straight cut Flexbelt® waistband stretchable at the sides 2 slash pockets 2 back pockets with Velcro fastening, one with flap right leg: functional multi-piece ruler pocket with multipurpose loops left leg: multi-compartment cargo pocket, divided into a large main compartment with Velcro® closure, a spacious smartphone compartment and a zipped security pocket innovative slide system on the left and right side of the trousers especially for attaching the e.s.concrete tool bags (not included) reinforced knee section made of 100 % polyamide knee pad pockets with insertion at the top and Velcro fastener	

Appendix B - Time and construction schedule of work units

Work Unit 1 – Building Site Equipment and Preparation

	Work shift 1: 7-12:30 & 13:00- 15:00			**Anfahrt aus Erkheim - Alpenstraße**		
	Work shift 2: 15 -18 & 19- 23 Uhr					
Aktiv	**Name**	**Comments**	**Work Unit**	**Machinery**	**approximate start**	**approximate end**
1	Construction Demonstration Unit				20.05.2022 00:00:07	04.06.2022 14:00:00
1	**Earthworks**	Working time	Work Unit 3 Task 1: Ground		20.05.2022 07:00:00	20.05.2022 15:00:00
0	Measuring the terrain	Surveyor, stake out high poi	Work Unit 3 Task 1: Ground	Levelling device, surveyor, cords, iron needle	20.05.2022 07:00:00	20.5.2022 09:00:00
1	Removal of terrain		Work Unit 3 Task 1: Ground	Excavator, wheelbarrow, shovels, trough	20.05.2022 09:00:00	20.05.2022 12:00:00
0	*Levelling & compacting the site	Apply circuit, Which fill, Mate	Work Unit 3 Task 1: Ground	Tamper	20.05.2022 12:00:00	20.05.2022 15:00:00
	Site set-up	Working time			20.5.2022 14:00:00	20.05.2022 17:00:00
1	Crane erection	Foundations for crane?		Experts	20.5.2022 14:00:00	20.05.2022 15:00:00
	Truck Container	Container, magazine	Work Unit 1, Task 1		20.5.2022 15:30:00	20.5.2022 16:30:00
1	01_Container	**Siri** Organise container, c	Work Unit 1, Task 3	Crane, ropes for orientation	20.05.2022 15:30:00	20.05.2022 16:00:00
1	*01_Magazine	**Siri ** Organise magazine,	Work Unit 1, Task 3	Crane, ropes for orientation	20.05.2022 16:00:00	20.5.2022 16:30:00
	Truck Container	Waste, WC	Work Unit 1, Task 1		20.5.2022 16:30:00	20.5.2022 17:30:00
1	01_Container rubbish	**Siri ** Organise magazine,	Work Unit 1, Task 3	Crane, ropes for orientation	20.5.2022 16:30:00	20.5.2022 17:00:00
1	01_WC (2 pieces)	???	Work Unit 1, Task 3	Crane, ropes for orientation	20.5.2022 17:00:00	20.5.2022 17:30:00
1	01_Connection building current	What do you need for this?	Work Unit 1, Task 3	Electrician (Jonas)	20.05.2022 15:00:00	20.05.2022 17:00:00
1	04_Insertion of underground pipe/construction w	Lines,	Work Unit 1, Task 3	HLS (Jonas)	20.05.2022 15:00:00	20.05.2022 17:00:00
0	* 05_Levelling	Final	Work Unit 3 Task 1: Ground	Laser, waterways etc	21.5.2022 07:00:00	21.5.2022 10:00:00

Work Unit 2 - Scaffolding

	Scaffolding	Working time			21.05.2022 10:00:00	21.5.2022 15:00:00
	Truck scaffolding - transport	From where is the delivery	Work Unit 2, Task 1	Truck scaffolding	??	21.5.2022 09:00:00
	Truck scaffolding - unloading	Coordinate scaffold erector	Work Unit 2, Task 2		21.5.2022 09:00:00	21.5.2022 10:00:00
1	06_Establishment scaffold part1		Work Unit 2, Task 3	Scaffolder	21.05.2022 10:00:00	21.5.2022 11:00:00
1	06_Scaffold erection part2		Work Unit 2, Task 3	Scaffolder	21.5.2022 11:00:00	21.5.2022 12:00:00
1	06_Scaffold erection part3		Work Unit 2, Task 3	Scaffolder	21.5.2022 12:00:00	21.05.2022 13:00:00
1	06_Scaffold erection part4		Work Unit 2, Task 3	Scaffolding erectors	21.05.2022 13:00:00	21.5.2022 14:00:00
	*06_Acceptance scaffold		Work Unit 2, Task 4	Scaffolding erectors	21.5.2022 14:00:00	21.5.2022 15:00:00

Work Unit 3 – Timber construction

	Foundations	Working time			22.5.2022 11:00:00	22.5.2022 17:00:00
	Truck foundations - transport	Sprinter -> Pallet	Work Unit 3, Task 1		??	22.05.2022 10:00:00
	Truck foundations - unloading		Work Unit 3, Task 1	Forklift	22.05.2022 10:00:00	22.5.2022 10:30:00
	07_ Pre-assembling & measuring foundations	Align	Work Unit 3, Task 1	Cordless screwdriver, hammer, spirit level, screws	22.5.2022 11:00:00	22.5.2022 17:00:00
	Ground floor - carcass	Working time			23.05.2022 08:00:00	23.5.2022 21:30:00
	Truck_1 Ground floor (Bopla & walls) - transport	Floor slab & wall 1-3	Work Unit 3, Task 2,5		???	23.05.2022 07:00:00
	LKW_1 EG - (Bopla & walls) unloading	Floor slab & wall 1-3	Work Unit 3, Task 3,6	Unloading crane	23.05.2022 07:00:00	23.05.2022 08:00:00
1	07_Floor slab EG	?? Is this still current - i.e. 2	Work Unit 3, Task 4	Crane, tool Baufritz, sledge hammer	23.05.2022 08:00:00	23.05.2022 09:00:00
1	08_Wall_1_EG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledge Hammer	23.05.2022 09:00:00	23.05.2022 10:00:00
1	09_Wall_2_Stair_EG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledge Hammer	23.05.2022 10:00:00	23.05.2022 11:00:00
1	10_Wall_3_EG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledge hammer	23.05.2022 11:00:00	23.05.2022 12:00:00
	LKW_2 EG (walls)- delivery	Wall 4-6	Work Unit 3, Task 5		???	23.5.2022 13:00:00
	LKW_2 EG - (walls) unloading	Wall 4-6	Work Unit 3, Task 6	Unloading crane	23.5.2022 13:00:00	23.05.2022 14:00:00
1	13_Wall_4_EG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledgehammer	23.5.2022 14:00:00	23.5.2022 15:00:00
1	14_Wall_5_EG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledgehammer	23.5.2022 15:00:00	23.5.2022 16:00:00
1	15_Wand_6_inkl_Brüstung_EG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledgehammer	23.5.2022 16:00:00	23.5.2022 17:00:00
	HGV_3 Ground floor - modules & ceiling - delive	Modules & Ceiling	Work Unit 3, Task 8; Work		???	23.5.2022 17:00:00
	LKW_3 EG - Modules & Ceiling - Unloading	Modules & ceiling	Work Unit 3, Task 9; Work	Unload all - Crane	23.5.2022 17:00:00	23.5.2022 18:00:00
	Break Shift 2		———	---	23.5.2022 18:00:00	23.5.2022 19:00:00
1	18_Lifting in: Kitchen module		Work Unit 5, Task 3	Crane, ropes, crowbar large	23.5.2022 19:00:00	23.5.2022 19:30:00
0	*18_Lifting in: Bathroom module		Work Unit 5, Task 3	Crane, ropes, crowbar large	23.5.2022 19:30:00	23.5.2022 20:00:00
Nach	*18_Lift in: Bed module		Work Unit 5, Task 3	Crane, ropes, crowbar large	23.5.2022 20:00:00	23.5.2022 20:30:00
1	19_Ceiling slab_1_EG		Work Unit 3, Task 10	Crane, ropes, assembly cordless screwdriver, etc.	23.5.2022 20:30:00	23.5.2022 21:30:00

	OG - carcass				24.05.2022 07:00:00	24.5.2022 22:00:00
	truck_4 OG - walls - delivery	Wall 7-11	Work Unit 3, Task 5		??	24.05.2022 07:00:00
	truck_4 OG - walls - unloading		Work Unit 3, Task 6	Unload everything - loading area	24.05.2022 07:00:00	24.05.2022 08:00:00
1	20_Wall_7OG		Work Unit 3, Task 7	Crane, tool Baufritz, sledge hammer	24.05.2022 08:00:00	24.05.2022 09:00:00
1	21_Wall_8_OG		Work Unit 3, Task 7	Crane, tool Baufritz, sledge hammer	24.05.2022 09:00:00	24.05.2022 10:00:00
1	22_Wall_9_OG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledgehammer	24.05.2022 10:00:00	24.5.2022 11:00:00
1	24_Wall_10_OG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledgehammer	24.5.2022 11:00:00	24.05.2022 12:00:00
1	25_Wall_11_OG		Work Unit 3, Task 7	Crane, Tools Baufritz, Sledgehammer	24.05.2022 12:00:00	24.5.2022 13:00:00
	LKW_5 OG - Module & Ceiling - Delivery	Bed, Ceiling	Work Unit 5, Task 1; Work Unit 3, Task 2		??	24.05.2022 13:00:00
	Truck_5 OG - Module & Ceiling - Unloading		Work Unit 5, Task 2; Work	Crane	24.05.2022 13:00:00	24.5.2022 14:00:00
1	27_Interior_construction_OG_Bed		Work Unit 5, Task 3	Direct lift, crowbar	24.5.2022 14:00:00	24.5.2022 14:30:00
1	28_ceiling_panel_OG		Work Unit 3, Task 4	Crane, Tools Baufritz, Sledge Hammer	24.5.2022 14:30:00	24.05.2022 15:30:00
1	29_Roof covering	What kind of roofing	Work Unit 3, Task 4	Crane, Tool Baufritz, Sledge Hammer	24.05.2022 15:30:00	24.5.2022 16:30:00
	29_Roof covering greening		Work Unit 3, Task 4	*With Seb. To be clarified, crane, tool Baufritz	24.5.2022 16:30:00	24.5.2022 18:00:00
	Break Send 2		——-	---	24.5.2022 18:00:00	24.5.2022 19:00:00
	30_ Part_2_ Move scaffold		Work Unit 2, Task 3	Scaffolder	24.5.2022 19:00:00	24.5.2022 20:00:00
	*Foundation column feet & location	Sprinter - steel plates	Work Unit 3, Task 13	Material	24.5.2022 20:00:00	24.5.2022 22:00:00
	Grid				25.5.2022 08:00:00	25.5.2022 23:00:00
	LKW_6 Grid - unloading & wall cladding for interior work		Work Unit 3, Task 11		??	25.5.2022 07:00:00
	LKW_6 Grid - Unloading & wall cladding for interior work		Work Unit 3, Task 12	Loading area	25.5.2022 07:00:00	25.5.2022 08:00:00
1	32_Grid_support_feet	To be screwed in - thread **	Work Unit 3, Task 13	Spirit level, hammer, levelling tool, cordless screwdriver	25.5.2022 08:00:00	25.5.2022 10:00:00
	*32_Sorting Grid	On lateral bearing surface	Work Unit 3, Task 12	Screws, cordless screwdriver	25.5.2022 10:00:00	25.5.2022 11:00:00
1	32_Grid_EG_Base_1	Laying & screwing	Work Unit 3, Task 13	Crane, ropes, screws, cordless screwdriver	25.05.2022 11:00:00	25.05.2022 12:00:00
1	32_Grid_EG_Base_1_Deckung	Laying & screwing	Work Unit 3, Task 13	Screws, cordless screwdriver	25.05.2022 12:00:00	25.5.2022 13:00:00
1	33_Grid_EG_Colum_2	Position & screw	Work Unit 3, Task 13	Screws, cordless screwdriver	25.5.2022 13:00:00	25.5.2022 14:00:00
1	34.5_Lifting in external stairs	Base EG/OG before or after? How is it fastened? Base		Crane, Ropes, Cordless screwdriver	25.5.2022 14:00:00	25.5.2022 16:00:00
1	34_Grid_OG_Base_3	Position & screw together	Work Unit 3, Task 13	*Crane, Screws, Cordless screwdriver	25.5.2022 16:00:00	25.5.2022 17:00:00
	34_Grid_OG_Base_Deckung_3	Position & screw together	Work Unit 3, Task 13	Screws, Cordless screwdriver	25.5.2022 17:00:00	25.5.2022 18:00:00
1	Break layer 2		——	---	25.5.2022 18:00:00	25.5.2022 19:00:00
	35_Grid_OG_Colum_4	Position & screw together	Work Unit 3, Task 13	Crane, Ropes, Screws, Cordless screwdriver	25.5.2022 19:00:00	25.5.2022 20:00:00
1	36_Grid_Roof_Base_5	Position & screw	Work Unit 3, Task 13	Crane, Ropes, Screws, Cordless screwdriver	25.5.2022 20:00:00	25.5.2022 21:00:00
0	*36_Exterior_lighting			Electrician	25.5.2022 21:00:00	25.5.2022 23:00:00

Work Unit 4 – Facade (attention: overlapping work units)

	Facade	Work steps per façade element: Attach angle, lift in, screw tight			26.5.2022 07:00:00	26.05.2022 23:00:00
	Truck_7_Facade elements- Delivery		Work Unit 4, Task 1		??	26.5.2022 07:00:00
	Truck_7_Facade_elements- Unloading	When unloading, the sequer	Work Unit 4, Task 2	Crane, Ropes, Cordless screwdriver	26.5.2022 07:00:00	26.5.2022 09:00:00
1	37_Facade_element_Page1_Part1	Start on the left side	Work Unit 4, Task 3	Crane, Ropes, Cordless screwdriver, Laser, Waterways	26.05.2022 09:00:00	26.5.2022 09:30:00
1	37_Facade_element_Side1_Part2		Work Unit 4, Task 3	Crane, Ropes, Cordless screwdriver, Laser, Waterways	26.5.2022 09:30:00	26.05.2022 10:00:00
	37_Facade_element_Side1_Part3		Work Unit 4, Task 3	Crane, Ropes, Cordless screwdriver, Laser, Waterways	26.05.2022 10:00:00	26.05.2022 10:30:00
	37_Facade_element_Side1_Part4		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 10:30:00	26.5.2022 11:00:00
	37_Facade_element_Side1_Cabling	Who does it, What do you need for it		Electrician	26.5.2022 11:00:00	26.5.2022 13:00:00
1	37_Facade_element_Side2_Part1		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.5.2022 11:00:00	26.05.2022 11:30:00
1	37_Facade_element_Side2_Part2		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 11:30:00	26.05.2022 12:00:00
	37_Facade_element_Side2_Part3		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 12:00:00	26.5.2022 12:30:00
	37_Facade_element_Side2_Part4	*1 Send by 13:00!!! (excepti	Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.5.2022 12:30:00	26.5.2022 13:00:00
	37_Facade_element_Page2_Cabling	Who does it, What do you need for it		Electrician	26.5.2022 13:00:00	26.5.2022 20:00:00
	37_Facade_element_Side3_Part1	*2 Start shift	Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.5.2022 13:00:00	26.5.2022 13:30:00
	37_Facade_element_Side3_Part2		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.5.2022 13:30:00	26.5.2022 14:00:00
1	37_Facade_element_Side3_Part3		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.5.2022 14:00:00	26.05.2022 14:30:00
1	37_Facade_element_Side3_Part4	*Side facade parts are ready	Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 14:30:00	26.05.2022 15:00:00
	37_Facade_element_Page3_Cabling	Who does it, What do you need for it		Electrician	26.05.2022 15:00:00	26.5.2022 20:00:00
	38_Facade_element_roof_part1		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 15:00:00	26.05.2022 15:30:00
	38_Facade_element_roof_part2		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 15:30:00	26.05.2022 16:00:00
1	38_Facade_element_roof_part3		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 16:00:00	26.05.2022 16:30:00
	38_Facade_element_roof_part4		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 16:30:00	26.05.2022 17:00:00
	38_Facade_element_roof_part5		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 17:00:00	26.05.2022 17:30:00
	38_Facade_element_roof_part6		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 17:30:00	26.05.2022 18:00:00
	Break layer 2		_____	----	26.05.2022 18:00:00	26.05.2022 19:00:00
	38_Facade_element_roof_part7		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.05.2022 19:00:00	26.5.2022 19:30:00
	38_Facade_element_roof_part8		Work Unit 4, Task 3	Crane, ropes, cordless screwdriver, laser, waterways	26.5.2022 19:30:00	26.5.2022 20:00:00
	37_Facade_element_roof_wiring	Who does it, What do you need for it		Electrician	26.5.2022 20:00:00	26.05.2022 23:00:00
	Outdoor facilities				27.05.2022 07:00	27.5.2022 20:00:00
1	46_Dismantling of scaffolding	*Time? -> Start at scaffoldin	??	Scaffolder - safety belts	27.05.2022 07:00	27.5.2022 12:00:00
0	42_Connection of hot water tank	*Time?	??	Clamps, spanners, sealing	27.05.2022 07:00	27.5.2022 12:00:00
	Truck_8_Ramp construction - delivery		??		??	27.5.2022 12:00:00
	Truck_8_Ramp construction unloading		??		27.5.2022 12:00:00	27.5.2022 13:00:00
	Truck_8_loading scaffolding		??		27.5.2022 13:00:00	27.5.2022 13:30:00
1	Ramp construction	* Start at the place where the	??	Cordless screwdriver, pliers, etc	27.5.2022 13:00:00	27.5.2022 23:00:00
1	47_Assembly_Outdoor	Same with ramp construction	??	*Scaffolder	27.5.2022 13:00:00	27.5.2022 23:00:00
1	52_Building plant troughs	*Time?	??	Saw, hammer, cordless screwdriver,	27.5.2022 13:00:00	27.5.2022 17:00:00
	52_Plant troughs in place		??	(crane, ropes) or forklift/ wheel loader	27.5.2022 17:00:00	27.5.2022 20:00:00
	Delivery_Facade greening	Sprinter	Work Unit 4, Task 4	--		
	Unloading façade greening	Sprinter, delivery on pallet?	Work Unit 4, Task 5	Forklift/ wheel loader		
0	*52_Facade greening	*Time??	Work Unit 4, Task 6		30.05.2022 08:00:00	30.5.2022 17:00:00

Work Unit 5 – Interior construction

	Interior construction	*Material comes with grid			25.5.2022 08:00:00	27.5.2022 12:00:00
	Truck_9 Rotators, wall & floor elements /material- delivery		Work Unit 5, Task 4 &		??	25.5.2022 08:00:00
	Truck_9 Rotators, wall & floor elements /material. - Unloading		Work Unit 5, Task 5 &	Loading area	25.5.2022 08:00:00	25.5.2022 09:00:00
0	*A1_Construction ground floor interior wall & ceil	*Would renting a stand saw l	Work Unit 5, Task 6	Cordless screwdriver, spirit level, laser. Possibly: hand-held circular saw & table	25.5.2022 09:00:00	25.5.2022 23:00:00
0	*A2_Construction upper floor interior walls & ceil	Runs parallel to A3	Work Unit 5, Task 6	Cordless screwdriver, spirit level, laser. Possibly: hand-held circular saw & table	26.5.2022 08:00:00	26.5.2022 23:00:00
0	*A3_EG_Floor element	Runs parallel to A2	Work Unit 5, Task 6	Cordless screwdriver, spirit level, laser. Possibly: hand-held circular saw & table	26.5.2022 08:00:00	26.5.2022 23:00:00
0	*A4_OG_Floor element	To upper floor walls	Work Unit 5, Task 6	Scissor lift, cordless screwdriver, spirit level, laser. Possibly: hand-held circular s	27.05.2022 08:00:00	27.5.2022 23:00:00
0	*A5_EG_Installation rotating element	To ground floor	Work Unit 5, Task 8	Cordless screwdriver, spirit level, laser. Possibly: hand-held circular saw & table	27.5.2022 08:00:00	27.5.2022 23:00:00
	*A5_EG_"Installation" bed module -> move	To ground floor (module is a	Work Unit 5, Task 10	--	27.5.2022 08:00:00	27.5.2022 12:00:00

Unit 6 – Technical installation

	Sprinter_2_Technique_Delivery		Work Unit 6, Task 4		??	28.05.2022 07:00:00
	Sprinter_2_Technique_Installation		Work Unit 6, Task 5		28.05.2022 07:00:00	28.05.2022 08:00:00
0	*A6_EG_Installation_Technical room	To ground floor	Work Unit 6, Task 6		28.5.2022 08:00:00	28.5.2022 23:00:00
0	*A7_Assembly_Exhibition_Facility		Work Unit 5, Task 10	Cordless screwdriver, spirit level, laser. Possibly: saw, drill,	29.5.2022 08:00:00	30.5.2022 23:00:00
0	*T1_assembly_stair_cladding		??	Cordless screwdriver, spirit level, laser. Possibly: saw, drill,	31.5.2022 08:00:00	31.5.2022 12:00:00
0	*T2_Assembly_stair_list (Liftteck)		??	*Specialist company	31.5.2022 12:00:00	31.5.2022 18:00:00
0	*Connection_1 Kitchen model_		Work Unit 6, Task 8	*Water and electrician	27.05.2022 12:00:00	27.05.2022 14:00:00
	Connection_1 Bathroom		Work Unit 6, Task 8			
0	*Connection_2 HLS Technology WhyWaterStorage		Work Unit 6, Task 8	*Water and electrician	26.05.2022 10:00:00	27.05.2022 12:00:00
0	*Connection_3_Equipment - installation and connection		Work Unit 6, Task 8		30.5.2022 10:00:00	31.05.2022 15:00:00
0	Monitoring				30.05.2022 08:00:00	02.06.2022 15:00:00
0	58_Remaining work				01.06.2022 08:00:00	02.06.2022 17:00:00
0	58_Building cleaning				02.06.2022 08:00:00	02.06.2022 17:00:00
0	59_Final inspection				03.06.2022 08:00:00	04.06.2022 14:00:00
	Handheld devices					

Appendix C - Operating instructions

The following colour scheme is being be observed: Operation of machines or for work procedures = blue; Hazardous substances = orange; Use of personal protective equipment = green

The operating instructions, together with the risk assessment, form an important basis for the occupational Health & Safety training of Team members. When preparing operating instructions, the following points in particular are being taken into account:

1. Scope of application;

2. Hazards to man and the environment;

3. Protective measures and rules of conduct;

4. Behaviour in case of malfunctions;

5. Behaviour in case of accidents, first aid;

6. Maintenance;

7. Consequences of non-observance.

For hazardous substances the following structure is mandatory:

1. Work areas, workplace, activity;

2. Hazardous substance (designation);

3. Hazards for humans and environment;

4. Protective measures, rules of conduct;

5. Behaviour in case of danger;6. First aid;

7. Proper disposal.

Firma: HFT Stuttgart

Arbeitsbereich: Außer und innerhalb der HDU

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: HFT Lot 4

Tätigkeit: Assembly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Arbeitsmittel | Arbeiten mit Laserstrahlung

Gefährdungen für Mensch und Umwelt

- Bei Lasern der Klassen 1M und 2M in Verbindung mit optischen Instrumenten sind Schäden des Auges möglich!
- Laser der Klassen 3R, 3B und 4 sind sehr gefährlich für Augen und Haut!
- Durch das Einwirken des Strahls auf gewisse Materialien können gesundheitsschädliche
- Stoffe freigesetzt werden, Explosionen ausgelöst und Brände entfacht werden!

Schutzmaßnahmen und Verhaltensregeln

- Das Bedienpersonal muss im Umgang mit dem Laser unterwiesen sein!
- Wenn die Strahlung nicht benötigt wird, Laser in "Standby"-Modus bringen oder ausschalten!
- Nur mit eingeschalteter interner Absaugung arbeiten.
- Die Abschirmungen der Eingriffsöffnungen nicht verändern.
- Hände nicht unmittelbar in den Laserstrahl halten.
- Wer nicht direkt mit dem Laser arbeitet, hält Abstand zur Laserschweißanlage!
- Reflexionen vermeiden, Hilfsmittel und Instrumente mit mattierter Oberfläche verwenden oder diese mit schwarzer Folie bekleben!
- Filter sind gemäß den Wartungsintervallen vom Hersteller zu wechseln!
- Regelmäßige Elektrische Prüfung durch eine Elektrofachkraft durchführen lassen.
- Auf den festen Sitz der Befestigung der Gasflasche zur Inertisierung achten.
- Schutzbrille tragen.

Verhalten bei Betriebsstörungen

Bei Störungen sofort den Laser abschalten.
- Der Laserschutzbeauftragte ist umgehend zu informieren.
- Arbeiten an der Laserschweißanlage oder Teilen dürfen nur durch Fachpersonal durchgeführt werden!

Brandfall: Ruhe bewahren! Feuerwehr über 112 rufen!
- Mitarbeiter warnen! Vorgesetzten informieren, ggf. Feueralarm auslösen.
- Brand mit CO2- oder Schaumlöscher bekämpfen! Auf Selbstschutz achten!

Verhalten bei Unfällen – Erste Hilfe

- Maschine abschalten
- Verletzten bergen
- Unfall melden, ggf. Arzt oder Sanitäter anfordern, Unfallstelle absichern
- Ersthelfer hinzuholen – Erste Hilfe leisten (Blutung stillen, Schockbekämpfung)
- Eintrag in Verbandbuch und HS Reporting

Notruf: 112 Ersthelfer: ____

Instandhaltung/Prüfung

A

- Wartungsarbeiten dürfen nur von befähigten Personen durchgeführt werden!
- Die Wartungsunterlagen des Herstellers sind zu beachten!

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: Außer und innerhalb der HDU

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: HFT Lot 4

Tätigkeit: Assembly & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Gabelstaplerbetrieb

Gefährdungen für Mensch und Umwelt

- Anfahren von Personen
- Herabfallen der Last
- Überladen des Gabelstaplers
- Fahren mit ausgefahrenem Hubgerät, Umstürzen des Gabelstaplers.

Schutzmaßnahmen und Verhaltensregeln

- Gabelstapler dürfen nur von schriftlich beauftragten Mitarbeitern benutzt werden.
- Die Gabelstapler sind dafür vorgesehen, Flachpaletten und Gitterboxen in den
  Betriebsbereichen _____
  auf den als Fahrweg und Stapelfläche gekennzeichneten Flächen oder Regalen
  zu bewegen und einzulagern.
  Für andere Einsätze ist im Einzelfall ein zusätzlicher Auftrag erforderlich.
- Die Betriebsanleitung des Herstellers unbedingt beachten.
- Die Mitnahme von Personen auf dem Gabelstapler ist verboten.
- Das Fahrzeug vor Arbeitsbeginn auf betriebssicheren Zustand prüfen.
- Fahrerrückhalteeinrichtungen immer benutzen (d.h. Gurt anlegen bzw. Rückhaltebügel/ Kabinentür schließen, Kabinentür nicht aushängen).
- Unnötiges Laufenlassen des Motors vermeiden.
- Vor Verlassen des Fahrzeugs Feststellbremse anziehen, die Gabeln in die tiefste Stellung absenken und den Schlüssel abziehen.

Verhalten bei Betriebsstörungen

- Bei Störungen oder Beschädigungen, die die Arbeitssicherheit beeinträchtigen, den Stapler sofort stillsetzen und den Aufsichtsführenden verständigen.

Verhalten bei Unfällen – Erste Hilfe

- Stapler stillsetzen.
- Verletzte bergen.
- Erste Hilfe leisten.
- Rettung einleiten.

- **Notruf:** 112 Ersthelfer: _____

Instandhaltung/Prüfung

- Reinigen, Schmieren, Inspektion und Instandsetzung erfolgen ausschließlich durch das Instandhaltungspersonal.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: Außer und innerhalb der HDU

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: HFT Lot 4

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Arbeiten mit manueller Lastenhandhabung (Heben und Tragen)

Gefährdungen für Mensch und Umwelt

- Verletzung bzw. Erkrankung am Muskel-Skelett-System
- Stolper-, Rutsch-, Sturz- und Anstoß- bzw. Quetschgefahr
- Schnittverletzungen aufgrund scharfer Kanten oder Graten an der Last
- Herabfallen und Kippen von Gegenständen

Schutzmaßnahmen und Verhaltensregeln

- Grundsätzlich, wenn möglich: Hebe-, Trage- oder Transporthilfen benutzen
- Schwere und sperrige Lasten immer mit mehreren Personen heben und tragen
- Persönliche Schutzausrüstung wie z.B. geeignete Schutzhandschuhe und Sicherheitsschuhe verwenden
- Anheben und Absetzen von Lasten:
  - Auf einen sicheren Stand und ausreichenden Bewegungsraum achten
  - In die Knie gehen und die Last nach Möglichkeit mit beiden Händen greifen
  - Einseitige Belastung vermeiden
  - Den Körper durch Einsatz der Beinmuskulatur gleichmäßig und langsam aufrichten, den Rücken dabei möglichst gerade halten
  - Die Last möglichst körpernah heben
  - Die Last niemals ruckartig bewegen
  - Beim Heben und Absetzen einer Last das Verdrehen der Wirbelsäule vermeiden. Eine Änderung der Bewegungsrichtung erfolgt über ein Drehen des ganzen Körpers mit den Füßen
  - Beim Absetzen der Last ebenfalls auf eine möglichst gerade Haltung des Rückens achten
  - Beim Absetzen der Last auf die Finger achten! → Quetschgefahr
- Tragen von Lasten:
  - Den Rücken beim Tragen möglichst gerade halten
  - Die Last möglichst nah am Körper tragen (beidhändig vor dem Körper, auf beide Arme verteilt neben dem Körper, auf dem Rücken oder den Schultern)
  - Auf freie Sicht achten
  - Auf freie, ebene und sichere Verkehrswege achten

Verhalten bei Betriebsstörungen

- Beschädigte Hebe-, Trage- und Transporthilfen dürfen nicht benutzt werden. Sie sind sofort aus dem Verkehr zu nehmen. Die Mängel sind dem Vorgesetzten zu melden.

Verhalten bei Unfällen – Erste Hilfe

- Ruhe bewahren
- Ersthelfer heranziehen
- Unfall melden

Notruf: 112 Ersthelfer: ____

Instandhaltung/Prüfung

- Instandhaltungsarbeiten an Hebe-, Trage- und Transporthilfen nur durch beauftragte und fachlich qualifizierte Personen durchführen lassen.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Allgemeiner Umgang mit kraftbetriebenen Betriebsmaschinen

Gefährdungen für Mensch und Umwelt

- Schwere Verletzungen durch Erfasst werden an Kleidung, Haaren, Schmuck.
- Gefahr durch Quetsch-, Scher-, Schneid-, Stich-, Fang-, und Einzustellen.
- Augenverletzung durch herumfliegende Späne und Splitter
- Gesundheits- und Umweltgefährdung durch Öle, Fette, Kühlschmier- und Reinigungsmittel.

Schutzmaßnahmen und Verhaltensregeln

- Vor Arbeitsbeginn Maschinen auf betriebssicheren Zustand überprüfen.
- Qualität des Kühlschmiermittels regelmäßig überprüfen, ggf. austauschen.
- Entfernung der Schutzeinrichtung oder Manipulation an Schaltern/ Schlössern sind verboten.
- Niemals an schadhaften Maschinen arbeiten.
- Bedienungsanleitung beachten; Maschine nur für vorgeschriebene Arbeiten/ Werkstoffe verwenden.
- Enganliegende Kleidung tragen (Ärmel mit Bündchen oder nach Innen aufkrempeln).
- Hand-, Arm-, Halsschmuck (Krawatten, Ketten, Ringe, Uhren) sind unzulässig.
- Lange Haare durch Haarnetz, Mütze oder Band abbinden oder verdecken.
- Schutzbrille und Schutzschuhe tragen.
- Keine Schutzhandschuhe an rotierenden Maschinenteilen tragen.
- Werkstücke stets festspannen.
- Bei Gefährdung durch Lärm und Vibration von 80dB(A) Mittelwert über 8Std. muss ein entsprechender Gehörschutz getragen werden.
- Nicht in rotierende Werkstücke/Maschinenteile fassen.
- Handgeführte Werkzeugmaschinen sollen immer mit einer Rutschkupplung und einer Überlastsicherung ausgestattet sein.
- Sicherheitseinrichtung muss vorhanden sein, die ein Rollen oder Gleiten verhindern bzw. die rollenden oder gleitende Teile auffangen kann (z.B. Auffangvorrichtung, Schutzwände).
- Kühlschmiermittelzufuhr so einstellen, dass nur der Arbeitsbereich besprüht wird; Hautkontakt mit Kühlschmiermittel vermeiden.
- Maschine nach Gebrauch abschalten und gegen unbefugtes Einschalten sichern.
- Maschine zum Werkzeug-/Werkstückwechsel, zum Reinigen und zu Kontrollmessungen ausschalten.
- Späne mit Pinsel, Handfeger oder Spänehaken bei ausgeschalteter Maschine entfernen.
- Bei Benutzung von feuergefährlichen/entzündlichen Reinigungsmitteln sind Rauchen, Feuer und offenes Licht verboten.

Verhalten bei Betriebsstörungen

- Bei Gefahrensituationen/ Störungen sofort Not-Halt-Schalter bedienen und Verantwortlichen verständigen.
- Leckagen sofort beseitigen.

Verhalten bei Unfällen – Erste Hilfe

- Maschine abschalten.
- Verletzten bergen.
- Unfall melden, ggf. Arzt oder Sanitäter anfordern, Unfallstelle absichern.
- Ersthelfer hinzuholen – Erste Hilfe leisten (Blutung stillen, Schockbekämpfung).
- Eintrag in Verbandbuch und HS Reporting.

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

A

- Maschine zum Arbeitsende reinigen.
- Instandhaltungsarbeiten nur durch hiermit beauftragte Personen durchführen lassen.
- Reparaturen und wiederkehrende Prüfung durch befähigte und dafür beauftragte Person, Prüffristen beachten.
- Öle, Fette, Kühlschmier- und Reinigungsmittel sind umweltgefährdend und ordnungsmäßig zu entsorgen (nicht in die Kanalisation oder Baugrund).
- Beschmutze Putzlappen und Späne zur Entsorgung in geeignete und entsprechend gekennzeichneten Behältern sammeln.
- Mängel an der Muster-Maschine dem Vorgesetzten melden.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Allgemeiner Umgang mit elektrischen Arbeitsmitteln

Gefährdungen für Mensch und Umwelt

Gefahren durch das Benutzen von handgeführten elektrischen Arbeitsmitteln ergeben sich durch

- elektrischen Strom
- wegfliegende Werkstücke
- Schneiden, Quetschen, herabfallende Werkstücke, Aufwickeln durch drehende Werkzeuge oder Lärm und Staub
- Die erhöhte mechanische Beanspruchung der elektrischen Betriebsmittel kann zu gefährlichen Körperströmen durch beschädigte Arbeitsmittel und Leitungen führen.

Schutzmaßnahmen und Verhaltensregeln

- Vor der Benutzung eines neuen Gerätes ist die Gebrauchsanweisung zu lesen und zu beachten.
  Das Arbeitsmittel ist bestimmungsgemäß zu benutzen.
- In handgeführten elektrischen Arbeitsmitteln sind nur die dafür zugelassenen Werkzeuge einzuspannen (z. B. bei Schleif- und Trennscheiben).
- Elektrische Betriebsmittel sind nur bei sicherem Stand und mit beiden Händen zu führen.
- Schutzeinrichtungen dürfen nicht abmontiert oder blockiert werden.
- Vor jedem Gebrauch ist eine Sichtprüfung auf sichtbare Beschädigungen durchzuführen.
  Sind Beschädigungen erkennbar, ist das Arbeitsmittel bis zur Instandsetzung durch eine Elektrofachkraft der Benutzung zu entziehen.
- In explosionsgefährdeten Räumen und Bereichen dürfen nur EX- geschützte Arbeitsmittel benutzt werden.
- Es ist eng anliegende Arbeitskleidung zu tragen.
- Je nach Arbeitsumgebung ist persönliche Schutzausrüstung zu benutzen: Schutzhelm, Schutzschuhe, Gehörschutz, Schutzbrille, Handschuhe (nicht bei drehenden Werkzeugen), etc.
- Die Vorgaben der DGUV Information 203-006 sind zu beachten:
  Versorgung der elektrischen Anlage über besondere Anschlusspunkte, z. B. Baustromverteiler, Ersatzstromerzeuger, Schutztrennung, Schutzkleinspannung, ortsveränderliche Schutzeinrichtungen, Schutzverteiler
  Stromkreise mit Steckvorrichtungen bis AC 32 A müssen im TT- oder TN-S-System über Fehlerstrom-Schutzeinrichtungen mit einem Bemessungsdifferenzstrom von max. 30 mA betrieben werden.
  Schaltanlagen und Verteiler müssen mind. der Schutzart IP 43 entsprechen.
  Flexible Leitungen müssen vom Typ H07RN-F oder H07BQ-F sein.
  Leitungsroller müssen schutzisoliert und vollständig aus Isolierstoff aufgebaut und für erschwerte Bedingungen geeignet sein, Schutzart: IP 44.
  Handleuchten: Schutzklasse II, Schutzart IP 55 (Schutzglas und Schutzkorb verwenden)
  Leitungen sind bei Gefahr der Beschädigung geschützt zu verlegen.
- Bei erhöhter elektrischer Gefährdung sind besondere Schutzmaßnahmen zu ergreifen (z. B. Schutzkleinspannung, Schutztrennung).

Verhalten bei Betriebsstörungen

- Defekte Arbeitsmittel sind sofort sicher der Benutzung zu entziehen und von einer Elektrofachkraft instand setzen zu lassen.

Verhalten bei Unfällen – Erste Hilfe

- Zuerst Eigensicherung
- Niederspannung: Person ansprechbar? Befragung; Vorstellung, wenn mobil, beim nächst erreichbaren Arzt. Person nicht mobil/nicht ansprechbar? Rettungskette: Notruf: ,Vitalfunktionen prüfen, ggf. Herz-Lungen-Wiederbelebung, AED
- Hochspannung: Rettungskette: Notruf: , Person ansprechbar? Befragung. Person nicht ansprechbar? Vitalfunktionen prüfen, ggf. Herz-Lungen-Wiederbelebung, AE
- Eintrag in Verbandbuch und HS Reporting.

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

A

- Elektrische Arbeitsmittel müssen regelmäßig entsprechend den Einsatzbedingungen von einer befähigten Person geprüft werden.
- Die Zeitabstände für die Prüfung richten sich nach den Betriebsverhältnissen und sind von der befähigten Person zu ermitteln.
- Die Instandsetzung ist nur durch eine Elektrofachkraft bzw. Fachfirma durchzuführen.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Diese Betriebsanweisung gilt für Elektrofachkräfte und elektrotechnisch unterwiesene Personen, die mit Arbeiten an elektrischen Anlagen und Betriebsmitteln (an der elektrotechnischen Ausrüstung von Arbeitsmitteln) beauftragt sind.

Gefährdungen für Mensch und Umwelt

- Gefahr des Berührens aktiver Teile und damit verbundener Körperdurchströmung
- Gefahr des Auslösens eines Lichtbogens
- Gefahr des Berührens aktiver Teile und damit verbundenen Schreckreaktionen (z. B. Sturz von der Leiter)

Schutzmaßnahmen und Verhaltensregeln

- Der Anlageteil, an dem gearbeitet werden soll, ist vom Arbeitsverantwortlichen bzw. Anlagenverantwortlichen allpolig und allseitig frei zu schalten.
- Die Anlage ist gegen Wiedereinschalten zu sichern (z. B. Schloss). Ein Verbotsschild ist anzubringen.
- An der Arbeitsstelle ist die Spannungsfreiheit mit geeigneten Spannungsprüfern (DIN EN 61243-3 VDE 0682-401) bis 1 kV zweipolig feststellen.
- In Anlagen über 1 kV sind alle aktiven Teile an der Ausschaltstelle und sichtbar an der Arbeitsstelle zu erden und kurzzuschließen. Besteht in Niederspannungsverteilanlagen die Möglichkeit zum Erden und Kurzschließen (z. B. an NH-Sicherungseisätzen) sollte es auch hier durchgeführt werden.
- Benachbarte, unter Spannung stehende Teile ohne Berührungsschutz sind mit isolierenden Gummitüchern abzudecken, bzw. die Bereiche sind abzuschranken.
- Die angebrachten Abdeckungen müssen ausreichende mechanische Festigkeit besitzen.
- Bei der Anbringung der Abdeckmaterialien sind isolierende Handschuhe, Gesichtsschutz und ggf. Schutzhelm zu tragen. Eventuell sind diese Anlagenteile für den Zeitraum der Anbringung von Abdeckungen freizuschalten.
- Es ist zu gewährleisten, dass nur für den Einsatzzweck geprüfte Werkzeuge und Hilfsmittel verwendet und benutzt werden.
- Fehlerhaftes Werkzeug und Hilfsmittel sind sicher der Benutzung zu entziehen.

Verhalten bei Betriebsstörungen

- Beim Auftreten von unerwarteten Schwierigkeiten sind die Arbeiten einzustellen, der Analgenverantwortliche ist zu informieren.
- Schadhafte Werkzeuge und Hilfsmittel sofort austauschen.

Verhalten bei Unfällen – Erste Hilfe

- Zuerst Eigensicherung
- Niederspannung: Person ansprechbar? Befragung; Vorstellung, wenn mobil, beim nächst erreichbaren Arzt. Person nicht mobil/nicht ansprechbar? Rettungskette: Notruf: ,Vitalfunktionen prüfen, ggf. Herz-Lungen-Wiederbelebung, AED
- Hochspannung: Rettungskette: Notruf: , Person ansprechbar? Befragung. Person nicht ansprechbar? Vitalfunktionen prüfen, ggf. Herz-Lungen-Wiederbelebung, AE
- Eintrag in Verbandbuch und HS Reporting.

Notruf: 112 Ersthelfer: ____

Instandhaltung/Prüfung

- Es ist zu gewährleisten, dass nur für den Einsatzzweck geprüfte Werkzeuge und Hilfsmittel verwendet und benutzt werden.
- Schadhafte Werkzeuge und Hilfsmittel ist sicher der Benutzung zu entziehen.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Benutzung von Steh- und Anlegeleitern; Allgemeine Regeln

Gefährdungen für Mensch und Umwelt

- Gefahr durch Sturz von der Leiter
- Gefahr durch Umkippen, Abrutschen, Bruch oder Umkanten der Leiter
- Gefahr durch Herabfallen von Gegenständen

Schutzmaßnahmen und Verhaltensregeln

- Leitern sind nur für Arbeiten von geringem Umfang einzusetzen.
- Arbeiten nicht länger als insgesamt 2 Stunden/Schicht.
- **Leiter vor Verwendung überprüfen, Prüfzeichen beachten, keine beschädigten Leitern benutzen.**
- Den richtigen Anstellwinkel von 65° – 75° einhalten. Die Leiter unter Umständen zur Sicherung anbinden oder von einem zweiten Mann festhalten lassen..
- Anlegeleitern gegen Wegrutschen, Einsinken, Abrutschen sichern.
- Leitern nicht hinter geschlossenen Türen aufstellen, nicht an Glasscheiben, Drähte oder Stangen anlehnen.
- An Treppen und anderen unebenen Standorten einen sicheren Höhenausgleich oder eine Spezialleiter verwenden.
- Anlegeleitern mindestens einen Meter über die Austrittsstelle hinausragen lassen (ca. 4 Sprossen).
- Geschlossene Schuhe tragen, Schuhsohlen frei von Verunreinigungen und Öl halten (Abrutschgefahr).
- Mit dem Gesicht zur Leiter auf- und absteigen und sich mit mindestens einer Hand festhalten.
- Standfläche maximal 5,0 m über der Aufstellfläche.
- Gesamtgewicht von Werkzeug und Material nicht mehr als 10 kg, Gesamtbelastung der Leiter max. 150 kg.
- Im Freien keine Gegenstände mit mehr als 1,0 m² Windfläche mitnehmen.
- Keine Stoffe und Geräte benutzen, die zusätzliche Gefahren darstellen (z.B. Gefahrstoffe oder Schweißgeräte).
- Bei der Arbeit nicht zu weit hinauslehnen, Schwerpunkt beachten.
- Leitern nicht provisorisch flicken und nicht behelfsmäßig verlängern.
- Stehleitern nicht als Anlegeleitern benutzen.
- Stehleitern nur auf festem, ebenem Untergrund aufstellen.
- Stehleitern nicht ungesichert in Verkehrswegen aufstellen.
- Bei Stehleitern müssen die Spreizsicherungen immer gespannt sein
- Die oberste Stufe einer Stehleiter darf nur betreten werden, wenn eine Sicherheitsbrücke und Haltevorrichtung vorhanden ist.
- Von Stehleitern darf nicht auf andere hochgelegene Plätze übergestiegen werden.

Verhalten bei Betriebsstörungen

- Schadhafte Leitern und Tritte sind der Benutzung zu entziehen.
- Vorgesetzte informieren.

Verhalten bei Unfällen – Erste Hilfe

- Sofortmaßnahmen am Unfallort, Ersthelfer heranziehen.

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

- Reparaturen, Wartungsarbeiten und Inspektionen dürfen nur von hiermit beauftragten Personen durchgeführt werden.
- **Leiternbeauftragte(r): _____**

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb der HDU

Tätigkeit: Assembly & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Auslegerbühnen (Gelenk-Teleskop-, Lkw- oder Anhängerbühne)

Gefährdungen für Mensch und Umwelt

- Absturz/Herausschleudern aus dem Arbeitskorb (Peitschen- bzw. Katapulteffekt)
- Umkippen der Hubarbeitsbühne (z. B. bei der Lastenübernahme)
- Quetschungen an Gebäudeteilen oder Gegenständen
- Kollision im Straßenverkehr
- Stromschlag bei Arbeiten in der Nähe von stromführenden Leitungen
- Herabfallende Gegenstände

Schutzmaßnahmen und Verhaltensregeln

- Hubarbeitsbühnen dürfen nur von ausgebildeten und unterwiesenen Personen bedient werden
- Bedienpersonen müssen mind. 18 Jahre alt sein, von Unternehmer/-in schriftlich beauftragt worden sein und müssen ihre Befähigung nachgewiesen haben (z. B. Bedien-Schein)
- Bereitgestellte Schutzausrüstung (PSA gegen Absturz, Helm mit Kinnriemen, Sicherheitsschuhe) ist zu verwenden
- Bedienpersonen sind in die Besonderheiten der Hubarbeitsbühne einzuweisen (z. B. Verleihbühne)
- Auf ausreichende Tragfähigkeit und Befahrbarkeit der Verkehrswege achten und grundsätzlich nur mit abgesenktem Arbeitskorb verfahren. Fahrweg kontrollieren!
- Arbeitsbühne standsicher aufstellen (maximale seitliche Auslage der Abstützung, ausreichend große Unterlegplatten in Abhängigkeit von der Bodentragfähigkeit, ggf. Kreuzverbund verwenden)
- Wind- und Wetterverhältnisse beachten
- Bei Arbeiten im öffentlichen Verkehrsraum ist die Arbeitsstelle in Absprache mit der zuständigen Behörde abzusichern (verkehrsrechtliche Anordnung)
- Sicherheitsabstand zu elektrischen Freileitungen einhalten oder Freileitungen durch den Energieversorger freischalten lassen
- Schutzabstände zu Baugruben und Gräben einhalten
- Die maximale Tragfähigkeit der Arbeitsbühne beachten (Personen inkl. Ausrüstung)
- Bei der Übernahme von Lasten Reichweitendiagramm und maximale Tragfähigkeit der Bühne beachten (Gefahr des Umstürzens der Arbeitsbühne)
- Hubarbeitsbühne nicht als Kran oder Aufzug verwenden
- Arbeitsbereiche absperren, Gefahrenbereich der Hubarbeitsbühne von Personen freihalten
- Standplatz auf der Hubarbeitsbühne nicht erhöhen, nicht hinausbeugen
- Bedienungsanleitung und Prüfbuch der Hubarbeitsbühne müssen vor Ort verfügbar sein
- Vor Arbeitsaufnahme Sicht- und Funktionskontrolle (z. B. Not-Aus, Lastmomentbegrenzer) durchführen
- Eine zweite Person befindet sich in Rufweite
- Die zweite Person ist unterwiesen und in der Lage, die Notbedienung zu betätigen
- Hubarbeitsbühnen sind nach Herstellerangaben aufzustellen und bestimmungsgemäß zu verwenden

Verhalten bei Betriebsstörungen

- Bei Fehlfunktionen Not-Aus und ggf. Notbedienung betätigen, Arbeiten sofort einstellen
- Bühne bis zur Reparatur der weiteren Verwendung entziehen
- Festgestellte Mängel sofort der/dem Vorgesetzten melden

Verhalten bei Unfällen – Erste Hilfe

- **Verletzte Personen retten (z. B. Notbedienung), verletzte Personen ggf. in stabile Seitenlage bringen**
- **Erste Hilfe leisten, Unfall melden (Rettungskette)**

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

- Reparaturen und Instandhaltungsarbeiten nur durch befähigte Personen durchführen lassen
- Prüfung der Hubarbeitsbühne mindestens jährlich nach Herstellerangaben (Prüfbuch führen)
- Die Angaben in der Bedienanleitung des Herstellers beachten und befolgen

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____

Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb der HDU

Tätigkeit: Assembly & Disassebly

BG ETEM Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Die Betriebsanweisung enthält allgemeine Regeln für den Umgang mit Kranen (Flurgesteuerte-, Funkgesteuerte-, Turmdrehkrane, Autokrane).

Gefährdungen für Mensch und Umwelt

- Herabstürzende Lasten und Gegenstände, ab- und umstürzender sowie herabfallender Gegenstände.
- Kollision durch ungesicherte Gegenstände/ Abstützungen im Straßenverkehr.
- Anfahren von Personen und Gegenständen mit dem Kran.
- Quetsch-, Scher- und Einzugsstellen an Lastaufnahmemittel und Last.

Schutzmaßnahmen und Verhaltensregeln

- Betriebsanleitung des Herstellers/ DGUV Vorschrift 52 Krane lesen und beachten.
- Turmdreh-, Autokrane (Führerscheinklasse II) nur von unterwiesenen, min. 18jährigen, körperlich & geistlich geeigneten, befähigt und beauftragten Kranführern bedienen lassen.
- Vor Arbeitsbeginn Sicht- und Funktionskontrolle durchführen, besonders der Bremsen und Not-End-Halt-Einrichtungen. Die durch Not-End-Schalter begrenzten Endstellungen des Hubwerkes dürfen betriebsmäßig nicht angefahren werden!
- Kontrolle: Keine losen Gegenstände auf dem Kran, Handbetätigte Abstützungen sichern, Seilführung auf der Trommel, Hubseil ohne Beschädigungen, Steuereinrichtungen ohne Beschädigungen, im Arbeitsbereich keine abgestellten Gegenstände im Sicherheitsbereich von 0,5m zum Kran/ zu kraftbewegten Teilen, Funktion der Hakensicherungen.
- Krankontrollbuch führen, festgestellte Mängel und Prüfungen eintragen.
- Abstützungen gemäß Herstellerangaben durchführen. Tragfähigen Unterbau waagerecht verlegen und verdichten. Maßgebend für die Größe der Abstützfläche sind Stützendruck und zulässige Bodenpressung. Die Stützendrücke können den Herstellerunterlagen oder dem Kranprüfbuch entnommen werden. Für Gleisanlagen Prellböcke verwenden, Fahrnotendschalter 1m vor Gleisende einbauen, am Arbeitsende mit Schienenzangen sichern. Nur statisch nachgewiesene Konstruktionen verwenden.
- Bei Gittermastauslegern Montageanweisung beachten. Lösbare Verbindungsbolzen sichern.
- Schutzabstand zu Böschungen/ Verbau: <12t Gesamtgewicht 1m; >12t Gesamtgewicht 2m. Sicherheitsabstand zu Stromleitungen unbekannter Spannung mindestens 5m; sonst z.B. Abschrankung oder Drehwerksbegrenzung.
- Bei mehreren Kranen/ spezielle Regelungen Arbeitsabläufe vorher festlegen und für einwandfreie Verständigung untereinander sorgen.
- Persönliche Schutzausrüstung benutzen (Schutzschuhe, Schutzhelm, Steigschutz).
- Autokrane: Hubnotendschalter und Lastmomentbegrenzer zur Auslegerlänge einstellen.
- Auf die Angaben über die Tragfähigkeit des Kranes ist zu achten.
- Darauf achten, dass kein Unbefugter aufsteigt oder den Kran betreibt.
- Hochziehbare Personenaufnahmemittel 2 Wochen vor Verwendung bei der BG anzeigen.
- Vor dem Anschlagen der Last Gewicht und Schwerpunkt ermitteln. Überlastsicherung nicht als Waage benutzen. Festsitzende Last nicht losreissen.
- Lasten sachgerecht anschlagen; nicht am unbesetzten Kran hängen lassen. Vor Anheben aus dem Gefahrenbereich treten. Pendeln vermeiden. Nicht Schrägziehen oder Schleifen.
- Last und Lastaufnahmemittel während der Fahrbewegungen beobachten. Große Lasten mit Leitseilen führen. Last nicht über Personen hinwegfahren (nie, wenn die Last an Magnet oder Vakuumheber angeschlagen ist).
- Autokrane: Verfahren des Kranes mit der Last an Haken nur bei niedrigster Fahrgeschwindigkeit, möglichst kurzem Ausleger und Transport über der Hinterachse. Last dicht über dem Boden führen.
- Arbeiten mit zweiter Person: Von Hand angeschlagene Last erst auf Zeichen anheben. Kann die Last beim Aufnehmen, Fahren und Absetzen nicht beobachtet werden, nur auf Zeichen des Einweisers bewegen.
- Am Arbeitsende Haken lastfrei machen und Kran windfrei schalten oder festlegen.

Verhalten bei Betriebsstörungen

- Kranbetrieb bei Unsicherheit durch Windeinwirkung einstellen.
- Mängel sind sofort dem Vorgesetzten zu melden. Gegen Wiedereinschalten sichern.

Verhalten bei Unfällen – Erste Hilfe

- Informieren Sie sich, wo Verbandmittel aufbewahrt werden.
- Verletzten retten, Erste Hilfe leisten, Ersthelfer holen, Unfallstelle absichern!
- Lassen Sie auch kleinere Verletzungen sofort verbinden.
- Suchen Sie den Durchgangsarzt bei wahrscheinlicher Arbeitsunfähigkeit auf.
- Melden Sie jeden Unfall unverzüglich Ihrem Vorgesetzten oder dessen Vertreter.

Jede Erste-Hilfe-Leistung im Verbandbuch dokumentieren

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

- Regelmäßig Krane durch befähigte Person prüfen lassen (Prüfbuch).
- Reparaturen dürfen nur von beauftragten Personen durchgeführt werden.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb der HDU

Tätigkeit: Assembly & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Gerüste und Arbeitsbühnen

Gefährdungen für Mensch und Umwelt

- Bei unsachgemäßem Handhaben, Aufstellen von Gerüsten bei starken Wind besteht die Gefahr von Absturz von Gerüsten und verfahrbaren Arbeitsbühnen.

Schutzmaßnahmen und Verhaltensregeln

- Arbeitsplätze auf Gerüsten nur über dafür vorgesehene Zugänge betreten oder verlassen
- Nicht auf Gerüstbelägen abspringen oder abwerfen
- Ab 1 m Arbeitshöhe, bei Bauarbeiten ab 2 m, dreiteiliger Seitenschutz, bestehend aus Geländerholm, Zwischenholm und Bordbrett anbringen
- Bei Arbeitsplätzen an und über Wasser oder anderen festen oder flüssigen
- Stoffen, in denen man versinken kann, z. B. Silos, immer Absturzsicherungen anlegen
- Nach außergewöhnlichen Einwirkungen (z. B. Sturm) Gerüst überprüfen
- Fahrbare Arbeitsbühnen gegen unbeabsichtigte Fahrbewegungen sichern
- Während des Verfahrens keine Personen auf fahrbaren Arbeitsbühnen
- Aufbau ausschließlich durch Fachfirmen
- Fahrbare Arbeitsbühnen mittels Aufbau- und Gebrauchsanweisung aufbauen und benutzen
- Gerüste erst nach schriftlicher Freigabe durch Ersteller betreten
- Gegen herunterfallende Objekte schützen mit Schutzhelmen

Verhalten bei Betriebsstörungen

- Bei festgestellten Mängeln Arbeiten unverzüglich einstellen
- Gerüst gegen Benutzung sichern, und den nächsten Vorgesetzten benachrichtigen

Verhalten bei Unfällen – Erste Hilfe

- Ruhe bewahren
- Ersthelfer heranziehen
- Notruf: 112
- Unfall melden
- Jede Erste-Hilfe-Leistung im Verbandbuch dokumentieren

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

- Baustellenverantwortlicher überprüft Gerüst arbeitstäglich vor Benutzung
- auf augenfällige Mängel und gibt es zur Benutzung frei
- Werden Mängel festgestellt, sind diese dem Gerüstersteller anzuzeigen.
- Gerüst darf bis zu deren Beseitigung nicht benutzt werden
- Gerüst darf nur vom Gerüstersteller verändert werden

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Gefahrstoffbezeichnung

Lack: Klarlack, Dachabdichtung **und** Verdünnung: -_____ **enthält Xylol und Ethylbenzol**

Gefahren für Mensch und Umwelt

- Gesundheitsschädlich beim Einatmen und Hautkontakt; wirkt narkotisierend
- Reizt Haut und Schleimhäute
- Entzündbar
- Beim Ausfall der Absaugung ist die Bildung explosionsfähiger Gemische mit Luft möglich
- Wassergefährdend; darf nicht in die Kanalisation gelangen

Schutzmaßnahmen und Verhaltensregeln

- Absaugung einschalten
- Zündquellen fernhalten
- Arbeitskleidung aus Baumwolle tragen; Schutzhandschuhe _____ tragen
- Hautschutzmittel benutzen:
  Schutz (vor der Arbeit) _____
  Reinigung (vor Pausen und Arbeitsschluss) _____
  Pflege (nach der Arbeit) _____
- Schutzbrille _____ tragen.
- Schutzschuhe mit leitfähigen Sohlen _____ tragen.
- Lackiergut bis zur vollständigen Trocknung im abgesaugten Bereich (Abdunstplatz) belassen.
- Mit Farbe oder Verdünnung getränkte Lappen in _____ Sicherheitstonne geben.
- Am Arbeitsplatz nicht rauchen, essen oder trinken und hier keine Lebensmittel aufbewahren.

Verhalten im Gefahrfall

- Verschüttete Farbe und Verdünner mit Universalbinder _____ abdecken und so eindämmen, dass nichts in die Kanalisation gelangt. Dabei Atemschutz-Filtergerät mit Gasfilter A2 (Kennfarbe braun) tragen.
- Universalbinder aufnehmen, in _____ Sicherheitstonne füllen und _____ , Tel.: _____ zur Entsorgung geben
- Im Brandfall vorhandenen Feuerlöscher _____ benutzen; Vorgesetzten _____ informieren

Notruf: 112

Erste Hilfe

- Spritzer im Auge: Sofort mit viel Wasser ausspülen, umgehend Vorgesetzten _____ informieren, Augenarzt aufsuchen.
- Hautkontakt: Zunächst mit Tuch oder Papier säubern, dann mit Wasser und Hautreinigungsmittel _____ (**niemals** mit Verdünner!) reinigen.
- Mit Farbe oder Verdünner getränkte Kleidung sofort wechseln.

Notruf: 112 Ersthelfer: _____

Sachgerechte Entsorgung

- Mit Lack oder Verdünner getränkte Lappen oder gebrauchten Universalbinder
- in _____ Sicherheitstonne geben
- Entleerung erfolgt täglich durch _____ , Tel.; _____

Firma: HFT Stuttgart

Arbeitsbereich: Außer und innerhalb der HDU

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: HFT Lot 4

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Benutzung von Gehörschutz im Lärmbereich

Nach der Verordnung zum Schutz der Beschäftigten vor Gefährdungen durch Lärm und Vibrationen liegt ab einem Lärmexpositionspegel von **80 dB(A)** ein Lärmbereich vor (über einen 8-stündigen Arbeitstag gemittelter Wert); ab einem Lärmexpositionspegel von **85 dB(A)** muss der Lärmbereich gekennzeichnet werden.

Gefährdungen für Mensch und Umwelt

- Bei Nichttragen oder falschem Tragen von Gehörschutz in Lärmbereichen besteht die Gefahr einer bleibenden Schwerhörigkeit.
- Diese Schwerhörigkeit kann durch langjährigen Dauerlärm oder durch extreme Lärmspitzen entstehen.

Schutzmaßnahmen und Verhaltensregeln

- Gehörschutz muss im gekennzeichneten Lärmbereich von allen Personen getragen werden.
- Gehörschutz muss über die gesamte Arbeitsschicht bzw. über alle Lärmphasen getragen werden.
- Gehörschutz muss richtig benutzt werden (siehe Herstellerangaben).
- Am Gehörschutz dürfen keine Manipulationen vorgenommen werden.
- Gehörschutz muss so ausgewählt werden, dass die Schalldämmung ausreichend hoch ist.
- Sprachverständlichkeit sollte möglich sein.
- Bei Gefahr muss die Hörbarkeit von Warnsignalen garantiert werden.

Verhalten bei Betriebsstörungen

- Defekte oder verschmutzte Gehörschützer sind schnellstmöglich auszutauschen.

Verhalten bei Unfällen – Erste Hilfe

- Nach Knallereignissen mit plötzlichem Hörverlust oder Ohrgeräuschen schnellstmöglich einen Arzt aufsuchen.
- HS Reporting

Notruf: 112 Ersthelfer: ____

Instandhaltung/Prüfung

- Gehörschützer in geeigneten Behältern aufbewahren.
- Nach Herstellerangaben regelmäßig reinigen.
- Spröde Dichtungskissen an Kapseln auswechseln.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Benutzung von Kopfschutz

Diese Betriebsanweisung findet Anwendung auf die Auswahl und Benutzung von Industrieschutzhelmen bzw. Industrie Anstoßkappen. Industrieschutzhelme müssen den Anforderungen der DIN EN 397 "Industrieschutzhelme" entsprechen. IndustrieAnstoßkappen müssen den Anforderungen der DIN EN 812 "Industrie Weitere Informationen können der berufsgenossenschaftlichen Regel Anstoßkappen" entsprechen. DGUV R 1121 93 entnommen werden.

Gefährdungen für Mensch und Umwelt

- Herabfallende Gegenstände;
- Anstoßen an Gegenständen;
- pendelnde Gegenstände;
- umfallende Gegenstände oder wegfliegende Gegenstände.

Schutzmaßnahmen und Verhaltensregeln

- Es dürfen nur Industrieschutzhelme bzw. Industrie che CEKennzeichnung tragen.
- Ein Schutzhelm oder eine Anstoß-- Anstoßkappen ausgewählt werden, welche die erforderliSchutzkappe wird jedem Mitarbeiter je nach Bedarf individuell kostenfrei zur Verfügung gestellt . Von der Weitergabe getragener Helme oder Kappen ist abzusehen (Hygiene).
- Für folgende besondere Gefährdungen (sehr hohe oder niedere Temperatur, kurzfristigen Kontakt mit Wechselspannungen, Spritzer von geschmolzenem Metall, seitliche Beanspruchung, Flam mbeständigkeit) müssen Schutzhelme und Anstoßschutzkappen mit speziellen Eigenschaften zur Verfügung gestellt werden.
- Es darf nur solcher Kopfschutz ausgewählt werden, der dem Benutzer individuell passt bzw. angepasst werden kann. Die Tragbänder der Innenau sstattung sollten aus Textilbändern hergestellt und es sollte ein Schweißband vorhanden sein.
- Auf den Kopfschutz dürfen keine Anstrichstoffe, Lösemittel, Klebemittel oder selbstklebende Etiketten aufgebracht werden.
- IndustrieAnstoßkappen ersetzen unter keinen Umständen einen Industrieschutzhelm nach DIN EN 397.
- Werden bei der Sichtprüfung oder beim "Knacktest" (siehe BGR 193 Abs. 3.2.3.1) Mängel festgestellt, dürfen Schutzhelme bzw. Anstoßschutzkappen nicht mehr weiterbenutzt werden.
- Unansehnliche Innenaus stattungen und Schweißbänder sind aus hygienischen Gründen durch neue zu ersetzen.
- Bei der Reinigung von Schutzhelmen bzw. IndustrieAnstoßkappen sind die Angaben des Herstellers über die Reinigungsmethode und die Reinigungsmittel zu beachten.
- Schutzhelme bzw. IndustrieAnstoßkappen sind entsprechend den Informationen des Herstellers aufzubewahren. Sie dürfen keinen schädigenden Einflüssen ausgesetzt sein (z.B. Sonne, aggressive Stoffe).

Verhalten bei Betriebsstörungen

- Nach einer starken rieBeaufschlagung und bei sichtbaren Mängeln dürfen Industrieschutzhelme bzw. IndustAnstoßkappen nicht mehr weiterbenutzt werden. Sie sind der weiteren Benutzung zu entziehen durch den Arbeitgeber zu ersetzen.

Verhalten bei Unfällen – Erste Hilfe

- Ersthelfer und Vorgesetzten verständigen
- Verletzten ruhigstellen. Stabile Seitenlage bei Bewusstlosen.
- Ggf. Rettungsdienst benachrichtigen.
- Eintrag in Verbandbuch und HS Reporting

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

- Schutzhelme und Anstoßschutzkappen sind vom jeweiligen Träger auf erkennbare Mängel zu prüfen. Beschädigte Schutzhelme und Anstoßschutzkappen dürfen nicht weiter getragen werden.
- Bei Bedarf sollte ein Knacktest durchgeführt werden. Knacktest: Dabei wird die Helmschale mit den Händen seitlich leicht eingedrückt bzw. der Schirm leicht verbogen. Nimmt man bei aufgelegtem Ohr Knister Knackgeräusche wahr, sollte der Helm der weiteren Benutzung entzogen werden.
- Die Gebrauchsdauer von Schutzhelmen aus thermoplastischen Kunststoffen beträgt vier Jahre, die von duroplastisch en Schutzhelmen maximal acht Jahre ab dem Herstelldatum (siehe Stempel).

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Benutzung von Schutzhandschuhen

Schnittschutz,- Chemikalienschutz-, Hitzeschutz-, Kälteschutz- und Einmalschutzhandschuhe

Gefährdungen für Mensch und Umwelt

- Schnitt- und Stichverletzungen an Fingern und Händen durch scharfkantige Werkstücke und Material oder Maschinenteile
- Verätzungen der Finger und Hände durch Gefahrstoffe
- Gefahrstoffaufnahme durch die Haut (Finger, Hände) durch falsche Handhabung
- Verbrennungen an Fingern und Händen durch heiße Werkstücke oder Geräte
- Frostschäden an Fingern und Händen durch tiefkalte Werkstücke oder Geräte

Schutzmaßnahmen und Verhaltensregeln

- Nur die für die Tätigkeit nach Gefährdungsbeurteilung vorgesehenen Schutzhandschuhe benutzen.
- Bei allen Arbeiten, die zu Gefährdungen der Hände führen können (Umgang mit ätzenden, giftigen, sensibilisierenden Gefahrstoffe, Tätigkeiten mit pathogenen biologischen Arbeitsstoffen, Handhabung heißer oder tief kalter Gegenstände bzw. Geräte) geeignete Schutzhandschuhe tragen:
  - Giftige, ätzende und sensibilisierende Stoffe: Nitrilhandschuhe
  - Scharfkantige oder spitze Gegenstände: Leder- oder Latexhandschuhe
  - Heiße Glas-, Metall- und Porzellanteile: Hitzeschutzhandschuhe
  - Tiefkalte Gegenstände: Isolierhandschuhe
- Die genaue Typisierung der Handschuhe ist auf das entsprechende Verfahren bzw. auf den verwendeten Gefahrstoff im Vorfeld der Arbeiten abzustimmen.
- Biologische Arbeitsstoffe und normaler Schmutz (z.B. Öl): Einmalschutzhandschuhe aus Nitril oder puderfreie Latex-Schutzhandschuhe (letztere nicht geeignet für Latex-Allergiker).
- Widerstandsfähigkeit des Handschuhmateriales in Abhängigkeit vom Gefahrstoff beachten. Einmalschutzhandschuhe sind gegen viele chemische, mechanische und thermische Einwirkungen nur sehr wenig oder überhaupt nicht widerstandsfähig.
- Nur unbeschädigte, innen saubere und trockene Schutzhandschuhe benutzen.
- Schutzhandschuhe nur mit sauberen, trockenen Händen anziehen
- Verschwitzte Schutzhandschuhe wechseln oder dünne Baumwollunterzieh-Handschuhe benutzen. Diese nach der Benutzung trocknen lassen.
- Nur die persönlich zugeordneten Schutzhandschuhe benutzen. Schutzhandschuhe nicht zwischen Personen tauschen.
- Benutzte Schutzhandschuhe so ausziehen, dass ein Kontakt mit den anhaftenden Arbeitsstoffen vermieden wird.
- Kontaminierte Handschuhe sofort ablegen und reinigen oder entsorgen. Mit Handschuhen keine Gegenstände außerhalb des Arbeitsvorganges berühren (z.B. Telefonhörer, Schreibgerät, Griffe, Tastaturen), Schmierkontaminationen zu vermeiden.
- Einmalschutzhandschuhe nach Gebrauch nicht wiederverwenden.
- Das Tragen von flüssigkeitsdichten Handschuhen belastet die Haut durch Bildung eines Feuchtmilieus. Handschuhe daher nur solange tragen, wie dies für den Schutz unbedingt erforderlich ist. Bei lang anhaltenden Arbeiten empfiehlt sich das zwischenzeitliche Einlegen einer handschuhfreien Pause. Die Verwendung von saugfähigen Baumwoll-Unterhandschuhen ist in Erwägung zu ziehen. Der Hautzustand von Personen, die solche Handschuhe im Durchschnitt länger als 2 Stunden pro Tag tragen, ist regelmäßig vom Betriebsarzt überwachen zu lassen.
- Hautschutz, Hautreinigung und Hautpflege gemäß Hautschutzplan unbedingt beachten.

Verhalten bei Betriebsstörungen

- Überlagerte oder brüchig gewordene Handschuhe nicht verwenden.
- Handschuhe mit augenscheinlichen Mängeln nicht verwenden.
- Kontaminierte und stark verschmutzte Handschuhe nicht verwenden.

Verhalten bei Unfällen – Erste Hilfe

- Verletzungen sofort versorgen.
- Bei Hautproblemen durch Gefahrstoff, Verletzungen oder Unverträglichkeiten der Schutzhandschuhe den Vorgesetzten und ggfs. den Betriebsarzt informieren.
- Eintrag in Verbandbuch und HS Reporting

Notruf: 112 Ersthelfer: ____

Instandhaltung/Prüfung

- Bei festgestellten Mängeln, Beschädigungen oder Überlagerung ist unverzüglich der Vorgesetzte zu informieren, der schnellstmöglich für Ersatz und Austausch sorgt.
- Schutzhandschuhe, aller benötigten Größen, in einem belüfteten Raum, in der Originalverpackung lagern – geschützt vor Sonneneinstrahlung, Wärmequellen und UV-Licht.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Benutzung von Augen- und Gesichtsschutz

Diese Betriebsanweisung findet Anwendung auf die Auswahl und die Benutzung von Augenschutzmaßnahmen innerhalb des Unternehmens; sie ist anzuwenden soweit für Mitarbeiter eine Augengefährdung durch thermische (Hitze, Kälte), chemische und mechanische Einflüsse besteht. Weitere Informationen können der berufsgenossenschaftlichen Regel DGUV R 112-192 entnommen werden.

Gefährdungen für Mensch und Umwelt

- Augenverletzungen durch Metallsplitter;
- Augenschäden durch Kontakt mit Chemikalien;
- Augenverletzungen durch Hitze oder tiefkalte Einflüsse (z.B. Schweißperlenflug, flüssiger Stickstoff);
- Augenverletzungen durch UV-Strahlung (z.B. Schweißarbeiten, Metallbrand).

Schutzmaßnahmen und Verhaltensregeln

- Um einen geeigneten Schutz gegen mechanische, thermische oder chemische Einwirkungen zu erhalten, muss ein entsprechend der Gefährdung geeigneter Augenschutz ausgewählt werden. Folgender Augenschutz steht zur Verfügung:

Typ / Einsatzort	z.B. Armamax	z.B: Nassau R. Green IR	z.B. Schutzbrille P MG1S	z.B. Handschutzschild	z.B. Speedglas 9000 Xi
Allgemein (mechanische Gefahren)	++	+	+	+	+
UV-Strahlung (Metallbrand)	--	++	++	+	+
Chemikalien	+	+	--	--	--
Autogenschweißen	--	--	++	O	O
MIG, MAG, Elektro	--	--	O	++	++
WIG	--	--	O	+	++
Tragekomfort	++	+	O	-	+
Ausgabe durch:	Kunde	Kunde	Kunde	Kunde	Kunde

++ = sehr gut; + gut; 0 = gering; - schlecht; -- = sehr schlecht

- Der falsche Einsatz von Augenschutzmaßnahmen kann zu einer ungenügenden Schutzwirkung, bzw. zu Verletzungen oder Gesundheitsschäden beim Träger führen.
- Vor dem Tragen muss der Augenschutz auf Schäden, welche die Schutzwirkung beeinträchtigen, sichtgeprüft werden.
- Die Nutzungsdauer von Schutzbrillen mit Kunststoffsichtscheiben kann durch richtige und regelmäßige Reinigung dieser Schutzbrillen erheblich verlängert werden.
- Die Reinigung von Schutzbrillen sollte innerhalb der Pausen erfolgen. Hierbei keine Reinigungspaste und grobe Handpapiertücher verwenden – diese verkratzen die Sichtscheibe. Zum Trocknen ausschließlich weiche Tücher verwenden.

Verhalten bei Betriebsstörungen

- Schadhafte Schutzausrüstung für die Augen sind vom zuständigen Vorgesetzten (ggf. auf Vorlage des be-schädigten Augenschutzes) unverzüglich auszutauschen.

Verhalten bei Unfällen – Erste Hilfe

- Ersthelfer hinzuziehen. Verletzung dem Vorgesetzten melden. Eintrag in das Verbandbuch vornehmen.
- Metallsplitter falls möglich sofort ausspülen. Augenreiben vermeiden. Facharzt aufsuchen.
- Bei schweren Augenverletzungen ggf. Rettungsdienst rufen. Verletzte Augen abdecken Eintrag in Verbandbuch und HS Reporting

Notruf: 112 Ersthelfer: _____

Instandhaltung/Prüfung

- __Augenschutzmaßnahmen vor dem Tragen auf sichtbare Mängel, welche die Schutzwirkung reduzieren, prü-fen. Beschädigter Augenschutz (Schutzbrillen usw.) ist vom zuständigen Vorgesetzten auszutauschen.

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

Firma: HFT Stuttgart

Arbeitsbereich: HFT Lot 4

Verantwortlich: _____
Unterschrift

BETRIEBSANWEISUNG

Arbeitsplatz: Außerhalb und innerhalb der HDU

Tätigkeit: Assembly, Maintainance & Disassebly

BG ETEM
Energie Textil Elektro Medienerzeugnisse

Stand: 23.03.2022

Anwendungsbereich

Benutzung von Sicherheitshochschuhen

Sicherheitsschuhe sind Schuhe mit Zehenkappen für hohe Belastungen, deren Schutzwirkung mit einer Prüfenergie von 200 J geprüft wurde (Kurzbezeichnung S). Sicherheitsschuhe müssen den Normenanforderungen der Reihe DIN EN 345 genügen. Sicherheitsschuhe sind in Tätigkeitsund Einsatzbereichen zu tragen, in welchen eine Gefährdung der Füße besteht. Weitere Informationen können der berufsgenossenschaftlichen Regel DGUV R 112191 entnommen werden.

Gefährdungen für Mensch und Umwelt

- Sturz durch Ausgleiten;
- Stoßen / Einklemmen / Überrollen (z.B. durch Flurförderzeuge);
- herabfallende schwere Gegenstände;
- hineintreten in spitze / scharfe Gegenstände;
- Kontakt mit heißen / ätzenden Flüssigkeiten.

Schutzmaßnahmen und Verhaltensregeln

Auswahlkriterien für Sicherheitsschuhe (S1 – S5) in Bezug zum Einsatzbereich (siehe auch DGUV R 112-191):

- Sicherheitsschuhe werden jedem Mitarbeiter je nach Bedarf individuell kostenfrei zur Verfügung gestellt. Von der Weitergabe getragener Schuhe ist abzusehen (Hygiene).

Kategorie	Grundanforderung	Zusatzanforderung
S 1	Schuhe aus Leder oder anderen Materialien, hergestellt nach herkömmlichen Schuhfertigungsmethoden (z.B. Lederschuhe)	Geschlossener Fersenbereich Antistatik, Energieaufnahmevermögen im Fersenbereich
S 2		Wie S 1, zusätzlich: Wasserdurchtritt, Wasseraufnahme
S 3		Wie S 2, zusätzlich: Durchtrittsicherheit, profilierte Laufsohle
S 4	Schuhe vollständig geformt oder vulkanisiert (Gummistiefel, Polymerstiefel für den Nassbereich)	Antistatik, Energieaufnahmevermögen im Fersenbereich
S 5		Wie S 4, zusätzlich: Durchtrittsicherheit, profilierte Laufsohle

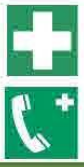
1000 V
(Kennzeichnung nach DIN 48699)

- Weitere Auswahlkriterien können z.B. sein: Rutschgefahr, Umknickgefahr, heiße oder ätzende Flüssigkeiten (ggf. flüssiges Metall z.B. Schweißperlen), Leitfähigkeit (ESD-Bereiche) oder isolierende Eigenschaft (DIN VDE 0680-1; Kennzeichnung nach DIN 48699) bei Arbeiten unter Spannung nach DGUV V3).
- Schuhe in nicht ordnungsgemäßem Zustand, z.B. mit abgelaufenen Profilen, freiliegenden Zehenkappen oder aufgegangenen Schaftnähten, sind der Benutzung zu entziehen.
- Die zur Verfügung gestellten Schuhe sind zu reinigen und zu pflegen (normale Schuhcreme).
- Die Schuhe sind nach den Informationen des Herstellers aufzubewahren.

Verhalten bei Betriebsstörungen

- Festgestellte Mängel an den Sicherheitsschuhen sind sofort dem Vorgesetzten zu melden. Sicherheitstechnisch beschädigte Sicherheitsschuhe sind unverzüglich durch den Arbeitgeber auszutauschen.

Verhalten bei Unfällen – Erste Hilfe



- Ersthelfer und Vorgesetzten verständigen
- Verletzten Fuß ruhigstellen. Verletzten betreuen.
- Ggf. Rettungsdienst benachrichtigen.
- Eintrag in Verbandbuch und HS Reporting

Notruf: 112 Ersthelfer: ____

Instandhaltung/Prüfung

- Sicherheitsschuhe sind vom Träger auf erkennbare Mängel zu prüfen. Beschädigte Sicherheitsschuhe dürfen nicht weiter getragen werden.
- Isolierender Fußschutz ist nach DIN VDE 06801 trocken aufzubewahren. Er ist vom Träger vor jeder Benutzung auf offensichtliche Beschädigungen zu prüfen. Außerdem ist er mindestens alle 6 Monate durch eine Elektro Fachkraft auf sicherheitstechnisch einwandfreien Zustand zu prüfen (elektroprüfung nach DIN VDE 06801 mit verringerter Prüfspannung).

Folgen bei Nichtbeachtung

- Bei wiederholtem Verstoß droht der Ausschluss an der weiteren Teilnahme am Auf-und Abbau der Demonstrationseinheit.
- Fahrlässige Gefährdung von Mensch und Umwelt kann mit einem Bußgeld und Freiheitsstrafe geahndet werden.
- Gesundheitliche Folgen: Verletzungen

20.7 **Structural Calculations**

Appendix A – Foundation

Ingenieurbüro Dr. Hartmann

Ingenieurbüro für Statik und Konstruktion im Holzbau
70376 Stuttgart, Moselstraße 28
Prof. Dr.-Ing. Heiner Hartmann; Prüfingenieur für Bautechnik, Fachrichtung Holzbau

Datum
07.03.2022

Statische Berechnung

Fundierung von Modulgebäude mit Grid
Gebäude Solar Decathlon der HFT- Stuttgart

1. Betreff:

Bauvorhaben: **Erstellung Gebäude und Grid für Wettbewerb Solar Decathlon**

Bauherr: HFT-STUTTGART

Entwurfsverfasser
Tragwerksplanung: **(A)** Prof. Dr.-Ing. Heiner Hartmann, HFT-STUTTGART
Ingenieurbüro Dr. Hartmann
70376 Stuttgart, Moselstraße 28

Prüfingenieur für Bautechnik
Fachrichtung Holzbau
BW - 28.02.2011
Prof. Dr.-Ing. Heiner Hartmann

Erstellt am 07.03.2022

Email: hartmann@ib-drhartmann.de;
Bankverbindung: VR-Bank Werdenfels eG (BIC GENODEF1 GAP),
Kto-Nr. 8636 656 (IBAN DE32 7039 0000 0008 636656);St.-Nr. 168/225/60028; FA-WM

Ingenieurbüro Dr. Hartmann
Ingenieurbüro für Statik und Konstruktion im Holzbau
70376 Stuttgart, Moselstraße 28
Prof. Dr.-Ing. Heiner Hartmann; Prüfingenieur für Bautechnik, Fachrichtung Holzbau

1. Technische Vorbemerkungen zur Gründung

1.1 Baubeschreibung

Das vorliegende Gebäude wird von Hochschule für Technik Stuttgart im Rahmen der Teilnahme am Wettbewerb Solar Decathlon 2022 in Wuppertal erstellt.

Gebäude:
Das Gebäude mit äußeren Abmessungen von ca. 6,8 x 9,6 m wird modular aus vorgefertigten Elementen erstellt – der überwiegende Baustoff für die Struktur besteht aus hölzernen Bauelementen. Um das Gebäude wird eine skelettartige Raumstruktur (GRID) erstellt, die neben dem Balkon und der Außentreppe ins 1. OG auch die Netzstruktur hält, die das Gebäude umhüllt. Für die Tragwerksplanung des Gebäudes mit GRID ist nach Vordimensionierung aus studentischen Projektarbeiten die Fa. Baufritz verantwortlich. Die Berechnungen für die umhüllenden Netzstruktur ist das Ingenieurbüro str.ucture GmbH Stuttgart verantwortlich.

Die nachfolgende statische Berechnung umfasst die Gründung von Gebäude (HDU) sowie GRID auf den durch die Wettbewerbsbedingungen (rules) definierten Baugrund.

Fundierung:
Gemäß den Wettbewerbsbedingungen kommt das Gebäude auf einer vorbereiteten Kies-Schotter-Sicht zu liegen, die für den Wettbewerb einheitlich auf allen „Grundstücken" eingebracht wurde. Die darauf absetzbaren Lasten sind gemäß den Rules in Tab. 3 zusammengefasst.

Grundsätzlich werden zur Gründung Stahlplatten verwendet, die auf der Schotterschicht waagrecht ausgerichtet und im Grundriss plaziert werden. Die Stahlplatten erhalten entweder vertikal aufgeschweißte Flachstähle, welche die Auflagerschuhe (Hartholz) aufnehmen und fixieren bzw. erhalten aufgeschweißte Gewindebolzen (M10), welche die Lagesicherung der industriellen Stützenfüße übernehmen.

Die Hartholzschuhe werden vorher von unten auf die Grundstruktur der HDU-Bodenelemente aufgebacht und mit den drei elementierten Bodenelementen in bzw. auf die Fundamentplatten eingehoben. Die horizontale Fixierung der Hartholzschuhe erfolgt entweder durch Formschluss (Fundamente F1) oder durch seitlich eingebrachte Verschraubungen durch die Flachstähle in den Hartholzschuh. Die Verschraubung erfolgt nach abgeschlossener Höhenregulierung – diese kann durch eingeschobene Hartholzstreifen zwischen „Schuh" und Fundamentplatte korrigiert werden.

Die Ableitung der Horizontalkräfte erfolgt durch die Reibung zwischen Stahlplatte und Schotter – der Reibbeiwert wird nach Rücksprache mit den Kollegen Prof. Thomas Benz (Geotechnik) mit 0,3 angenommen – für die Auflast wird nur der charakteristische Wert verwendet.
Abhebekräfte entstehen gerade nicht, der Nachweis der Zug/Druck-Verankerung wird mit 0,9-fachem charakteristischen Eigengewicht geführt.

Email: hartmann@ib-drhartmann.de;
Bankverbindung: VR-Bank Werdenfels eG (BIC GENODEF1 GAP),
Kto-Nr. 8636 656 (IBAN DE32 7039 0000 0008 636656);St.-Nr. 168/225/60028; FA-WM

Um bei der Ausrichtung die Fundierung von HDU und vom GRID unabhängig zu gestalten – das GRID wird horizontal über das HDU ausgesteift, ist aber vertikal direkt gelagert – werden alle Fußpunkte vom GRID mit eigenständigen Fundamentplatten ausgestattet. Da es im Bereich der Fundamente F2 (Mittelachse – außen) und F3 (Eckfundamente) zu geometrischen Kollisionen kommen könnte, werden hier die Fundamentplatten rechteckförmig angepasst, damit die Platten mit ausreichender Toleranz unabhängig ausgerichtet werden können.

1.2 Berechnungsgrundlagen

DIN-Normen und EC-Normen:

DIN EC2	Stahlbeton, mit zugehörigem nationalem Anhang
DIN EC3	Stahlbau, mit zugehörigem nationalem Anhang
DIN EC5	Holzbau, mit zugehörigem nationalem Anhang
DIN 1052:2008	Holzbau, Bemessung und Ausführung, Produktnorm

1.3 Lastannahmen

Siehe Aufstellung Tragwerksplanung HDU und GRID von Fa. Baufritz und str.ucture GmbH, die Übergabelasten sind im Lastenplan Fa Baufritz aufgeführt.

1.4 Baustoffe

- Stahl S235 nach DIN EC 3,
  Stahlplatten in verschiedenen Stärken und Abmessungen
- Stehbolzen M10, Güte 5.6
- Stählerne Stützenfüße nach Zulassung

1.5 Fundierung

Aufbauend auf die nachfolgenden Auszüge aus dem Regelwerk (rules) zum Wettbewerb werden für die Bodenpressungen folgende Grenzwerte angenommen

Für Plattenabmessungen kleiner/gleich 70 cm Breite

- a R_D = 235 kN/m² bei 1 cm Setzung bzw.
- a R_D = 320 kN/m² bei 2 cm Setzung bzw.

Als Reibbeiwert φ wird ein Wert von 30° angenommen.

Die maximal berechnete Bodenpressung von ca. 250 KN/m² würde damit zu einer Setzung von ca. 12 mm führen. Aufgrund der Lastausbreitung in der verdichteten Schotterschicht werden die Bodenpressungen in den tieferen Schichten deutlich geringer ausfallen und werden nicht mehr gesondert nachgewiesen.

Aufgestellt: Hohenpeißenberg, 07.03.2022

Bearbeiter Dr.-Ing. Hartmann

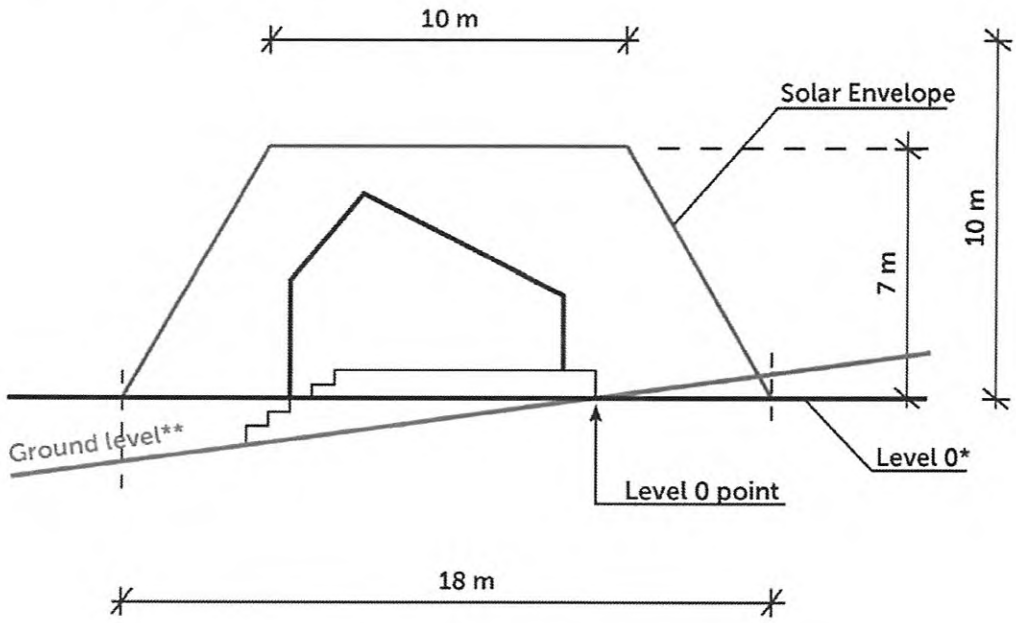
Ingenieurbüro Dr. Hartmann

Ingenieurbüro für Statik und Konstruktion im Holzbau

Prof. Dr.-Ing. Heiner Hartmann; Prüfingenieur für Bautechnik, Fachrichtung Holzbau

Anlage A1 (Ausschnitt Rules)
Grundsätzlicher Fundierungsausschnitt

FIGURE 1. SOLAR ENVELOPE (LEVEL 0 POINT)



Anlage A2 (Ausschnitt Rules)
Grundlage für die Fundierung

Geotechnical Report & Foundation

The following compilation is an abstract of the official Geotechnical Report of our specialists for all Teams. This report is based on previous investigations on ground & soil conditions.
As a basis for structural design, the present order now concerns the determination of the design values of soil base resistance for quadratic spread foundations for these temporary buildings.

The following documents were also adopted as a basis:

[-1-] DIN EN 1997-1:2014-03 (Eurocode 7: Geotechnical design - Part 1: General rules; German version EN 1997-1:2004 + AC:2009 + A1:2013)
[-2-] DIN 1054:2010-12 (Subsoil - Verification of the safety of earthworks and foundations - Supplementary rules to DIN EN 1997-1)

Ingenieurbüro Dr. Hartmann

Ingenieurbüro für Statik und Konstruktion im Holzbau

Prof. Dr.-Ing. Heiner Hartmann; Prüfingenieur für Bautechnik, Fachrichtung Holzbau

Anlage A3 (Ausschnitt Rules) Schichtenaufbau unterhalb der Schotterschicht

Ground conditions and preparatory measures

The area in question, north of the existing station building, is characterised by deposits of partially weathered clay rock accompanying the limestone, so-called Schwelmer Massenkalk, and clay gravel from the Wupper river terrace formations. Moreover, levelling works for previously existing rail tracks have formed a top layer of fill and crushed rock. Table 1 gives an overview of the representative soil properties as a calculative basis for design in accordance with [-1-] and [-2-].

TABLE 1. GROUND PROPERTIES (CHARACTERISTIC VALUES FOR CALCULATION)

Soil	Depth below ground level [m]	Bulk weight YF [kN/m²]	Friction angle q/ [o]	Cohesion c' [kN/m²]	Constrained modulus Es [MN/m²]
Crushed rock	0.0-0.3	20	40.0	0.0	80
Fill	0.3-0.5/1.0	20	35	0.0	80
Soft clayey rock	0.5/1.0-5.0	20	27.5	2.5	8
Sandy, clayey rock	>5.0	22	35	2.5	60

Preparatory measures are taken to ensure a levelled and evenly compacted ground surface before installation of the foundations, that is, compaction to a deformation modulus of Ev2 80 MN/m2 with Evzf Ev1 < 2.5 (measured in plate load tests according to DIN 18134) with a minimum of 30 cm of levelled crushed rock fill (grain size 0-45 mm).

The risk of earthquake-related accelerations can be neglected at this site as well as the latent risk of sinkholes originating from the limestone below, because the excitation time is rather limited.

Anlage A4 (Ausschnitt Rules) Zulässige Bemessungswerte für die Bodenpressung in Abhängigkeit der zu erwartenden Setzung

TABLE 3. LIVING LAB BUILDINGS, FROST-PROTECTED EMBEDMENT d=80cm – DESIGN VALUES aRd FOR THE BASE RESISTANCE OF SQUARE FOUNDATIONS FOR DIFFERENT WIDTHS

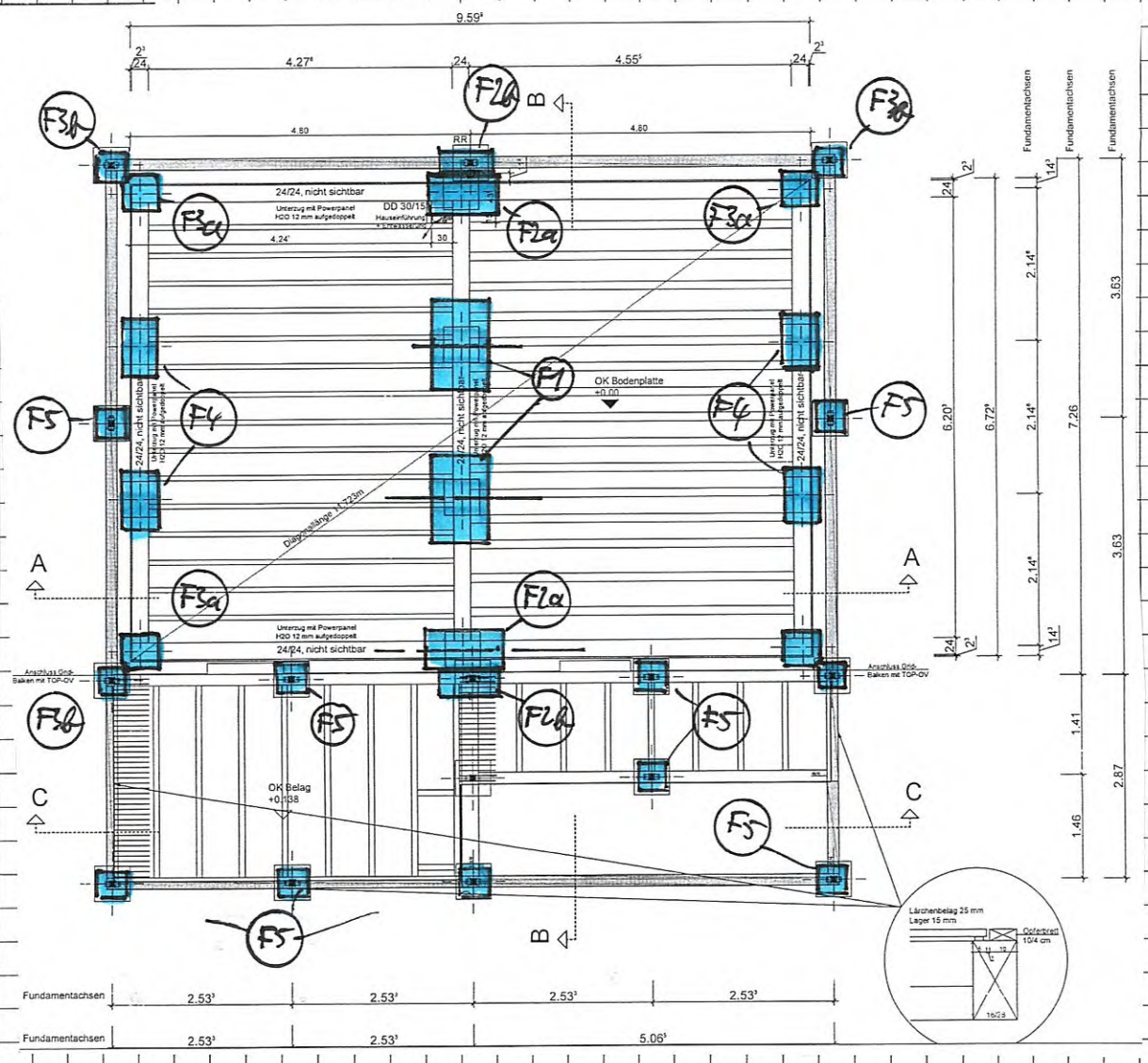
Width b' [m]	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40
aRd, s_{max}=1cm [kN/m²]	265	235	205	190	170	160	150	140	130
aRd, s_{max}=2cm [kN/m²]	310	320	325	330	320	295	275	260	245

Inhalt

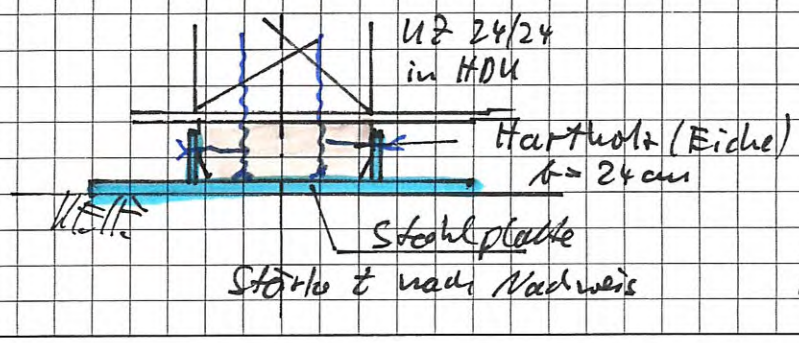
Pos.	Inhalt	Seite
•	– Bemessungsgrundlagen	1 ff
F1	Fundamentplatte 15 x 700 x 1200	4 ff
F2a,b	Fundamentplatten 10 x 500 x 700 und 20 x 240 x 800	10 ff
F3	Eckfundament	
	Platten 10 x 500 x 500 und 10 x 300 x 300	18 ff
F4	Fundamentplatte 10 x 500 x 500	26 ff
F5	" 10 x 350 x 350	31 ff
•	Übersicht Abmessung	35

F Fundierung

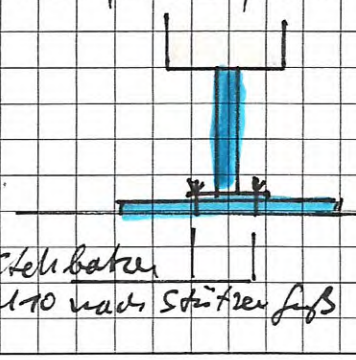
Übersicht



Prinzip F1, F2a, F3a, F4



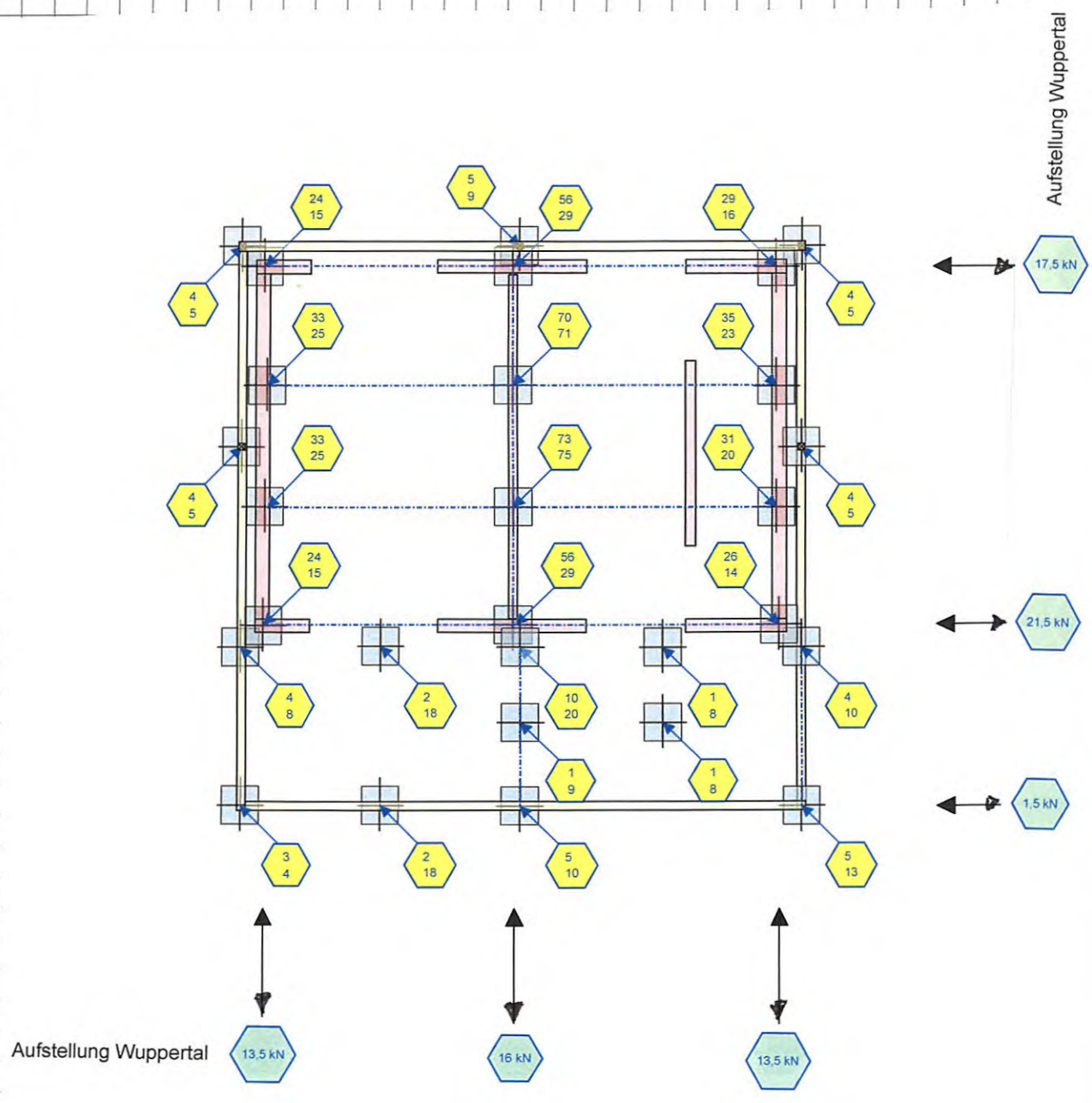
F2b, F3b, F5



Prof. Dr.-Ing. Heiner Hartmann, Hochschule für Technik Stuttgart
Schellingstraße 24, 70374 Stuttgart

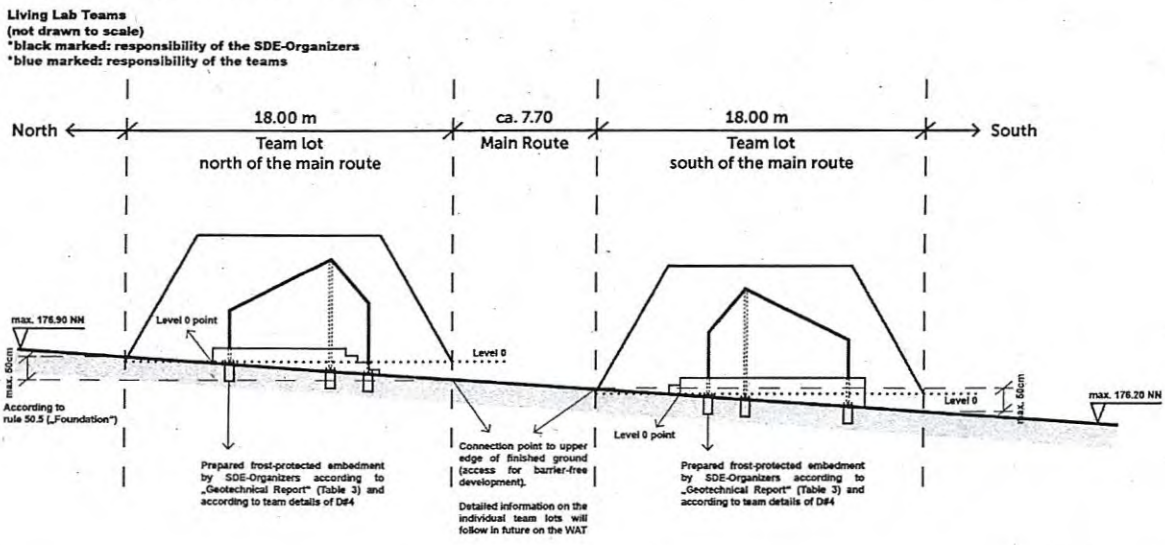
BV: SDE 2022_Wuppertal

Einwirkungen aus Lastenplan
von Modulreihe (Statik Baufritz) + GRID



Living Lab HDUs

FIGURE 3. FOUNDATION OF A LIVING LAB HDU



The Living Lab buildings are envisioned to stay for a duration of approximately three years. Consequently, the shallow foundations should be constructed with frost-protected embedment, that is, d = 80 cm, with reference to the final surface level. The design values for the base resistance aRd, according to [-1-] and [-2-] given in table 3 for different foundation widths, can be used as a basis for structural calculations of the Living Lab buildings, depending on an allowable settlement s_{max} of 1 cm to respectively 2 cm. The self-weight of the embedded concrete foundation, that is, below ground level, may be neglected.

In due time, Teams will receive detailed elevation plans (especially the defined connection point to the ground) and special features on their individual lots. Please note, that these are only planned heights that are to be implemented as part of the preparatory construction work. Furthermore, Rule 50.5 ('Foundation') applies, according to which Teams must still be able to react to special conditions and deviations from the plan heights on site (e.g. height-adjustable foundations).

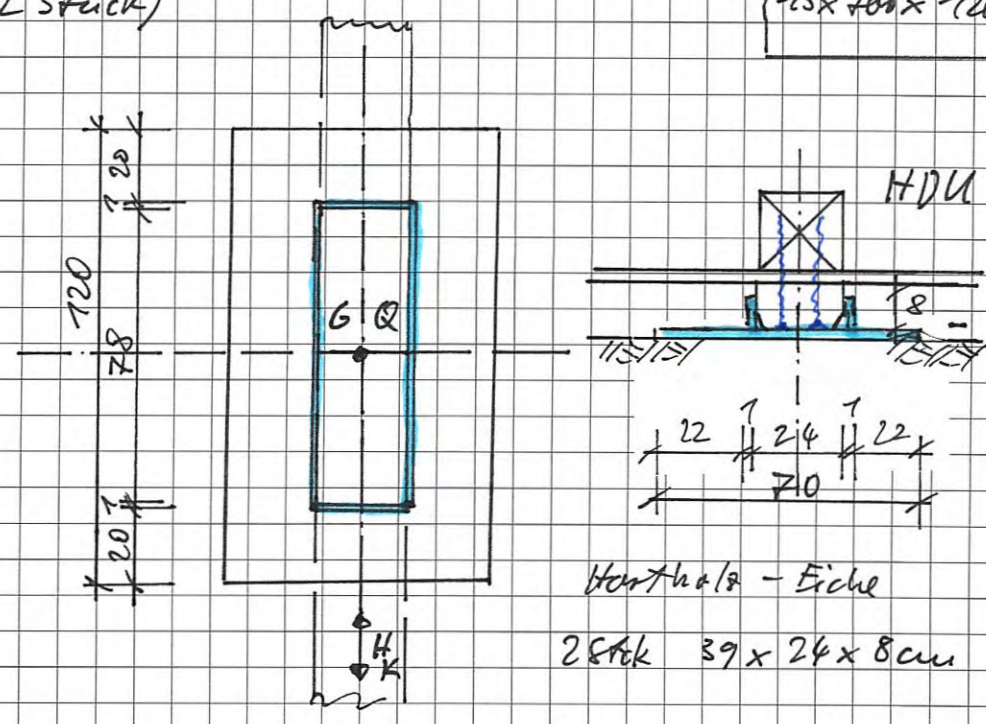
TABLE 3. LIVING LAB BUILDINGS, FROST-PROTECTED EMBEDMENT d=80cm – DESIGN VALUES aRd FOR THE BASE RESISTANCE OF SQUARE FOUNDATIONS FOR DIFFERENT WIDTHS

Width b' [m]	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40
aRd, s_{max}=1cm [kN/m²]	265	235	205	190	170	160	150	140	130
aRd, s_{max}=2cm [kN/m²]	310	320	325	330	320	295	275	260	245

F1 Fundamentplatte unter Mittelwand (2 Stück)

Stahlplatte 15 x 700 x 1200

- Geometrie:



Hartholz – Eiche

2 Stück 39 x 24 x 8 cm

- Einwirkung aus Lastenplan [Fu Bauforiz]

$G_k = 73$ kN, $G_d = 73 \cdot 1{,}35 = 99$ kN

$Q_k = 75$ kN, $Q_d = 75 \cdot 1{,}50 = 112{,}5$ kN

$\Sigma = 148$ kN, $\Sigma = 211{,}5$ kN

und Horizontallast $H_k = 16$ kN

- Bodenpressung, zul $\sigma = \sigma_{Rd} = 235$ kN/m² < 320 kN/m²

vorh $\sigma_d = \frac{211{,}5}{0{,}7 \cdot 1{,}2} = 251$ kN/m² < 320 kN/m²

[SDE, Rules, Teil 3]

zu Setzungen in der Größe von 1,2 cm

- Gleitsicherheit Reibbeiwert Stahl – Schotter = 0,3

$H_{Rd} = 0{,}3 \cdot 2 \cdot 73 = 43{,}8$ kN >> $16 \cdot 1{,}5 = 24$ kN

→ Sicherheit $\eta = 0{,}55 \ll 1{,}0$

- Nachweis vertikale Verankerung

$M_{destab,d} = 3 \cdot 1{,}5 \cdot 16 = 72$ kNm

$\Rightarrow D = Z = \pm 72/2{,}0$ (Abstand F_D)

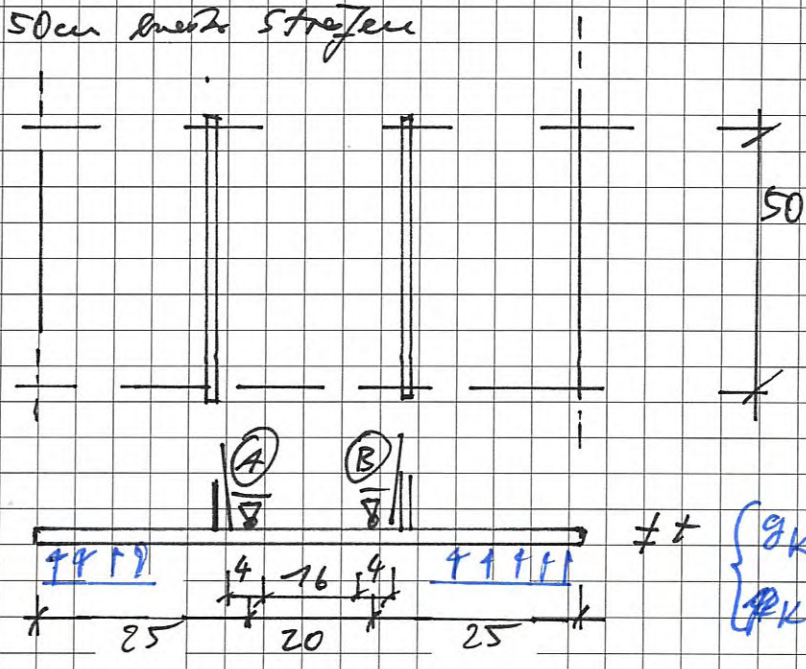
$= \pm 36$ kN

Nachweis Auflast $0{,}9 \cdot G_k = 0{,}9 \cdot 73 = 65$ kN $\gg Z = 36$

$\eta = 0{,}55 < 1{,}0$

- Nachweis Plattenstreifen

Teilsystem 50cm breite Streifen



$g_k =$
$p_k =$

Bodenpressung $= 251$ kN/m², pro 50 cm $= 126$ kN/m $= G_{Rd}$

≙ Ersatzlast $g_k = 44$ kN/m $\longrightarrow g_k = 60$ kN/m

$p_k = 44$ kN/m $\longrightarrow p_k = 66$ kN/m

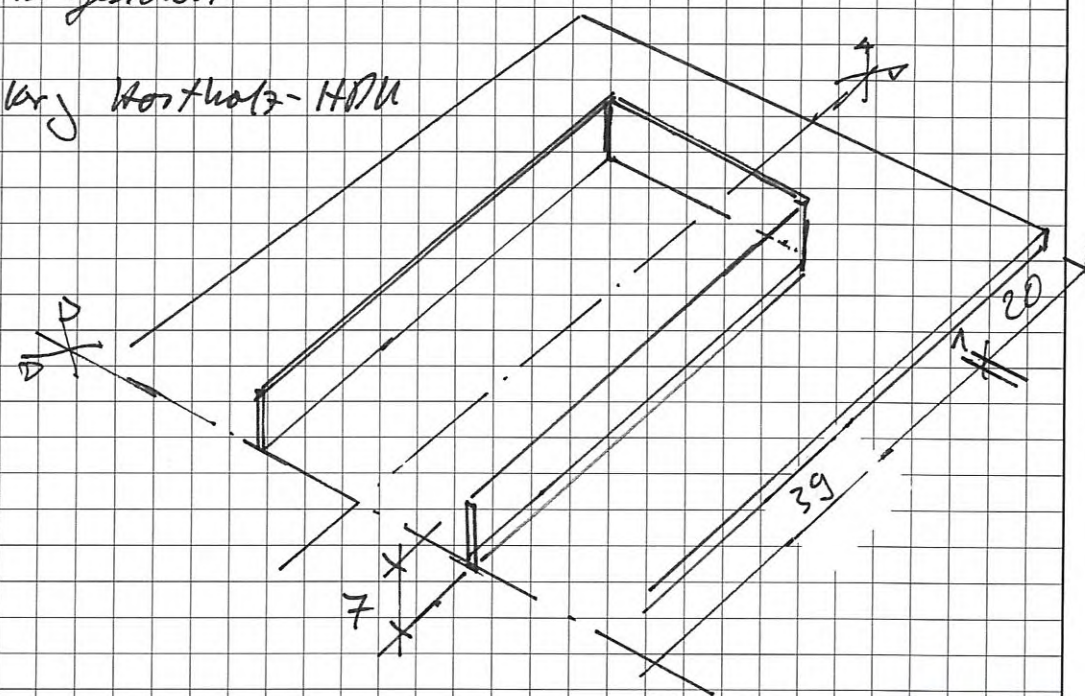
Bemessung Stahlplatte (Streifen) nachfolgend mit FEDV

- Verankerung von H_d

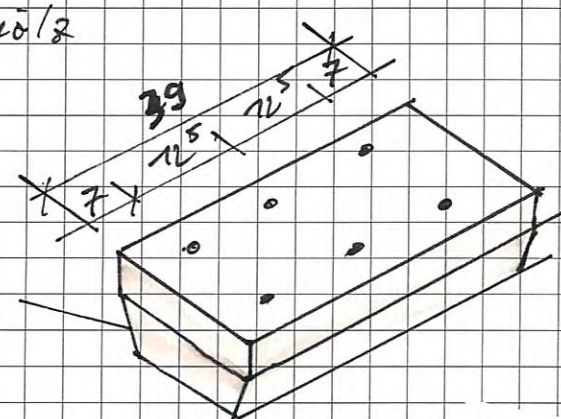
a) Stahlblech – Schraube – Hartholz
zu Hirn Formschluß,
Lage ist gesichert

Flachstahl
⊡ 10 × 70 mm

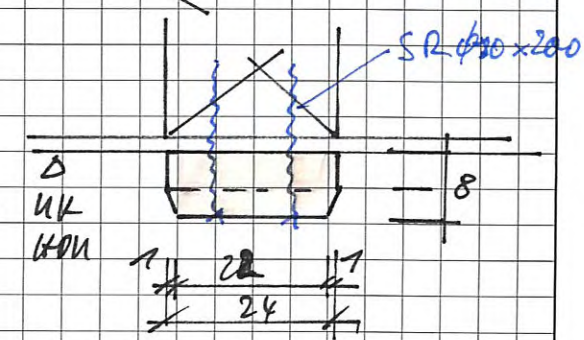
b) Verankerung Hartholz – HDU
→



Hartholz
z.B. Eiche



Fase 1cm
an drei
Seiten



in Summe $2 \times 2 \times 3$ SR ϕ10 × 200

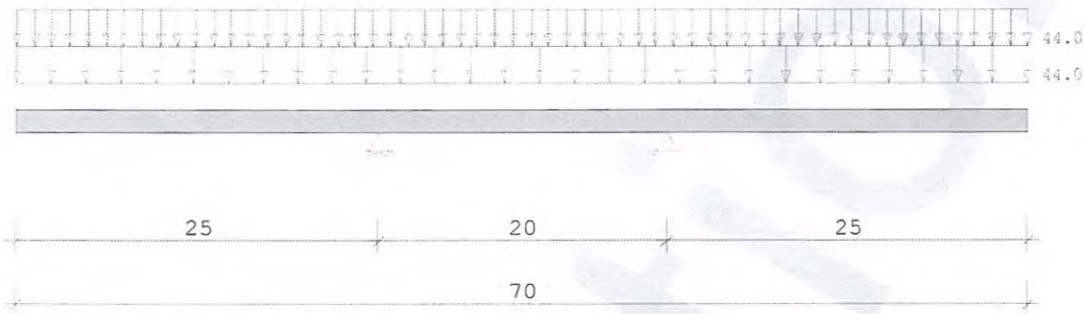
$$F_{VRK} = 2{,}7 \cdot \sqrt{\frac{530}{350}} = 3{,}3 \text{ kN je Fuge}$$

$$R_{Bd} = 2 \cdot 2 \cdot 3 \cdot 3{,}3 \cdot \frac{0{,}9}{1{,}3} = \underline{27{,}60 \text{ kN}} > H_d = 16 \cdot 1{,}5 = \underline{24 \text{ kN}}$$

1. Position: Fundamentplatte-Stahl

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

Maßstab 1 : 5



Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.200	konstant	1	14.1	18.8	18.8	BRFL500X15
Kragarm							
links	0.250	konstant	1	14.1	18.8	18.8	BRFL500X15
rechts	0.250	x = 0.000	1	14.1	18.8	18.8	BRFL500X15
		x = 0.050	1	14.1	18.8	18.8	BRFL500X15
		x = 0.250	1	14.1	18.8	18.8	BRFL500X15

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	44.000	44.000	1.000	0.000	0.700		
				44.000	44.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.100	-0.93	-1.38	-1.37	8.80	-8.80

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-2.75	-2.75	-22.00	15.68	37.68	8.53
2	-2.75	-2.75	-15.67	22.00	37.67	8.52

Auflagerkräfte			1,0 - fach			(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	15.40	22.28	-6.87	30.80	37.68	8.53
2	15.40	22.27	-6.88	30.80	37.67	8.52
Summe:	30.80	44.55	-13.75	61.60	75.35	17.05

bezogen auf 0,5m

Auflagerkräfte					(kN)
	Stütze 1		Stütze 2		
EG	max	min	max	min	
g	15.4	15.4	15.4	15.4	
A	22.3	-6.9	22.3	-6.9	
Sum	37.7	8.5	37.7	8.5	

$\hat{=}\ 61{,}6 \cdot \frac{1{,}2}{0{,}5} = 148$ kN, vergl. Auflast.

Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert γG * KFi = 1.35 über Trägerlänge konstant

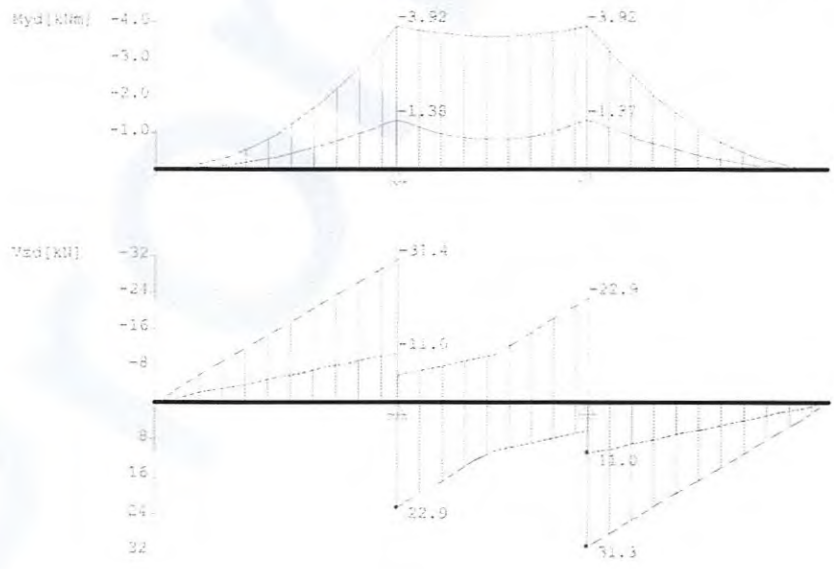
Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.100	-0.82	-1.38	-1.37	11.00	-11.00

Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-3.92	-3.92	-31.35	22.85	54.20	5.09
2	-3.92	-3.92	-22.85	31.35	54.20	5.09

max $A_d = B_d =$ $54{,}2 \cdot \frac{1{,}2}{0{,}5} = 130$ kN je Kante

$\Sigma = 2 \cdot 130 = \underline{260\ \text{kN}}$

Maßstab 1 : 7.5



max w ≤ 0,4cm
— ≅ 4mm

Querschnitte S235		fyk =	235 N/mm2			
Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL500X15	1763	7	1018	220	1018
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.250	1	-3.9	-31.4	208	0	1	0.89
1	0.000	1	-3.9	5.9	208	0	1	0.89
	0.100	1	-3.6	0.0	193	0	1	0.82
	0.200	1	-3.9	-22.9	208	0	1	0.89
Krre	0.000	1	-3.9	31.3	208	0	1	0.89
	0.250	1	0.0	0.0	0	0	1	0.00

< 1,0

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	6.6	0.00
	0.250	-3.9	-31.4	1	0.00	6.6	0.59
1	0.000	-3.9	5.9	1	0.00	6.6	0.59
	0.100	-3.6	0.0	1	0.00	6.6	0.55
	0.200	-3.9	-22.9	1	0.00	6.6	0.59
Krre	0.000	-3.9	31.3	1	0.00	6.6	0.59
	0.250	0.0	0.0	1	0.00	6.6	0.00

≤ 1,0

Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.18	0.36	0.365	0.167	**2.19!!**	2
1	0.100	-0.02	-0.04	-0.043	0.067	0.65	2
Krre	0.250	0.18	0.36	0.365	0.167	**2.19!!**	2

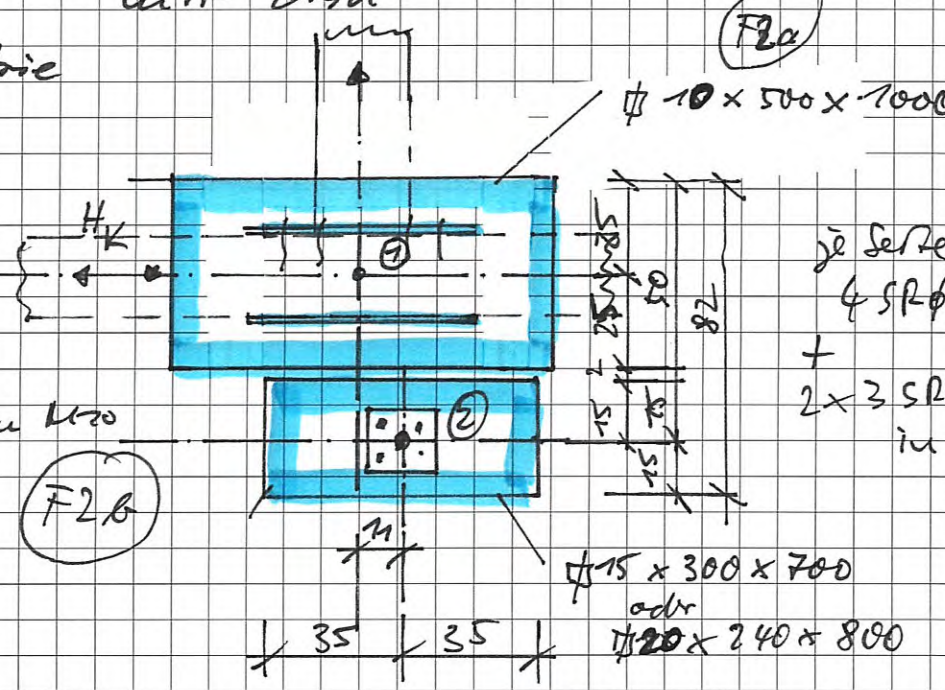
max. Verformung = 3,6mm << Setzung ~ 12mm

→ annähernd gleiche Bodenpressung

F2

Fundamentplatte Mittelachse mit Grid

• Geometrie



• Einwirkungen: (1): $G_k = 56$ kN (66%), $G_d = 75{,}6$ kN

$Q_k = 29$ kN (34%), $Q_d = 43{,}5$ kN

$P_k = 85$ kN (100%), $P_d = 119{,}1$ kN

Bodenpressung vorh $\sigma = \frac{119{,}1}{0{,}5 \cdot 1{,}0} = 238$ kN/m² < σ_{Rd}

• Einwirkungen (2): $G_k = 10$ kN, $G_d = 13{,}5$ kN

$Q_k = 20$ kN, $Q_d = 30{,}0$ "

$P_k = 30$ kN, $P_d = 43{,}5$ kN

Bodenpressung vorh $\sigma = \frac{43{,}5}{0{,}3 \cdot 0{,}7} = 207$ kN/m² < σ_{Rd}

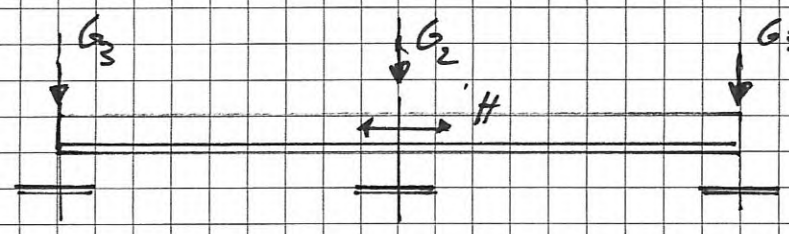
Horizontalkraft $H_d = 21{,}5 \cdot 1{,}5 = 32{,}2$ kN

aufnehmbar = $0{,}3 \cdot 56 = 16{,}8 < 32{,}2$

zu Randfundament F3 müssen mitwirken

Zusammenwirken Fundamente F2 und F3

System:



max Auflast aus $g_k = 56 + 2 \cdot 24 = 104$ kN

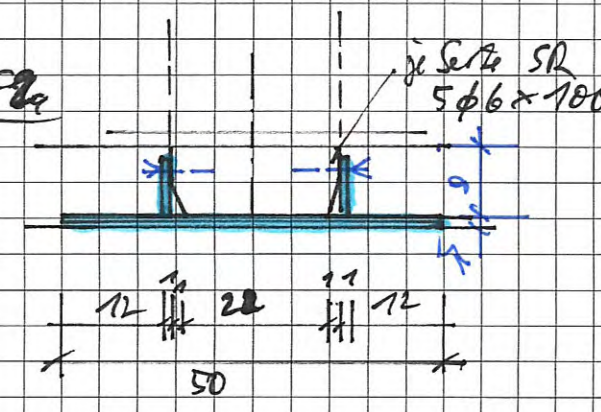
zu $0{,}3 \cdot 104 = 31{,}2$ kN ~ $H_d = 32$ kN ~ gerade ausreichend

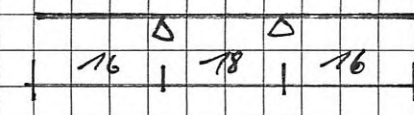
Nachweis Plattenbiegung: Pla

Platte 1,5 x 50 x 100

50 cm Streifen

$g_k = 56$ kN/m
$q_k = 29$ kN/m
$\Big\}\ q_d = 119$ kN/m

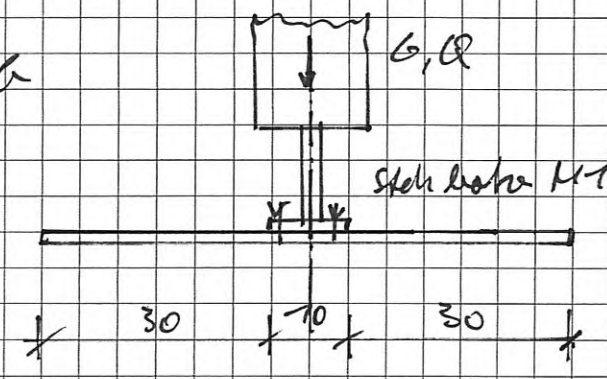




Nachweis wie folgend mit FEM

Nachweis Plattenbiegung F2b

$G_k = 10$ kN
$Q_k = 20$ kN
$\Big\}\ S = 30$ kN



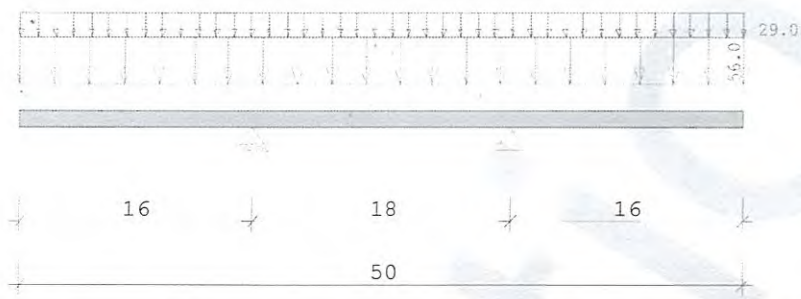
Plattenstreifen 30 cm, t = 15 mm

2. Position: F2-Fundamentplatte-Stahl

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

Platte ~~F~~ 10x 500 x 100

Maßstab 1 : 5



Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.180	konstant	1	4.2	8.3	8.3	BRFL500X10
Kragarm							
links	0.160	konstant	1	4.2	8.3	8.3	BRFL500X10
rechts	0.160	x = 0.000	1	4.2	8.3	8.3	BRFL500X10
		x = 0.050	1	4.2	8.3	8.3	BRFL500X10
		x = 0.160	1	4.2	8.3	8.3	BRFL500X10

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	56.000	29.000	1.000	0.000	0.500		
				56.000	29.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.090	-0.37	-0.72	-0.72	7.65	-7.65

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-1.09	-1.09	-13.60	9.71	23.31	11.94
2	-1.09	-1.09	-9.71	13.60	23.31	11.94

13

Auflagerkräfte						(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	14.00	9.31	-2.06	21.25	23.31	11.94
2	14.00	9.31	-2.06	21.25	23.31	11.94
Summe:	28.00	18.62	-4.12	42.50	46.62	23.88

Auflagerkräfte					(kN)
	Stütze 1		Stütze 2		
EG	max	min	max	min	
g	14.0	14.0	14.0	14.0	
A	9.3	-2.1	9.3	-2.1	
Sum	23.3	11.9	23.3	11.9	

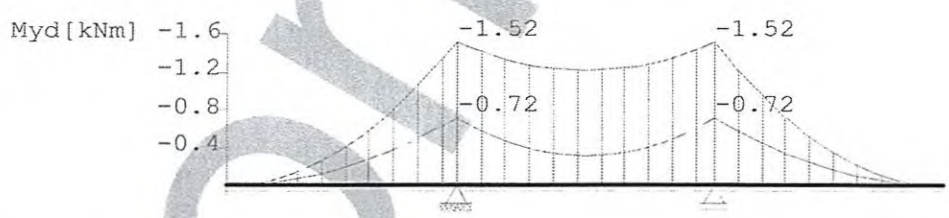
$2 \times 42{,}5 = 85$ kN $\hat{=} P_K$

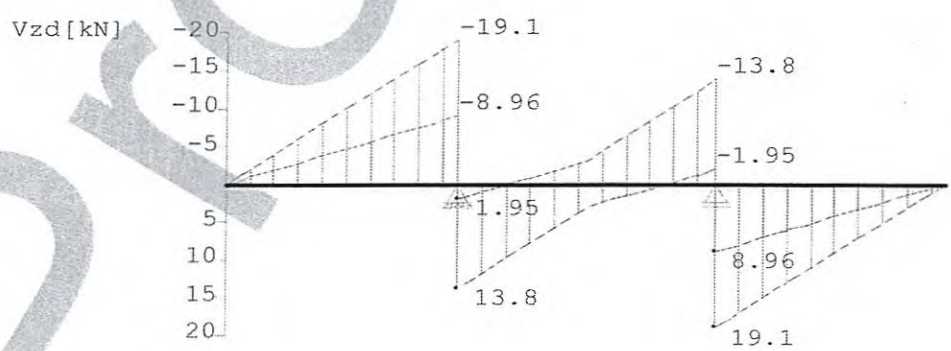
Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert $\gamma_G * K_{Fi} = 1.35$ über Trägerlänge konstant

Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.090	-0.31	-0.72	-0.72	8.95	-8.96

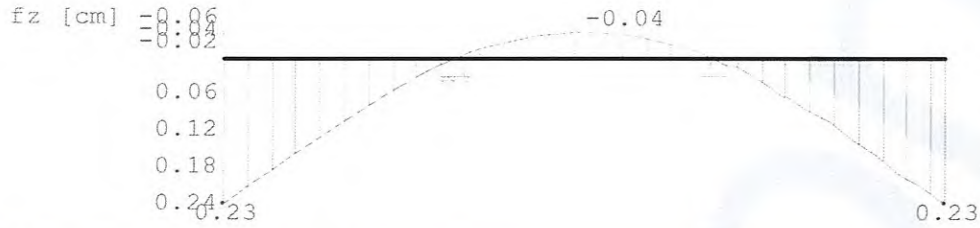
Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-1.52	-1.52	-19.06	13.81	32.87	10.91
2	-1.52	-1.52	-13.81	19.06	32.87	10.91

Maßstab 1 : 5





Promotion



max w = 2,3 mm

< Setzung

Querschnitte S235		fyk = 235 N/mm2				
Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL500X10	1175	3	678	147	678
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.160	1	-1.5	-19.1	183	0	1	0.78
1	0.000	1	-1.5	6.8	183	0	1	0.78
	0.090	1	-1.2	0.0	146	0	1	0.62
	0.180	1	-1.5	-6.8	183	0	1	0.78
Krre	0.000	1	-1.5	19.1	183	0	1	0.78
	0.160	1	0.0	0.0	0	0	1	0.00

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	2.9	0.00
	0.160	-1.5	-19.1	1	0.00	2.9	0.52
1	0.000	-1.5	6.8	1	0.00	2.9	0.52
	0.090	-1.2	0.0	1	0.00	2.9	0.41
	0.180	-1.5	-6.8	1	0.00	2.9	0.52
Krre	0.000	-1.5	19.1	1	0.00	2.9	0.52
	0.160	0.0	0.0	1	0.00	2.9	0.00

Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

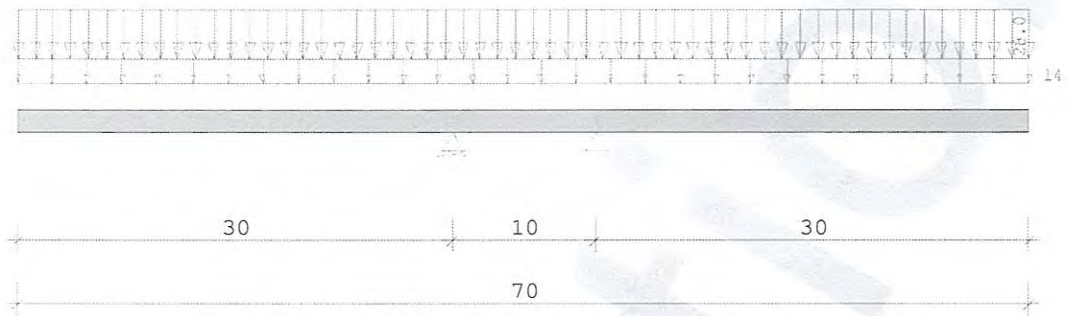
Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.15	0.23	0.234	0.107	**2.19!!**	2
1	0.090	-0.02	-0.04	-0.042	0.060	0.69	2
Krre	0.160	0.15	0.23	0.234	0.107	**2.19!!**	2

3. Position: F2b_Fundamentplatte

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

⊞ 15 x 300 x 700

Maßstab 1 : 5



Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.100	konstant	1	8.4	11.3	11.3	BRFL300X15
Kragarm							
links	0.300	konstant	1	8.4	11.3	11.3	BRFL300X15
rechts	0.300	x = 0.000	1	8.4	11.3	11.3	BRFL300X15
		x = 0.050	1	8.4	11.3	11.3	BRFL300X15
		x = 0.300	1	8.4	11.3	11.3	BRFL300X15

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	14.000	28.000	1.000	0.000	0.700		
				14.000	28.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.050	-0.58	-0.63	-0.63	2.10	-2.10

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-1.89	-1.89	-12.60	14.70	27.30	-7.70
2	-1.89	-1.89	-14.70	12.60	27.30	-7.70

Auflagerkräfte						(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	4.90	22.40	-12.60	14.70	27.30	-7.70
2	4.90	22.40	-12.60	14.70	27.30	-7.70
Summe:	9.80	44.80	-25.20	29.40	54.60	-15.40

$\hat{=} \Sigma\ 10 + 20 = 30$ kN

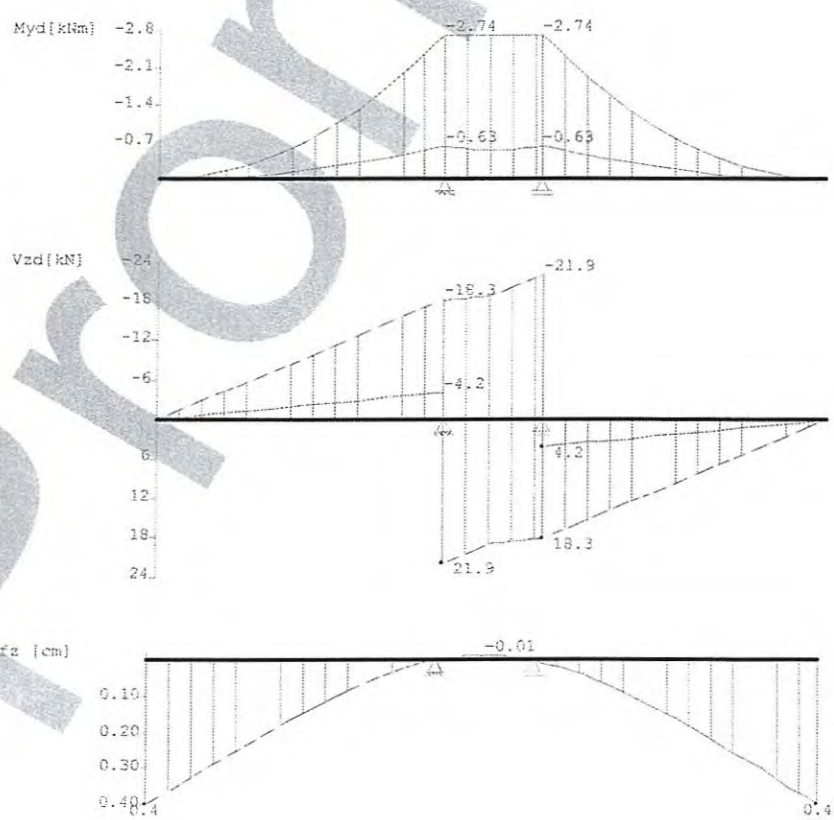
Auflagerkräfte					(kN)
	Stütze 1		Stütze 2		
EG	max	min	max	min	
g	4.9	4.9	4.9	4.9	
A	22.4	-12.6	22.4	-12.6	
Sum	27.3	-7.7	27.3	-7.7	

Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert $\gamma G * K_{Fi} = 1.35$ über Trägerlänge konstant

Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.050	-0.56	-0.63	-0.63	2.80	-2.80

Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-2.74	-2.74	-18.27	21.95	40.21	-14.00
2	-2.74	-2.74	-21.95	18.27	40.21	-14.00

Maßstab 1 : 7.5



Prüfexemplar

Querschnitte S235 fyk = 235 N/mm2

Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL300X15	1058	4	611	79	611
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η elastisch
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.300	1	-2.7	-18.3	244	0	1	**1.04!!**
1	0.000	1	-2.7	0.9	244	0	1	**1.04!!**
	0.050	1	-2.7	0.0	241	0	1	**1.03!!**
	0.100	1	-2.7	-21.9	244	0	1	**1.04!!**
Krre	0.000	1	-2.7	18.3	244	0	1	**1.04!!**
	0.300	1	0.0	0.0	0	0	1	0.00

plastisch

$\eta = 0{,}7 < 1$

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	4.0	0.00
	0.300	-2.7	-18.3	1	0.00	4.0	0.69
1	0.000	-2.7	0.9	1	0.00	4.0	0.69
	0.050	-2.7	0.0	1	0.00	4.0	0.69
	0.100	-2.7	-21.9	1	0.00	4.0	0.69
Krre	0.000	-2.7	18.3	1	0.00	4.0	0.69
	0.300	0.0	0.0	1	0.00	4.0	0.00

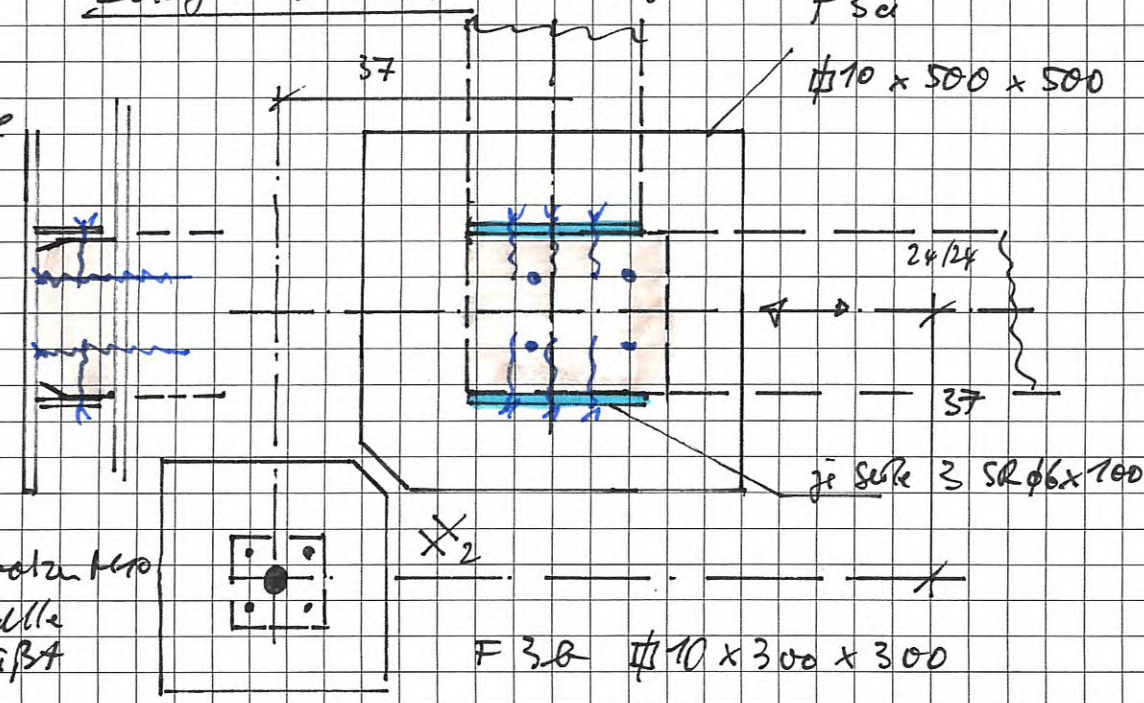
Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.13	0.40	0.399	0.200	**1.99!!**	2
1	0.050	0.00	-0.01	-0.013	0.033	0.40	2
Krre	0.300	0.13	0.40	0.399	0.200	**1.99!!**	2

F3 **Eckfundament** (4x)

Geometrie



Teilplatte F3a:

$G_k = 24\ kN$ (61%) → $G_d = 32{,}4\ kN$

$Q_k = 15\ kN$ (39%) → $Q_d = 22{,}5\ kN$

$\Sigma P_k = 39\ kN$ (100%) → $P_d = 54{,}9\ kN$

Bodenpressung vorl. $\sigma = \frac{54{,}9}{0{,}5 \cdot 0{,}5} = 220\ kN/m^2 < \sigma_{Rd}$

Teilplatte F3b:

$G_k = 4\ kN$ (29%) → $G_d = 5{,}4\ kN$

$Q_k = 10\ kN$ (71%) → $Q_d = 15{,}0$ "

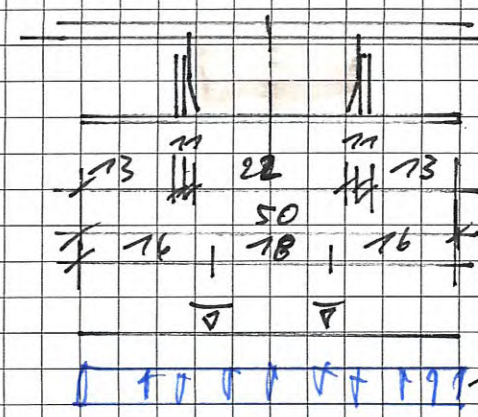
$P_k = 14\ kN$ (100%) → $P_d = 20{,}4\ kN$

Bodenpressung vor $\sigma = \frac{20{,}4}{0{,}3^2} = 226\ kN/m^2 < \sigma_{Rd}$

- Nachweis horizontale Lasteinleitung
  → siehe Nachweis auf F2a
  Verbindung HDM – Hartholz

- Nachweis Stahlplatten

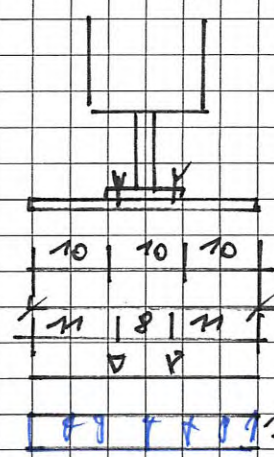
F3a:



g_k = 47 kN/m
q_k = 31 kN/m
Σ = 78 kN/m

P_k = 39 kN ≙ 78 kN/m (ℓ = 0,5)

F3b



Stabdübel M10

g_k = 14 kN/m
q_k = 33 kN/m
Σ = 47 kN/m

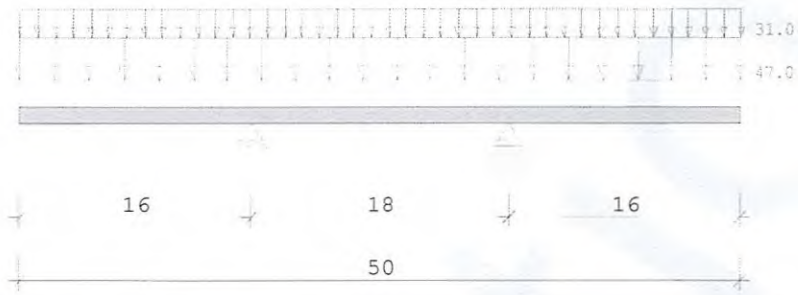
bei ℓ = 0,3 m, ΣP_k = 0,3 · 47 = 14,1 kN

Nachweise nach folgend mit EDV

4. Position: F3a-Fundamentplatte-Stahl

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

Maßstab 1 : 5



Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.180	konstant	1	4.2	8.3	8.3	BRFL500X10
Kragarm							
links	0.160	konstant	1	4.2	8.3	8.3	BRFL500X10
rechts	0.160	x = 0.000	1	4.2	8.3	8.3	BRFL500X10
		x = 0.050	1	4.2	8.3	8.3	BRFL500X10
		x = 0.160	1	4.2	8.3	8.3	BRFL500X10

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	47.000	31.000	1.000	0.000	0.500		
				47.000	31.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.090	-0.29	-0.60	-0.60	7.02	-7.02

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-1.00	-1.00	-12.48	9.22	21.70	9.55
2	-1.00	-1.00	-9.22	12.48	21.70	9.55

21

Auflagerkräfte				1,0-fach		(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	11.75	9.95	-2.20	19.50	21.70	9.55
2	11.75	9.95	-2.20	19.50	21.70	9.55
Summe:	23.50	19.91	-4.41	39.00	43.41	19.09

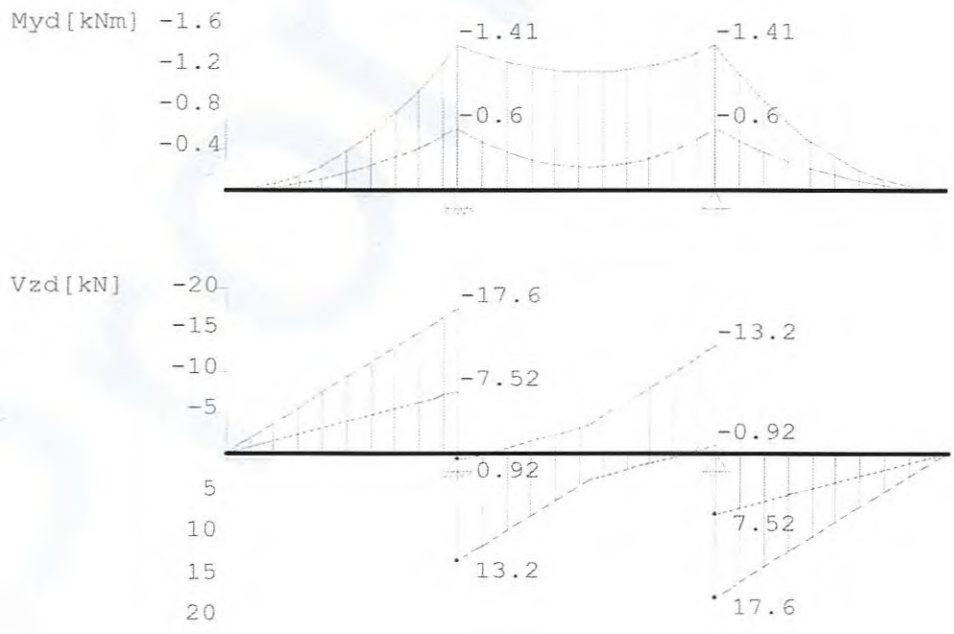
Auflagerkräfte				≙ Auflast P_K	(kN)
	Stütze 1		Stütze 2		
EG	max	min	max	min	
g	11.8	11.8	11.7	11.7	
A	10.0	-2.2	10.0	-2.2	
Sum	21.7	9.5	21.7	9.5	

Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert $\gamma G * K_{Fi} = 1.35$ über Trägerlänge konstant

Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.090	-0.22	-0.60	-0.60	8.42	-8.41

Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-1.41	-1.41	-17.59	13.20	30.79	8.44
2	-1.41	-1.41	-13.20	17.59	30.79	8.44

Maßstab 1 : 5



22

max
w = 2,2 mm

Querschnitte S235		fyk =	235 N/mm2			
Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL500X10	1175	3	678	147	678
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.160	1	-1.4	-17.6	169	0	1	0.72
1	0.000	1	-1.4	5.7	169	0	1	0.72
	0.090	1	-1.2	0.0	138	0	1	0.59
	0.180	1	-1.4	-13.2	169	0	1	0.72
Krre	0.000	1	-1.4	17.6	169	0	1	0.72
	0.160	1	0.0	0.0	0	0	1	0.00

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	2.9	0.00
	0.160	-1.4	-17.6	1	0.00	2.9	0.48
1	0.000	-1.4	5.7	1	0.00	2.9	0.48
	0.090	-1.2	0.0	1	0.00	2.9	0.39
	0.180	-1.4	-13.2	1	0.00	2.9	0.48
Krre	0.000	-1.4	17.6	1	0.00	2.9	0.48
	0.160	0.0	0.0	1	0.00	2.9	0.00

Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

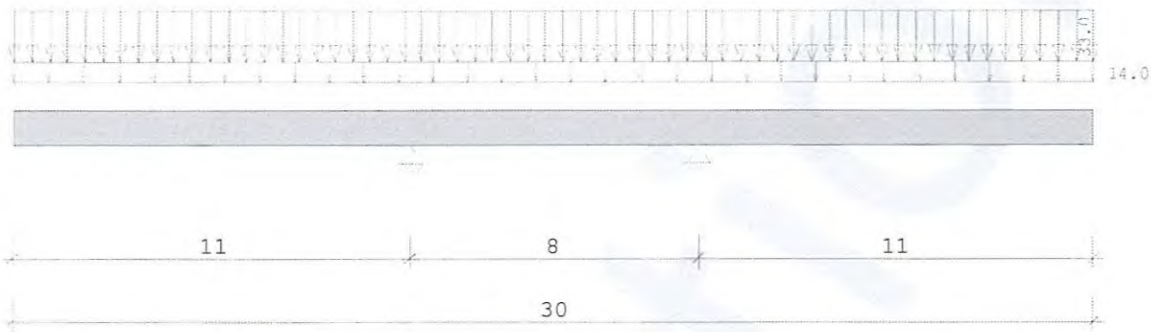
Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.12	0.22	0.216	0.107	**2.03!!**	2
1	0.090	-0.02	-0.04	-0.039	0.060	0.65	2
Krre	0.160	0.12	0.22	0.216	0.107	**2.03!!**	2

5. Position: F3b_Fundamentplatte

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

Maßstab 1 : 2



Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.080	konstant	1	2.5	5.0	5.0	BRFL300X10
Kragarm							
links	0.110	konstant	1	2.5	5.0	5.0	BRFL300X10
rechts	0.110	x = 0.000	1	2.5	5.0	5.0	BRFL300X10
		x = 0.050	1	2.5	5.0	5.0	BRFL300X10
		x = 0.110	1	2.5	5.0	5.0	BRFL300X10

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	14.000	33.000	1.000	0.000	0.300		
				14.000	33.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.040	-0.05	-0.08	-0.08	1.88	-1.88

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-0.28	-0.28	-5.17	4.38	9.55	-0.40
2	-0.28	-0.28	-4.38	5.17	9.55	-0.40

Auflagerkräfte				1,0 - fach		(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	2.10	7.45	-2.50	7.05	9.55	-0.40
2	2.10	7.45	-2.50	7.05	9.55	-0.40
Summe:	4.20	14.89	-4.99	14.10	19.09	-0.79

= was Bodenpr. PK

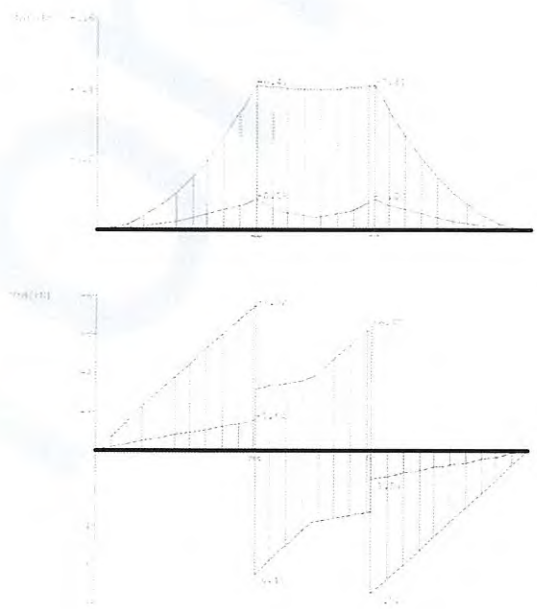
Auflagerkräfte				
	Stütze 1		Stütze 2	
EG	max	min	max	min
g	2.1	2.1	2.1	2.1
A	7.4	-2.5	7.4	-2.5
Sum	9.5	-0.4	9.5	-0.4

Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert $\gamma G * K_{Fi} = 1.35$ über Trägerlänge konstant

Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.040	-0.03	-0.08	-0.08	2.54	-2.54

Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-0.41	-0.41	-7.52	6.48	14.00	-1.64
2	-0.41	-0.41	-6.48	7.52	14.00	-1.64

Maßstab 1 : 5



Querschnitte S235 fyk = 235 N/mm2

Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL300X10	705	2	407	53	407
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.110	1	-0.4	-7.5	83	0	1	0.35
1	0.000	1	-0.4	0.8	83	0	1	0.35
	0.040	1	-0.4	0.0	80	0	1	0.34
	0.080	1	-0.4	-6.5	83	0	1	0.35
Krre	0.000	1	-0.4	7.5	83	0	1	0.35
	0.110	1	0.0	0.0	0	0	1	0.00

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	1.8	0.00
	0.110	-0.4	-7.5	1	0.00	1.8	0.23
1	0.000	-0.4	0.8	1	0.00	1.8	0.23
	0.040	-0.4	0.0	1	0.00	1.8	0.23
	0.080	-0.4	-6.5	1	0.00	1.8	0.23
Krre	0.000	-0.4	7.5	1	0.00	1.8	0.23
	0.110	0.0	0.0	1	0.00	1.8	0.00

Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

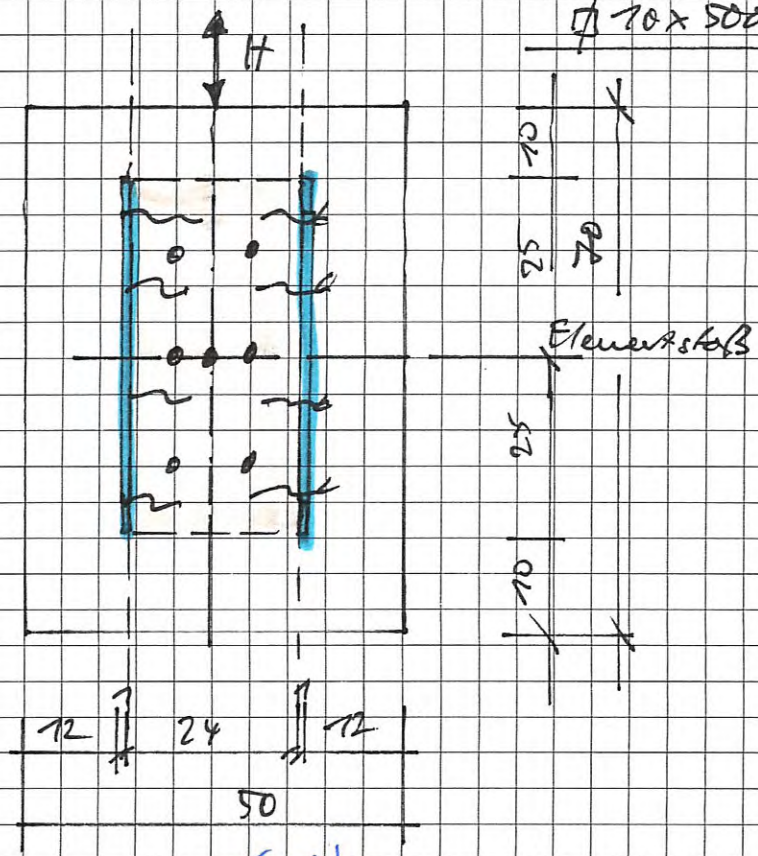
Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.01	0.04	0.040	0.073	0.54	2
1	0.040	0.00	0.00	-0.004	0.027	0.16	2
Krre	0.110	0.01	0.04	0.040	0.073	0.54	2

F4 Fundamentplatte Längswände (4x)

□ 10 x 500 x 700

Geometrie



Bestehend
2 x 4 SR ϕ 6 x 100
Geschlossen in
HDU
2 x 3 ϕ 10 x 200

Einwirkungen:

$G_k = 33$ kN (57%) → $G_d = 45$ kN

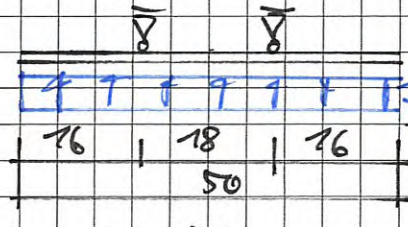
$Q_k = 25$ kN (43%) → $Q_d = 33{,}3$ kN

$P_k = 58$ kN (100%) → $P_d = 78{,}3$ kN

Bodenpressung: erf $\sigma = \frac{78{,}3}{0{,}5 \cdot 0{,}7} = 223$ kN < □ Rd =

Nachweis Platte

0,5 m-Streifen



$g_k = 47$ kN/m · 0,5/0,7

$q_k = 36$ kN/m · 0,5/0,7

$\Sigma = 83$ kN/m · 0,5/0,7

$= 59$ kN/m

P_k bezogen auf 0,5 m-Streifen

$= 58 \cdot \frac{0{,}5}{0{,}7} = 41{,}5$ kN

Bemessung nachfolgend mit FEM

Nachweis Verankerung.

max H_k = 13,5 kN, wirkt auf 2 Fundamente F4

M_{dstab} = 1,5 · 13,5 · 3 = 60,7 kNm

Achsabstand 2,1 m

→ $D = \frac{M}{a} = \frac{60,7}{2,1} = 28,9$ kN

Aufgrund 0,9 · G_k = 29,7 kN > 28,9 kN ✓

→ keine Zugverankerung erforderlich.

Gleitsicherheit Beiwert 0,3 (Stahl-Schotter).

→ 2 · 33 · 0,3 = 19,8 kN < vorh H_d = 20,25 kN
G_k

Zu + Verbindung Eckfundament

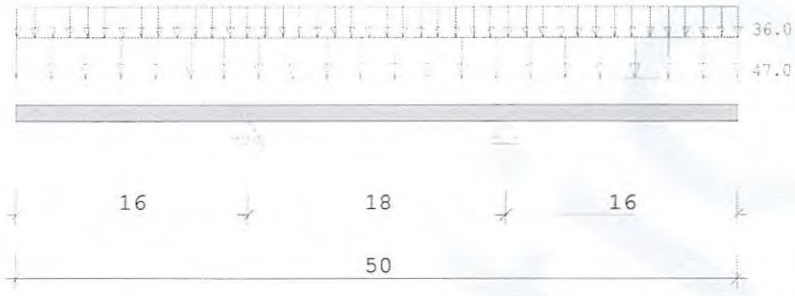
→ ΣV_k = 2 · 33 + 50% · 2 · 24 = 90 kN

→ 0,3 · 90 = 27 kN > vorh H_d = 20,25 kN

6. Position: F4-Fundamentplatte-Stahl

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

Maßstab 1 : 5



50 cm - Stütze

Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.180	konstant	1	4.2	8.3	8.3	BRFL500X10
Kragarm							
links	0.160	konstant	1	4.2	8.3	8.3	BRFL500X10
rechts	0.160	x = 0.000	1	4.2	8.3	8.3	BRFL500X10
		x = 0.050	1	4.2	8.3	8.3	BRFL500X10
		x = 0.160	1	4.2	8.3	8.3	BRFL500X10

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	47.000	36.000	1.000	0.000	0.500		
				47.000	36.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.090	-0.27	-0.60	-0.60	7.47	-7.47

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-1.06	-1.06	-13.28	10.03	23.31	9.19
2	-1.06	-1.06	-10.03	13.28	23.31	9.19

Auflagerkräfte						(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	11.75	11.56	-2.56	20.75	23.31	9.19
2	11.75	11.56	-2.56	20.75	23.31	9.19
Summe:	23.50	23.12	-5.12	41.50	46.62	18.38

≙ $P_K = 47{,}5$ (kN) bei 50cm-Streifen

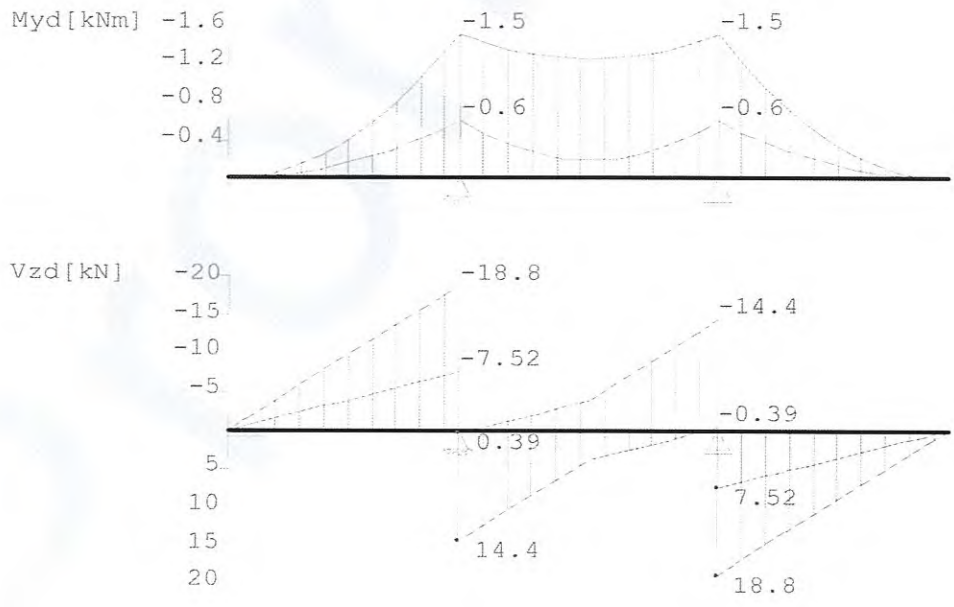
Auflagerkräfte				
	Stütze 1		Stütze 2	
EG	max	min	max	min
g	11.8	11.8	11.7	11.7
A	11.6	-2.6	11.6	-2.6
Sum	23.3	9.2	23.3	9.2

Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert $\gamma G * K_{Fi} = 1.35$ über Trägerlänge konstant

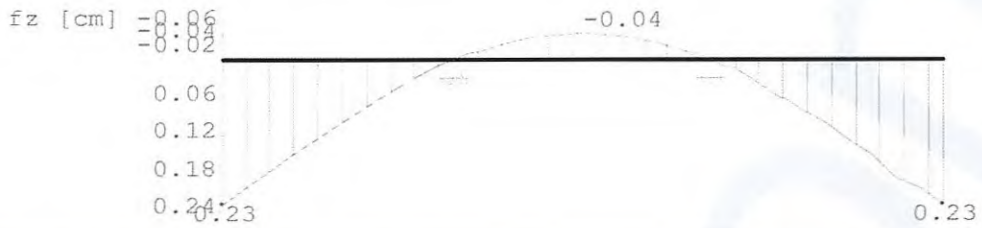
Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.090	-0.19	-0.60	-0.60	9.09	-9.09

Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-1.50	-1.50	-18.79	14.41	33.20	7.91
2	-1.50	-1.50	-14.41	18.79	33.20	7.91

Maßstab 1 : 5



30



max
w = 2,3 cm

Querschnitte S235		fyk = 235 N/mm2				
Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL500X10	1175	3	678	147	678
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.160	1	-1.5	-18.8	180	0	1	0.77
1	0.000	1	-1.5	5.7	180	0	1	0.77
	0.090	1	-1.2	0.0	149	0	1	0.64
	0.180	1	-1.5	-14.4	180	0	1	0.77
Krre	0.000	1	-1.5	18.8	180	0	1	0.77
	0.160	1	0.0	0.0	0	0	1	0.00

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	2.9	0.00
	0.160	-1.5	-18.8	1	0.00	2.9	0.51
1	0.000	-1.5	5.7	1	0.00	2.9	0.51
	0.090	-1.2	0.0	1	0.00	2.9	0.42
	0.180	-1.5	-14.4	1	0.00	2.9	0.51
Krre	0.000	-1.5	18.8	1	0.00	2.9	0.51
	0.160	0.0	0.0	1	0.00	2.9	0.00

Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

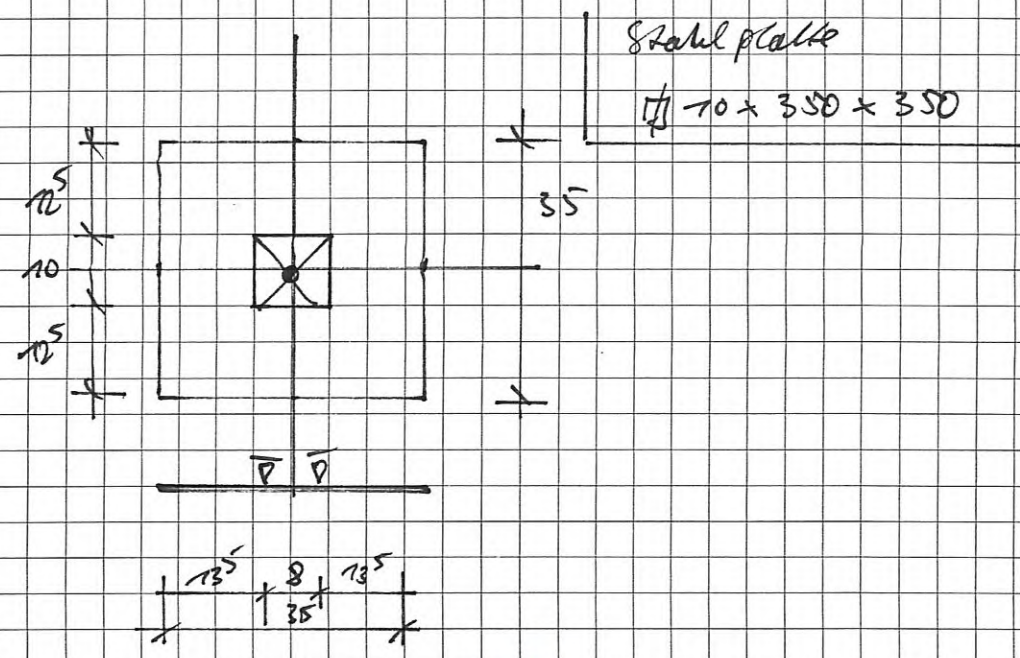
Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.12	0.23	0.231	0.107	**2.17!!**	2
1	0.090	-0.02	-0.04	-0.042	0.060	0.70	2
Krre	0.160	0.12	0.23	0.231	0.107	**2.17!!**	2

FS Fundamentplatte unter Grid

Geometrie

Stahlplatte
10 × 350 × 350



max. Einwirkung:

$G_k = 2\,kN$ 10% → $G_d = 2{,}7\,kN$

$Q_k = 18\,kN$ 90% → $Q_d = 27{,}0\,kN$

$P_k = 20\,kN$ 100% $P_d = 29{,}7\,kN$

max. Bodenpressung $\sigma = \frac{29{,}7}{0{,}35^2} = 242\,kN/m^2 < \sigma_{Rd}$

Nachweis Platte, Belastung $g_k = 6\,kN/m$

$p_k = 57\,kN/m$

7. Position: F5-Fundamentplatte-Stahl_Grid

Durchlaufträger DLT10 01/2022/A (Frilo R-2022-1/P05)

Maßstab 1 : 5

Stahlträger S235 DIN EN 1993-1-1/NA:2015-08
E-Modul E =210000 N/mm2

System	Länge		Querschnittswerte				
Feld	L (m)		QNr.	I (cm4)	Wo (cm3)	Wu (cm3)	
1	0.080	konstant	1	2.9	5.8	5.8	BRFL350X10
Kragarm							
links	0.135	konstant	1	2.9	5.8	5.8	BRFL350X10
rechts	0.135	x = 0.000	1	2.9	5.8	5.8	BRFL350X10
		x = 0.050	1	2.9	5.8	5.8	BRFL350X10
		x = 0.135	1	2.9	5.8	5.8	BRFL350X10

Trägerbezogene Lasten (kN,m)

Belastung (kN,m) Lasttyp: 1=Gleichlast über L 2=Einzellast bei a 3=Einzelmoment bei a 4=Trapezlast von a - a+b 5=Dreieckslast über L 6=Trapezlast über L

Typ	EG	Gr	VK	g_l/r	q_l/r	Fak.	Abst. Lb/Lc		ausPOS	Phi
4	A		0.000	6.000	51.000	1.000	0.000	0.350		
				6.000	51.000					

Einwirkungen:

Nr	Kl	Bezeichnung	ψ0	ψ1	ψ2	γ
A	1	Wohnräume	0.70	0.50	0.30	1.50

Schadensfolgeklasse CC 2 nach EN 1990 Tab. B1 -> K_{Fi} = 1.0 Tab. B3

Ergebnisse für 1-fache Lasten

Feldmomente Maximum (kNm , kN)

Feld		Mf	M li	M re	V li	V re
1	x0 = 0.040	-0.01	-0.05	-0.05	2.28	-2.28

Stützmomente Maximum (kNm , kN)

Stütze	M li	M re	V li	V re	max F	min F
1	-0.52	-0.52	-7.70	8.09	15.78	-4.76
2	-0.52	-0.52	-8.09	7.69	15.78	-4.76

Auflagerkräfte						(kN)
Stütze	aus g	max q	min q	Vollast	max	min
1	1.05	14.73	-5.81	9.98	15.78	-4.76
2	1.05	14.73	-5.81	9.97	15.78	-4.76
Summe:	2.10	29.47	-11.62	19.95	31.57	-9.52

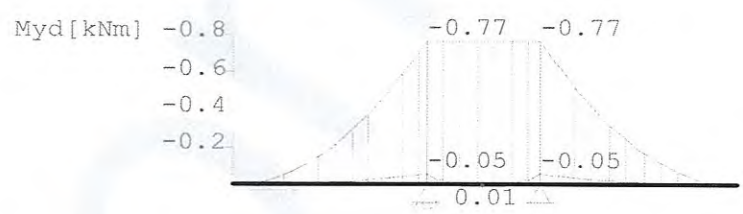
Auflagerkräfte					(kN)
	Stütze 1		Stütze 2		
EG	max	min	max	min	
g	1.1	1.1	1.0	1.0	
A	14.7	-5.8	14.7	-5.8	
Sum	15.8	-4.8	15.8	-4.8	

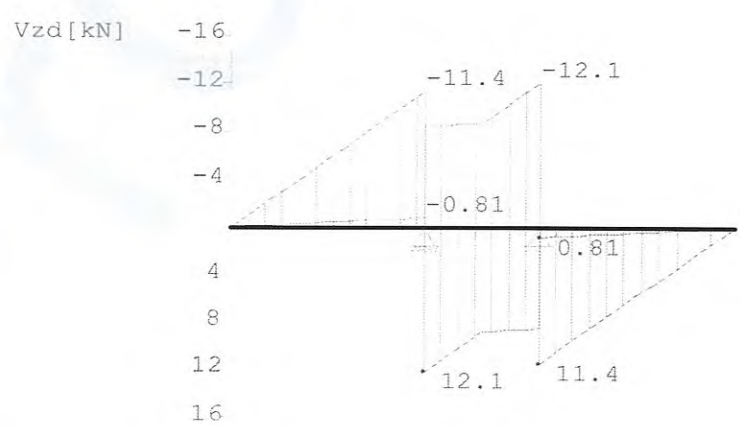
Ergebnisse für γ-fache Lasten
Teilsicherheitsbeiwert $\gamma G * K_{Fi} = 1.35$ über Trägerlänge konstant

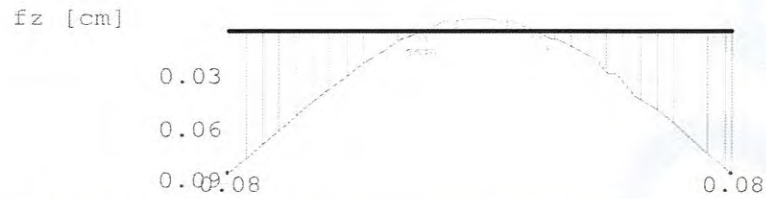
Feldmomente Maximum						(kNm , kN)
Feld		Mfd	Mdli	Mdre	V li	V re
1	x0 = 0.040	0.01	-0.05	-0.05	3.30	-3.30

Stützmomente Maximum						(kNm , kN)
Stütze	Mdli	Mdre	Vdli	Vdre	max F	min F
1	-0.77	-0.77	-11.42	12.10	23.52	-7.66
2	-0.77	-0.77	-12.10	11.42	23.52	-7.66

Maßstab 1 : 5







Querschnitte S235 fyk = 235 N/mm2

Art	Name	Npl	Mplyd	Vplzd	Mplzd	Vplyd
17	BRFL350X10	823	2	475	72	475
17	BRFL600X25	3525	22	2035	529	2035

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.1) γM0 = 1.00

Feld Nr.	x (m)	QNr.	My,ed (kNm)	Vz,ed (kN)	σv (N/mm2)	τ	QKL	η
Krli	0.000	1	0.0	0.0	0	0	1	0.00
	0.135	1	-0.8	-11.4	132	0	1	0.56
1	0.000	1	-0.8	0.3	132	0	1	0.56
	0.040	1	-0.8	0.0	131	0	1	0.56
	0.080	1	-0.8	-0.3	132	0	1	0.56
Krre	0.000	1	-0.8	11.4	132	0	1	0.56
	0.135	1	0.0	0.0	0	0	1	0.00

Nachweis nach DIN EN 1993-1-1/NA:2015-08 6.2.1 (6.2) γM0 = 1.00

Feld Nr.	x (m)	My,ed (kNm)	Vz,ed (kN)	QKL (-)	ρ (-)	M,Rd (kNm)	η
Krli	0.000	0.0	0.0	1	0.00	2.1	0.00
	0.135	-0.8	-11.4	1	0.00	2.1	0.37
1	0.000	-0.8	0.3	1	0.00	2.1	0.37
	0.040	-0.8	0.0	1	0.00	2.1	0.37
	0.080	-0.8	-0.3	1	0.00	2.1	0.37
Krre	0.000	-0.8	11.4	1	0.00	2.1	0.37
	0.135	0.0	0.0	1	0.00	2.1	0.00

Der Druckgurt ist kontinuierlich gehalten.
Nachweis Biegedrillknicken ist nicht erforderlich.

Zulässige Durchbiegungen : im Feld zul f = L / 300
charakteristische KombinationKragarm L / 150

Feld Nr.	x (m)	fg (cm)	ftot (cm)	f (cm)	zulf (cm)	η	
Krli	0.000	0.01	0.08	0.084	0.090	0.93	2
1	0.040	0.00	-0.01	-0.007	0.027	0.25	2
Krre	0.135	0.01	0.08	0.084	0.090	0.93	2

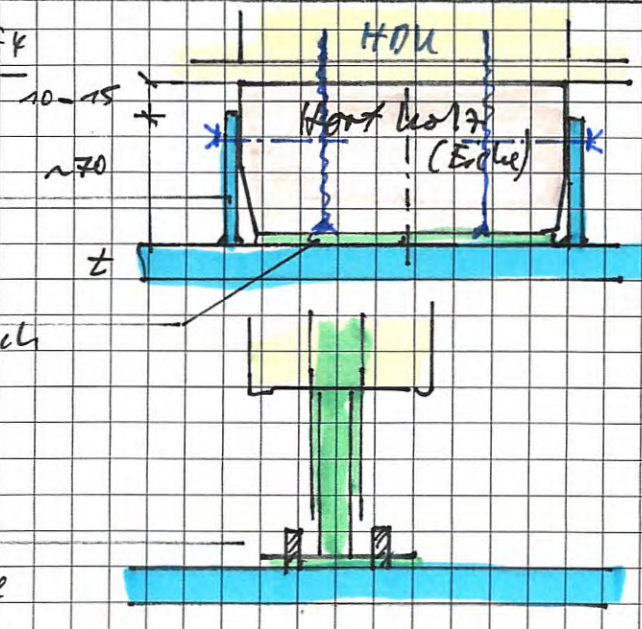
Auflistung Plattenabmessungen usw in mm

Pos.	Dicke t	Länge l	Breite b	Anzahl	Aufk. Blech	Bohrungen im Flachstahl	Hartholz	SR
F1	15	1000	700	2	2×70×800 2×70×240	/	2× l = 39cm	6 ϕ10×200
F2a	10	1000	500	2	2×70×600	2×4 ϕ8	1× l = 60cm	6×ϕ10×200 8×ϕ6×100
F2b	20	800	240	2	/	/	/	Stehbolzen 4×M10
F3a	10	500	500	4	2×70×240	2×3 ϕ8	1×l = 24cm	4×ϕ10×200 / 6×ϕ6×100
F3b	10	300	300	4	/	/	/	4 Stehbolzen M10
F4	10	700	500	4	2×70×500	2×4 ϕ8	2×l = 25cm	6×ϕ10×200 8×ϕ6×100
F5	10	350	350	9	/	/	/	4 Stehbolzen M10

Prinzip Platte F1, F2a, F3a, F4

Flachstahl t = 8mm
+ Hohlkehlt Δ3mm

event. Futterstücke
zum Höhenausgleich



Prinzip Platten F2b, F3b, F5

2×2 Stehbolzen M10

Geometrie in Plattenmitte
gemäß Stützenfußplatte

Appendix B – Timber construction

Statische Berechnung

Auftrags-Nr.: 48-2021

Bauvorhaben: Solar Decathlon
Alpenweg 25, 87746 Erkheim

Bauherr: Bau-Fritz GmbH & Co. KG
Alpenweg 25 , 87746 Erkheim

Architekt: Bau-Fritz GmbH & Co. KG
Alpenweg 25, 87746 Erkheim
Tel.:
E-Mail:

Tragwerksplanung: Tobias Müller B.Eng.
Alpenweg 25, 87746 Erkheim
Tel.: 08336 900-325
E-Mail: tobias.mueller@baufritz.de

aufgestellt: Erkheim, den 02.02.2022

Tobias Müller B.Eng.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Inhaltsverzeichnis

Position	Beschreibung	Seite
TB	Titelblatt	1
	Inhalt	2
B	Baubeschreibung	4
GEO	Standortdaten	5
W+S	Wind und Schneelast	6
L1	Bauteile - Einwirkungen und Lasten	13
Positionsliste		15
G0	Lastermittlung Solarnetz BSH GL24c b/h = 16/16 cm	16
G01	Lastermittlung Solarnetz BSH GL24c b/h = 16/16 cm	17
G02	Lastermittlung Solarnetz BSH GL24c b/h = 16/16 cm	18
G03	Lastermittlung Solarnetz BSH GL24c b/h = 16/16 cm	19
G1	Grid Randträger BSH GL24c b/h = 16/16 cm	20
G2	Grid Randträger BSH GL24c b/h = 16/24 cm	24
G3	Grid Randträger BSH GL24c b/h = 16/20 cm	28
G4	Grid Randträger BSH GL24c b/h = 16/16 cm	32
G5	Grid Dachträger BSH GL24c b/h = 16/16 cm	36
G5a	Grid Dachträger BSH GL24c b/h = 16/16 cm	40
G6	Grid Dachträger BSH GL24c b/h = 16/16 cm	45
D1.1	Sparren NH C24 b/h = 7/24 cm	50
D1.2	Sparren NH C24 b/h = 7/24 cm	56
D1.3	Sparren mit Zusatzlasten BSH GL24c b/h = 18/24 cm	62
D1.4	Sparren mit Zusatzlasten BSH GL24c b/h = 18/24 cm	66
D2	Unterzug deckengleich (beidseitig SSV) BSH GL24c b/h = 18/24 cm	70
St1.1	Holzstütze Zwischenwand NH C24 b/h = 12/12 cm	74
St1.2	Holzstütze Außenbereich BSH GL24c b/h = 16/16 cm	76
St1.3	Holzstütze Zwischenwand NH C24 b/h = 24/12 cm	78
St1.4	Holzstütze Zwischenwand NH C24 b/h = 12/12 cm	80
B1	Balkon BSH GL24c b/h = 8/16 cm	82
B2	Randbalken, SSV einseitig BSH GL24c b/h = 16/28 cm	85
E1	geschlossene Decke KVH C24 b/h = 7/24 cm	87
Decke EG	Nachweis der Feuerwiderstandsdauer	92
E2	geschlossene Decke KVH C24 b/h = 7/24 cm	94
E3	Treppenwechsel, SSV einseitig BSH GL24c b/h = 12/24 cm	100
E4	Treppenwechsel BSH GL24c b/h = 18/24 cm	103
E5	Wandgurt BSH GL24c b/h = 18/28 cm	106
E6	Gridträger mit Treppe BSH GL24c b/h = 16/28 cm	111
E7	Wandgurt BSH GL24c b/h = 24/24 cm	115
St0.1	Holzstütze Aussenwand Trio C24 b/h = 12/24 cm	118
St0.2	Holzstütze Außenbereich BSH GL24c b/h = 16/16 cm	119
St0.3	Holzstütze Außenbereich BSH GL24c b/h = 16/16 cm	122
St0.4	Holzstütze Zwischenwand NH C24 b/h = 36/18 cm	124
St0.5	Holzstütze Zwischenwand NH C24 b/h = 32/18 cm	126
T1	Terrasse EG BSH GL24c b/h = 8/16 cm	128
T2	Randbalken mit SSV BSH GL24c b/h = 16/16 cm	131
T3	Terrasse EG BSH GL24c b/h = 8/16 cm	134
T4	Randbalken mit SSV BSH GL24c b/h = 16/16 cm	137
T5	Randbalken BSH GL24c b/h = 16/16 cm	140
T6	Randbalken BSH GL24c b/h = 16/16 cm	144
BE1	Bodenplattenelement KVH C24 b/h = 7/24 cm	147
BE2	Bodenplattenelement KVH C24 b/h = 12/24 cm	151
BE3	Bodenplattenelement KVH C24 b/h = 12/24 cm	155
BP4	Zwischenträger, SSV beidseitig BSH GL24c b/h = 24/24 cm	159
BP5	Zwischenträger, SSV beidseitig BSH GL24c b/h = 24/24 cm	162
BP6.1	Randträger, SSV einseitig BSH GL24c b/h = 24/24 cm	165
BP6.2	Randträger, SSV einseitig BSH GL24c b/h = 24/24 cm	169
BP6.3	Randträger, SSV einseitig BSH GL24c b/h = 24/24 cm	170
BP7.1	Randträger, SSV einseitig BSH GL24c b/h = 24/24 cm	171

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Position	Beschreibung	Seite
BP7.2	Randträger, SSV einseitig BSH GL24c b/h = 24/24 cm	175
BP7.3	Zwischenträger, SSV einseitig BSH GL24c b/h = 24/24 cm	176
BP8	Randträger BSH GL24c b/h = 24/24 cm	177
DT_BP	Holz-Auflager erforderliches Auflager, b = 24 cm, Länge > 40 cm	182
Gebäudeaussteifung		183
HAS	Holzaussteifungssystem	184
1-AW.DG	Wand 1-AW im Geschoss DG NH C24, Span P5 b/h = 5/24 cm, h = 12 mm	195
4.1-AW.DG	Wand 4.1-AW im Geschoss DG NH C24, Span P5 b/h = 5/24...12/24 cm, h = 12 mm	199
5.2-AW.DG	Wand 5.2-AW im Geschoss DG NH C24, Span P5 b/h = 5/24...12/24 cm, h = 12 mm	202
1-AW.EG	Wand 1-AW im Geschoss EG NH C24, Span P5 b/h = 5/24 cm, h = 12 mm	205
4.1-AW.EG	Wand 4.1-AW im Geschoss EG NH C24, Span P5 b/h = 5/24...12/24 cm, h = 12 mm	208
5.2-AW.EG	Wand 5.2-AW im Geschoss EG NH C24, Span P5 b/h = 5/24...12/24 cm, h = 12 mm	212
SWK1	Holz-Bemessung, ebenes Stabwerk BSH GL24c b/h = 4.5/5...16/28 cm	216
SK0	Stahlkreuz, Aussteifung Verankerung mit je vier Schrauben 8.0 x 160 Stahlseilaussteifung analog VE022, Seildurchmesser 12 mm	219
SK1	Stahlkreuz, Aussteifung Dach Verankerung mit je vier Schrauben 8.0 x 100 Stahlseilaussteifung analog VE022, Seildurchmesser 8 mm	222
DE-T	Deckenscheibe Traufe NH C24, kunstharzgebundene Spanplatten P5 b/h = 12/24 cm, h = 25 mm	225
DA	Dachscheibe NH C24, kunstharzgebundene Spanplatten P5 b/h = 7/24...12/24 cm, h = 25 mm	228
Positionspläne		231
Verankerungspläne		231
Lastenplan		231

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. B **Baubeschreibung**

Angaben zum Standsicherheitsnachweis

Standsicherheitsnachweis für das Projekt Solar Decathlon zur temporären Aufstellung in Wuppertal und der dauerhaften Aufstellung in Erkheim. Die Nachrechnung des Gebäudes erfolgt für den Standort Erkheim, da die Lasten hierfür maßgebend werden.

Berechnungsgrundlagen

Eingabepläne im Maßstab M 1:100. Die statischen Berechnungen werden nach DIN EN 1995 erstellt.

Beschreibung der Konstruktion

Das Gebäude wird in Holzrahmenbauweise ausgeführt. Die Lasten vom Dach werden über Pfetten in die Dachgeschosswandkonstruktion und davon weiter in das Erdgeschoss geleitet. Die Lasten der Erdgeschossdecke werden über Obergurte und Unterzüge in die Erdgeschosswand oder Stützen und davon in eine punktgelagerte Holzbalkenbodenplatte eingeleitet.

Zur Aussteifung des Gebäudes dienen Außen-, Innenwände, Dach- und Deckenscheiben. Das Dach wird durch eine außenliegende, mitteldichte Faserplatte (Agepan-DWD) als Scheibe ausgebildet. Die Aussteifung der Wände erfolgt durch eine Kombination einer außenliegende mitteldichte Faserplatte und einer innenliegenden Gipskartonplatte bzw. bei verputzten Fassaden nur durch die innenliegende Bekleidung. Bei höheren Lasten werden die innenliegenden Gipskartonplatte durch Holzwerkstoffplatten ersetzt. Die Deckenscheiben werden durch Holzwerkstoffplatten ausgesteift.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. GEO Standortdaten

Gebäude					
Gebäudestandort	Postleitzahl	PLZ	=	87746	
	Ortsname	Ort	=	Erkheim	
Gemeinde	Gemeindeschlüssel	AGS	=	09778136	
	Bundesland	Bayern			
Geodätische Daten	Geogr. Breite	Dz	=	48.03714	°
	Geogr. Länge	Ř	=	10.34262	°
Geograf. Daten	Geländehöhe ü. NN	H_s	=	599.00	m
	Windzone	WZ	=	2	
	Schneelastzone	SLZ	=	1a	
	char. Schneelast	s_k	=	1.31	kN/m²

Die Schnee- und Windlasten am Standort Wuppertal sind geringer als die Lasten am Standort Erkheim. Aus diesem Grund werden nur die Lasten für den Standort Erkheim nachgewiesen.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. W+S Wind und Schneelast

System	Gebäudedaten				
Abmessungen	Gebäudebreite	B	=	7.26	m
	Gebäudelänge	L	=	10.30	m
	Gebäudehöhe	H	=	6.66	m
Geograf. Angaben	Geländehöhe über NN	A	=	599.00	m
	Windzone	WZ	=	2	
	Schneelastzone	SLZ	=	1a	
	Geländekategorie	Kat	=	III	
Geometrie	Satteldach				
	Neigung links	$Ä_l$	=	0.00	°
	Neigung rechts	$Ä_r$	=	0.00	°
Wandöffnungen	geschlossene Außenwände				

Einwirkungen Einwirkungen nach DIN EN 1990:2010-12

Qk.S Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W Windeinwirkung
Windlasten
Qk.W min/max Werte

Windlasten Windlastermittlung nach DIN EN 1991-1-4:2010-12

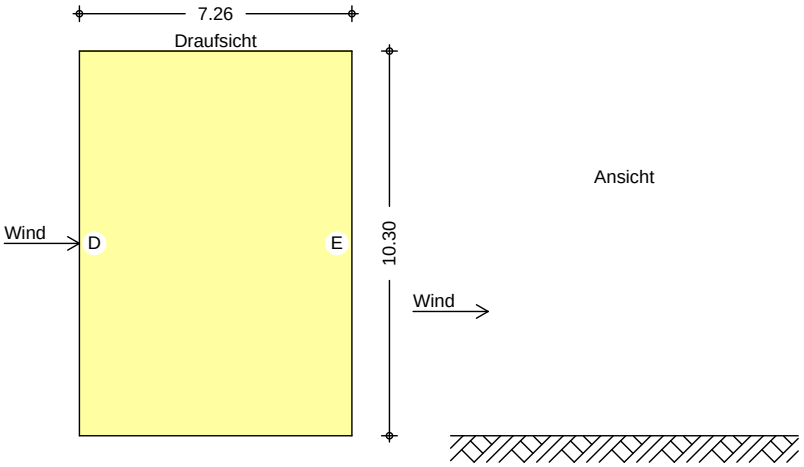
Ermittlung nach Anhang NA.B
Anströmrichtung 0° auf Traufe links

Basiswindgeschwindigkeit	$v_{b,0}$	=	25.00	m/s
Basisgeschwindigkeitsdruck	$q_{b,0}$	=	0.39	kN/m²
Bezugshöhe	z_e	=	6.66	m
Geschwindigkeitsdruck	q_p	=	0.59	kN/m²
Lasteinflussfläche	A Ó		10.00	m²

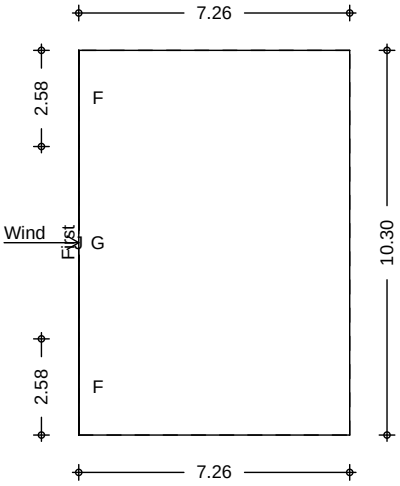
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.W.000 Bereichsgröße e_D = 10.30 m
Richtung dž=0Á e_W = 10.30 m

Bereichseinteilung
M 1:200



M 1:200



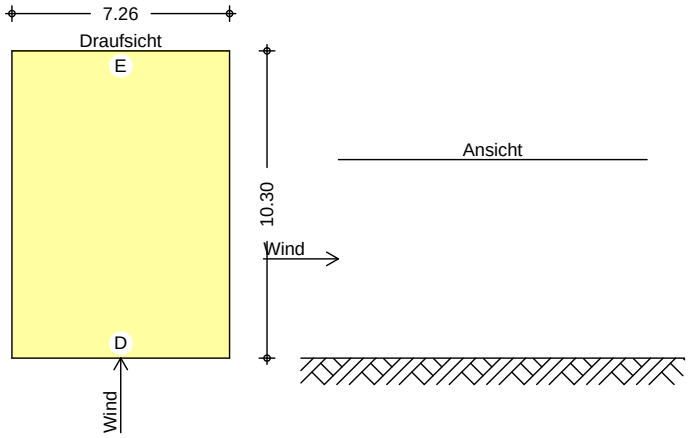
Bereich	d,b [m]	h [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
A	2.06	6.66	-1.40	-1.20	-0.70
B	5.20	6.66	-1.10	-0.80	-0.47
D	10.30	6.66	1.00	0.79	0.46
E	10.30	6.66	-0.50	-0.48	-0.28

Bereich	d [m]	b [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
F	0.00	2.58	-2.50	-1.80	-1.05
G	0.00	5.15	-2.00	-1.20	-0.70
J-	0.00	10.30	-0.60	-0.60	-0.35
J+	0.00	10.30	0.20	0.20	0.12

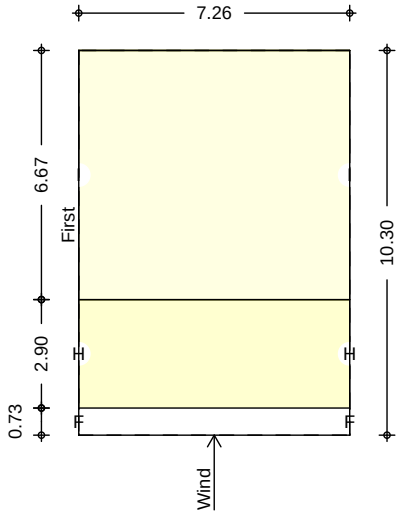
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.W.090 Bereichsgröße e_D = 7.26 m
Richtung dž=90Á e_W = 7.26 m

Bereichseinteilung
M 1:250



M 1:200



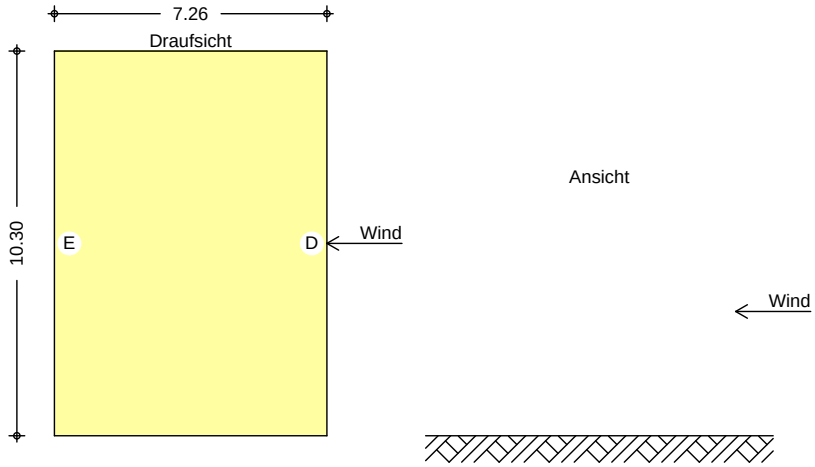
Bereich	d,b [m]	h [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
A	1.45	6.66	-1.40	-1.20	-0.70
B	5.81	6.66	-1.10	-0.80	-0.47
C	3.04	6.66	-0.50	-0.50	-0.29
D	7.26	6.66	1.00	0.75	0.44
E	7.26	6.66	-0.50	-0.41	-0.24

Bereich	d [m]	b [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
F	0.73	1.82	-2.35	-1.70	-0.99
G	0.73	3.63	-2.00	-1.25	-0.73
H	2.90	7.26	-1.20	-0.70	-0.41
I	6.67	7.26	-0.90	-0.60	-0.35

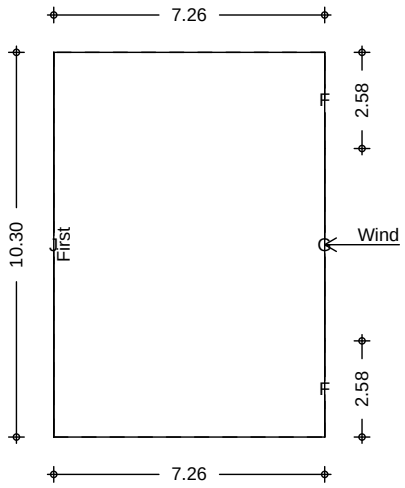
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.W.180 Bereichsgröße e_D = 10.30 m
Richtung dž=180Á e_W = 10.30 m

Bereichseinteilung
M 1:200



M 1:200



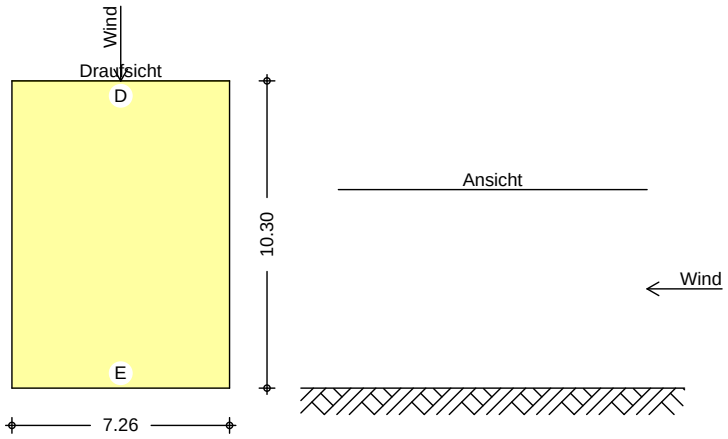
Bereich	d,b [m]	h [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
A	2.06	6.66	-1.40	-1.20	-0.70
B	5.20	6.66	-1.10	-0.80	-0.47
D	10.30	6.66	1.00	0.79	0.46
E	10.30	6.66	-0.50	-0.48	-0.28

Bereich	d [m]	b [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
F	0.00	2.58	-2.50	-1.80	-1.05
G	0.00	5.15	-2.00	-1.20	-0.70
J-	0.00	10.30	-0.60	-0.60	-0.35
J+	0.00	10.30	0.20	0.20	0.12

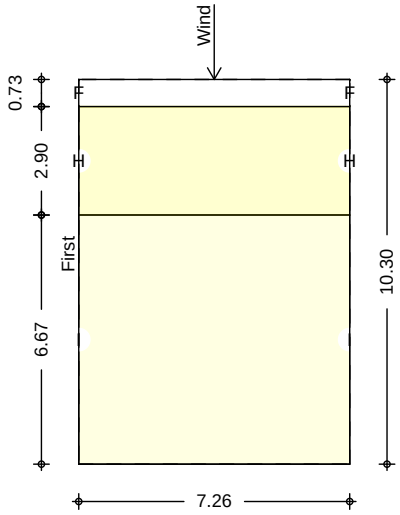
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.W.270 Bereichsgröße e_D = 7.26 m
Richtung dž=270Á e_W = 7.26 m

Bereichseinteilung
M 1:250



M 1:200



Bereich	d,b [m]	h [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
A	1.45	6.66	-1.40	-1.20	-0.70
B	5.81	6.66	-1.10	-0.80	-0.47
C	3.04	6.66	-0.50	-0.50	-0.29
D	7.26	6.66	1.00	0.75	0.44
E	7.26	6.66	-0.50	-0.41	-0.24

Bereich	d [m]	b [m]	$c_{pe,1}$ [-]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
F	0.73	1.82	-2.35	-1.70	-0.99
G	0.73	3.63	-2.00	-1.25	-0.73
H	2.90	7.26	-1.20	-0.70	-0.41
I	6.67	7.26	-0.90	-0.60	-0.35

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Schneelasten

Schneelastermittlung nach DIN EN 1991-1-3:2010-12

char. Schneelast auf Boden	s_k	=	1.31	kN/m²
Formbeiwert für Schneelast	$\check{k}_2(\bar{A}_l)$	=	0.80	-
	$\check{k}_2(\bar{A}_r)$	=	0.80	-

Qk.S.A

Fall (i): unverwehte Lastverteilung

Schneelast auf dem Dach	s_l	=	1.05	kN/m²
	s_r	=	1.05	kN/m²

Qk.S.B

Fall (ii): verwehte Lastverteilung

Schneelast auf dem Dach	s_l	=	0.53	kN/m²
	s_r	=	1.05	kN/m²

Qk.S.C

Fall (iii): verwehte Lastverteilung

Schneelast auf dem Dach	s_l	=	1.05	kN/m²
	s_r	=	0.53	kN/m²

Wandlage

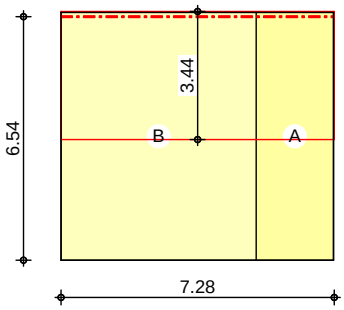
Windlasten für Bauteile in Wandlage

Grafik

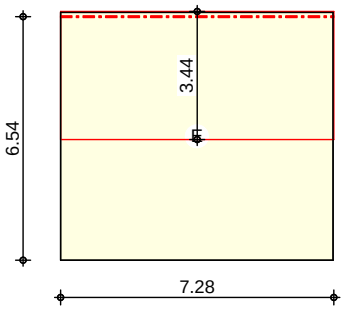
Giebel hinten

M 1:200

0°

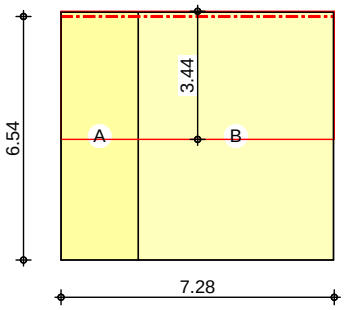


90°

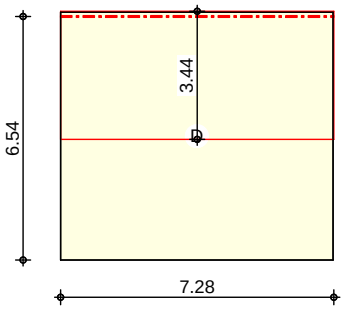


M 1:200

180°



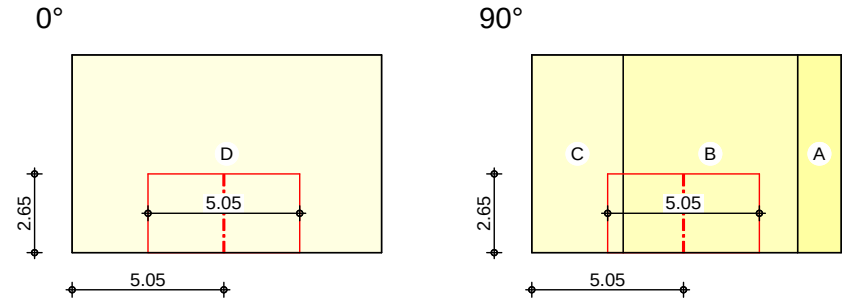
270°



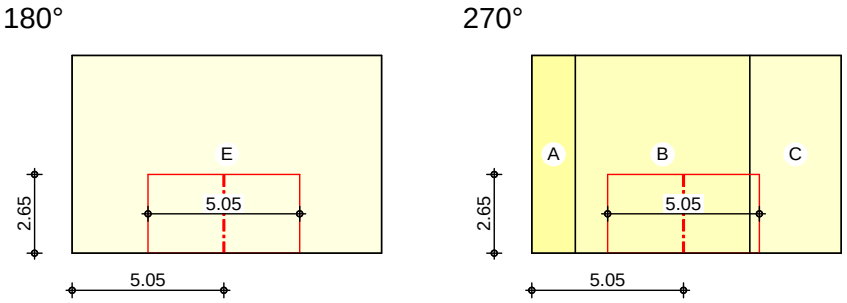
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Traufe links

M 1:250



M 1:250



Giebel hinten
Bauteil Grid

Bauteile in hinterer Giebelwand

x_A [m]	y_A [m]	l [m]	LB_{li} [m]	LB_{re} [m]	A [m²]
0.00	6.54	7.28	0.14	3.30	25.04

	Richtung	Bereich	x_A [m]	x_E [m]	q+ [kN/m]	q- [kN/m]
Qk.W.000	lokal	A	5.20	7.26	-	-2.40
	lokal	B	0.00	5.20	-	-1.60
Qk.W.090	lokal	E	0.00	7.26	-	-0.81
Qk.W.180	lokal	A	0.00	2.06	-	-2.40
	lokal	B	2.06	7.26	-	-1.60
Qk.W.270	lokal	D	0.00	7.26	1.50	-

Traufe links
Bauteil Stütze

Bauteile in linker Traufwand

x_A [m]	y_A [m]	l [m]	LB_{li} [m]	LB_{re} [m]	A [m²]
5.05	0.00	2.65	2.53	2.53	13.38

	Richtung	Bereich	y_A [m]	y_E [m]	q+ [kN/m]	q- [kN/m]
Qk.W.000	lokal	D	0.00	2.65	2.33	-
Qk.W.090	lokal	B	0.00	2.65	-	-2.12
	lokal	C	0.00	2.65	-	-0.15
Qk.W.180	lokal	E	0.00	2.65	-	-1.41
Qk.W.270	lokal	B	0.00	2.65	-	-2.22
	lokal	C	0.00	2.65	-	-0.09

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. L1 Bauteile - Einwirkungen und Lasten

Belastungen
Flächenlasten Dach

Gk-gk_SD	Steildachausbau	=	0.61	kN/m²
Gk-gk_FD	Flachdachausbau	=	0.81	kN/m²
Gk-gk_GD	Garagendachausbau	=	0.27	kN/m²

Zusammenstellungen

gk_SD	Steildachausbau				
	DWD	8*.016	=	0.13	kN/m²
	Hoiz-Hobelspandämmung	0.8*0.24	=	0.19	kN/m²
	XundE	9*0.0125	=	0.11	kN/m²
	Lattung	5*0.03*0.05/0.4	=	0.02	kN/m²
	GKF Untersicht	9*0.018	=	0.16	kN/m²
			=	0.61	kN/m²
gk_FD	Flachdachausbau				
	Gefälledämmung	1*0.12	=	0.12	kN/m²
	HWS	8*0.025	=	0.20	kN/m²
	Hoiz-Hobelspandämmung	0.8*0.24	=	0.19	kN/m²
	XundE	9*0.0125	=	0.11	kN/m²
	Lattung	5*0.03*0.05/0.4	=	0.02	kN/m²
	GKF Untersicht	9*0.018	=	0.16	kN/m²
			=	0.81	kN/m²
gk_GD	Garagendachausbau				
	Lattung	5*0.03*0.05/0.4	=	0.02	kN/m²
	Konterlattung	5*0.03*0.05/0.625	=	0.01	kN/m²
	DWD	8*0.018	=	0.14	kN/m²
	N+F Schalung	5*0.018	=	0.09	kN/m²
			=	0.27	kN/m²

Flächenlasten Decke

Gk-gk;Dnsi	Deckenaufbau geschlossene Decke ohne Estrich	=	1.04	kN/m²
Gk-gk;SD	Decke Solar Decathlon	=	0.99	kN/m²
Gk-gk;WTD'o	oberer Deckenaufbau geschlossene Wohnungstrenndecke ohne Estrich	=	1.92	kN/m²
Gk-gk;WTD'u	unterer Deckenaufbau geschlossene Wohnungstrenndecke ohne Estrich	=	0.67	kN/m²
Gk-gk;Dsi	Deckenaufbau sichtbare Decke ohne Estrich	=	0.49	kN/m²
Qk.N.B-qk;N	Verkehr+TWZ	=	2.80	kN/m²

Zusammenstellungen

gk;Dnsi	Deckenaufbau geschlossene Decke ohne Estrich				
	Estrich zwischen Heizungsrohre (die restlichen 4 cm sind direkt eingegeben)				
		22*0.015	=	0.33	kN/m²
	Trittschalldämmung (HWS-Platte und Balken sind direkt eingegeben)				
		1*0.06	=	0.06	kN/m²
	HOIZ	1.5*0.24	=	0.36	kN/m²
	XundE	9*0.0125	=	0.11	kN/m²
	Lattung	5*0.03*0.05/0.4	=	0.02	kN/m²

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	Gipskartonplatte	9*0.018	=	0.16	kN/m²
			=	1.04	kN/m²
gk;SD	Decke Solar Decathlon Trittschalldämmung (HWS-Platte und Balken sind direkt eingegeben)				
		1*0.08	=	0.08	kN/m²
	HWS-Platte	0.043*6	=	0.26	kN/m²
	HOIZ	1.5*0.24	=	0.36	kN/m²
	XundE	9*0.0125	=	0.11	kN/m²
	Lattung	5*0.03*0.05/0.4	=	0.02	kN/m²
	Gipskartonplatte	9*0.018	=	0.16	kN/m²
			=	0.99	kN/m²
gk;WTD'o	oberer Deckenaufbau geschlossene Wohnungstrenndecke ohne Estrich Estrich zwischen Heizungsrohre (die restlichen 4 cm sind direkt eingegeben)				
		22*0.015	=	0.33	kN/m²
	Trittschalldämmung (HWS-Platte und Balken sind direkt eingegeben)				
		2*0.04	=	0.08	kN/m²
	Schüttung	20*0.07	=	1.40	kN/m²
	GKB	9*0.0125	=	0.11	kN/m²
			=	1.92	kN/m²
gk;WTD'u	unterer Deckenaufbau geschlossene Wohnungstrenndecke ohne Estrich				
	HOIZ	0.8*0.24	=	0.19	kN/m²
	GKF erste Lage	9*0.018	=	0.16	kN/m²
	Lattung	5*0.03	=	0.15	kN/m²
	GKF zweite Lage	9*0.018	=	0.16	kN/m²
			=	0.67	kN/m²
gk;Dsi	Deckenaufbau sichtbare Decke ohne Estrich Estrich zwischen Heizungsrohre (die restlichen 4 cm sind direkt eingegeben)				
		22*0.015	=	0.33	kN/m²
	Trittschalldämmung	1*0.06	=	0.06	kN/m²
	Holzwerkstoffplatte (die Schalung ist direkt eingegeben)				
		8*0.013	=	0.10	kN/m²
			=	0.49	kN/m²
qk;N	Verkehr+TWZ Nutzlast A2 für Wohn- u. Aufenthaltsräume ohne Querverteilung				
		2	=	2.00	kN/m²
	Trennwandzuschlag für LTW bis 3.0kN/m				
		0.8	=	0.80	kN/m²
			=	2.80	kN/m²

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

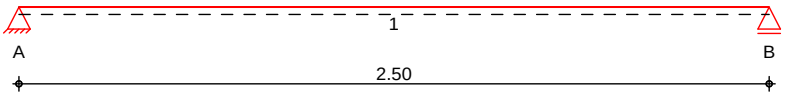
Positionsliste

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G0 Lastermittlung Solarnetz

System — Holz-Einfeldträger

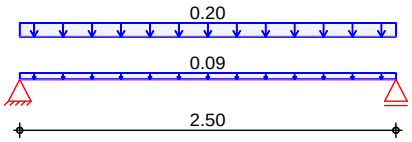
M 1:25



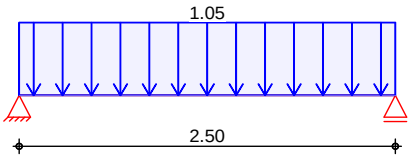
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

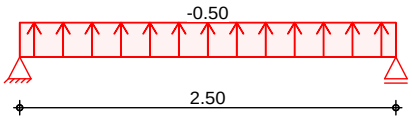
Einwirkungen — Gk



Qk.S



Qk.W



Flächenlasten in z-Richtung — Gleichflächenlasten

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*	1	Eigengew	0.00	2.50		0.09
	1		0.00	2.50		0.20
Einw. *Qk.S*	1		0.00	2.50		1.05
Einw. *Qk.W*	1		0.00	2.50		-0.50

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

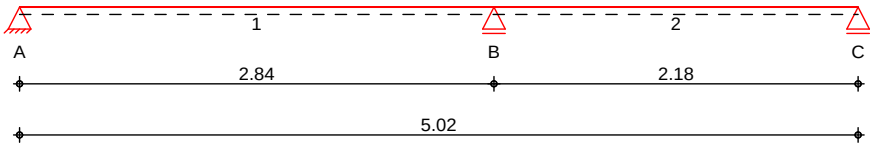
	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	0.36
	B	0.36
Einw. *Qk.S*	A	1.31
	B	1.31
Einw. *Qk.W*	A	-0.63
	B	-0.63

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G01 Lastermittlung Solarnetz

System — Holz-Zweifeldträger

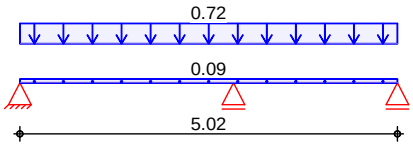
M 1:45



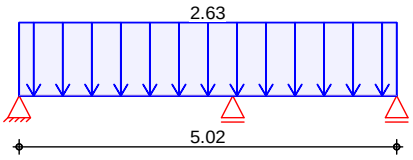
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

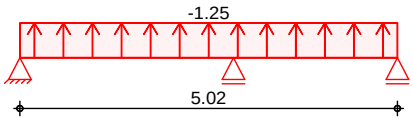
Einwirkungen — Gk



Qk.S



Qk.W



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	5.02		0.09
	(a)	1	G0	0.00	5.02		0.72
Einw. *Qk.S*	(a)	1	G0	0.00	5.02		2.63
Einw. *Qk.W*	(a)	1	G0	0.00	5.02		-1.25

(a) aus Pos. 'G0', Lager 'A', Faktor = 2.00 (Seite 16)

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

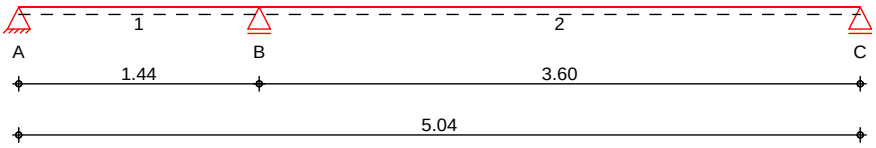
	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.92
	B	2.59
	C	0.58
Einw. *Qk.S*	A	2.96
	B	8.36
	C	1.86
Einw. *Qk.W*	A	-1.41
	B	-3.98
	C	-0.89

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G02 Lastermittlung Solarnetz

System — Holz-Zweifeldträger

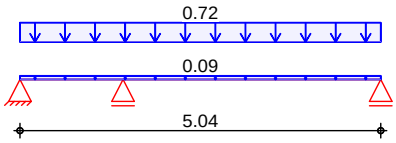
M 1:45



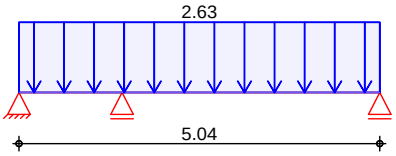
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

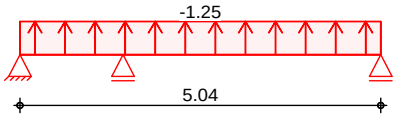
Einwirkungen — Gk



Qk.S



Qk.W



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	5.04		0.09
	(a)	1	G0	0.00	5.04		0.72
Einw. *Qk.S*	(a)	1	G0	0.00	5.04		2.63
Einw. *Qk.W*	(a)	1	G0	0.00	5.04		-1.25

(a) aus Pos. 'G0', Lager 'A', Faktor = 2.00 (Seite 16)

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

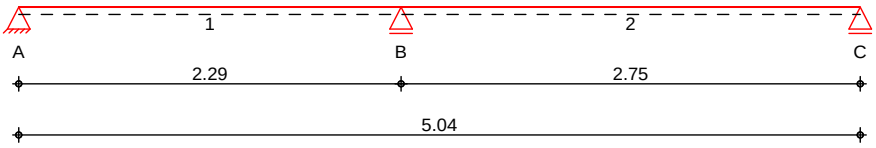
	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	-0.11
	B	3.02
	C	1.19
Einw. *Qk.S*	A	-0.35
	B	9.76
	C	3.83
Einw. *Qk.W*	A	0.17
	B	-4.65
	C	-1.82

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G03 Lastermittlung Solarnetz

System Holz-Zweifeldträger

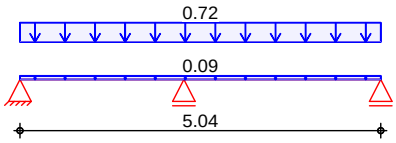
M 1:45



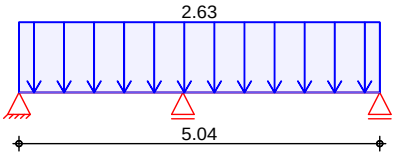
Belastungen Belastungen auf das System

Grafik Belastungsgrafiken (einwirkungsbezogen)

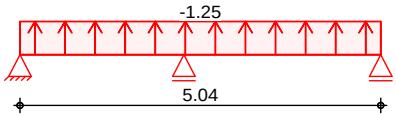
Einwirkungen Gk



Qk.S



Qk.W



Streckenlasten in z-Richtung Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	5.04		0.09
	(a)	1	G0	0.00	5.04		0.72
Einw. *Qk.S*	(a)	1	G0	0.00	5.04		2.63
Einw. *Qk.W*	(a)	1	G0	0.00	5.04		-1.25

(a) aus Pos. 'G0', Lager 'A', Faktor = 2.00 (Seite 16)

Auflagerkräfte Charakteristische Auflagerkräfte

Char. Auflagerkr.

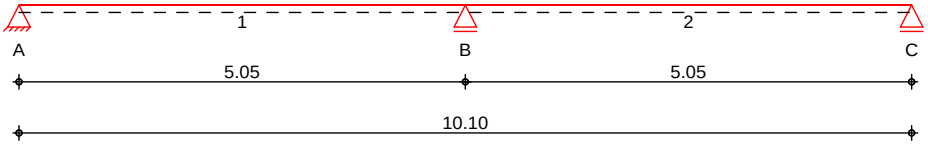
	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.64
	B	2.58
	C	0.88
Einw. *Qk.S*	A	2.07
	B	8.33
	C	2.83
Einw. *Qk.W*	A	-0.99
	B	-3.96
	C	-1.35

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G1 — Grid Randträger

System — Holz-Zweifeldträger

M 1:85



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	5.05	5.05	2
2	5.05	5.05	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	5.05	12.00	starr	frei
C	10.10	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

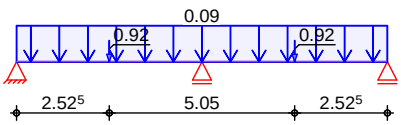
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

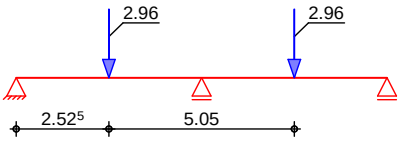
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

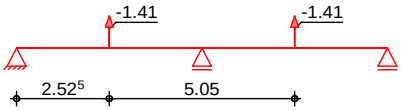
Einwirkungen — Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	10.10		0.09

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	G01	2.53	0.92
	(a)	1	G01	7.58	0.92
Einw. *Qk.S*	(a)	1	G01	2.53	2.96
	(a)	1	G01	7.58	2.96
Einw. *Qk.W*	(a)	1	G01	2.53	-1.41
	(a)	1	G01	7.58	-1.41

(a) aus Pos. 'G01', Lager 'A' (Seite 17)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	+1.00*Qk.S
	13		1.00*Gk	+1.00*Qk.S
quasi-ständig	15		1.00*Gk	

ku: kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	2	-0.20	3	2.01	2
	2.53	-0.80	3	4.68	2	-3.98	2	0.77	3
	5.05	-5.77	2	0.85	3	-4.29	2	0.54	3
Feld 2	0.00	-5.77	2	0.85	3	-0.54	3	4.29	2
	2.53	-0.80	3	4.68	2	-1.70	2	0.43	3
	5.05	0.00	3	0.00	2	-2.01	2	0.20	3

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	16.0	256.0	5461.3

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 5.05 m, k_{crit} = 1.00)*						
	5.05	2	0.90	-5.77	8.45	16.62	0.51*
Feld 2	*(L = 5.05 m, k_{crit} = 1.00)*						
	0.00	2	0.90	-5.77	8.45	16.62	0.51*

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.20	2	0.90	1.98	0.16	2.42	0.07
	4.83	2	0.90	-4.26	0.35	2.42	0.14*
Feld 2	0.22	2	0.90	4.26	0.35	2.42	0.14*
	4.85	2	0.90	-1.98	0.16	2.42	0.07

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	5.05	5.05
Feld 2	5.05	5.05

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	2	0.90	2.01	240.0	1.75	0.08	3.03	0.03
Auflager B	2	0.90	8.58	288.0	1.75	0.30	3.03	0.10
Auflager C	2	0.90	2.01	240.0	1.75	0.08	3.03	0.03

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	η [-]
Feld 1	*(L= 5.05 m, NKL 2, k_{def} = 0.80)*						
	2.26	11	w_{inst}	8.3	l/300=	16.8	0.49
	2.26	13	w_{fin}	10.2	l/200=	25.3	0.40
	2.23	15	$w_{net,fin}$	4.2	l/300=	16.8	0.25
Feld 2	*(L= 5.05 m, NKL 2, k_{def} = 0.80)*						
	2.79	11	w_{inst}	8.3	l/300=	16.8	0.49
	2.79	13	w_{fin}	10.2	l/200=	25.3	0.40
	2.82	15	$w_{net,fin}$	4.2	l/300=	16.8	0.25

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.46
	B	1.83
	C	0.46
Einw. *Qk.S*	A	0.93
	B	4.07
	C	0.93
Einw. *Qk.W*	A	-0.44
	B	-1.94
	C	-0.44

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.51
Querkraft	Feld 1	4.83	OK	0.14
Auflagerpressung	Auflager B		OK	0.10

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

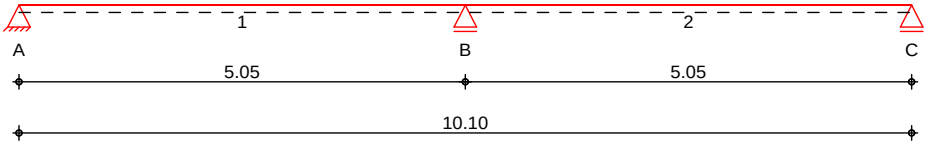
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 2	2.79	OK	0.49
Enddurchbiegung	Feld 2	2.79	OK	0.40
gesamte Enddurchb.	Feld 1	2.23	OK	0.25

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G2 Grid Randträger

System — Holz-Zweifeldträger

M 1:85



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	5.05	5.05	2
2	5.05	5.05	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	5.05	12.00	starr	frei
C	10.10	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

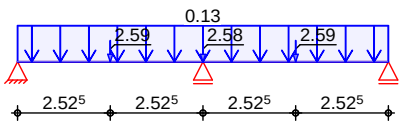
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

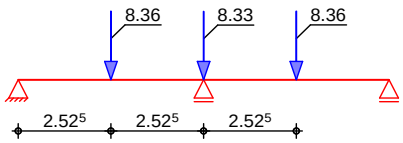
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

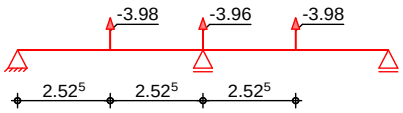
Einwirkungen — Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

Einw. *Gk*

Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
1	Eigengew	0.00	10.10		0.13

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	G01	2.53	2.59
	(a)	1	G01	7.58	2.59
	(b)	1	G03	5.05	2.58
Einw. *Qk.S*	(a)	1	G01	2.53	8.36
	(a)	1	G01	7.58	8.36
	(b)	1	G03	5.05	8.33
Einw. *Qk.W*	(a)	1	G01	2.53	-3.98
	(a)	1	G01	7.58	-3.98
	(b)	1	G03	5.05	-3.96

(a) aus Pos. 'G01', Lager 'B' (Seite 17)

(b) aus Pos. 'G03', Lager 'B' (Seite 19)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	+1.00*Qk.S
	13		1.00*Gk	+1.00*Qk.S
quasi-ständig	15		1.00*Gk	

ku: kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	2	-0.80	3	5.35	2
	2.53	-2.45	3	12.94	2	-11.13	2	2.24	3
	5.05	-15.75	2	2.77	3	-11.59	2	1.90	3
Feld 2	0.00	-15.75	2	2.77	3	-1.90	3	11.59	2
	2.53	-2.45	3	12.94	2	-4.89	2	1.14	3
	5.05	0.00	3	0.00	2	-5.35	2	0.80	3

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	24.0	384.0	18432.0

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 5.05 m, k_{crit} = 1.00)*						
	5.05	2	0.90	-15.75	10.26	16.62	0.62*
Feld 2	*(L = 5.05 m, k_{crit} = 1.00)*						
	0.00	2	0.90	-15.75	10.26	16.62	0.62*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	2	0.90	5.30	0.29	2.42	0.12
	4.75	2	0.90	-11.54	0.63	2.42	0.26*
Feld 2	0.30	2	0.90	11.54	0.63	2.42	0.26*
	4.77	2	0.90	-5.30	0.29	2.42	0.12

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	5.05	5.05
Feld 2	5.05	5.05

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.90	5.35	240.0	1.75	0.22	3.03	0.07
Auflager B	2	0.90	39.16	288.0	1.75	1.36	3.03	0.45
Auflager C	2	0.90	5.35	240.0	1.75	0.22	3.03	0.07

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 5.05 m, NKL 2, k_{def} = 0.80)*						
	2.26	11	w_{inst}	6.7	l/300=	16.8	0.40
	2.26	13	w_{fin}	8.1	l/200=	25.3	0.32
	2.24	15	$w_{net,fin}$	3.2	l/300=	16.8	0.19
Feld 2	*(L= 5.05 m, NKL 2, k_{def} = 0.80)*						
	2.79	11	w_{inst}	6.7	l/300=	16.8	0.40
	2.79	13	w_{fin}	8.1	l/200=	25.3	0.32
	2.81	15	$w_{net,fin}$	3.2	l/300=	16.8	0.19

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	1.06
	B	6.99
	C	1.06
Einw. *Qk.S*	A	2.61

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	B	19.82
	C	2.61
Einw. *Qk.W*	A	-1.24
	B	-9.43
	C	-1.24

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.62
Querkraft	Feld 1	4.75	OK	0.26
Auflagerpressung	Auflager B		OK	0.45

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

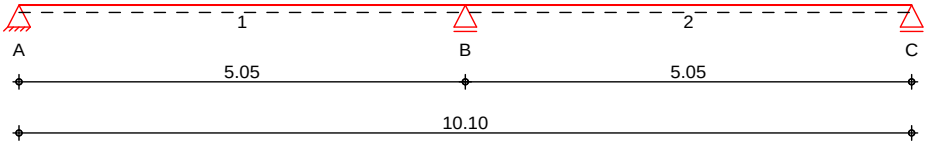
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.26	OK	0.40
Enddurchbiegung	Feld 1	2.26	OK	0.32
gesamte Enddurchb.	Feld 1	2.24	OK	0.19

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G3 Grid Randträger

System — Holz-Zweifeldträger

M 1:85



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	5.05	5.05	2
2	5.05	5.05	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	5.05	12.00	starr	frei
C	10.10	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/20 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

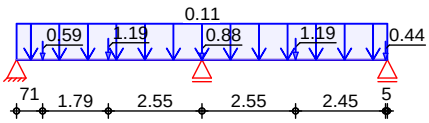
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

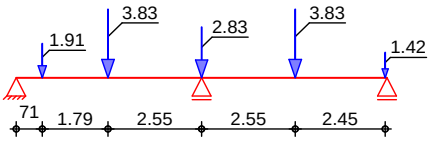
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

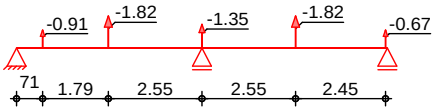
Einwirkungen — Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	10.10		0.11

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	G02	2.50	1.19
	(b)	1	G03	5.05	0.88
	(a)	1	G02	7.60	1.19
	(c)	1	G02	0.71	0.59
	(d)	1	G03	10.05	0.44
Einw. *Qk.S*	(a)	1	G02	2.50	3.83
	(b)	1	G03	5.05	2.83
	(a)	1	G02	7.60	3.83
	(c)	1	G02	0.71	1.91
	(d)	1	G03	10.05	1.42
Einw. *Qk.W*	(a)	1	G02	2.50	-1.82
	(b)	1	G03	5.05	-1.35
	(a)	1	G02	7.60	-1.82
	(c)	1	G02	0.71	-0.91
	(d)	1	G03	10.05	-0.67

(a) aus Pos. 'G02', Lager 'C' (Seite 18)

(b) aus Pos. 'G03', Lager 'C' (Seite 19)

(c) aus Pos. 'G02', Lager 'C', Faktor = 0.50 (Seite 18)

(d) aus Pos. 'G03', Lager 'C', Faktor = 0.50 (Seite 19)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	+1.00*Qk.S
	13		1.00*Gk	+1.00*Qk.S
quasi-ständig	15		1.00*Gk	

ku: kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	2	-0.92	3	5.65	2
	2.50	-1.26	3	7.07	2	-0.42	3	1.60	2
	5.05	-8.09	2	1.25	3	-6.14	2	0.84	3
Feld 2	0.00	-8.09	2	1.25	3	-0.74	3	5.65	2
	2.55	-1.00	3	5.82	2	-2.08	2	0.53	3
	5.05	0.00	3	0.00	2	-5.18	2	0.82	3

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	20.0	320.0	10666.7

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 5.05 m, k_{crit} = 1.00)*						
	5.05	2	0.90	-8.09	7.58	16.62	0.46*
Feld 2	*(L = 5.05 m, k_{crit} = 1.00)*						
	0.00	2	0.90	-8.09	7.58	16.62	0.46*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.24	2	0.90	5.61	0.37	2.42	0.15
	4.79	2	0.90	-6.10	0.40	2.42	0.17*
Feld 2	0.26	2	0.90	5.61	0.37	2.42	0.15*
	4.81	2	0.90	-2.43	0.16	2.42	0.07

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	5.05	5.05
Feld 2	5.05	5.05

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.90	5.65	240.0	1.75	0.24	3.03	0.08
Auflager B	2	0.90	17.22	288.0	1.75	0.60	3.03	0.20
Auflager C	2	0.90	5.18	240.0	1.75	0.22	3.03	0.07

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 5.05 m, NKL 2, k_{def} = 0.80)*						
	2.18	11	w_{inst}	7.3	l/300=	16.8	0.43
	2.18	13	w_{fin}	8.9	l/200=	25.3	0.35
	2.18	15	$w_{net,fin}$	3.6	l/300=	16.8	0.21
Feld 2	*(L= 5.05 m, NKL 2, k_{def} = 0.80)*						
	2.86	11	w_{inst}	5.0	l/300=	16.8	0.30
	2.86	13	w_{fin}	6.2	l/200=	25.3	0.25
	2.86	15	$w_{net,fin}$	2.6	l/300=	16.8	0.15

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	1.08
	B	3.33
	C	1.00
Einw. *Qk.S*	A	2.79
	B	8.48
	C	2.55
Einw. *Qk.W*	A	-1.33
	B	-4.04
	C	-1.21

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.46
Querkraft	Feld 1	4.79	OK	0.17
Auflagerpressung	Auflager B		OK	0.20

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.18	OK	0.43
Enddurchbiegung	Feld 1	2.18	OK	0.35
gesamte Enddurchb.	Feld 1	2.18	OK	0.21

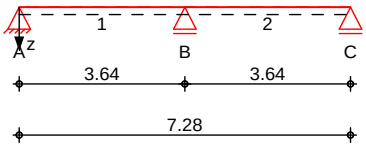
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G4 Grid Randträger

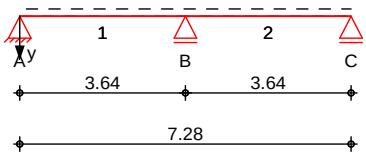
System Holz-Zweifeldträger

M 1:165

System z-Richtung



System y-Richtung



Abmessungen Mat./Querschnitt

Feld	l [m]	Material	b/h [cm]	NKL
1-2	3.64	*BSH GL24c*	**16.0/16.0**	2

Auflager

Lager	x [m]	b [cm]	$K_{T,z}$ [kN/m]	$K_{T,y}$ [kN/m]
A	0.00	12.0	fest	fest
B	3.64	12.0	fest	fest
C	7.28	12.0	fest	fest

Belastungen Belastungen auf das System

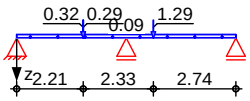
Eigengewicht

A [cm²]	Ā [kN/m³]	g [kN/m]
256.0	3.5	0.09

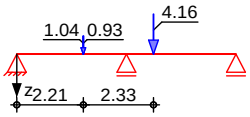
Grafik Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

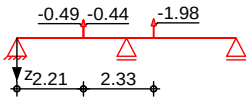
Gk



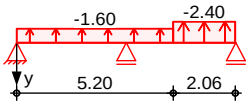
Qk.S



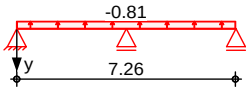
Qk.W



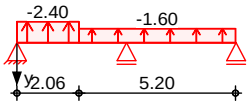
Qk.W.000



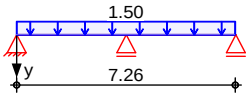
Qk.W.090



Qk.W.180



Qk.W.270



Streckenlasten in y-Richtung Trapezlasten

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Qk.W.000*	1	Ber. A	5.20	2.06	-2.40	-2.40
	1	Ber. B	0.00	5.20	-1.60	-1.60
Einw. *Qk.W.090*	1	Ber. E	0.00	7.26	-0.81	-0.81
Einw. *Qk.W.180*	1	Ber. A	0.00	2.06	-2.40	-2.40
	1	Ber. B	2.06	5.20	-1.60	-1.60
Einw. *Qk.W.270*	1	Ber. D	0.00	7.26	1.50	1.50

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

Trapezlasten

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	7.28		0.09

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1		2.21	0.29
	(b)	1		2.21	0.32
	(c)	1		4.54	1.29
Einw. *Qk.S*	(a)	1		2.21	0.93
	(b)	1		2.21	1.04
	(c)	1		4.54	4.16
Einw. *Qk.W*	(a)	1		2.21	-0.44
	(b)	1		2.21	-0.49
	(c)	1		4.54	-1.98

(a) aus Pos. 'G01', Lager 'C', Faktor = 0.50 (Seite 17)

(b) aus Pos. 'G03', Lager 'A', Faktor = 0.50 (Seite 19)

(c) aus Pos. 'G03', Lager 'B', Faktor = 0.50 (Seite 19)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S	
	6	ku/sk	1.35*Gk	+0.75*Qk.S	+1.50*Qk.W.180
	16	ku/sk	1.35*Gk	+0.75*Qk.S	+1.50*Qk.W.000
selten	41		1.00*Gk	+0.50*Qk.S	+1.00*Qk.W.180
	52		1.00*Gk	+0.50*Qk.S	+1.00*Qk.W.180
	59		1.00*Gk	+0.50*Qk.S	+1.00*Qk.W.000
	61		1.00*Gk	+0.50*Qk.S	+1.00*Qk.W.000
quasi-ständig	57		1.00*Gk		

ku: kurz
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Material- und Querschnittswerte nach DIN EN 1995-1-1

Material

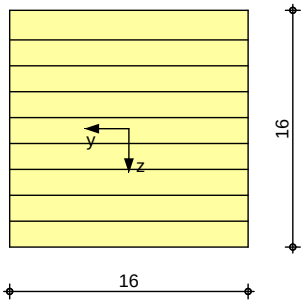
Material	f_{mk}	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{mean}
			[N/mm²]			
BSH GL24c	24.0	17.0	21.5	2.5	3.5	11000

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]	I_z [cm⁴]
16.0	16.0	256	5461	5461

Grafik
M 1:5

Querschnittsgrafik



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	N_d / M_{yd} / M_{zd} [kN,kNm]	$\sigma_{0,d}$ / $\sigma_{my,d}$ / $\sigma_{mz,d}$ [N/mm²]	$f_{0,d}$ / $f_{my,d}$ / $f_{mz,d}$ [N/mm²]	G [-]
Feld 1	*(L = 3.64 m, $k_{c,y}$= 0.59, $k_{c,z}$= 0.59, k_{crit} = 1.00)*						
	3.64	16	1.00	0.00	0.00	13.08	
				-2.45	3.58	18.46	
				-4.51	6.61	18.46	0.49*
Feld 2	*(L = 3.64 m, $k_{c,y}$= 0.59, $k_{c,z}$= 0.59, k_{crit} = 1.00)*						
	0.00	16	1.00	0.00	0.00	13.08	
				-2.45	3.58	18.46	
				-4.51	6.61	18.46	0.49*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ / $V_{y,d}$ [kN]	$\tau_{z,d}$ / $\tau_{y,d}$ [N/mm²]	$f_{zv,d}$ / $f_{yv,d}$ [N/mm²]	G [-]
Feld 1	0.20	6	1.00	0.43	0.04	2.69	0.13
				-4.18	0.34	2.69	
	3.42	6	1.00	-2.26	0.19	2.69	0.19*
				5.77	0.47	2.69	
Feld 2	0.22	2	0.90	7.27	0.60	2.42	0.25*
				0.00	0.00	2.42	
	3.44	16	1.00	-0.73	0.06	2.69	0.13
				4.19	0.34	2.69	

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,cy}$ [m]	$l_{ef,cz}$ [m]	$l_{ef,m}$ [m]
Feld 1	3.64	3.64	3.64	3.64
Feld 2	3.64	3.64	3.64	3.64

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.90	0.64	240.0	1.00	0.03	1.73	0.02
Auflager B	2	0.90	10.88	288.0	1.00	0.38	1.73	0.22
Auflager C	2	0.90	1.13	240.0	1.00	0.05	1.73	0.03

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 3.64 m, NKL 2, k_{def} = 0.80)*						
	1.56	41	w_{inst}	3.9	l/300=	12.1	0.32
	1.56	52	w_{fin}	4.0	l/200=	18.2	0.22
	1.52	57	$w_{net,fin}$	0.5	l/300=	12.1	0.04
Feld 2	*(L= 3.64 m, NKL 2, k_{def} = 0.80)*						
	2.05	59	w_{inst}	4.3	l/300=	12.1	0.35
	2.05	61	w_{fin}	4.6	l/200=	18.2	0.25

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

1.76	57	$w_{net,fin}$	1.4	l/300=	12.1	0.12

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]	$F_{y,k}$ [kN]
Einw. *Gk*	A	0.20	0.00
	B	2.08	0.00
	C	0.28	0.00
Einw. *Qk.S*	A	0.25	0.00
	B	5.39	0.00
	C	0.50	0.00
Einw. *Qk.W*	A	-0.12	0.00
	B	-2.56	0.00
	C	-0.24	0.00
Einw. *Qk.W.000*	A	0.00	-2.08
	B	0.00	-7.95
	C	0.00	-3.22
Einw. *Qk.W.090*	A	0.00	-1.11
	B	0.00	-3.69
	C	0.00	-1.09
Einw. *Qk.W.180*	A	0.00	-3.26
	B	0.00	-7.93
	C	0.00	-2.05
Einw. *Qk.W.270*	A	0.00	2.05
	B	0.00	6.84
	C	0.00	2.02

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.49
Querkraft	Feld 2	0.22	OK	0.25
Auflagerpressung	Auflager B		OK	0.22

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

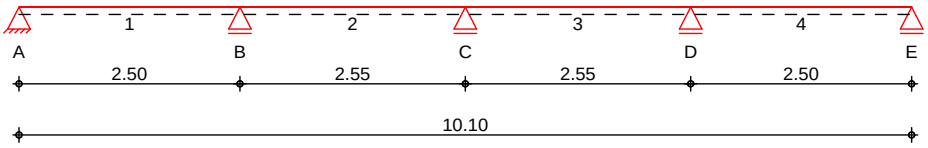
Nachweis	Feld/Auflager	x [m]		G [-]
Verform. w_{inst}	Feld 2	2.05	OK	0.35
Verform. w_{fin}	Feld 2	2.05	OK	0.25
Verform. $w_{net,fin}$	Feld 2	1.76	OK	0.12

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G5 Grid Dachträger

System Holz-Mehrfeldträger

M 1:85



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.50	2.50	2
2	2.55	2.55	2
3	2.55	2.55	2
4	2.50	2.50	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.50	12.00	starr	frei
C	5.05	12.00	starr	frei
D	7.60	12.00	starr	frei
E	10.10	12.00	starr	frei

Material *BSH GL24c*

Querschnitt **b/h = 16/16 cm**

Einwirkungen Einwirkungen nach DIN EN 1990:2010-12

Gk Ständige Einwirkung
Ständige Einwirkungen

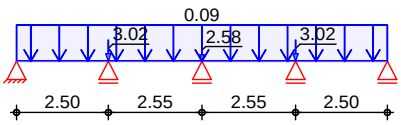
Qk.S Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W Windeinwirkung
Windlasten
Qk.W min/max Werte

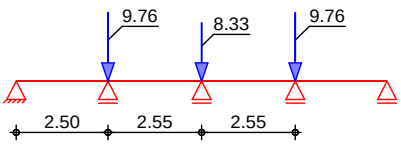
Belastungen Belastungen auf das System

Grafik Belastungsgrafiken (einwirkungsbezogen)

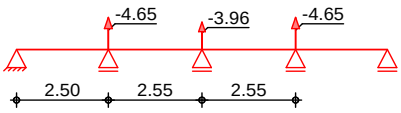
Einwirkungen Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

Einw. *Gk*

Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
1	Eigengew	0.00	10.10		0.09

Punktlasten in z-Richtung

Einzellasten

	Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*				
(a)	1	G02	2.50	3.02
(b)	1	G03	5.05	2.58
(a)	1	G02	7.60	3.02
Einw. *Qk.S*				
(a)	1	G02	2.50	9.76
(b)	1	G03	5.05	8.33
(a)	1	G02	7.60	9.76
Einw. *Qk.W*				
(a)	1	G02	2.50	-4.65
(b)	1	G03	5.05	-3.96
(a)	1	G02	7.60	-4.65

(a) aus Pos. 'G02', Lager 'B' (Seite 18)

(b) aus Pos. 'G03', Lager 'B' (Seite 19)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	5	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	
	16		1.00*Gk	
quasi-ständig	21		1.00*Gk	

st: ständig
ku: kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	1	0.09	2	0.12	1
	0.98	0.04	2	0.06	1	0.00	1	0.00	2
	2.50	-0.08	1	-0.06	2	-0.18	1	-0.14	2
Feld 2	0.00	-0.08	1	-0.06	2	0.12	2	0.16	1
	1.35	0.02	2	0.03	1	0.00	1	0.00	2
	2.55	-0.06	1	-0.04	2	-0.14	1	-0.11	2
Feld 3	0.00	-0.06	1	-0.04	2	0.11	2	0.14	1
	1.20	0.02	2	0.03	1	0.00	2	0.00	1
	2.55	-0.08	1	-0.06	2	-0.16	1	-0.12	2
Feld 4	0.00	-0.08	1	-0.06	2	0.14	2	0.18	1
	1.52	0.04	2	0.06	1	0.00	2	0.00	1
	2.50	0.00	2	0.00	1	-0.12	1	-0.09	2

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	16.0	256.0	5461.3

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.50 m, k_{crit} = 1.00)*						
	2.50	1	0.60	-0.08	0.12	11.08	0.01*
Feld 2	*(L = 2.55 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-0.08	0.12	11.08	0.01*
Feld 3	*(L = 2.55 m, k_{crit} = 1.00)*						
	2.55	1	0.60	-0.08	0.12	11.08	0.01*
Feld 4	*(L = 2.50 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-0.08	0.12	11.08	0.01*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.20	1	0.60	0.09	0.01	1.62	0.00
	2.28	1	0.60	-0.16	0.01	1.62	0.01*
Feld 2	0.22	1	0.60	0.14	0.01	1.62	0.01*
	2.33	1	0.60	-0.12	0.01	1.62	0.01
Feld 3	0.22	1	0.60	0.12	0.01	1.62	0.01
	2.33	1	0.60	-0.14	0.01	1.62	0.01*
Feld 4	0.22	1	0.60	0.16	0.01	1.62	0.01*
	2.30	1	0.60	-0.09	0.01	1.62	0.00

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.50	2.50
Feld 2	2.55	2.55
Feld 3	2.55	2.55
Feld 4	2.50	2.50

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	1	0.60	0.12	240.0	1.75	0.00	2.02	0.00
Auflager B	5	0.90	19.07	288.0	1.75	0.66	3.03	0.22
Auflager C	5	0.90	16.26	288.0	1.75	0.56	3.03	0.19
Auflager D	5	0.90	19.07	288.0	1.75	0.66	3.03	0.22
Auflager E	1	0.60	0.12	240.0	1.75	0.00	2.02	0.00

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.50 m, NKL 2, k_{def} = 0.80)*						
	1.10	11	w_{inst}	0.0	l/300=	8.3	0.00
	1.10	16	w_{fin}	0.1	l/200=	12.5	0.01
	1.10	21	$w_{net,fin}$	0.1	l/300=	8.3	0.01
Feld 2	*(L= 2.55 m, NKL 2, k_{def} = 0.80)*						
	1.37	11	w_{inst}	0.0	l/300=	8.5	0.00

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	1.37	16	w_{fin}	0.0	l/200=	12.8	0.00
	1.37	21	$w_{net,fin}$	0.0	l/300=	8.5	0.00
Feld 3	*(L= 2.55 m, NKL 2, k_{def} = 0.80)*						
	1.18	11	w_{inst}	0.0	l/300=	8.5	0.00
	1.18	16	w_{fin}	0.0	l/200=	12.8	0.00
	1.18	21	$w_{net,fin}$	0.0	l/300=	8.5	0.00
Feld 4	*(L= 2.50 m, NKL 2, k_{def} = 0.80)*						
	1.40	11	w_{inst}	0.0	l/300=	8.3	0.00
	1.40	16	w_{fin}	0.1	l/200=	12.5	0.01
	1.40	21	$w_{net,fin}$	0.1	l/300=	8.3	0.01

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.09
	B	3.28
	C	2.79
	D	3.28
	E	0.09
Einw. *Qk.S*	A	0.00
	B	9.76
	C	8.33
	D	9.76
	E	0.00
Einw. *Qk.W*	A	0.00
	B	-4.65
	C	-3.96
	D	-4.65
	E	0.00

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.01
Querkraft	Feld 1	2.28	OK	0.01
Auflagerpressung	Auflager B		OK	0.22

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

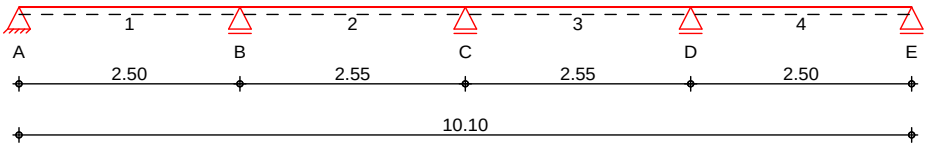
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.10	OK	0.00
Enddurchbiegung	Feld 1	1.10	OK	0.01
gesamte Enddurchb.	Feld 1	1.10	OK	0.01

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G5a — Grid Dachträger

System — Holz-Mehrfeldträger

M 1:85



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.50	2.50	2
2	2.55	2.55	2
3	2.55	2.55	2
4	2.50	2.50	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.50	12.00	starr	frei
C	5.05	12.00	starr	frei
D	7.60	12.00	starr	frei
E	10.10	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

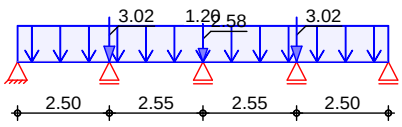
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

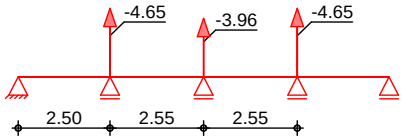
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.W



Streckenlasten in z-Richtung — Gleichlasten

Einw. *Gk*

Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
1		0.00	10.10		1.20

Punktlasten in z-Richtung — Einzellasten

Einw. *Gk*

	Feld	Komm.	a [m]	F_z [kN]
(a)	1	G02	2.50	3.02
(b)	1	G03	5.05	2.58
(a)	1	G02	7.60	3.02

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Einw. *Qk.W*	(a)	1	G02	2.50	-4.65
	(b)	1	G03	5.05	-3.96
	(a)	1	G02	7.60	-4.65

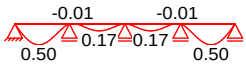
(a) aus Pos. 'G02', Lager 'B' (Seite 18)

(b) aus Pos. 'G03', Lager 'B' (Seite 19)

Char. Verformungen — charakteristische Verformungen

Grafik — Verformungen (je Einwirkung)

Einw. *Gk* — $w_{z,k}$ [mm]



Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
selten	5		1.00*Gk	
	7		1.00*Gk	
quasi-ständig	9		1.00*Gk	
Lagesicherheit	12	st	0.90*Gk	
	13	ku/sk	0.90*Gk	+1.50*Qk.W
st./vor. Auflagerkr.	15	st	1.00*Gk	
	17	ku/sk	1.00*Gk	+1.50*Qk.W

st: ständig
ku/sk: kurz/sehr kurz

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	1	1.17	2	1.59	1
	0.98	0.58	2	0.78	1	0.00	1	0.00	2
	2.50	-1.10	1	-0.81	2	-2.46	1	-1.83	2
Feld 2	0.00	-1.10	1	-0.81	2	1.63	2	2.19	1
	1.35	0.29	2	0.39	1	0.00	1	0.00	2
	2.55	-0.77	1	-0.57	2	-1.94	1	-1.43	2
Feld 3	0.00	-0.77	1	-0.57	2	1.43	2	1.94	1
	1.20	0.29	2	0.39	1	0.00	2	0.00	1
	2.55	-1.10	1	-0.81	2	-2.19	1	-1.63	2
Feld 4	0.00	-1.10	1	-0.81	2	1.83	2	2.46	1
	1.52	0.58	2	0.78	1	0.00	2	0.00	1
	2.50	0.00	2	0.00	1	-1.59	1	-1.17	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	16.0	256.0	5461.3

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.50 m, k_{crit} = 1.00)*						
	2.50	1	0.60	-1.10	1.61	11.08	0.15*
Feld 2	*(L = 2.55 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-1.10	1.61	11.08	0.15*
Feld 3	*(L = 2.55 m, k_{crit} = 1.00)*						
	2.55	1	0.60	-1.10	1.61	11.08	0.15*
Feld 4	*(L = 2.50 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-1.10	1.61	11.08	0.15*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.20	1	0.60	1.26	0.10	1.62	0.06
	2.28	1	0.60	-2.11	0.17	1.62	0.11*
Feld 2	0.22	1	0.60	1.84	0.15	1.62	0.09*
	2.33	1	0.60	-1.58	0.13	1.62	0.08
Feld 3	0.22	1	0.60	1.58	0.13	1.62	0.08
	2.33	1	0.60	-1.84	0.15	1.62	0.09*
Feld 4	0.22	1	0.60	2.11	0.17	1.62	0.11*
	2.30	1	0.60	-1.26	0.10	1.62	0.06

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.50	2.50
Feld 2	2.55	2.55
Feld 3	2.55	2.55
Feld 4	2.50	2.50

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	1	0.60	1.59	240.0	1.75	0.07	2.02	0.03
Auflager B	1	0.60	8.74	288.0	1.75	0.30	2.02	0.15
Auflager C	1	0.60	7.36	288.0	1.75	0.26	2.02	0.13
Auflager D	1	0.60	8.74	288.0	1.75	0.30	2.02	0.15
Auflager E	1	0.60	1.59	240.0	1.75	0.07	2.02	0.03

f^*_{c90d}: $k_{c90} * f_{c90d}$

Lagesicherheit
DIN EN 1990, 6.4.2

Lagesicherheitsnachweis in vertikaler Richtung nach NDP zu A1.3.1(3)

Aufl.	Ek [-]	$F_{d,dst}$ [kN]	$F_{d,stb}$ [kN]	G [-]
A	12	0.00	1.06	0.00
B	13	-6.97	5.83	1.20!
C	13	-5.95	4.90	1.21!
D	13	-6.97	5.83	1.20!
E	12	0.00	1.06	0.00

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zugverankerung

ständig/vorüberg.

Aufl.	$F_{d,anch}$ [kN]	EK
B	-0.49	17
C	-0.50	17
D	-0.49	17

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen — Nachweise der Verformungen

Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.50 m, NKL 2, k_{def} = 0.80)*						
	1.10	5	w_{inst}	0.5	l/300=	8.3	0.06
	1.10	7	w_{fin}	0.9	l/200=	12.5	0.07
	1.10	9	$w_{net,fin}$	0.9	l/300=	8.3	0.11
Feld 2	*(L= 2.55 m, NKL 2, k_{def} = 0.80)*						
	1.37	5	w_{inst}	0.2	l/300=	8.5	0.02
	1.37	7	w_{fin}	0.3	l/200=	12.8	0.02
	1.37	9	$w_{net,fin}$	0.3	l/300=	8.5	0.04
Feld 3	*(L= 2.55 m, NKL 2, k_{def} = 0.80)*						
	1.18	5	w_{inst}	0.2	l/300=	8.5	0.02
	1.18	7	w_{fin}	0.3	l/200=	12.8	0.02
	1.18	9	$w_{net,fin}$	0.3	l/300=	8.5	0.04
Feld 4	*(L= 2.50 m, NKL 2, k_{def} = 0.80)*						
	1.40	5	w_{inst}	0.5	l/300=	8.3	0.06
	1.40	7	w_{fin}	0.9	l/200=	12.5	0.07
	1.40	9	$w_{net,fin}$	0.9	l/300=	8.3	0.11

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	1.17
	B	6.47
	C	5.45
	D	6.47
	E	1.17
Einw. *Qk.W*	A	0.00
	B	-4.65
	C	-3.96
	D	-4.65
	E	0.00

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 4	0.00	OK	0.15
Querkraft	Feld 4	0.22	OK	0.11
Auflagerpressung	Auflager B		OK	0.15
Lagesicherheit			Zugv.	1.21

Zugv.: Für die Auflager B , C und D ist eine Zugkraftverankerung erforderlich.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

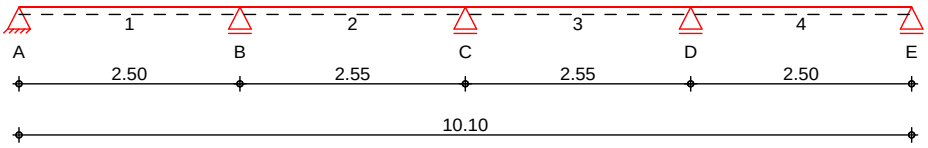
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 4	1.40	OK	0.06
Enddurchbiegung	Feld 4	1.40	OK	0.07
gesamte Enddurchb.	Feld 4	1.40	OK	0.11

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. G6 Grid Dachträger

System — Holz-Mehrfeldträger

M 1:85



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.50	2.50	2
2	2.55	2.55	2
3	2.55	2.55	2
4	2.50	2.50	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.50	12.00	starr	frei
C	5.05	12.00	starr	frei
D	7.60	12.00	starr	frei
E	10.10	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

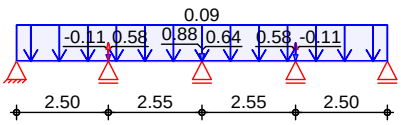
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

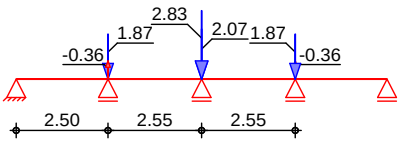
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

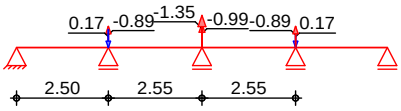
Einwirkungen — Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	10.10		0.09

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	G01	2.50	0.58
	(b)	1	G02	2.50	-0.11
	(c)	1	G03	5.05	0.64
	(d)	1	G03	5.05	0.88
	(b)	1	G02	7.60	-0.11
	(a)	1	G01	7.60	0.58
Einw. *Qk.S*	(a)	1	G01	2.50	1.86
	(b)	1	G02	2.50	-0.35
	(c)	1	G03	5.05	2.07
	(d)	1	G03	5.05	2.83
	(b)	1	G02	7.60	-0.35
	(a)	1	G01	7.60	1.86
Einw. *Qk.W*	(a)	1	G01	2.50	-0.89
	(b)	1	G02	2.50	0.17
	(c)	1	G03	5.05	-0.99
	(d)	1	G03	5.05	-1.35
	(b)	1	G02	7.60	0.17
	(a)	1	G01	7.60	-0.89

(a) aus Pos. 'G01', Lager 'C' (Seite 17)

(b) aus Pos. 'G02', Lager 'A' (Seite 18)

(c) aus Pos. 'G03', Lager 'A' (Seite 19)

(d) aus Pos. 'G03', Lager 'C' (Seite 19)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	5	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	
	16		1.00*Gk	
quasi-ständig	21		1.00*Gk	

st: ständig
ku: kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	1	0.09	2	0.12	1
	0.98	0.04	2	0.06	1	0.00	1	0.00	2
	2.50	-0.08	1	-0.06	2	-0.18	1	-0.14	2
Feld 2	0.00	-0.08	1	-0.06	2	0.12	2	0.16	1
	1.35	0.02	2	0.03	1	0.00	1	0.00	2
	2.55	-0.06	1	-0.04	2	-0.14	1	-0.11	2
Feld 3	0.00	-0.06	1	-0.04	2	0.11	2	0.14	1
	1.20	0.02	2	0.03	1	0.00	2	0.00	1
	2.55	-0.08	1	-0.06	2	-0.16	1	-0.12	2
Feld 4	0.00	-0.08	1	-0.06	2	0.14	2	0.18	1

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

1.52	0.04	2	0.06	1	0.00	2	0.00	1
2.50	0.00	2	0.00	1	-0.12	1	-0.09	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	16.0	256.0	5461.3

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 2.50 m, k_{crit} = 1.00)*						
	2.50	1	0.60	-0.08	0.12	11.08	0.01*
Feld 2	*(L = 2.55 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-0.08	0.12	11.08	0.01*
Feld 3	*(L = 2.55 m, k_{crit} = 1.00)*						
	2.55	1	0.60	-0.08	0.12	11.08	0.01*
Feld 4	*(L = 2.50 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-0.08	0.12	11.08	0.01*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.20	1	0.60	0.09	0.01	1.62	0.00
	2.28	1	0.60	-0.16	0.01	1.62	0.01*
Feld 2	0.22	1	0.60	0.14	0.01	1.62	0.01*
	2.33	1	0.60	-0.12	0.01	1.62	0.01
Feld 3	0.22	1	0.60	0.12	0.01	1.62	0.01
	2.33	1	0.60	-0.14	0.01	1.62	0.01*
Feld 4	0.22	1	0.60	0.16	0.01	1.62	0.01*
	2.30	1	0.60	-0.09	0.01	1.62	0.00

Stabilität — Nachweis der Stabilität
Abs. 6.3

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.50	2.50
Feld 2	2.55	2.55
Feld 3	2.55	2.55
Feld 4	2.50	2.50

Auflagerpressung — Nachweis der Auflagerpressung
Abs. 6.1.5

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	1	0.60	0.12	240.0	1.75	0.00	2.02	0.00
Auflager B	5	0.90	3.24	288.0	1.75	0.11	3.03	0.04
Auflager C	5	0.90	9.70	288.0	1.75	0.34	3.03	0.11
Auflager D	5	0.90	3.24	288.0	1.75	0.11	3.03	0.04
Auflager E	1	0.60	0.12	240.0	1.75	0.00	2.02	0.00

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen — Nachweise der Verformungen
Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.50 m, NKL 2, k_{def} = 0.80)*						
	1.10	11	w_{inst}	0.0	l/300=	8.3	0.00
	1.10	16	w_{fin}	0.1	l/200=	12.5	0.01
	1.10	21	$w_{net,fin}$	0.1	l/300=	8.3	0.01
Feld 2	*(L= 2.55 m, NKL 2, k_{def} = 0.80)*						
	1.37	11	w_{inst}	0.0	l/300=	8.5	0.00
	1.37	16	w_{fin}	0.0	l/200=	12.8	0.00
	1.37	21	$w_{net,fin}$	0.0	l/300=	8.5	0.00
Feld 3	*(L= 2.55 m, NKL 2, k_{def} = 0.80)*						
	1.18	11	w_{inst}	0.0	l/300=	8.5	0.00
	1.18	16	w_{fin}	0.0	l/200=	12.8	0.00
	1.18	21	$w_{net,fin}$	0.0	l/300=	8.5	0.00
Feld 4	*(L= 2.50 m, NKL 2, k_{def} = 0.80)*						
	1.40	11	w_{inst}	0.0	l/300=	8.3	0.00
	1.40	16	w_{fin}	0.1	l/200=	12.5	0.01
	1.40	21	$w_{net,fin}$	0.1	l/300=	8.3	0.01

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.09
	B	0.73
	C	1.73
	D	0.73
	E	0.09
Einw. *Qk.S*	A	0.00
	B	1.51
	C	4.91
	D	1.51
	E	0.00
Einw. *Qk.W*	A	0.00
	B	-0.72
	C	-2.34
	D	-0.72
	E	0.00

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.01
Querkraft	Feld 1	2.28	OK	0.01
Auflagerpressung	Auflager C		OK	0.11

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.10	OK	0.00
Enddurchbiegung	Feld 1	1.10	OK	0.01

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

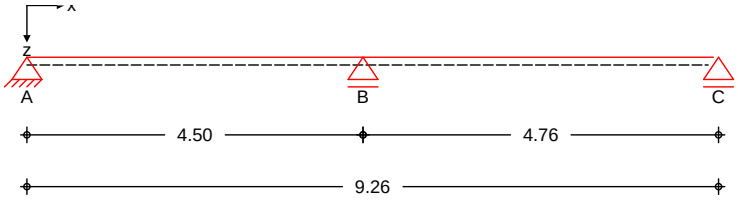
gesamte Enddurchb. Feld 1	1.10	OK	0.01

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. D1.1 Sparren

System
M 1:100

2-Feld Sparren



Abmessungen
Mat./Querschnitt

Feld	l [m]	Material	b/h [cm]
1	4.50	*NH C24*	**7.0/24.0**
2	4.76		

Auflager

Lager	x [m]	z [m]	$K_{T,z}$ [kN/m]	$K_{T,x}$ [kN/m]
A	0.00	0.00	fest	fest
B	4.50	0.00	fest	frei
C	9.26	0.00	fest	frei

Einschnitttiefe am Auflager t = 4.0 cm

Dachneigung — Dachneigungswinkel ä = 0.0 °

Sparrenabstand — Abstand a = 0.52 m

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte
Qk.S.A Fall (i)

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte
Qk.W.000 Anstrºmrichtung dž = 0Á
Qk.W.090 Anstrºmrichtung dž = 90Á
Qk.W.180 Anstrºmrichtung dž = 180Á
Qk.W.270 Anstrºmrichtung dž = 270Á

Wind/Schnee — Wind- und Schneelastermittlung

Dachform — Flachdach
Dachneigungswinkel ä = 0.00 °

Gebäudeabmessungen
Breite (Giebel) B = 9.26 m
Länge (Traufe) L = 10.30 m
Höhe (First) H = 6.66 m

Bauteillage
Ortgangabstand a_{Ov} = 2.20 m
Lasteinzugsbreite links L_{Bl} = 0.26 m
Lasteinzugsbreite rechts L_{Br} = 0.26 m

geograf. Angaben
Gelände über Meeresniveau A = 599.00 mü NN
Gebäudestandort: Binnenland

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Windlasten

Windzone 2, DIN EN 1991-1-4:2010-12
Anströmrichtung 0° auf Traufe links
Geschwindigkeitsdruck q_p = 0.59 kN/m²
$e_B/10$ = 1.03 m $e_B/4$ = 2.58 m
$e_L/10$ = 0.93 m $e_L/4$ = 2.32 m

Außendruck

für Unterkonstruktion mit A = 4.82 m²

B.	$c_{pe,0}$	$c_{pe,90}$	$c_{pe,180}$	$c_{pe,270}$	$w_{e,0}$	$w_{e,90}$	$w_{e,180}$	$w_{e,270}$
			[-]				[kN/m²]	
F	-2.02	-2.02	-2.02	-2.02	-1.18	-1.18	-1.18	-1.18
H	-0.86	-0.86	-0.86	-0.86	-0.50	-0.50	-0.50	-0.50
I	0.20	0.20	0.20	0.20	0.12	0.12	0.12	0.12

Außendruck

für Lastweiterleitung mit A Ó 10.00 m²

B.	$c_{pe,0}$	$c_{pe,90}$	$c_{pe,180}$	$c_{pe,270}$	$w_{e,0}$	$w_{e,90}$	$w_{e,180}$	$w_{e,270}$
			[-]				[kN/m²]	
F	-1.80	-1.80	-1.80	-1.80	-1.05	-1.05	-1.05	-1.05
H	-0.70	-0.70	-0.70	-0.70	-0.41	-0.41	-0.41	-0.41
I	0.20	0.20	0.20	0.20	0.12	0.12	0.12	0.12

Schneelasten

Schneelastzone 1a, nach DIN EN 1991-1-3:2010-12
char. Schneelast auf dem Boden s_k = 1.31 kN/m²
Schneefanggitter vorhanden

Lastbild	ǩ1	s [kN/m²]
(i)	0.80	1.05

Belastungen

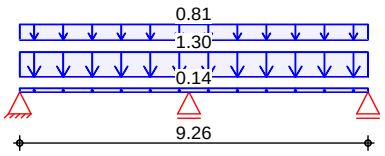
Belastungen auf das System

Grafik

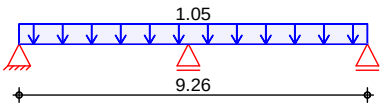
Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

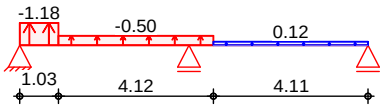
Gk



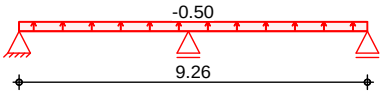
Qk.S.A



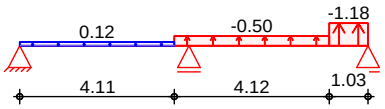
Qk.W.000



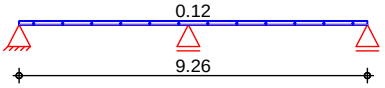
Qk.W.090



Qk.W.180



Qk.W.270



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Flächenlasten in z-Richtung

		Feld	Richt.	Komm.	a [m]	s [m]	q_a [kN/m²]	q_e [kN/m²]
Einw. *Gk*		1	global	Eigengew	0.00	9.26		0.14
		1	vert.DF	Eindeck.	0.00	9.26		1.30
	(a)	1	vert.DF	Ausbau	0.00	9.26		0.81
Einw. *Qk.S.A*		1	vert.GF	Volllast	0.00	9.26		1.05
Einw. *Qk.W.000*		1	lokal	Ber. F	0.00	1.03		-1.18
		1	lokal	Ber. H	1.03	4.12		-0.50
		2	lokal	Ber. I	0.65	4.11		0.12
Einw. *Qk.W.090*		1	lokal	Ber. H	0.00	9.26		-0.50
Einw. *Qk.W.180*		2	lokal	Ber. F	3.73	1.03		-1.18
		1	lokal	Ber. H	4.11	4.12		-0.50
		1	lokal	Ber. I	0.00	4.11		0.12
Einw. *Qk.W.270*		1	lokal	Ber. I	0.00	9.26		0.12

(a) aus Pos. 'L1' Flächenlast Gk 'gk_FD'

0.806 = 0.81 kN/m²

global: Belastung bezogen auf das globale Koordinatensystem
lokal: lokale Belastung orthogonal zur Dachfläche
vert.DF: vertikale Belastung bezogen auf die Dachfläche
vert.GF: vertikale Belastung bezogen auf die Grundfläche

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S.A	
quasi-ständig	29		1.00*Gk		
selten	36		1.00*Gk	+1.00*Qk.S.A	+0.60*Qk.W.000
Lagesicherheit	50	ku/sk	1.10*Gk	+1.50*Qk.S.A	+0.90*Qk.W.000
	54	ku/sk	1.10*Gk	+1.50*Qk.S.A	+0.90*Qk.W.180
	56	ku/sk	1.10*Gk	+1.50*Qk.S.A	+0.90*Qk.W.270
	60	ku/sk	0.90*Gk	+1.50*Qk.W.000	
	61	ku/sk	0.90*Gk	+1.50*Qk.W.090	
	62	ku/sk	0.90*Gk	+1.50*Qk.W.180	
st./vor. Auflagerkr.	72	st	1.35*Gk		
	78	ku/sk	1.35*Gk	+1.50*Qk.S.A	+0.90*Qk.W.000
	82	ku/sk	1.35*Gk	+1.50*Qk.S.A	+0.90*Qk.W.180
	84	ku/sk	1.35*Gk	+1.50*Qk.S.A	+0.90*Qk.W.270
	91	ku/sk	1.00*Gk	+1.50*Qk.W.000	
	93	ku/sk	1.00*Gk	+1.50*Qk.W.090	
	95	ku/sk	1.00*Gk	+1.50*Qk.W.180	

ku: kurz
ku/sk: kurz/sehr kurz
st: ständig

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (maßgebende)

	Feld	x [m]	$M_{y,d}$ [kNm/m]	$V_{z,d}$ [kN/m]
Komb. *2*	1	0.00	0.00	7.61
		4.50	-12.36*	-13.10*
	2	0.00	-12.36	13.55*
		2.99	7.58*	-0.20
		4.76	0.00	-8.36

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Mat./Querschnitt — Material- und Querschnittswerte nach DIN EN 1995-1-1

Material

Material	f_{mk}	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{mean}
			[N/mm²]			
NH C24	24.0	14.5	21.0	2.5	4.0	11000

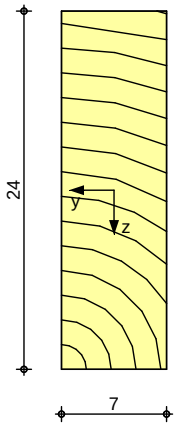
Querschnitt

Art	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
RE	7.0	24.0	168	8064

RE: Rechteckquerschnitt

Grafik — Querschnittsgrafik [cm]

M 1:5



Nutzungsklasse 1

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	N_d / M_{yd} [kN,kNm]	$\sigma_{0,d}$ / $\sigma_{my,d}$ [N/mm²]	$f_{0,d}$ / $f_{my,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.50 m, $k_{c,y}$= 0.61)*						
	4.50	2	0.90	0.00	0.00	10.04	
				-6.43	9.56	16.62	0.58*
Feld 2	*(L = 4.76 m, $k_{c,y}$= 0.57)*						
	0.00	2	0.90	0.00	0.00	10.04	
				-6.43	9.56	16.62	0.58*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	4.50	2	0.90	-6.81	1.22	2.77	0.44*
Feld 2	0.00	2	0.90	7.05	1.26	2.77	0.45*

Stabilität — Nachweis der Stabilität
Abs. 6.3

Der Sparren wird in der Dachebene als gehalten betrachtet.
Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Ersatzstablängen

	l [m]	$l_{ef,cy}$ [m]
Feld 1	4.50	4.50
Feld 2	4.76	4.76

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit (geschwächter Querschnitt)

	t [cm]	Ek	k_{mod} [-]	N_d / M_{yd} [kN, kNm]	$\sigma_{0,d}$ / $\sigma_{my,d}$ [N/mm²]	$f_{0,d}$ / $f_{my,d}$ [N/mm²]	G [-]
Auflager B	4.0	2	0.90	0.00	0.00	10.04	
				-6.43	13.77	16.62	0.83

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit (geschwächter Querschnitt)

	t [cm]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Auflager A	4.0	2	0.90	3.96	0.85	2.77	0.31
Auflager B	4.0	2	0.90	7.05	1.51	2.77	0.55
Auflager C	4.0	2	0.90	-4.35	0.93	2.77	0.34

Lagesicherheit
DIN EN 1990, 6.4.2

Lagesicherheitsnachweis in vertikaler Richtung nach NDP zu A1.3.1(3)

Aufl.	Ek [-]	$F_{d,dst}$ [kN]	$F_{d,stb}$ [kN]	G [-]
A	60	-1.26	1.73	0.73
B	61	-2.27	6.08	0.37
C	62	-1.31	1.90	0.69

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.50 m, NKL 1, k_{def} = 0.60)*						
	1.90	40	w_{inst}	4.4	l/300=	15.0	0.29*
	1.89	40	w_{fin}	6.0	l/200=	22.5	0.27*
	1.86	29	$w_{net,fin}$	4.3	l/300=	15.0	0.29*
Feld 2	*(L= 4.76 m, NKL 1, k_{def} = 0.60)*						
	2.69	36	w_{inst}	6.2	l/300=	15.9	0.39*
	2.70	36	w_{fin}	8.6	l/200=	23.8	0.36*
	2.72	29	$w_{net,fin}$	6.3	l/300=	15.9	0.39*

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Auflagerkräfte

je lfd. m (Windlasten mit $c_{pe,10}$)

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN/m]	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	0.00	3.71
	B		12.98
	C		4.07
Einw. *Qk.S.A*	A	0.00	1.74
	B		6.08
	C		1.91
Einw. *Qk.W.000*	A	0.00	-1.41
	B		-1.24
	C		0.35
Einw. *Qk.W.090*	A	0.00	-0.68

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	B		-2.37
	C		-0.74
Einw. *Qk.W.180*	A	0.00	0.38
	B		-1.22
	C		-1.45
Einw. *Qk.W.270*	A	0.00	0.19
	B		0.68
	C		0.21

Ankerkräfte

je Sparren (Windlasten mit $c_{pe,A}$)
Lasteinzugsfläche des Sparren A = 4.82 m²

Bem.-ankerkräfte ständig/vorüberg.

Aufl.	$F_{x,d,min}$ [kN]	EK	$F_{x,d,max}$ [kN]	EK	$F_{z,d,min}$ [kN]	EK	$F_{z,d,max}$ [kN]	EK
A	0.00	72	0.00	72	0.66	91	4.15	82
B					4.48	93	14.18	84
C					0.81	95	4.52	78

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld	x [m]		G [-]
Biegung	Feld 1	4.50	OK	0.58
Querkraft	Feld 2	0.00	OK	0.45
Biegung	Auflager B		OK	0.83
Querkraft	Auflager B		OK	0.55
Lagesicherheit			OK	

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

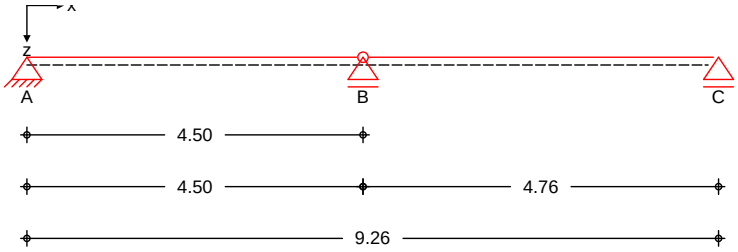
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbiegung	Feld 2	2.69	OK	0.39
Enddurchbiegung	Feld 2	2.70	OK	0.36
ges. Enddurchbiegung	Feld 2	2.72	OK	0.39

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. D1.2 Sparren

System
M 1:100

2-Feld Sparren



Abmessungen
Mat./Querschnitt

Feld	l [m]	Material	b/h [cm]
1	4.50	*NH C24*	**7.0/24.0**
2	4.76		

Gelenke

Feld	x [m]
1	4.50

Auflager

Lager	x [m]	z [m]	$K_{T,z}$ [kN/m]	$K_{T,x}$ [kN/m]
A	0.00	0.00	fest	fest
B	4.50	0.00	fest	frei
C	9.26	0.00	fest	frei

Einschnitttiefe am Auflager t = 4.0 cm

Dachneigung — Dachneigungswinkel ā = 0.0 °

Sparrenabstand — Abstand a = 0.40 m

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte
Qk.S.A Fall (i)

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte
Qk.W.000 Anstrºmrichtung dž = 0Á
Qk.W.090 Anstrºmrichtung dž = 90Á
Qk.W.180 Anstrºmrichtung dž = 180Á
Qk.W.270 Anstrºmrichtung dž = 270Á

Wind/Schnee — Wind- und Schneelastermittlung

Dachform — Flachdach
Dachneigungswinkel ā = 0.00 °

Gebäudeabmessungen
Breite (Giebel) B = 9.26 m
Länge (Traufe) L = 10.30 m
Höhe (First) H = 6.66 m

Bauteillage
Ortgangabstand a_{Ov} = 0.20 m
Lasteinzugsbreite links L_{Bl} = 0.20 m

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Lasteinzugsbreite rechts L_{Br} = 0.20 m

geograf. Angaben

Gelände über Meeresniveau A = 599.00 mü NN
Gebäudestandort: Binnenland

Windlasten

Windzone 2, DIN EN 1991-1-4:2010-12
Anströmrichtung 0° auf Traufe links
Geschwindigkeitsdruck q_p = 0.59 kN/m²
$e_B/10$ = 1.03 m $e_B/4$ = 2.58 m
$e_L/10$ = 0.93 m $e_L/4$ = 2.32 m

Außendruck

für Unterkonstruktion mit A = 3.70 m²

B.	$c_{pe,0}$	$c_{pe,90}$	$c_{pe,180}$	$c_{pe,270}$	$w_{e,0}$	$w_{e,90}$	$w_{e,180}$	$w_{e,270}$
	[-]				[kN/m²]			
F	-2.10	-2.10	-2.10	-2.10	-1.23	-1.23	-1.23	-1.23
G	-1.55	-1.55	-1.55	-1.55	-0.90	-0.90	-0.90	-0.90
H	-0.92	-0.92	-0.92	-0.92	-0.54	-0.54	-0.54	-0.54
I	0.20	0.20	0.20	0.20	0.12	0.12	0.12	0.12

Außendruck

für Lastweiterleitung mit A Ó 10.00 m²

B.	$c_{pe,0}$	$c_{pe,90}$	$c_{pe,180}$	$c_{pe,270}$	$w_{e,0}$	$w_{e,90}$	$w_{e,180}$	$w_{e,270}$
	[-]				[kN/m²]			
F	-1.80	-1.80	-1.80	-1.80	-1.05	-1.05	-1.05	-1.05
G	-1.20	-1.20	-1.20	-1.20	-0.70	-0.70	-0.70	-0.70
H	-0.70	-0.70	-0.70	-0.70	-0.41	-0.41	-0.41	-0.41
I	0.20	0.20	0.20	0.20	0.12	0.12	0.12	0.12

Schneelasten

Schneelastzone 1a, nach DIN EN 1991-1-3:2010-12
char. Schneelast auf dem Boden s_k = 1.31 kN/m²
Schneefanggitter vorhanden

Lastbild	$\check{k}_1$	s [kN/m²]
(i)	0.80	1.05

Belastungen

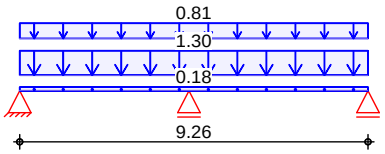
Belastungen auf das System

Grafik

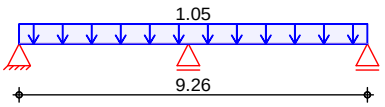
Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

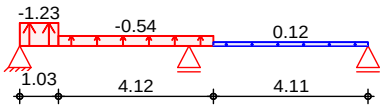
Gk



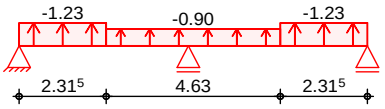
Qk.S.A



Qk.W.000



Qk.W.090



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.W.180 Qk.W.270

		Feld	Richt.	Komm.	a [m]	s [m]	q_a [kN/m²]	q_e [kN/m²]
Flächenlasten in z-Richtung								
Einw. *Gk*		1	global	Eigengew	0.00	9.26		0.18
		1	vert.DF	Eindeck.	0.00	9.26		1.30
	(a)	1	vert.DF	Ausbau	0.00	9.26		0.81
Einw. *Qk.S.A*		1	vert.GF	Volllast	0.00	9.26		1.05
Einw. *Qk.W.000*		1	lokal	Ber. F	0.00	1.03		-1.23
		1	lokal	Ber. H	1.03	4.12		-0.54
		2	lokal	Ber. I	0.65	4.11		0.12
Einw. *Qk.W.090*		1	lokal	Ber. F	0.00	2.32		-1.23
		2	lokal	Ber. F	2.45	2.32		-1.23
		1	lokal	Ber. G	2.32	4.63		-0.90
Einw. *Qk.W.180*		2	lokal	Ber. F	3.73	1.03		-1.23
		1	lokal	Ber. H	4.11	4.12		-0.54
		1	lokal	Ber. I	0.00	4.11		0.12
Einw. *Qk.W.270*		1	lokal	Ber. I	0.00	9.26		0.12

(a) aus Pos. 'L1' Flächenlast Gk 'gk_FD'

0.806 = 0.81 kN/m²

global: Belastung bezogen auf das globale Koordinatensystem
lokal: lokale Belastung orthogonal zur Dachfläche
vert.DF: vertikale Belastung bezogen auf die Dachfläche
vert.GF: vertikale Belastung bezogen auf die Grundfläche

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)		
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S.A	
quasi-ständig	29		1.00*Gk		
selten	42		1.00*Gk	+1.00*Qk.S.A	+0.60*Qk.W.270
Lagesicherheit	56	ku/sk	1.10*Gk	+1.50*Qk.S.A	+0.90*Qk.W.270
	61	ku/sk	0.90*Gk	+1.50*Qk.W.090	
st./vor. Auflagerkr.	72	st	1.35*Gk		
	84	ku/sk	1.35*Gk	+1.50*Qk.S.A	+0.90*Qk.W.270
	93	ku/sk	1.00*Gk	+1.50*Qk.W.090	

ku: kurz
ku/sk: kurz/sehr kurz
st: ständig

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (maßgebende)

	Feld	x [m]	$M_{y,d}$ [kNm/m]	$V_{z,d}$ [kN/m]
Komb. *2*	1	0.00	0.00	10.48
		4.50	0.00	-10.48
	2	0.00	0.00	11.08*
		2.38	13.19*	0.00
		4.76	0.00	-11.08*

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Mat./Querschnitt — Material- und Querschnittswerte nach DIN EN 1995-1-1

Material

Material	f_{mk}	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{mean}
	[N/mm²]					
NH C24	24.0	14.5	21.0	2.5	4.0	11000

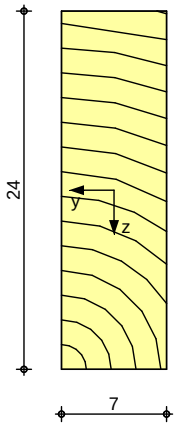
Querschnitt

Art	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
RE	7.0	24.0	168	8064

RE: Rechteckquerschnitt

Grafik — Querschnittsgrafik [cm]

M 1:5



Nutzungsklasse 1

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	N_d / M_{yd} [kN,kNm]	$\sigma_{0,d}$ / $\sigma_{my,d}$ [N/mm²]	$f_{0,d}$ / $f_{my,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.50 m, $k_{c,y}$= 0.61)*						
	2.25	2	0.90	0.00	0.00	10.04	
				4.72	7.02	16.62	0.42*
Feld 2	*(L = 4.76 m, $k_{c,y}$= 0.57)*						
	2.38	2	0.90	0.00	0.00	10.04	
				5.28	7.85	16.62	0.47*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	4.50	2	0.90	-4.19	0.75	2.77	0.27*
Feld 2	0.00	2	0.90	4.43	0.79	2.77	0.29*

Stabilität — Nachweis der Stabilität
Abs. 6.3

Der Sparren wird in der Dachebene als gehalten betrachtet.
Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Ersatzstablängen

	l [m]	$l_{ef,cy}$ [m]
Feld 1	4.50	4.50
Feld 2	4.76	4.76

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit (geschwächter Querschnitt)

	t [cm]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Auflager A	4.0	2	0.90	4.19	0.90	2.77	0.32
Auflager B	4.0	2	0.90	4.43	0.95	2.77	0.34
Auflager C	4.0	2	0.90	-4.43	0.95	2.77	0.34

Lagesicherheit
DIN EN 1990, 6.4.2

Lagesicherheitsnachweis in vertikaler Richtung nach NDP zu A1.3.1(3)

Aufl.	Ek [-]	$F_{d,dst}$ [kN]	$F_{d,stb}$ [kN]	η [-]
A	61	-1.56	1.85	0.84
B	61	-2.74	3.80	0.72
C	61	-1.63	1.96	0.84

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	η [-]
Feld 1	*(L= 4.50 m, NKL 1, k_{def} = 0.60)*						
	2.25	42	w_{inst}	8.2	l/300=	15.0	0.55*
	2.25	42	w_{fin}	11.5	l/200=	22.5	0.51*
	2.25	29	$w_{net,fin}$	8.8	l/300=	15.0	0.59*
Feld 2	*(L= 4.76 m, NKL 1, k_{def} = 0.60)*						
	2.38	42	w_{inst}	10.3	l/300=	15.9	0.65*
	2.38	42	w_{fin}	14.4	l/200=	23.8	0.60*
	2.38	29	$w_{net,fin}$	11.0	l/300=	15.9	0.69*

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Auflagerkräfte

je lfd. m (Windlasten mit $c_{pe,10}$)

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN/m]	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	0.00	5.14
	B		10.57
	C		5.43
Einw. *Qk.S.A*	A	0.00	2.36
	B		4.86
	C		2.50
Einw. *Qk.W.000*	A	0.00	-1.51
	B		-1.04
	C		0.26
Einw. *Qk.W.090*	A	0.00	-2.18
	B		-3.66
	C		-2.29
Einw. *Qk.W.180*	A	0.00	0.25
	B		-0.98
	C		-1.57
Einw. *Qk.W.270*	A	0.00	0.26
	B		0.54
	C		0.28

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Ankerkräfte

je Sparren (Windlasten mit $c_{pe,A}$)
Lasteinzugsfläche des Sparren A = 3.70 m²

Bem.-ankerkräfte ständig/vorüberg.

Aufl.	$F_{x,d,min}$ [kN]	EK	$F_{x,d,max}$ [kN]	EK	$F_{z,d,min}$ [kN]	EK	$F_{z,d,max}$ [kN]	EK
A	0.00	72	0.00	72	0.50	93	4.29	84
B					1.49	93	8.82	84
C					0.54	93	4.53	84

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld	x [m]		G [-]
Biegung	Feld 2	2.38	OK	0.47
Querkraft	Feld 2	0.00	OK	0.29
Querkraft	Auflager B		OK	0.34
Lagesicherheit			OK	

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

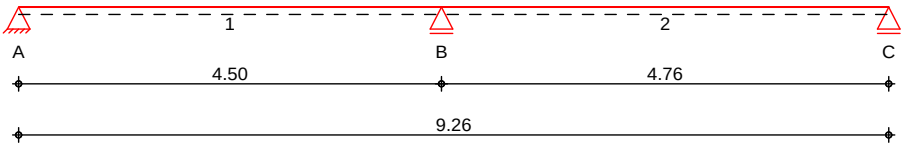
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbiegung	Feld 2	2.38	OK	0.65
Enddurchbiegung	Feld 2	2.38	OK	0.60
ges. Enddurchbiegung	Feld 2	2.38	OK	0.69

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. D1.3 Sparren mit Zusatzlasten

System — Holz-Zweifeldträger

M 1:80



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	4.50	4.50	1
2	4.76	4.76	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.50	16.00	starr	frei
C	9.26	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 18/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

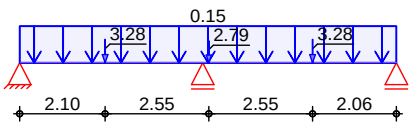
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

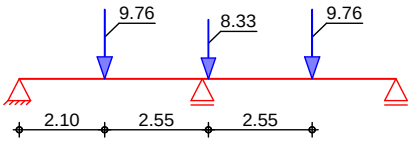
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

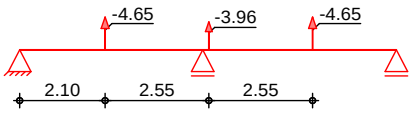
Einwirkungen — Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	9.26		0.15

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	G5	2.10	3.28
	(b)	1	G5	4.65	2.79
	(c)	1	G5	7.20	3.28
Einw. *Qk.S*	(a)	1	G5	2.10	9.76
	(b)	1	G5	4.65	8.33
	(c)	1	G5	7.20	9.76
Einw. *Qk.W*	(a)	1	G5	2.10	-4.65
	(b)	1	G5	4.65	-3.96
	(c)	1	G5	7.20	-4.65

(a) aus Pos. 'G5', Lager 'B' (Seite 39)

(b) aus Pos. 'G5', Lager 'C' (Seite 39)

(c) aus Pos. 'G5', Lager 'D' (Seite 39)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	+1.00*Qk.S
	13		1.00*Gk	+1.00*Qk.S
quasi-ständig	15		1.00*Gk	
Lagesicherheit	18	ku/sk	0.90*Gk	+1.50*Qk.W
st./vor. Auflagerkr.	25	ku/sk	1.00*Gk	+1.50*Qk.W

ku: kurz
ku/sk: kurz/sehr kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	2	-0.99	3	6.73	2
	2.10	-2.40	3	13.68	2	-12.77	2	2.38	3
	4.50	-17.56	2	2.88	3	-13.26	2	2.02	3
Feld 2	0.00	-17.56	2	2.88	3	-4.89	3	28.18	2
	2.70	-2.84	3	16.31	2	-7.71	2	1.54	3
	4.76	0.00	3	0.00	2	-8.13	2	1.23	3

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
18.0	24.0	432.0	20736.0

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.50 m, k_{crit} = 1.00)*						
	4.50	2	0.90	-17.56	10.16	16.62	0.61*
Feld 2	*(L = 4.76 m, k_{crit} = 1.00)*						
	0.00	2	0.90	-17.56	10.16	16.62	0.61*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	2	0.90	6.67	0.32	2.42	0.13
	4.18	2	0.90	-13.20	0.64	2.42	0.26*
Feld 2	0.32	2	0.90	11.85	0.58	2.42	0.24*
	4.48	2	0.90	-8.07	0.39	2.42	0.16

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	4.50	4.50
Feld 2	4.76	4.76

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.90	6.73	270.0	1.75	0.25	3.03	0.08
Auflager B	2	0.90	41.44	396.0	1.75	1.05	3.03	0.35
Auflager C	2	0.90	8.13	270.0	1.75	0.30	3.03	0.10

f^*_{c90d}: $k_{c90} * f_{c90d}$

Lagesicherheit
DIN EN 1990, 6.4.2

Lagesicherheitsnachweis in vertikaler Richtung nach NDP zu A1.3.1(3)

Aufl.	Ek [-]	$F_{d,dst}$ [kN]	$F_{d,stb}$ [kN]	G [-]
A	18	-2.34	1.21	1.92!
B	18	-14.71	7.02	2.10!
C	18	-2.83	1.45	1.96!

ständig/vorüberg.

Zugverankerung

Aufl.	$F_{d,anch}$ [kN]	EK
A	-0.99	25
B	-6.92	25
C	-1.23	25

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen — Nachweise der Verformungen
Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.50 m, NKL 1, k_{def} = 0.60)*						
	1.92	11	w_{inst}	4.7	l/300=	15.0	0.31
	1.92	13	w_{fin}	5.4	l/200=	22.5	0.24
	1.92	15	$w_{net,fin}$	2.0	l/300=	15.0	0.14
Feld 2	*(L= 4.76 m, NKL 1, k_{def} = 0.60)*						
	2.72	11	w_{inst}	6.8	l/300=	15.9	0.43
	2.72	13	w_{fin}	7.9	l/200=	23.8	0.33
	2.72	15	$w_{net,fin}$	3.0	l/300=	15.9	0.19

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	1.35
	B	7.80
	C	1.61
Einw. *Qk.S*	A	3.27
	B	20.61
	C	3.97
Einw. *Qk.W*	A	-1.56
	B	-9.81
	C	-1.89

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.61
Querkraft	Feld 1	4.18	OK	0.26
Auflagerpressung	Auflager B		OK	0.35
Lagesicherheit			Zugv.	2.10

Zugv.: Für die Auflager A , B und C ist eine Zugkraftverankerung erforderlich.

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

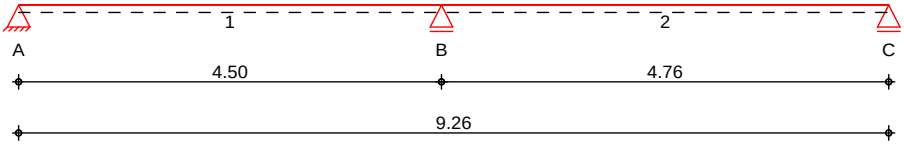
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 2	2.72	OK	0.43
Enddurchbiegung	Feld 2	2.72	OK	0.33
gesamte Enddurchb.	Feld 2	2.72	OK	0.19

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. D1.4 Sparren mit Zusatzlasten

System — Holz-Zweifeldträger

M 1:80



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	4.50	4.50	1
2	4.76	4.76	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.50	16.00	starr	frei
C	9.26	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 18/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

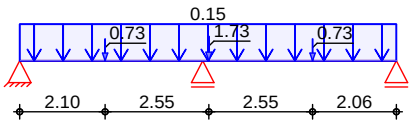
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

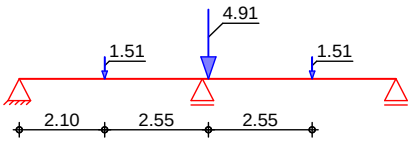
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

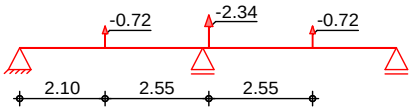
Einwirkungen — Gk



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	9.26		0.15

Punktlasten in z-Richtung

Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	G6	2.10	0.73
	(b)	1	G6	4.65	1.73
	(c)	1	G6	7.20	0.73
Einw. *Qk.S*	(a)	1	G6	2.10	1.51
	(b)	1	G6	4.65	4.91
	(c)	1	G6	7.20	1.51
Einw. *Qk.W*	(a)	1	G6	2.10	-0.72
	(b)	1	G6	4.65	-2.34
	(c)	1	G6	7.20	-0.72

(a) aus Pos. 'G6', Lager 'B' (Seite 48)

(b) aus Pos. 'G6', Lager 'C' (Seite 48)

(c) aus Pos. 'G6', Lager 'D' (Seite 48)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
selten	11		1.00*Gk	+1.00*Qk.S
	13		1.00*Gk	+1.00*Qk.S
quasi-ständig	15		1.00*Gk	
Lagesicherheit	18	ku/sk	0.90*Gk	+1.50*Qk.W
st./vor. Auflagerkr.	25	ku/sk	1.00*Gk	+1.50*Qk.W

ku: kurz
ku/sk: kurz/sehr kurz

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	2	0.16	3	1.31	2
	2.10	-0.01	3	2.30	2	-2.36	2	0.19	3
	4.50	-3.95	2	0.02	3	-2.85	2	-0.17	3
Feld 2	0.00	-3.95	2	0.02	3	-1.51	3	12.12	2
	2.70	-0.10	3	3.28	2	-1.38	2	0.20	3
	4.76	0.00	3	0.00	2	-1.80	2	-0.11	3

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
18.0	24.0	432.0	20736.0

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.50 m, k_{crit} = 1.00)*						
	4.50	2	0.90	-3.95	2.29	16.62	0.14*
Feld 2	*(L = 4.76 m, k_{crit} = 1.00)*						
	0.00	2	0.90	-3.95	2.29	16.62	0.14*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	2	0.90	1.25	0.06	2.42	0.03
	4.18	2	0.90	-2.79	0.14	2.42	0.06*
Feld 2	0.32	2	0.90	2.35	0.11	2.42	0.05*
	4.48	2	0.90	-1.74	0.08	2.42	0.04

Stabilität — Nachweis der Stabilität
Abs. 6.3

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	4.50	4.50
Feld 2	4.76	4.76

Auflagerpressung — Nachweis der Auflagerpressung
Abs. 6.1.5

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.90	1.31	270.0	1.75	0.05	3.03	0.02
Auflager B	2	0.90	14.97	396.0	1.75	0.38	3.03	0.12
Auflager C	2	0.90	1.80	270.0	1.75	0.07	3.03	0.02

f^*_{c90d}: $k_{c90} * f_{c90d}$

Lagesicherheit — Lagesicherheitsnachweis in vertikaler Richtung nach NDP zu A1.3.1(3)
DIN EN 1990, 6.4.2

Aufl.	Ek [-]	$F_{d,dst}$ [kN]	$F_{d,stb}$ [kN]	G [-]
A	18	-0.32	0.43	0.75
B	18	-4.86	3.17	1.53!
C	18	-0.48	0.53	0.91

Zugverankerung

ständig/vorüberg.

Aufl.	$F_{d,anch}$ [kN]	EK
B	-1.34	25

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen — Nachweise der Verformungen
Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.50 m, NKL 1, k_{def} = 0.60)*						
	1.81	11	w_{inst}	0.7	l/300=	15.0	0.05
	1.81	13	w_{fin}	0.9	l/200=	22.5	0.04
	1.86	15	$w_{net,fin}$	0.6	l/300=	15.0	0.04
Feld 2	*(L= 4.76 m, NKL 1, k_{def} = 0.60)*						

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

2.68	11	w_{inst}	1.5	l/300=	15.9	0.10
2.68	13	w_{fin}	1.9	l/200=	23.8	0.08
2.69	15	$w_{net,fin}$	1.0	l/300=	15.9	0.06

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.48
	B	3.52
	C	0.59
Einw. *Qk.S*	A	0.45
	B	6.81
	C	0.67
Einw. *Qk.W*	A	-0.21
	B	-3.24
	C	-0.32

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.14
Querkraft	Feld 1	4.18	OK	0.06
Auflagerpressung	Auflager B		OK	0.12
Lagesicherheit			Zugv.	1.53

Zugv.: Für das Auflager B ist eine Zugkraftverankerung erforderlich.

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

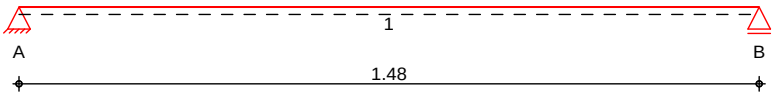
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 2	2.68	OK	0.10
Enddurchbiegung	Feld 2	2.68	OK	0.08
gesamte Enddurchb.	Feld 2	2.69	OK	0.06

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. D2 Unterzug deckengleich (beidseitig SSV)

System — Holz-Einfeldträger

M 1:15



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	1.48	1.48	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	1.48	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 12/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

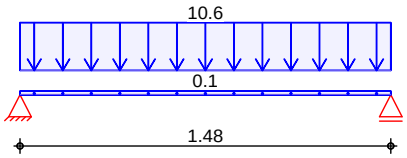
Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte
Qk.S.A Fall (i)

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte
Qk.W.000 Anstrºmrichtung dž = 0Á
Qk.W.090 Anstrºmrichtung dž = 90Á
Qk.W.180 Anstrºmrichtung dž = 180Á
Qk.W.270 Anstrºmrichtung dž = 270Á

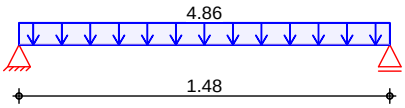
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

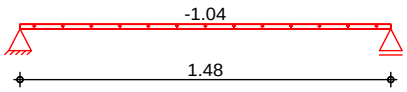
Einwirkungen — Gk



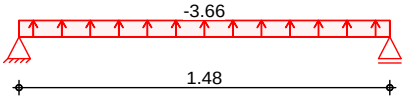
Qk.S.A



Qk.W.000

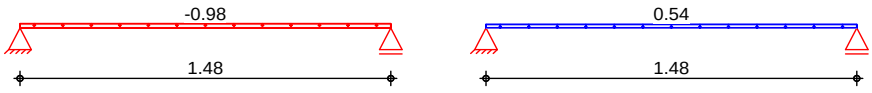


Qk.W.090



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.W.180 Qk.W.270



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	1.48		0.10
	(a)	1	D1.2	0.00	1.48		10.57
Einw. *Qk.S.A*	(a)	1	D1.2	0.00	1.48		4.86
Einw. *Qk.W.000*	(a)	1	D1.2	0.00	1.48		-1.04
Einw. *Qk.W.090*	(a)	1	D1.2	0.00	1.48		-3.66
Einw. *Qk.W.180*	(a)	1	D1.2	0.00	1.48		-0.98
Einw. *Qk.W.270*	(a)	1	D1.2	0.00	1.48		0.54

(a) aus Pos. 'D1.2', Lager 'B' (Seite 60)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S.A	
selten	30		1.00*Gk	+1.00*Qk.S.A	+0.60*Qk.W.270
	32		1.00*Gk	+1.00*Qk.S.A	+0.60*Qk.W.270
quasi-ständig	33		1.00*Gk		

ku: kurz

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	14	3.84	3	16.42	14
	0.74	1.42	3	6.07	14	0.00	14	0.00	3
	1.48	0.00	3	0.00	14	-16.42	14	-3.84	3

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k} [N/mm²]	f_{vk}	E_{0mean}
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
12.0	24.0	288.0	13824.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 1.48 m, k_{crit} = 1.00)*						
	0.74	2	0.90	5.94	5.16	16.62	0.31*

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.28	2	0.90	9.98	0.73	2.42	0.30
	1.20	2	0.90	-9.98	0.73	2.42	0.30*

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	1.48	1.48

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	2	0.90	16.06	180.0	1.75	0.89	3.03	0.29
Auflager B	2	0.90	16.06	180.0	1.75	0.89	3.03	0.29

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	η [-]
Feld 1	*(L= 1.48 m, NKL 1, k_{def} = 0.60)*						
	0.74	30	w_{inst}	0.7	l/300=	4.9	0.13
	0.74	32	w_{fin}	0.9	l/200=	7.4	0.12
	0.74	33	$w_{net,fin}$	0.7	l/300=	4.9	0.14

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	7.89
	B	7.89
Einw. *Qk.S.A*	A	3.60
	B	3.60
Einw. *Qk.W.000*	A	-0.77
	B	-0.77
Einw. *Qk.W.090*	A	-2.71
	B	-2.71
Einw. *Qk.W.180*	A	-0.73
	B	-0.73
Einw. *Qk.W.270*	A	0.40
	B	0.40

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		η [-]
Biegung	Feld 1	0.74	OK	0.31
Querkraft	Feld 1	1.20	OK	0.30
Auflagerpressung	Auflager A		OK	0.29

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	0.74	OK	0.13
Enddurchbiegung	Feld 1	0.74	OK	0.12
gesamte Enddurchb.	Feld 1	0.74	OK	0.14

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St1.1 Holzstütze Zwischenwand

System

Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen
Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.50	*NH C24*	**12/12**

Nutzungsklasse 1 beheizte Innenräume

Belastungen

Belastungen auf das System

Streckenlasten
in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.50		0.06

Punktlasten
in x-Richtung

Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	D2	2.50	7.89	0.0	0.0
Einw. *Qk.S.A*	(a)	D2	2.50	3.60	0.0	0.0
Einw. *Qk.W.000*	(a)	D2	2.50	-0.77	0.0	0.0
Einw. *Qk.W.090*	(a)	D2	2.50	-2.71	0.0	0.0
Einw. *Qk.W.180*	(a)	D2	2.50	-0.72	0.0	0.0
Einw. *Qk.W.270*	(a)	D2	2.50	0.40	0.0	0.0

(a) aus Pos. 'D2', Lager 'B' (Seite 72)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)
ständig/vorüberg.	1	st	1.35*Gk

st: ständig

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	8.05	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S.A*	A	3.60	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W.000*	A	-0.77	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W.090*	A	-2.71	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W.180*	A	-0.73	0.00	0.00	0.00	0.00
	B		0.00		0.00	

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Einw. *Qk.W.270*

A	0.40	0.00	0.00	0.00	0.00
B		0.00		0.00	

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweis im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.15
Druck	0.00	OK	0.42

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St1.2 Holzstütze Außenbereich

System

Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen
Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.50	*BSH GL24c*	**16/16**

Nutzungsklasse 3 frei der Witterung ausgesetzte Bauteile

Belastungen

Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.50		0.09

Punktlasten in x-Richtung

Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	G2	2.50	6.99	0.0	0.0
Einw. *Qk.S*	(a)	G2	2.50	19.82	0.0	0.0
Einw. *Qk.W*	(a)	G2	2.50	-9.43	0.0	0.0

(a) aus Pos. 'G2', Lager 'B' (Seite 26)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
	8	ku/sk	1.00*Gk	+1.50*Qk.W

ku: kurz
ku/sk: kurz/sehr kurz

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	7.21	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	19.82	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-9.43	0.00	0.00	0.00	0.00
	B		0.00		0.00	

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.15
Druck	2.50	OK	0.47

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St1.3 Holzstütze Zwischenwand

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.50	*NH C24*	**24/12**

Nutzungsklasse 1 beheizte Innenräume

Belastungen — Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.50		0.12

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	D1.3	2.50	7.80	0.0	0.0
Einw. *Qk.S*	(a)	D1.3	2.50	20.61	0.0	0.0
Einw. *Qk.W*	(a)	D1.3	2.50	-9.81	0.0	0.0

(a) aus Pos. 'D1.3', Lager 'B' (Seite 65)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
	8	ku/sk	1.00*Gk	+1.50*Qk.W

ku: kurz
ku/sk: kurz/sehr kurz

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	8.10	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	20.61	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-9.81	0.00	0.00	0.00	0.00
	B		0.00		0.00	

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.19
Druck	0.00	OK	0.60

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St1.4 Holzstütze Zwischenwand

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.50	*NH C24*	**12/12**

Nutzungsklasse 1 beheizte Innenräume

Belastungen — Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.50		0.06

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	D1.4	2.50	3.52	0.0	0.0
Einw. *Qk.S*	(a)	D1.4	2.50	6.81	0.0	0.0
Einw. *Qk.W*	(a)	D1.4	2.50	-3.24	0.0	0.0

(a) aus Pos. 'D1.4', Lager 'B' (Seite 69)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	2	ku	1.35*Gk	+1.50*Qk.S
	8	ku/sk	1.00*Gk	+1.50*Qk.W

ku: kurz
ku/sk: kurz/sehr kurz

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	3.67	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	6.81	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-3.24	0.00	0.00	0.00	0.00
	B		0.00		0.00	

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

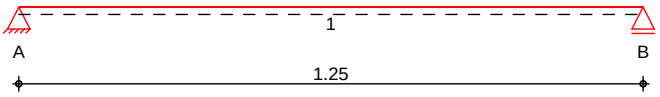
Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.14
Druck	0.00	OK	0.39

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. B1 Balkon

System — Holz-Einfeldträger

M 1:15



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	1.25	1.25	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	5.00	starr	frei
B	1.25	5.00	starr	frei

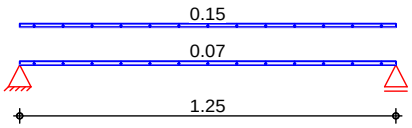
Material — *BSH GL24c*

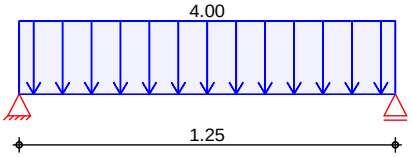
Querschnitt / Balkenabstand — **b/h = 8/16 cm; a = 0.625 m**

Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk | Qk.N





Flächenlasten in z-Richtung — Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*		1	Eigengew	0.00	1.25		0.07
	(a)	1		0.00	1.25		0.15
Einw. *Qk.N*		1		0.00	1.25		4.00

(a) Belag 5*0.03 = 0.15 kN/m

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
8.0	16.0	128.0	2730.7

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 1.25 m, k_{crit} = 1.00)*						
	0.63	3	0.80	0.77	2.25	14.77	0.15*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.18	3	0.80	1.77	0.29	2.15	0.13*
	1.07	3	0.80	-1.77	0.29	2.15	0.13

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	1.25	1.25

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	3	0.80	2.46	64.0	1.75	0.38	2.69	0.14
Auflager B	3	0.80	2.46	64.0	1.75	0.38	2.69	0.14

f^*_{c90d}: k_{c90} * f_{c90d}

Auflagerkräfte

Charakteristische und Bemessungsauflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	0.14
	B	0.14
Einw. *Qk.N*	A	2.50
	B	2.50

Bem.-auflagerkräfte ständig/vorüberg.

Aufl.	$F_{z,d,min}$ [kN/m]	EK	$F_{z,d,max}$ [kN/m]	EK
A	0.14	12	3.94	13
B	0.14	12	3.94	13

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		η [-]
Biegung	Feld 1	0.63	OK	0.15
Querkraft	Feld 1	0.18	OK	0.13
Auflagerpressung	Auflager A		OK	0.14

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

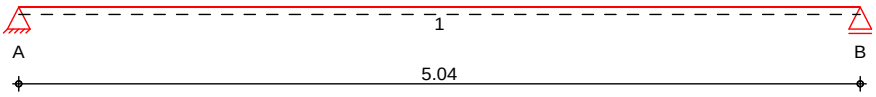
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	0.63	OK	0.07
Enddurchbiegung	Feld 1	0.63	OK	0.06
gesamte Enddurchb.	Feld 1	0.63	OK	0.04

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. B2 Randbalken, SSV einseitig

System — Holz-Einfeldträger

M 1:45



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	5.04	5.04	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	5.04	12.00	starr	frei

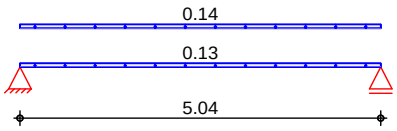
Material — *BSH GL24c*

Querschnitt — **b/h = 13/28 cm**

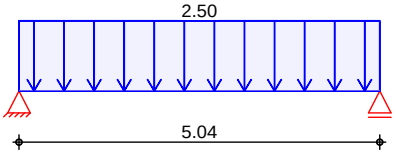
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	5.04		0.13
	(a)	1	B1	0.00	5.04		0.14
Einw. *Qk.N*	(a)	1	B1	0.00	5.04		2.50

(a) — aus Pos. 'B1', Lager 'A' (Seite 83)

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
13.0	28.0	364.0	23781.3

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 5.04 m, k_{crit} = 1.00)*						
	2.52	3	0.80	13.05	7.68	14.77	0.52*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.32	3	0.80	9.04	0.52	2.15	0.24
	4.72	3	0.80	-9.04	0.52	2.15	0.24*

Stabilität — Nachweis der Stabilität
Abs. 6.3

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	5.04	5.04

Auflagerpressung — Nachweis der Auflagerpressung
Abs. 6.1.5

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	10.36	195.0	1.75	0.53	2.69	0.20
Auflager B	3	0.80	10.36	195.0	1.75	0.53	2.69	0.20

f^*_{c90d}: k_{c90} * f_{c90d}

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.67
	B	0.67
Einw. *Qk.N*	A	6.30
	B	6.30

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	2.52	OK	0.52
Querkraft	Feld 1	0.32	OK	0.24
Auflagerpressung	Auflager A		OK	0.20

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

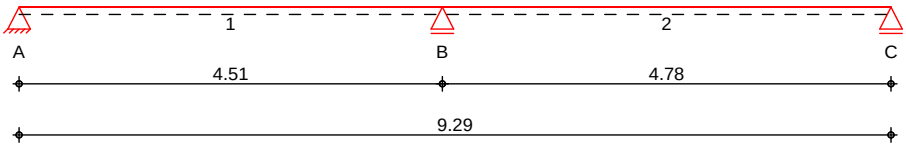
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.52	OK	0.53
Enddurchbiegung	Feld 1	2.52	OK	0.46
gesamte Enddurchb.	Feld 1	2.52	OK	0.35

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E1 geschlossene Decke

System — Einachsig gespannte Holz-Balkendecke

M 1:80



Abmessungen / Nutzungsklassen

Feld	l [m]	NKL
1	4.51	1
2	4.78	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.51	12.00	starr	frei
C	9.29	12.00	starr	frei

Material/ Querschnitt

Bauteil	Material	Querschnitt [cm]
Balken	*KVH C24*	**7/24**
Beplankung	*Span P5*	**t = 25 mm**

Balkenabstand **a = 0.45 m**
Deckenbreite **b = 2.50 m**

System in Querrichtung als Einfeldträger

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

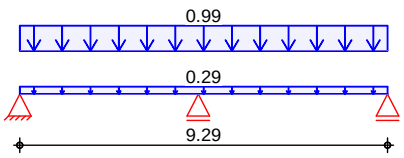
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume — fw

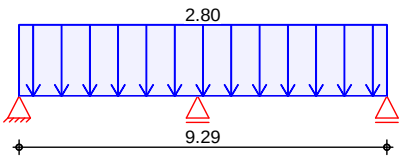
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Flächenlasten in z-Richtung — Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*	(a)	1	Eigengew	0.00	9.29		0.29
	(b)	1	G	0.00	9.29		0.99
Einw. *Qk.N*	(c)	1	Nutzlast	0.00	9.29		2.80

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a)	Holzbalken	0.07*0.24*4.2/0.45	=	0.16	kN/m²
	Beplankung	0.025*5.5	=	0.14	kN/m²
			å	0.29	kN/m²
(b)	aus Pos. 'L1' Flächenlast Gk 'gk;SD'	0.992	=	0.99	kN/m²
(c)	Nutzlast q	2.3	=	2.30	kN/m²
	‡q	0.5	=	0.50	kN/m²
			=	2.80	kN/m²

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ï (Ä*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	2	mi	1.35*Gk	+1.50*Qk.N (1)
	4	mi	1.35*Gk	+1.50*Qk.N (1,2)
	7	mi	1.35*Gk	+1.50*Qk.N (2)
selten	9		1.00*Gk	+1.00*Qk.N (1)
	10		1.00*Gk	+1.00*Qk.N (2)
	11		1.00*Gk	+1.00*Qk.N (1)
	12		1.00*Gk	+1.00*Qk.N (2)
quasi-ständig	13		1.00*Gk	+0.30*Qk.N (1)
	14		1.00*Gk	+0.30*Qk.N (2)
Brand	18		1.00*Gk	+0.30*Qk.N (1,2)

st: ständig
mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	3	0.00	2	0.76	3	11.20	2
	1.86	-0.81	3	10.56	2	-1.73	7	0.23	5
	4.51	-16.05	4	-3.48	6	-16.95	4	-3.67	6
Feld 2	0.00	-16.05	4	-3.48	6	3.80	6	17.55	4
	2.79	-0.04	5	11.96	7	-0.17	3	1.38	2
	4.78	0.00	5	0.00	7	-11.91	7	-1.26	5

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}	k_{fi}
	[N/mm²]						[-]
KVH C24	24.0	14.5	21.0	2.5	4.0	11000	1.25
Span P5^{Pf}	11.7	7.4	10.3	10.0	1.5	3000	1.15

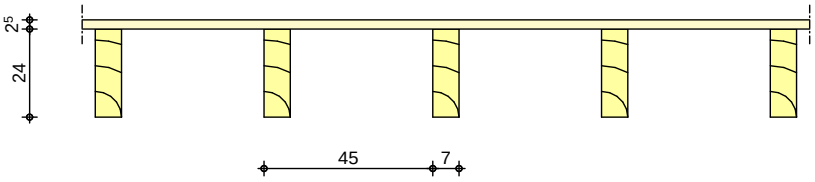
P: Beanspruchung als Platte
f: Lamellenlage flachkant

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Querschnittswerte

Bauteil	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
Balken	7.0	24.0	168.0	8064.0

M 1:20



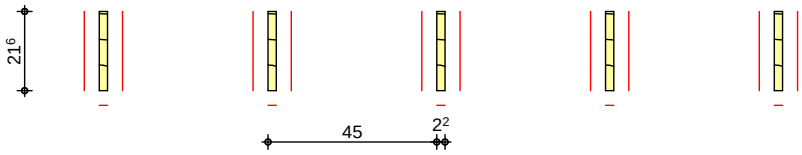
Brandfall

Brandbeanspruchung	t_{req} [min]
dreiseitig (unten/links/rechts)	30

Querschnittswerte Restquerschnitt

Bauteil	$\bar{a}_n$ [mm/min]	b_r [cm]	h_r [cm]	p [cm]	A_r [cm²]	$I_{y,r}$ [cm⁴]
Balken	0.80	2.2	21.6	45.4	47.5	1847.6

M 1:20



beflammte Querschnittsseiten

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.51 m)*						
	4.51	4	0.80	-7.22	10.75	14.77	0.73*
Feld 2	*(L = 4.78 m)*						
	0.00	4	0.80	-7.22	10.75	14.77	0.73*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	4.51	4	0.80	-7.63	1.36	2.46	0.55*
Feld 2	0.00	4	0.80	7.90	1.41	2.46	0.57*

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.80	5.04	105.0	1.50	0.48	2.31	0.21
Auflager B	4	0.80	15.52	126.0	1.50	1.23	2.31	0.53
Auflager C	7	0.80	5.36	105.0	1.50	0.51	2.31	0.22

f^*_{c90d}: $k_{c90} * f_{c90d}$

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.51 m, NKL 1, k_{def} = 0.60)*						
	2.08	9	w_{inst}	6.6	l/300=	15.0	0.44
	2.08	11	w_{fin}	8.3	l/200=	22.6	0.37
	2.08	13	$w_{net,fin}$	4.6	l/300=	15.0	0.31
Feld 2	*(L= 4.78 m, NKL 1, k_{def} = 0.60)*						
	2.58	10	w_{inst}	8.5	l/300=	15.9	0.53
	2.58	12	w_{fin}	10.8	l/200=	23.9	0.45
	2.58	14	$w_{net,fin}$	6.2	l/300=	15.9	0.39

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Schwingungen

Nachweis nach F. Colling, 'Holzbau', 07/2012 und P. Hamm, 'Schwingungen bei Holzdecken', 2012

Decke innerhalb einer Nutzungseinheit

Frequenzkriterium

f_1 [Hz]	f_{grenz} [Hz]	G [-]
8.7	6.0	0.69

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

Nachweise (Brand)

Nachweise der Feuerwiderstandsfähigkeit nach DIN EN 1995-1-2, 4.2.3

Brandfall

Brandbeanspruchung	t_{req} [min]
dreiseitig (unten/links/rechts)	30

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	$k_{mod,fi}$ [-]	$M_{yd,fi}$ [kNm]	$\sigma_{m,d,fi}$ [N/mm²]	$f_{m,d,fi}$ [N/mm²]	G [-]
Feld 1	*(L = 4.51 m)*						
	4.51	18	0.52	-2.59	15.12	15.67	0.97*
Feld 2	*(L = 4.78 m)*						
	0.00	18	0.52	-2.59	15.12	15.67	0.97*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	$k_{mod,fi}$ [-]	$V_{z,d,fi}$ [kN]	$\tau_{d,fi}$ [N/mm²]	$f_{v,d,fi}$ [N/mm²]	G [-]
Feld 1	4.51	18	0.52	-2.73	1.72	2.61	0.66*
Feld 2	0.00	18	0.52	2.83	1.79	2.61	0.68*

Auflagerkräfte

Charakteristische Auflagerkräfte

- Der Nutzlastanteil ‡q wird nicht berücksichtigt.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Char. Auflagerkr.

	Aufl.	$F_{z,k,min}$ [kN/m]	$F_{z,k,max}$ [kN/m]
Einw. *Gk*	A	2.13	2.13
	B	7.47	7.47
	C	2.35	2.35
Einw. *Qk.N*	A	-0.75	4.56
	B	6.41	13.36
	C	-0.59	4.79

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.73
Querkraft	Feld 2	0.00	OK	0.57
Auflagerpressung	Auflager B		OK	0.53

Nachweise (Brand) — Brandfall im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.97
Querkraft	Feld 2	0.00	OK	0.68

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 2	2.58	OK	0.53
Enddurchbiegung	Feld 2	2.58	OK	0.45
gesamte Enddurchb.	Feld 2	2.58	OK	0.39
Schwingung	Feld 2	2.41	OK	0.69

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. Decke EG Nachweis der Feuerwiderstandsdauer

BAUFRITZ
WIR BAUEN GESUNDHEIT

Feuerwiderstand Deckenkonstruktion
solar decathlon

Deckenaufbau	25 mm ESB $\rho_k \geq 600 \frac{kg}{m^3}$
	240 mm Deckenbalken mit Spänedämmung
	12,5 mm GKF-Platte
	(12 mm ESB $\rho_k > 600 \frac{kg}{m^3}$)
Nachweis	nach Anhang E DIN EN 1995-1-2
	$t_{ins} > t_{req} = 30$ min
	$t_{ins} = \sum t_{ins,0,i} \cdot k_{pos} \cdot k_j$
$t_{ins,0}$	
GKF-Platte	12,5 mm $t_{ins,0} = 1,4 \cdot 12,5 = 17,5$ min
	18 mm $t_{ins,0} = 1,4 \cdot 18 = 25,2$ min
Spanplatte ESB	12 mm $t_{ins,0} = 1,1 \cdot 12 = 13,2$ min
	25 mm $t_{ins,0} = 1,1 \cdot 25 = 27,5$ min
k_{pos}	
für alle Platten	aufgrund der Spänedämmung wird "ungedämmt" angenommen.
	brandbeanspruchte Seite $k_{pos} = 0,8 \cdot 0,8 = 0,64$
	feuerabgewandte Seite $k_{pos} = 0,6 \cdot 0,8 = 0,4$

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

BAUFRITZ
WIR BAUEN GESUNDHEIT

k_{pos}

Spanplatte ESB	1	k_{pos}	= 1,0	Tabelle E.5
Gipsplatte	2	k_{pos}	= 0,6	— " —
Spanplatte ESB	4	k_{pos}	= 0,7	Tabelle E.4

Zusammenfassung

1. Lage	ESB 12 mm	15,2 mm · 0,64 · 1,0	= 8,45 min
2. Lage	GKF 18 mm	25,2 · 0,6 · 1,0	= 15,12 min
3. Lage	ESB 25 mm	27,5 · 0,7 · 0,2	= 3,85 min
ungedämmter Hohlraum		t_{ins} = 5 min, k_{pos} = 1,0	= 5 min
			32,42 min

Nachweis $\Sigma\, t_{ins} = 32{,}42 \text{ min} \geq 30 \text{ min} = t_{req}$

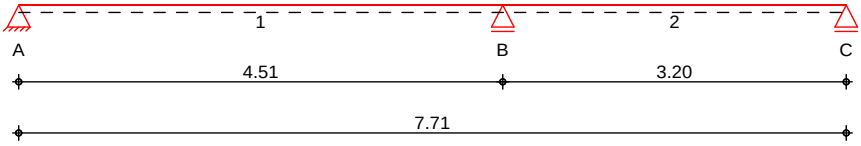
Der Nachweis der Feuerwiderstandsdauer kann für die Decke ohne Ansatz des Fußbodenaufbaus geführt werden

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E2 geschlossene Decke

System Einachsig gespannte Holz-Balkendecke

M 1:70



Abmessungen / Nutzungsklassen

Feld	l [m]	NKL
1	4.51	1
2	3.20	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.51	12.00	starr	frei
C	7.71	12.00	starr	frei

Material/ Querschnitt

Bauteil	Material	Querschnitt [cm]
Balken	*KVH C24*	**7/24**
Beplankung	*Span P5*	**t = 25 mm**

Balkenabstand **a = 0.55 m**
Deckenbreite **b = 2.50 m**

System in Querrichtung als Einfeldträger

Einwirkungen Einwirkungen nach DIN EN 1990:2010-12

Gk Ständige Einwirkung
Ständige Einwirkungen

Qk.N Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume fw

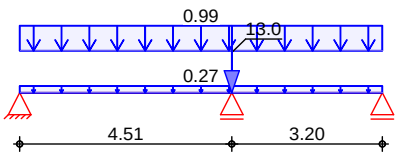
Qk.S Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

Qk.W Windeinwirkung
Windlasten
Qk.W min/max Werte

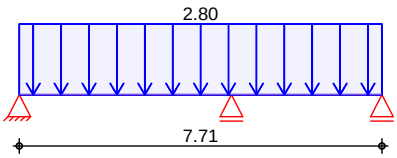
Belastungen Belastungen auf das System

Grafik Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen Gk

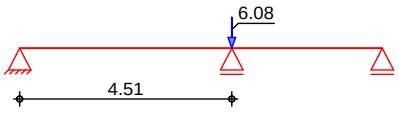


Qk.N

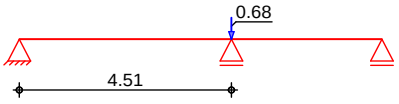


mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Qk.S



Qk.W



Flächenlasten in z-Richtung

Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*	(a)	1	Eigengew	0.00	7.71		0.27
	(b)	1	G	0.00	7.71		0.99
Einw. *Qk.N*	(c)	1	Nutzlast	0.00	7.71		2.80

(a)

Holzbalken	0.07*0.24*4.2/0.55	= 0.13	kN/m²
Beplankung	0.025*5.5	= 0.14	kN/m²
		= 0.27	kN/m²

(b)

aus Pos. 'L1' Flächenlast Gk 'gk;SD'

	0.992	= 0.99	kN/m²

(c)

Nutzlast q	2.3	= 2.30	kN/m²
‡q	0.5	= 0.50	kN/m²
		= 2.80	kN/m²

Streckenlasten in z-Richtung

Streckenlasten senkrecht zum Bauteil

		Feld	Komm.	a [m]	q [kN/m]
Einw. *Gk*	(a)	2	D1.1	0.00	12.98
Einw. *Qk.S*	(a)	2	D1.1	0.00	6.08
Einw. *Qk.W*	(a)	2	D1.1	0.00	0.68

(a) aus Pos. 'D1.1', Lager 'B' (Seite 54)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	2	mi	1.35*Gk	+1.50*Qk.N (1)
	4	mi	1.35*Gk	+1.50*Qk.N (2)
	7	mi	1.35*Gk	+1.50*Qk.N (1,2)
selten	53		1.00*Gk	+1.00*Qk.N (1)
	54		1.00*Gk	+1.00*Qk.N (2)
	59		1.00*Gk	+1.00*Qk.N (1)
	60		1.00*Gk	+1.00*Qk.N (2)
quasi-ständig	65		1.00*Gk	+0.30*Qk.N (1)
	66		1.00*Gk	+0.30*Qk.N (2)
Brand	72		1.00*Gk	+0.30*Qk.N (1,2)

st: ständig
mi: mittel

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	3	0.00	2	1.78	3	11.16	2
	1.86	1.13	3	10.55	2	-0.59	4	0.19	5
	4.51	-11.91	7	-2.54	8	-15.94	7	-3.40	8
Feld 2	0.00	-11.91	7	-2.54	8	2.81	8	13.16	7
	1.90	-2.02	5	4.99	4	-0.15	3	2.51	2
	3.20	0.00	5	0.00	4	-7.67	4	0.73	5

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

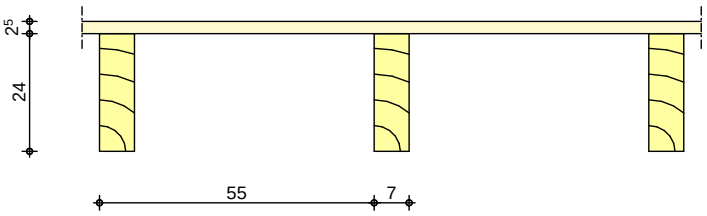
Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}	k_{fi}
			[N/mm²]				[-]
KVH C24	24.0	14.5	21.0	2.5	4.0	11000	1.25
Span P5^{Pf}	11.7	7.4	10.3	10.0	1.5	3000	1.15

P: Beanspruchung als Platte
f: Lamellenlage flachkant

Querschnittswerte

Bauteil	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
Balken	7.0	24.0	168.0	8064.0

M 1:15



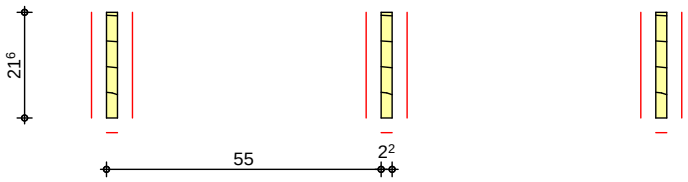
Brandfall

Brandbeanspruchung	t_{req} [min]
dreiseitig (unten/links/rechts)	30

Querschnittswerte Restquerschnitt

Bauteil	$\bar{a}_n$ [mm/min]	b_r [cm]	h_r [cm]	p [cm]	A_r [cm²]	$I_{y,r}$ [cm⁴]
Balken	0.80	2.2	21.6	45.4	47.5	1847.6

M 1:15



beflammte Querschnittsseiten

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.51 m)*						
	4.51	7	0.80	-6.55	9.74	14.77	0.66*
Feld 2	*(L = 3.20 m)*						
	0.00	7	0.80	-6.55	9.74	14.77	0.66*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	4.51	7	0.80	-8.77	1.57	2.46	0.64*
Feld 2	0.00	7	0.80	7.24	1.29	2.46	0.52*

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.80	6.14	105.0	1.50	0.58	2.31	0.25
Auflager B	7	0.80	25.64	126.0	1.50	2.04	2.31	0.88
Auflager C	4	0.80	4.22	105.0	1.50	0.40	2.31	0.17

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.51 m, NKL 1, k_{def} = 0.60)*						
	2.07	53	w_{inst}	8.2	l/300=	15.0	0.54
	2.07	59	w_{fin}	10.6	l/200=	22.6	0.47
	2.07	65	$w_{net,fin}$	6.4	l/300=	15.0	0.43
Feld 2	*(L= 3.20 m, NKL 1, k_{def} = 0.60)*						
	1.80	54	w_{inst}	1.8	l/300=	10.7	0.17
	1.80	60	w_{fin}	2.2	l/200=	16.0	0.14
	1.80	66	$w_{net,fin}$	1.0	l/300=	10.7	0.09

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Schwingungen

Nachweis nach F. Colling, 'Holzbau', 07/2012 und P. Hamm, 'Schwingungen bei Holzdecken', 2012

Decke innerhalb einer Nutzungseinheit

Frequenzkriterium

f_1 [Hz]	f_{grenz} [Hz]	G [-]
9.9	6.0	0.61

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (Brand) — Nachweise der Feuerwiderstandsfähigkeit nach DIN EN 1995-1-2, 4.2.3

Brandfall

Brandbeanspruchung	t_{req} [min]
dreiseitig (unten/links/rechts)	30

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	$k_{mod,fi}$ [-]	$M_{yd,fi}$ [kNm]	$\sigma_{m,d,fi}$ [N/mm²]	$f_{m,d,fi}$ [N/mm²]	G [-]
Feld 1	*(L = 4.51 m)*						
	4.51	72	0.52	-2.33	13.61	15.67	0.87*
Feld 2	*(L = 3.20 m)*						
	0.00	72	0.52	-2.33	13.61	15.67	0.87*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	$k_{mod,fi}$ [-]	$V_{z,d,fi}$ [kN]	$\tau_{d,fi}$ [N/mm²]	$f_{v,d,fi}$ [N/mm²]	G [-]
Feld 1	4.51	72	0.52	-3.12	1.97	2.61	0.75*
Feld 2	0.00	72	0.52	2.57	1.62	2.61	0.62*

Auflagerkräfte — Charakteristische Auflagerkräfte

- Der Nutzlastanteil ±q wird nicht berücksichtigt.

Char. Auflagerkr.

	Aufl.	$F_{z,k,min}$ [kN/m]	$F_{z,k,max}$ [kN/m]
Einw. *Gk*	A	2.27	2.27
	B	19.19	19.19
	C	1.22	1.22
Einw. *Qk.N*	A	-0.27	4.43
	B	4.33	11.35
	C	-1.07	3.30
Einw. *Qk.S*	A	0.00	0.00
	B	6.08	6.08
	C	0.00	0.00
Einw. *Qk.W*	A	0.00	0.00
	B	0.68	0.68
	C	0.00	0.00

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.66
Querkraft	Feld 2	0.00	OK	0.64
Auflagerpressung	Auflager B		OK	0.88

Nachweise (Brand) — Brandfall im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.87
Querkraft	Feld 2	0.00	OK	0.75

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

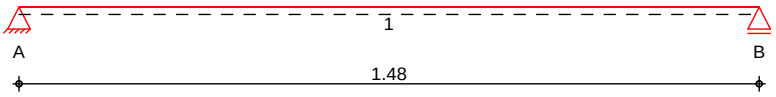
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.07	OK	0.54
Enddurchbiegung	Feld 1	2.07	OK	0.47
gesamte Enddurchb.	Feld 1	2.07	OK	0.43
Schwingung	Feld 1	2.17	OK	0.61

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E3 Treppenwechsel, SSV einseitig

System — Holz-Einfeldträger

M 1:15



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	1.48	1.48	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	1.48	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 9/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

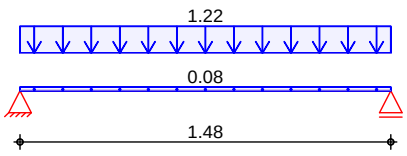
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

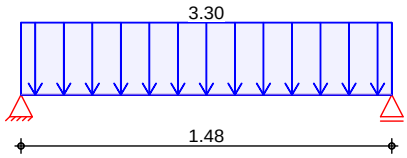
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	1.48		0.08
	(a)	1	E2	0.00	1.48		1.22
Einw. *Qk.N*	(a)	1	E2	0.00	1.48		3.30

(a) aus Pos. 'E2', Lager 'C' (Seite 98)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

st: ständig
mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.96	2	4.95	3
	0.74	0.35	2	1.83	3	0.00	3	0.00	2
	1.48	0.00	2	0.00	3	-4.95	3	-0.96	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
9.0	24.0	216.0	10368.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 1.48 m, k_{crit} = 1.00)*						
	0.74	3	0.80	1.83	2.12	14.77	0.14*

Querkraft
Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.28	3	0.80	3.08	0.30	2.15	0.14
	1.20	3	0.80	-3.08	0.30	2.15	0.14*

Stabilität
Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	1.48	1.48

Auflagerpressung
Abs. 6.1.5 — Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	3	0.80	4.95	135.0	1.75	0.37	2.69	0.14
Auflager B	3	0.80	4.95	135.0	1.75	0.37	2.69	0.14

f^*_{c90d}: $k_{c90} * f_{c90d}$

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen — Nachweise der Verformungen
Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 1.48 m, NKL 1, k_{def} = 0.60)*						
	0.74	6	w_{inst}	0.3	l/300=	4.9	0.05
	0.74	8	w_{fin}	0.3	l/200=	7.4	0.04
	0.74	10	$w_{net,fin}$	0.2	l/300=	4.9	0.04

Schwingungen — Nachweis nach Schneider: Bautabellen (20. Aufl.)

Decke innerhalb einer Nutzungseinheit

Frequenzkriterium

7.3.3(1)

f_1 [Hz]	f_{grenz} [Hz]	G [-]
66.4	6.0	0.09

Steifigkeitskriterium

7.3.3(2)

w_{1kN} [mm]	w_{grenz} [mm]	G [-]
0.06	1.00	0.06

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.96
	B	0.96
Einw. *Qk.N*	A	2.44
	B	2.44

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	0.74	OK	0.14
Querkraft	Feld 1	1.20	OK	0.14
Auflagerpressung	Auflager A		OK	0.14

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

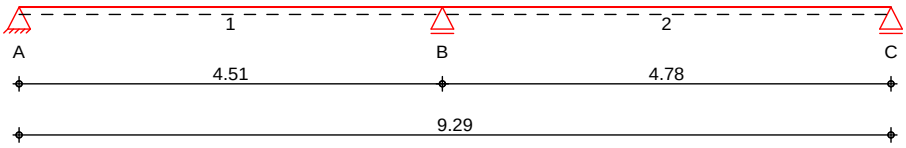
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	0.74	OK	0.05
Enddurchbiegung	Feld 1	0.74	OK	0.04
gesamte Enddurchb.	Feld 1	0.74	OK	0.04
Schwingung	Feld 1	0.74	OK	0.09

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E4 Treppenwechsel

System — Holz-Zweifeldträger

M 1:80



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	4.51	4.51	1
2	4.78	4.78	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.51	12.00	starr	frei
C	9.29	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 18/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

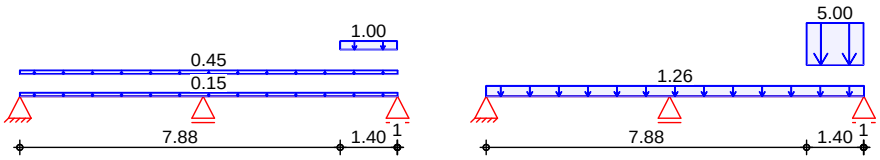
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk — Qk.N



Streckenlasten in z-Richtung — Gleich- und Blocklasten

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	9.29		0.15
	1	Decke	0.00	9.29		0.45
	1	Treppe	7.88	1.40		1.00
Einw. *Qk.N*	1	Decke	0.00	9.29		1.26
	1	Treppe	7.88	1.40		5.00

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

quasi-ständig 10 1.00*Gk +0.30*Qk.N
mi: mittel

Bem.-schnittgrößen Bemessungsschnittgrößen

Tabelle Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.93	2	3.98	3
	1.47	0.73	2	2.94	3	0.00	4	0.08	1
	4.51	-9.45	3	-1.86	2	-8.18	3	-1.76	2
Feld 2	0.00	-9.45	3	-1.86	2	2.02	2	10.26	3
	3.49	1.56	2	9.88	3	-0.23	1	-0.10	4
	4.78	0.00	2	0.00	3	-15.02	3	-2.23	2

Mat./Querschnitt nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
			[N/mm²]			
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
18.0	24.0	432.0	20736.0

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung Abs. 6.1 Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 4.51 m, k_{crit} = 1.00)*						
	4.51	3	0.80	-9.45	5.47	14.77	0.37*
Feld 2	*(L = 4.78 m, k_{crit} = 1.00)*						
	3.49	3	0.80	9.88	5.72	14.77	0.39*

Querkraft Abs. 6.1.7 Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.28	3	0.80	3.23	0.16	2.15	0.07
	4.21	3	0.80	-7.37	0.36	2.15	0.17*
Feld 2	0.30	3	0.80	9.45	0.46	2.15	0.21
	4.50	3	0.80	-11.87	0.58	2.15	0.27*

Stabilität Abs. 6.3 Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	4.51	4.51
Feld 2	4.78	4.78

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	3.98	270.0	1.75	0.15	2.69	0.05
Auflager B	3	0.80	18.44	324.0	1.75	0.57	2.69	0.21
Auflager C	3	0.80	15.02	270.0	1.75	0.56	2.69	0.21

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.51 m, NKL 1, k_{def} = 0.60)*						
	1.57	6	w_{inst}	1.0	l/300=	15.0	0.06
	1.57	8	w_{fin}	1.3	l/200=	22.6	0.06
	1.57	10	$w_{net,fin}$	0.9	l/300=	15.0	0.06
Feld 2	*(L= 4.78 m, NKL 1, k_{def} = 0.60)*						
	2.79	6	w_{inst}	5.2	l/300=	15.9	0.33
	2.79	8	w_{fin}	6.7	l/200=	23.9	0.28
	2.79	10	$w_{net,fin}$	3.9	l/300=	15.9	0.24

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.93
	B	3.78
	C	2.23
Einw. *Qk.N*	A	1.81
	B	8.89
	C	8.00

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	3.49	OK	0.39
Querkraft	Feld 2	4.50	OK	0.27
Auflagerpressung	Auflager B		OK	0.21

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

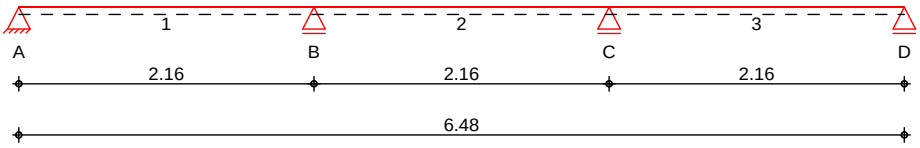
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 2	2.79	OK	0.33
Enddurchbiegung	Feld 2	2.79	OK	0.28
gesamte Enddurchb.	Feld 2	2.79	OK	0.24

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E5 Wandgurt

System — Holz-Dreifeldträger

M 1:55



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.16	2.16	1
2	2.16	2.16	1
3	2.16	2.16	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.16	36.00	starr	frei
C	4.32	32.00	starr	frei
D	6.48	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 18/28 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte

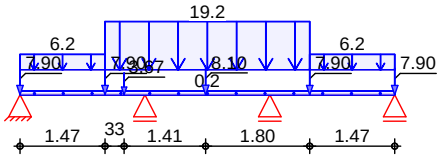
Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte

Belastungen — Belastungen auf das System

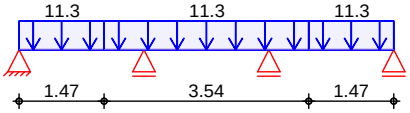
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

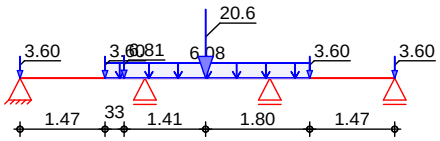
Gk



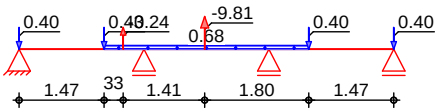
Qk.N



Qk.S



Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung — Blocklasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	6.48		0.18
	(a)	1	E2	0.00	1.47		6.21
	(b)	1	E2	1.47	3.54		19.19
	(a)	1	E2	5.01	1.47		6.21
Einw. *Qk.N*	(a)	1	E2	0.00	1.47		11.35
	(b)	1	E2	1.47	3.54		11.35
	(a)	1	E2	5.01	1.47		11.35
Einw. *Qk.S*	(b)	1	E2	1.47	3.54		6.08
Einw. *Qk.W*	(b)	1	E2	1.47	3.54		0.68

(a) aus Pos. 'E2_Last', Lager 'B'

(b) aus Pos. 'E2', Lager 'B' (Seite 98)

Punktlasten in z-Richtung — Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	D2	0.00	7.89
	(b)	1	D2	1.47	7.89
	(b)	1	D2	5.01	7.89
	(b)	1	D2	6.48	7.89
	(c)	1	St1.4	1.80	3.67
	(d)	1	St1.3	3.21	8.10
Einw. *Qk.S*	(a)	1	D2	0.00	3.60
	(b)	1	D2	1.47	3.60
	(b)	1	D2	5.01	3.60
	(b)	1	D2	6.48	3.60
	(c)	1	St1.4	1.80	6.81
	(d)	1	St1.3	3.21	20.61
Einw. *Qk.W*	(a)	1	D2	0.00	0.40
	(b)	1	D2	1.47	0.40
	(b)	1	D2	5.01	0.40
	(b)	1	D2	6.48	0.40
	(c)	1	St1.4	1.80	-3.24
	(d)	1	St1.3	3.21	-9.81

(a) aus Pos. 'D2', Lager 'A' (Seite 72)

(b) aus Pos. 'D2', Lager 'B' (Seite 72)

(c) aus Pos. 'St1.4', Lager 'A' (Seite 80)

(d) aus Pos. 'St1.3', Lager 'A' (Seite 78)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	2	mi	1.35*Gk	+1.50*Qk.N	
	9	ku	1.35*Gk	+1.05*Qk.N	+1.50*Qk.S
selten	26		1.00*Gk	+1.00*Qk.N	+0.60*Qk.W
	28		1.00*Gk	+1.00*Qk.N	+0.60*Qk.W
	36		1.00*Gk	+0.70*Qk.N	+1.00*Qk.S
	38		1.00*Gk	+0.70*Qk.N	+1.00*Qk.S
quasi-ständig	30		1.00*Gk	+0.30*Qk.N	

mi: mittel
ku: kurz

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	4	0.00	15	6.55	4	24.38	15
	0.98	3.36	4	11.58	15	-1.58	12	1.52	7
	2.16	-29.23	9	-7.26	8	-74.73	9	-23.16	8
Feld 2	0.00	-29.23	9	-7.26	8	18.50	8	73.84	9
	1.05	0.92	8	22.29	9	-17.90	10	4.07	11
	2.16	-26.23	9	-7.51	8	-69.91	9	-18.91	8
Feld 3	0.00	-26.23	9	-7.51	8	24.09	20	60.95	14
	1.18	2.33	4	11.42	15	-1.50	7	2.24	12
	2.16	0.00	4	0.00	15	-24.22	15	-5.51	4

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
18.0	28.0	504.0	32928.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 2.16 m, k_{crit} = 1.00)*						
	2.16	9	0.90	-29.23	12.43	16.62	0.75*
Feld 2	*(L = 2.16 m, k_{crit} = 1.00)*						
	0.00	9	0.90	-29.23	12.43	16.62	0.75*
Feld 3	*(L = 2.16 m, k_{crit} = 1.00)*						
	0.00	9	0.90	-26.23	11.15	16.62	0.67*

Querkraft
Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.32	2	0.80	15.72	0.66	2.15	0.30
	1.70	2	0.80	-34.34	1.43	2.15	0.66*
Feld 2	0.46	9	0.90	52.14	2.17	2.42	0.90*
	1.72	9	0.90	-49.15	2.05	2.42	0.85
Feld 3	0.44	2	0.80	35.59	1.48	2.15	0.69*
	1.84	2	0.80	-15.34	0.64	2.15	0.30

Stabilität
Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.16	2.16
Feld 2	2.16	2.16
Feld 3	2.16	2.16

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	$\check{\zeta}_{c90d}$ [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.80	34.58	270.0	1.75	1.28	2.69	0.48
Auflager B	9	0.90	148.57	756.0	1.75	1.97	3.03	0.65
Auflager C	9	0.90	130.61	684.0	1.75	1.91	3.03	0.63
Auflager D	2	0.80	34.20	270.0	1.75	1.27	2.69	0.47

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.16 m, NKL 1, k_{def} = 0.60)*						
	0.98	26	w_{inst}	0.9	l/300=	7.2	0.13
	0.98	28	w_{fin}	1.3	l/200=	10.8	0.12
	0.98	30	$w_{net,fin}$	0.9	l/300=	7.2	0.12
Feld 2	*(L= 2.16 m, NKL 1, k_{def} = 0.60)*						
	1.08	36	w_{inst}	1.1	l/300=	7.2	0.16
	1.08	38	w_{fin}	1.4	l/200=	10.8	0.13
	1.08	30	$w_{net,fin}$	0.7	l/300=	7.2	0.10
Feld 3	*(L= 2.16 m, NKL 1, k_{def} = 0.60)*						
	1.18	26	w_{inst}	0.9	l/300=	7.2	0.13
	1.18	28	w_{fin}	1.2	l/200=	10.8	0.11
	1.18	30	$w_{net,fin}$	0.8	l/300=	7.2	0.11

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	14.72
	B	52.89
	C	48.61
	D	14.44
Einw. *Qk.N*	A	9.80
	B	26.96
	C	26.96
	D	9.80
Einw. *Qk.S*	A	3.41
	B	32.58
	C	24.45
	D	2.90
Einw. *Qk.W*	A	0.91
	B	-7.48
	C	-3.62
	D	1.15

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.75
Querkraft	Feld 2	0.46	OK	0.90
Auflagerpressung	Auflager B		OK	0.65

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

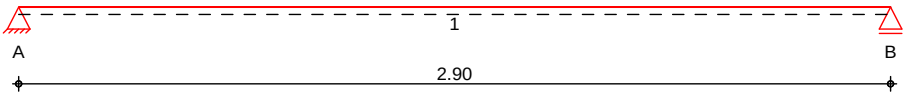
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 2	1.08	OK	0.16
Enddurchbiegung	Feld 2	1.08	OK	0.13
gesamte Enddurchb.	Feld 1	0.98	OK	0.12

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E6 — Gridträger mit Treppe

System — Holz-Einfeldträger

M 1:25



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.90	2.90	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.90	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/28 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

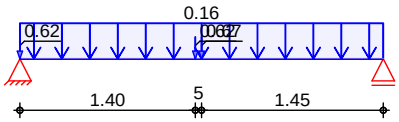
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

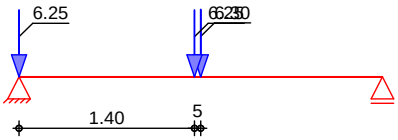
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	2.90		0.16

Punktlasten in z-Richtung — Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	B2	1.45	0.67
	(b)	1	Treppe	0.00	0.62
	(b)	1	Treppe	1.40	0.62
Einw. *Qk.N*	(a)	1	B2	1.45	6.30
	(b)	1	Treppe	0.00	6.25
	(b)	1	Treppe	1.40	6.25

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a) aus Pos. 'B2', Lager 'B' (Seite 86)

(b) aus Pos. 'T0', Lager 'B', Faktor = 0.50

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

st: ständig
mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.88	2	10.77	3
	1.45	1.08	2	14.88	3	-10.11	3	-0.63	2
	2.90	0.00	2	0.00	3	-10.41	3	-0.86	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
			[N/mm²]			
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	28.0	448.0	29269.3

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$ǯ_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.90 m, k_{crit} = 1.00)*						
	1.45	3	0.80	14.88	7.12	14.77	0.48*

Querkraft
Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	$ǰ_d$ [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.32	3	0.80	10.70	0.50	2.15	0.23*
	2.58	3	0.80	-10.35	0.48	2.15	0.23

Stabilität
Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.90	2.90

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	20.97	240.0	1.75	0.87	2.69	0.32
Auflager B	3	0.80	10.41	240.0	1.75	0.43	2.69	0.16

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.90 m, NKL 2, k_{def} = 0.80)*						
	1.44	6	w_{inst}	2.2	l/300=	9.7	0.23
	1.44	8	w_{fin}	2.9	l/200=	14.5	0.20
	1.44	10	$w_{net,fin}$	1.5	l/300=	9.7	0.16

Schwingungen

Nachweis nach Schneider: Bautabellen (20. Aufl.)

Decke innerhalb einer Nutzungseinheit

7.3.3(1)

Frequenzkriterium

f_1 [Hz]	f_{grenz} [Hz]	G [-]
35.5	6.0	0.17

7.3.3(2)

Steifigkeitskriterium

w_{1kN} [mm]	w_{grenz} [mm]	G [-]
0.16	1.00	0.16

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	1.50
	B	0.86
Einw. *Qk.N*	A	12.63
	B	6.17

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.45	OK	0.48
Querkraft	Feld 1	0.32	OK	0.23
Auflagerpressung	Auflager A		OK	0.32

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

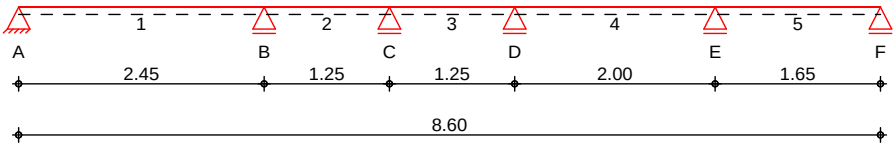
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.44	OK	0.23
Enddurchbiegung	Feld 1	1.44	OK	0.20
gesamte Enddurchb.	Feld 1	1.44	OK	0.16
Schwingung	Feld 1	1.44	OK	0.17

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. E7 Wandgurt

System — Holz-Mehrfeldträger

M 1:75



Abmessungen / Nutzungsklassen

Feld	l [m]	NKL
1	2.45	1
2	1.25	1
3	1.25	1
4	2.00	1
5	1.65	1

Das System ist kontinuierlich gegen Kippen gehalten.

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.45	12.00	starr	frei
C	3.70	12.00	starr	frei
D	4.95	12.00	starr	frei
E	6.95	12.00	starr	frei
F	8.60	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 24/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

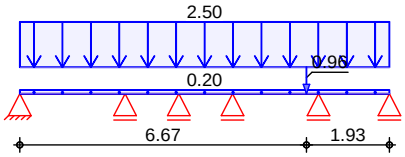
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

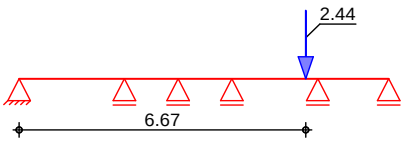
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleichlasten

Einw. *Gk*

Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
1	Eigengew	0.00	8.60		0.20
1	Wand	0.00	8.60		2.50

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Punktlasten in z-Richtung — Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	4	E3	1.72	0.96
Einw. *Qk.N*	(a)	4	E3	1.72	2.44

(a) aus Pos. 'E3', Lager 'A' (Seite 102)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)
ständig/vorüberg.	1	st	1.35*Gk

st: ständig

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	1	2.68	2	3.62	1
	0.99	1.33	2	1.80	1	0.00	4	0.00	3
	2.45	-2.07	4	-1.53	3	-5.31	4	-3.93	3
Feld 2	0.00	-2.07	4	-1.53	3	2.96	3	4.04	4
	1.09	0.09	3	0.16	4	0.00	3	0.05	4
	1.25	0.06	3	0.13	4	-0.57	1	-0.37	2
Feld 3	0.00	0.06	3	0.13	4	0.80	2	1.35	1
	0.37	0.22	2	0.33	1	-0.20	2	0.00	1
	1.25	-1.28	4	-0.80	3	-3.40	4	-2.37	3
Feld 4	0.00	-1.28	4	-0.80	3	2.71	3	4.07	4
	1.10	0.54	3	0.99	4	-0.35	1	0.15	2
	2.00	-1.82	4	-1.05	3	-8.18	4	-3.65	3
Feld 5	0.00	-1.82	4	-1.05	3	2.87	3	4.11	4
	1.06	0.33	2	0.63	1	0.00	1	0.24	2
	1.65	0.00	2	0.00	1	-2.15	1	-1.35	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
24.0	24.0	576.0	27648.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$ǯ_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	Ǵ [-]
Feld 1	*(L = 2.45 m)*						
	2.45	1	0.60	-2.07	0.90	11.08	0.08*
Feld 2	*(L = 1.25 m)*						
	0.00	1	0.60	-2.07	0.90	11.08	0.08*
Feld 3	*(L = 1.25 m)*						
	1.25	1	0.60	-1.08	0.47	11.08	0.04*
Feld 4	*(L = 2.00 m)*						
	2.00	1	0.60	-1.42	0.62	11.08	0.06*

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Feld 5 *(L = 1.65 m)*

0.00	1	0.60	-1.42	0.62	11.08	0.06*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	1	0.60	2.60	0.09	1.62	0.06
	2.15	1	0.60	-4.22	0.15	1.62	0.10*
Feld 2	0.30	1	0.60	2.90	0.11	1.62	0.07*
	0.95	1	0.60	0.53	0.02	1.62	0.01
Feld 3	0.30	1	0.60	0.26	0.01	1.62	0.01
	0.95	1	0.60	-2.11	0.08	1.62	0.05*
Feld 4	0.30	1	0.60	2.56	0.09	1.62	0.06*
	1.70	1	0.60	-2.54	0.09	1.62	0.06
Feld 5	0.30	1	0.60	2.78	0.10	1.62	0.06*
	1.37	1	0.60	-1.13	0.04	1.62	0.03

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	2.69
	B	6.89
	C	1.42
	D	5.08
	E	6.52
	F	1.59
Einw. *Qk.N*	A	0.00
	B	0.03
	C	-0.17
	D	0.41
	E	2.32
	F	-0.16

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.08
Querkraft	Feld 1	2.15	OK	0.10

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St0.1 Holzstütze Aussenwand

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.65	*Trio C24*	**12/24**

Nutzungsklasse 1 beheizte Innenräume

Belastungen — Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.65		0.12

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	E7	2.65	6.52	0.0	0.0
Einw. *Qk.N*	(a)	E7	2.65	2.33	0.0	0.0

(a) aus Pos. 'E7', Lager 'E' (Seite 117)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ	(Ä*Ǵ*EW)
ständig/vorüberg.	2	mi	1.35*Gk	+1.50*Qk.N

mi: mittel

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	6.84	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.N*	A	2.33	0.00	0.00	0.00	0.00
	B		0.00		0.00	

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.07
Druck	0.00	OK	0.15

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St0.2 Holzstütze Außenbereich

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.65	*BSH GL24c*	**16/16**

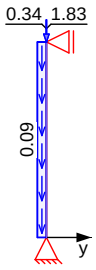
Nutzungsklasse 3 frei der Witterung ausgesetzte Bauteile

Belastungen — Belastungen auf das System

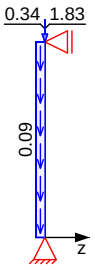
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

Gk



Gk



Qk.N

Qk.N

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

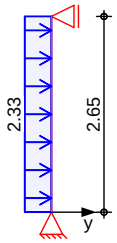
Qk.S

Qk.S

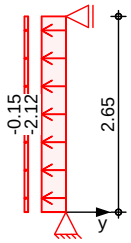
Qk.W

Qk.W

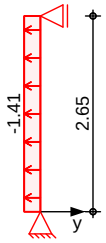
Qk.W.000



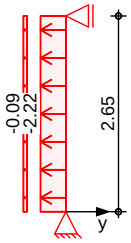
Qk.W.090



Qk.W.180



Qk.W.270



Streckenlasten in x-Richtung — Trapezlasten

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.65		0.09

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	G1	2.65	1.83	0.0	0.0
	(b)	B2	2.65	0.34	0.0	0.0
Einw. *Qk.N*	(b)	B2	2.65	3.15	0.0	0.0
Einw. *Qk.S*	(a)	G1	2.65	4.07	0.0	0.0
Einw. *Qk.W*	(a)	G1	2.65	-1.94	0.0	0.0

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a) aus Pos. 'G1', Lager 'B' (Seite 22)

(b) aus Pos. 'B2', Lager 'A', Faktor = 0.50 (Seite 86)

Streckenlasten in y-Richtung

Trapezlasten

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Qk.W.000*	Ber. D	0.00	2.65	2.33	2.33
Einw. *Qk.W.090*	Ber. B	0.00	2.65	-2.12	-2.12
	Ber. C	0.00	2.65	-0.15	-0.15
Einw. *Qk.W.180*	Ber. E	0.00	2.65	-1.41	-1.41
Einw. *Qk.W.270*	Ber. B	0.00	2.65	-2.22	-2.22
	Ber. C	0.00	2.65	-0.09	-0.09

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ	(Ä*Ǵ*EW)		
ständig/vorüberg.	5	ku/sk	1.35*Gk	+1.50*Qk.W.000		
	10	ku	1.35*Gk	+1.05*Qk.N	+1.50*Qk.S	
	34	ku/sk	1.35*Gk	+1.05*Qk.N	+0.75*Qk.S	
			+1.50*Qk.W.000			
	44	ku/sk	1.00*Gk	+1.50*Qk.W		

ku/sk: kurz/sehr kurz
ku: kurz

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	2.40	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.N*	A	3.15	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	4.07	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-1.94	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W.000*	A	0.00	0.00	0.00	3.09	0.00
	B		0.00		3.09	
Einw. *Qk.W.090*	A	0.00	0.00	0.00	-3.01	0.00
	B		0.00		-3.01	
Einw. *Qk.W.180*	A	0.00	0.00	0.00	-1.87	0.00
	B		0.00		-1.87	
Einw. *Qk.W.270*	A	0.00	0.00	0.00	-3.06	0.00
	B		0.00		-3.06	

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		G [-]
Biegung	1.32	OK	0.34
Druck	2.65	OK	0.15
Querkraft	0.00	OK	0.18

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St0.3 Holzstütze Außenbereich

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.65	*BSH GL24c*	**16/16**

Nutzungsklasse 3 frei der Witterung ausgesetzte Bauteile

Belastungen — Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.65		0.09

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	G1	2.65	0.46	0.0	0.0
	(b)	E6	2.65	1.50	0.0	0.0
Einw. *Qk.N*	(b)	E6	2.65	12.63	0.0	0.0
Einw. *Qk.S*	(a)	G1	2.65	0.93	0.0	0.0
Einw. *Qk.W*	(a)	G1	2.65	-0.44	0.0	0.0

(a) aus Pos. 'G1', Lager 'C' (Seite 22)

(b) aus Pos. 'E6', Lager 'A' (Seite 113)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ	(Ā*Ǵ*EW)
ständig/vorüberg.	2	mi	1.35*Gk	+1.50*Qk.N

mi: mittel

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

- Nach DIN EN 1995-1-1/NA NCI NA.5.9 wird der Einfluss des Kriechens für die Einwirkungskombinationen berücksichtigt, in denen der ständige und quasi-ständige Lastanteil 70% der Gesamtlast überschreitet.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

x	Ek	k_{mod}	N_d M_{yd} M_{zd}	$\sigma_{0,d}$ $\sigma_{my,d}$ $\sigma_{mz,d}$	$f_{0,d}$ $f_{my,d}$ $f_{mz,d}$	η
[m]		[-]	[kN,kNm]	[N/mm²]	[N/mm²]	[-]
(L = 2.65 m)						
0.00	2	0.65	-21.91	0.86	10.75	
			0.00	0.00	12.00	
			0.00	0.00	12.00	0.09

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

l	$l_{ef,cy}$	$l_{ef,cz}$	$l_{ef,m}$
[m]	[m]	[m]	[m]
2.65	2.65	2.65	2.65

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod}	F_d	A_{ef}	k_{c90}	σ_{c90d}	f^*_{c90d}	η
		[-]	[kN]	[cm²]	[-]	[N/mm²]	[N/mm²]	[-]
Stützenkopf	2	0.65	21.59	352.0	1.75	0.61	2.19	0.28

f^*_{c90d}: k_{c90} * f_{c90d}

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	2.19	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.N*	A	12.63	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	0.93	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-0.44	0.00	0.00	0.00	0.00
	B		0.00		0.00	

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		η [-]
Biegung	0.00	OK	0.09
Druck	2.65	OK	0.28

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St0.4 Holzstütze Zwischenwand

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.65	*NH C24*	**36/18**

Nutzungsklasse 1 beheizte Innenräume

Belastungen — Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.65		0.27

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	E5	2.65	52.89	0.0	0.0
Einw. *Qk.N*	(a)	E5	2.65	26.96	0.0	0.0
Einw. *Qk.S*	(a)	E5	2.65	32.58	0.0	0.0
Einw. *Qk.W*	(a)	E5	2.65	-7.49	0.0	0.0

(a) aus Pos. 'E5', Lager 'B' (Seite 109)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)		
ständig/vorüberg.	6	ku	1.35*Gk	+1.05*Qk.N	+1.50*Qk.S

ku: kurz

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	53.61	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.N*	A	26.96	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	32.58	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-7.49	0.00	0.00	0.00	0.00
	B		0.00		0.00	

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.20
Druck	0.00	OK	0.91

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. St0.5 Holzstütze Zwischenwand

System — Pendelstütze aus Holz nach DIN EN 1995-1-1

System

M 1:100

Abmessungen Mat./Querschnitt

l [m]	Material	b_y/b_z [cm]
2.65	*NH C24*	**32/18**

Nutzungsklasse 1 beheizte Innenräume

Belastungen — Belastungen auf das System

Streckenlasten in x-Richtung

	Komm.	a [m]	s [m]	q_u [kN/m]	q_o [kN/m]
Einw. *Gk*	Eigengew	0.00	2.65		0.24

Punktlasten in x-Richtung — Einzellasten

		Komm.	a [m]	F_x [kN]	e_y [cm]	e_z [cm]
Einw. *Gk*	(a)	E5	2.65	48.61	0.0	0.0
Einw. *Qk.N*	(a)	E5	2.65	26.96	0.0	0.0
Einw. *Qk.S*	(a)	E5	2.65	24.45	0.0	0.0
Einw. *Qk.W*	(a)	E5	2.65	-3.62	0.0	0.0

(a) aus Pos. 'E5', Lager 'C' (Seite 109)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)		
ständig/vorüberg.	6	ku	1.35*Gk	+1.05*Qk.N	+1.50*Qk.S

ku: kurz

Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]	$M_{y,k}$ [kNm]	$F_{y,k}$ [kN]	$M_{z,k}$ [kNm]
Einw. *Gk*	A	49.25	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.N*	A	26.96	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.S*	A	24.45	0.00	0.00	0.00	0.00
	B		0.00		0.00	
Einw. *Qk.W*	A	-3.62	0.00	0.00	0.00	0.00
	B		0.00		0.00	

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

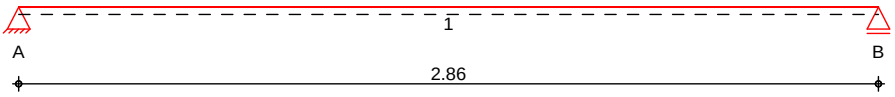
Nachweis	x [m]		G [-]
Biegung	0.00	OK	0.20
Druck	0.00	OK	0.89

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. T1 Terrasse EG

System — Holz-Einfeldträger

M 1:25



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.86	2.86	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	5.00	starr	frei
B	2.86	5.00	starr	frei

Material — *BSH GL24c*

Querschnitt / Balkenabstand — **b/h = 8/16 cm; a = 0.625 m**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

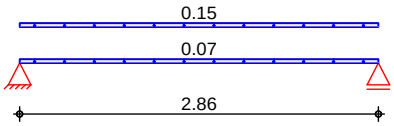
Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume — fw

Erläuterungen — Lastansatz ungünstig (fw)
Die Lasten der Einwirkung werden in ungünstiger Laststellung wirkend angesetzt.

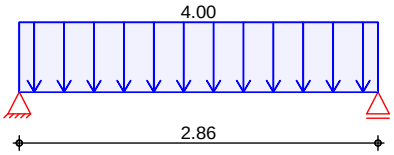
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Flächenlasten in z-Richtung — Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*		1	Eigengew	0.00	2.86		0.07
	(a)	1		0.00	2.86		0.15
Einw. *Qk.N*		1		0.00	2.86		4.00

(a) Belag 5*0.03 = 0.15 kN/m

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	Ek	KLED	ĭ (Ă*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N
st./vor. Auflagerkr.	12	st	1.00*Gk	
	13	mi	1.35*Gk	+1.50*Qk.N

mi: mittel
st: ständig

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.32	2	9.01	3
	1.43	0.23	2	6.44	3	0.00	1	0.00	3
	2.86	0.00	2	0.00	3	-9.01	3	-0.32	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
8.0	16.0	128.0	2730.7

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$ǯ_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.86 m, k_{crit} = 1.00)*						
	1.43	3	0.80	4.03	11.79	14.77	0.80*

Querkraft Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	$ǰ_d$ [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.18	3	0.80	4.93	0.81	2.15	0.38*
	2.68	3	0.80	-4.93	0.81	2.15	0.38

Stabilität Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.86	2.86

Auflagerpressung Abs. 6.1.5 — Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	$ǯ_{c90d}$ [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	5.63	64.0	1.75	0.88	2.69	0.33
Auflager B	3	0.80	5.63	64.0	1.75	0.88	2.69	0.33

f^*_{c90d}: k_{c90} * f_{c90d}

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen Abs. 7.2 — Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.86 m, NKL 2, k_{def} = 0.80)*						
	1.43	6	w_{inst}	7.7	l/300=	9.5	0.80
	1.43	8	w_{fin}	9.7	l/200=	14.3	0.68
	1.43	10	$w_{net,fin}$	4.6	l/300=	9.5	0.49

Auflagerkräfte — Charakteristische und Bemessungsauflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	0.32
	B	0.32
Einw. *Qk.N*	A	5.72
	B	5.72

Bem.-auflagerkräfte ständig/vorüberg.

Aufl.	$F_{z,d,min}$ [kN/m]	EK	$F_{z,d,max}$ [kN/m]	EK
A	0.32	12	9.01	13
B	0.32	12	9.01	13

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.43	OK	0.80
Querkraft	Feld 1	0.18	OK	0.38
Auflagerpressung	Auflager A		OK	0.33

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

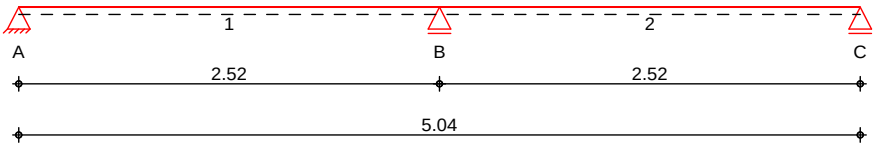
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.43	OK	0.80
Enddurchbiegung	Feld 1	1.43	OK	0.68
gesamte Enddurchb.	Feld 1	1.43	OK	0.49

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. T2 Randbalken mit SSV

System — Holz-Zweifeldträger

M 1:45



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.52	2.52	2
2	2.52	2.52	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.52	12.00	starr	frei
C	5.04	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 13/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

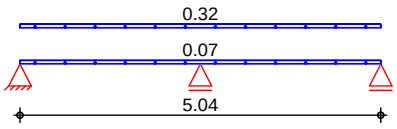
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

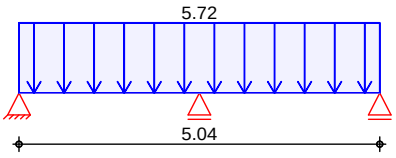
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleichlasten

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	5.04		0.07
(a)	1	T1	0.00	5.04		0.32
Einw. *Qk.N* (a)	1	T1	0.00	5.04		5.72

(a) aus Pos. 'T1', Lager 'A' (Seite 130)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

quasi-ständig 10 1.00*Gk +0.30*Qk.N
mi: mittel

Bem.-schnittgrößen Bemessungsschnittgrößen

Tabelle Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.37	2	8.61	3
	0.95	0.17	2	4.07	3	0.00	1	0.00	4
	2.52	-7.23	3	-0.31	2	-14.34	3	-0.61	2
Feld 2	0.00	-7.23	3	-0.31	2	0.61	2	14.34	3
	1.58	0.17	2	4.07	3	0.00	3	0.00	2
	2.52	0.00	2	0.00	3	-8.61	3	-0.37	2

Mat./Querschnitt nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
13.0	16.0	208.0	4437.3

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung Abs. 6.1 Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.52 m, k_{crit} = 1.00)*						
	2.52	3	0.80	-7.23	13.03	14.77	0.88*
Feld 2	*(L = 2.52 m, k_{crit} = 1.00)*						
	0.00	3	0.80	-7.23	13.03	14.77	0.88*

Querkraft Abs. 6.1.7 Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.20	3	0.80	6.78	0.68	2.15	0.32
	2.30	3	0.80	-12.34	1.25	2.15	0.58*
Feld 2	0.22	3	0.80	12.34	1.25	2.15	0.58*
	2.32	3	0.80	-6.78	0.68	2.15	0.32

Stabilität Abs. 6.3 Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.52	2.52
Feld 2	2.52	2.52

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	8.61	195.0	1.75	0.44	2.69	0.16
Auflager B	3	0.80	28.68	234.0	1.75	1.23	2.69	0.46
Auflager C	3	0.80	8.61	195.0	1.75	0.44	2.69	0.16

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.52 m, NKL 2, k_{def} = 0.80)*						
	1.06	6	w_{inst}	2.7	l/300=	8.4	0.33
	1.06	8	w_{fin}	3.5	l/200=	12.6	0.28
	1.06	10	$w_{net,fin}$	1.7	l/300=	8.4	0.20
Feld 2	*(L= 2.52 m, NKL 2, k_{def} = 0.80)*						
	1.46	6	w_{inst}	2.7	l/300=	8.4	0.33
	1.46	8	w_{fin}	3.5	l/200=	12.6	0.28
	1.46	10	$w_{net,fin}$	1.7	l/300=	8.4	0.20

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.37
	B	1.23
	C	0.37
Einw. *Qk.N*	A	5.41
	B	18.02
	C	5.41

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.88
Querkraft	Feld 2	0.22	OK	0.58
Auflagerpressung	Auflager B		OK	0.46

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

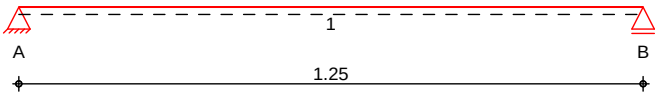
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.06	OK	0.33
Enddurchbiegung	Feld 1	1.06	OK	0.28
gesamte Enddurchb.	Feld 1	1.06	OK	0.20

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. T3 Terrasse EG

System — Holz-Einfeldträger

M 1:15



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	1.25	1.25	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	5.00	starr	frei
B	1.25	5.00	starr	frei

Material — *BSH GL24c*

Querschnitt / Balkenabstand — **b/h = 8/16 cm; a = 0.625 m**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

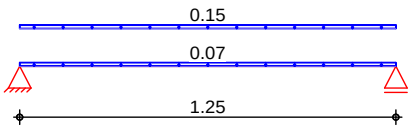
Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume — fw

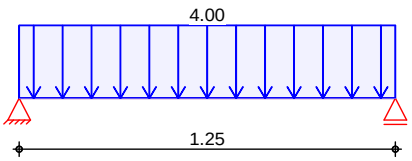
Erläuterungen — Lastansatz ungünstig (fw)
Die Lasten der Einwirkung werden in ungünstiger Laststellung wirkend angesetzt.

Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk — Qk.N





Flächenlasten in z-Richtung — Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*		1	Eigengew	0.00	1.25		0.07
	(a)	1		0.00	1.25		0.15
Einw. *Qk.N*		1		0.00	1.25		4.00

(a) Belag 5*0.03 = 0.15 kN/m

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	Ek	KLED	ĭ (Ă*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N
st./vor. Auflagerkr.	12	st	1.00*Gk	
	13	mi	1.35*Gk	+1.50*Qk.N

mi: mittel
st: ständig

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.14	2	3.94	3
	0.63	0.04	2	1.23	3	0.00	1	0.00	1
	1.25	0.00	2	0.00	3	-3.94	3	-0.14	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
8.0	16.0	128.0	2730.7

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$ǯ_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 1.25 m, k_{crit} = 1.00)*						
	0.63	3	0.80	0.77	2.25	14.77	0.15*

Querkraft Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	$ǰ_d$ [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.18	3	0.80	1.77	0.29	2.15	0.13*
	1.07	3	0.80	-1.77	0.29	2.15	0.13

Stabilität Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	1.25	1.25

Auflagerpressung Abs. 6.1.5 — Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	$ǯ_{c90d}$ [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	2.46	64.0	1.75	0.38	2.69	0.14
Auflager B	3	0.80	2.46	64.0	1.75	0.38	2.69	0.14

f^*_{c90d}: k_{c90} * f_{c90d}

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen Abs. 7.2 — Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 1.25 m, NKL 2, k_{def} = 0.80)*						
	0.63	6	w_{inst}	0.3	l/300=	4.2	0.07
	0.63	8	w_{fin}	0.4	l/200=	6.3	0.06
	0.63	10	$w_{net,fin}$	0.2	l/300=	4.2	0.04

Auflagerkräfte — Charakteristische und Bemessungsauflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	0.14
	B	0.14
Einw. *Qk.N*	A	2.50
	B	2.50

Bem.-auflagerkräfte ständig/vorüberg.

Aufl.	$F_{z,d,min}$ [kN/m]	EK	$F_{z,d,max}$ [kN/m]	EK
A	0.14	12	3.94	13
B	0.14	12	3.94	13

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	0.63	OK	0.15
Querkraft	Feld 1	0.18	OK	0.13
Auflagerpressung	Auflager A		OK	0.14

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

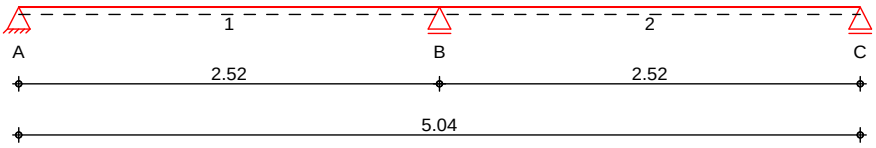
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	0.63	OK	0.07
Enddurchbiegung	Feld 1	0.63	OK	0.06
gesamte Enddurchb.	Feld 1	0.63	OK	0.04

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. T4 Randbalken mit SSV

System — Holz-Zweifeldträger

M 1:45



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.52	2.52	2
2	2.52	2.52	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.52	12.00	starr	frei
C	5.04	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 13/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

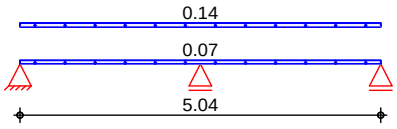
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

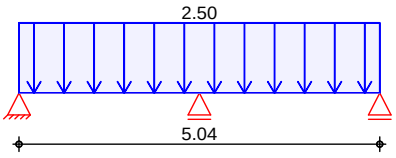
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	5.04		0.07
	(a)	1	T3	0.00	5.04		0.14
Einw. *Qk.N*	(a)	1	T3	0.00	5.04		2.50

(a) — aus Pos. 'T3', Lager 'A' (Seite 136)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

quasi-ständig 10 1.00*Gk +0.30*Qk.N
mi: mittel

Bem.-schnittgrößen Bemessungsschnittgrößen

Tabelle Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.20	2	3.81	3
	0.95	0.09	2	1.80	3	0.00	2	0.00	3
	2.52	-3.20	3	-0.17	2	-6.36	3	-0.33	2
Feld 2	0.00	-3.20	3	-0.17	2	0.33	2	6.36	3
	1.58	0.09	2	1.80	3	0.00	3	0.00	2
	2.52	0.00	2	0.00	3	-3.81	3	-0.20	2

Mat./Querschnitt nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
			[N/mm²]			
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
13.0	16.0	208.0	4437.3

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung Abs. 6.1 Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.52 m, k_{crit} = 1.00)*						
	2.52	3	0.80	-3.20	5.78	14.77	0.39*
Feld 2	*(L = 2.52 m, k_{crit} = 1.00)*						
	0.00	3	0.80	-3.20	5.78	14.77	0.39*

Querkraft Abs. 6.1.7 Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.20	3	0.80	3.01	0.30	2.15	0.14
	2.30	3	0.80	-5.47	0.55	2.15	0.26*
Feld 2	0.22	3	0.80	5.47	0.55	2.15	0.26*
	2.32	3	0.80	-3.01	0.30	2.15	0.14

Stabilität Abs. 6.3 Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.52	2.52
Feld 2	2.52	2.52

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	3.81	195.0	1.75	0.20	2.69	0.07
Auflager B	3	0.80	12.71	234.0	1.75	0.54	2.69	0.20
Auflager C	3	0.80	3.81	195.0	1.75	0.20	2.69	0.07

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.52 m, NKL 2, k_{def} = 0.80)*						
	1.06	6	w_{inst}	1.2	l/300=	8.4	0.14
	1.06	8	w_{fin}	1.6	l/200=	12.6	0.12
	1.06	10	$w_{net,fin}$	0.8	l/300=	8.4	0.09
Feld 2	*(L= 2.52 m, NKL 2, k_{def} = 0.80)*						
	1.46	6	w_{inst}	1.2	l/300=	8.4	0.14
	1.46	8	w_{fin}	1.6	l/200=	12.6	0.12
	1.46	10	$w_{net,fin}$	0.8	l/300=	8.4	0.09

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.20
	B	0.67
	C	0.20
Einw. *Qk.N*	A	2.36
	B	7.88
	C	2.36

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.39
Querkraft	Feld 1	2.30	OK	0.26
Auflagerpressung	Auflager B		OK	0.20

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

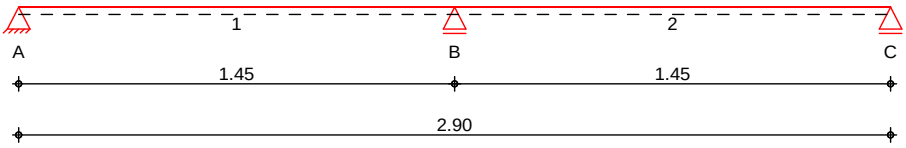
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.06	OK	0.14
Enddurchbiegung	Feld 1	1.06	OK	0.12
gesamte Enddurchb.	Feld 1	1.06	OK	0.09

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. T5 Randbalken

System — Holz-Zweifeldträger

M 1:25



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	1.45	1.45	2
2	1.45	1.45	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	1.45	12.00	starr	frei
C	2.90	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

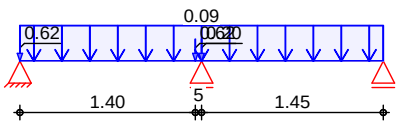
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

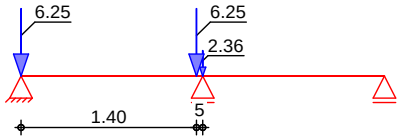
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	2.90		0.09

Punktlasten in z-Richtung — Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	T4	1.45	0.20
	(b)	1	Treppe	0.00	0.62
	(b)	1	Treppe	1.40	0.62
Einw. *Qk.N*	(a)	1	T4	1.45	2.36
	(b)	1	Treppe	0.00	6.25
	(b)	1	Treppe	1.40	6.25

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a) aus Pos. 'T4', Lager 'A' (Seite 139)

(b) aus Pos. 'T0', Lager 'A', Faktor = 0.50

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	mi	1.35*Gk	+1.50*Qk.N
	4	mi	1.00*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

st: ständig
mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.06	2	0.25	3
	1.40	-0.01	1	0.23	4	-0.09	1	0.10	4
	1.45	-0.27	3	-0.04	2	-10.13	3	-0.69	2
Feld 2	0.00	-0.27	3	-0.04	2	0.09	2	0.28	3
	1.02	-0.06	4	0.01	1	0.00	1	0.15	4
	1.45	0.00	4	0.00	1	-0.05	1	0.11	4

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	16.0	256.0	5461.3

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung — Nachweis der Biegetragfähigkeit
Abs. 6.1

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\check{\sigma}_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 1.45 m, k_{crit} = 1.00)*						
	1.45	3	0.80	-0.27	0.40	14.77	0.03*
Feld 2	*(L = 1.45 m, k_{crit} = 1.00)*						
	0.00	3	0.80	-0.27	0.40	14.77	0.03*

Querkraft — Nachweis der Querkrafttragfähigkeit
Abs. 6.1.7

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	$\check{\tau}_d$ [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.20	3	0.80	0.23	0.02	2.15	0.01*
	1.23	4	0.80	0.12	0.01	2.15	0.00
Feld 2	0.22	3	0.80	0.25	0.02	2.15	0.01*
	1.25	4	0.80	0.13	0.01	2.15	0.01

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	1.45	1.45
Feld 2	1.45	1.45

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	10.46	240.0	1.75	0.44	2.69	0.16
Auflager B	3	0.80	14.22	288.0	1.75	0.49	2.69	0.18
Auflager C	1	0.60	0.05	240.0	1.75	0.00	2.02	0.00

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 1.45 m, NKL 2, k_{def} = 0.80)*						
	0.84	6	w_{inst}	0.0	l/300=	4.8	0.01
	0.82	8	w_{fin}	0.1	l/200=	7.3	0.01
	0.76	10	$w_{net,fin}$	0.0	l/300=	4.8	0.01
Feld 2	*(L= 1.45 m, NKL 2, k_{def} = 0.80)*						
	0.60	6	w_{inst}	0.0	l/300=	-4.8	0.01
	0.60	8	w_{fin}	0.0	l/200=	-7.3	0.01
	0.60	10	$w_{net,fin}$	0.0	l/300=	-4.8	0.00

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.68
	B	0.98
	C	0.04
Einw. *Qk.N*	A	6.36
	B	8.60
	C	-0.10

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.03
Querkraft	Feld 2	0.22	OK	0.01
Auflagerpressung	Auflager B		OK	0.18

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	0.84	OK	0.01
Enddurchbiegung	Feld 1	0.82	OK	0.01

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

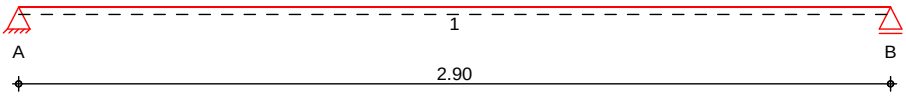
gesamte Enddurchb. Feld 1	0.76	OK	0.01

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. T6 Randbalken

System — Holz-Einfeldträger

M 1:25



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.90	2.90	2

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.90	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 16/16 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

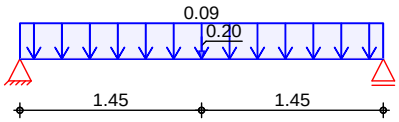
Gk — Ständige Einwirkung
Ständige Einwirkungen

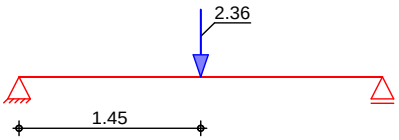
Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk — Qk.N





Streckenlasten in z-Richtung

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	2.90		0.09

Punktlasten in z-Richtung — Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	T4	1.45	0.20
Einw. *Qk.N*	(a)	1	T4	1.45	2.36

(a) — aus Pos. 'T4', Lager 'A' (Seite 139)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	8	1.00*Gk	+1.00*Qk.N
quasi-ständig	10	1.00*Gk	+0.30*Qk.N

mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	0.23	2	2.08	3
	1.45	0.24	2	2.89	3	-1.91	3	-0.10	2
	2.90	0.00	2	0.00	3	-2.08	3	-0.23	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
16.0	16.0	256.0	5461.3

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.90 m, k_{crit} = 1.00)*						
	1.45	3	0.80	2.89	4.24	14.77	0.29*

Querkraft
Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.20	3	0.80	2.06	0.17	2.15	0.08
	2.70	3	0.80	-2.06	0.17	2.15	0.08*

Stabilität
Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.90	2.90

Auflagerpressung
Abs. 6.1.5 — Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	2.08	240.0	1.75	0.09	2.69	0.03
Auflager B	3	0.80	2.08	240.0	1.75	0.09	2.69	0.03

f^*_{c90d}: k_{c90} * f_{c90d}

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen — Nachweise der Verformungen
Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.90 m, NKL 2, k_{def} = 0.80)*						
	1.45	6	w_{inst}	2.3	l/300=	9.7	0.24
	1.45	8	w_{fin}	3.0	l/200=	14.5	0.21
	1.45	10	$w_{net,fin}$	1.6	l/300=	9.7	0.17

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	0.23
	B	0.23
Einw. *Qk.N*	A	1.18
	B	1.18

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.45	OK	0.29
Querkraft	Feld 1	2.70	OK	0.08
Auflagerpressung	Auflager A		OK	0.03

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

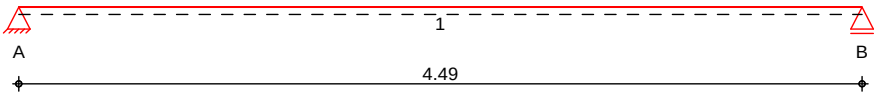
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.45	OK	0.24
Enddurchbiegung	Feld 1	1.45	OK	0.21
gesamte Enddurchb.	Feld 1	1.45	OK	0.17

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BE1 — Bodenplattenelement

System — Einachsig gespannte Holz-Balkendecke

M 1:40



Abmessungen / Nutzungsklassen

Feld	l [m]	NKL
1	4.49	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.49	12.00	starr	frei

Material/ Querschnitt

Bauteil	Material	Querschnitt [cm]
Balken	*KVH C24*	7/24
Beplankung	*Span P5*	t = 25 mm

Balkenabstand a = 0.40 m
Deckenbreite b = 2.50 m

System in Querrichtung als Einfeldträger

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

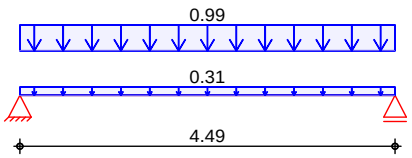
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume — fw

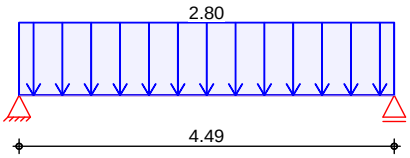
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Flächenlasten in z-Richtung — Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*	(a)	1	Eigengew	0.00	4.49		0.31
	(b)	1	G	0.00	4.49		0.99
Einw. *Qk.N*	(c)	1	Nutzlast	0.00	4.49		2.80

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a)	Holzbalken	0.07*0.24*4.2/0.4 =	0.18	kN/m²
	Beplankung	0.025*5.5 =	0.14	kN/m²
		=	0.31	kN/m²
(b)	aus Pos. 'L1' Flächenlast Gk 'gk;SD'	0.992 =	0.99	kN/m²
(c)	Nutzlast q	2.3 =	2.30	kN/m²
	‡q	0.5 =	0.50	kN/m²
		=	2.80	kN/m²

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ă*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

st: ständig
mi: mittel

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	2	0.00	3	2.93	2	13.39	3
	2.25	3.29	2	15.03	3	0.00	1	0.00	4
	4.49	0.00	2	0.00	3	-13.39	3	-2.93	2

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

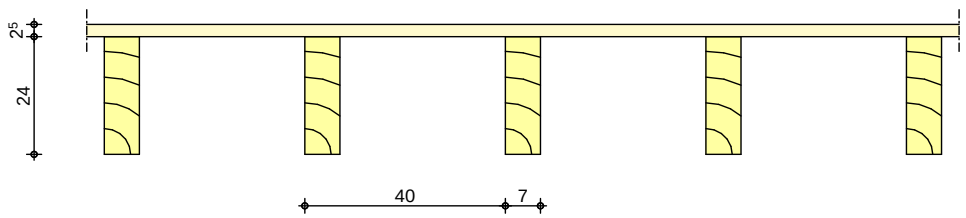
Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
KVH C24	24.0	14.5	21.0	2.5	4.0	11000
Span P5[Pf]	11.7	7.4	10.3	10.0	1.5	3000

P: Beanspruchung als Platte
f: Lamellenlage flachkant

Querschnittswerte

Bauteil	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
Balken	7.0	24.0	168.0	8064.0

M 1:15



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.49 m)*						
	2.25	3	0.80	6.01	8.94	14.77	0.61*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	4.49	3	0.80	-5.35	0.96	2.46	0.39*

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	5.35	105.0	1.50	0.51	2.31	0.22
Auflager B	3	0.80	5.35	105.0	1.50	0.51	2.31	0.22

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.49 m, NKL 1, k_{def} = 0.60)*						
	2.25	6	w_{inst}	9.7	l/300=	15.0	0.65
	2.25	8	w_{fin}	12.7	l/200=	22.5	0.57
	2.25	10	$w_{net,fin}$	8.1	l/300=	15.0	0.54

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Schwingungen

Nachweis nach F. Colling, 'Holzbau', 07/2012 und P. Hamm, 'Schwingungen bei Holzdecken', 2012

Decke innerhalb einer Nutzungseinheit

Frequenzkriterium

f_1 [Hz]	f_{grenz} [Hz]	G [-]
10.1	6.0	0.59

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

Auflagerkräfte

Charakteristische Auflagerkräfte

- Der Nutzlastanteil ‡q wird nicht berücksichtigt.

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	2.93
	B	2.93
Einw. *Qk.N*	A	5.16
	B	5.16

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	2.25	OK	0.61
Querkraft	Feld 1	4.49	OK	0.39
Auflagerpressung	Auflager A		OK	0.22

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.25	OK	0.65
Enddurchbiegung	Feld 1	2.25	OK	0.57
gesamte Enddurchb.	Feld 1	2.25	OK	0.54
Schwingung	Feld 1	2.25	OK	0.59

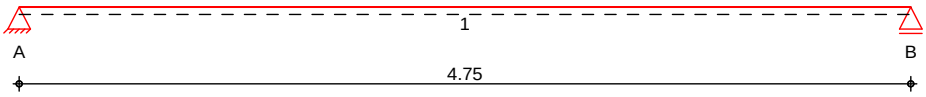
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BE2 Bodenplattenelement

System

Einachsig gespannte Holz-Balkendecke

M 1:40



Abmessungen / Nutzungsklassen

Feld	l [m]	NKL
1	4.75	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.75	12.00	starr	frei

Material/ Querschnitt

Bauteil	Material	Querschnitt [cm]
Balken	*KVH C24*	12/24
Beplankung	*Span P5*	t = 25 mm

Balkenabstand a = 0.50 m
Deckenbreite b = 2.50 m

System in Querrichtung als Einfeldträger

Einwirkungen

Einwirkungen nach DIN EN 1990:2010-12

Gk Ständige Einwirkung
Ständige Einwirkungen

Qk.N Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume fw

Belastungen

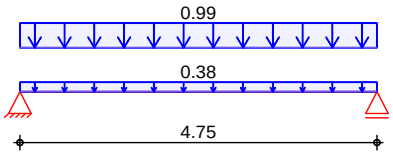
Belastungen auf das System

Grafik

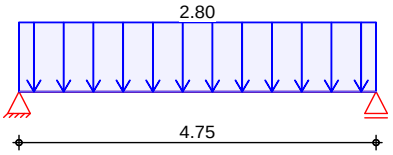
Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

Gk



Qk.N



Flächenlasten in z-Richtung

Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*	(a)	1	Eigengew	0.00	4.75		0.38
	(b)	1	G	0.00	4.75		0.99
Einw. *Qk.N*	(c)	1	Nutzlast	0.00	4.75		2.80

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a)	Holzbalken	0.12*0.24*4.2/0.5 =	0.24	kN/m²
	Beplankung	0.025*5.5 =	0.14	kN/m²
		=	0.38	kN/m²
(b)	aus Pos. 'L1' Flächenlast Gk 'gk;SD'	0.992 =	0.99	kN/m²
(c)	Nutzlast q	2.3 =	2.30	kN/m²
	‡q	0.5 =	0.50	kN/m²
		=	2.80	kN/m²

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

st: ständig
mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	2	0.00	3	3.26	2	14.37	3
	2.38	3.87	2	17.07	3	0.00	2	0.00	3
	4.75	0.00	2	0.00	3	-14.37	3	-3.26	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

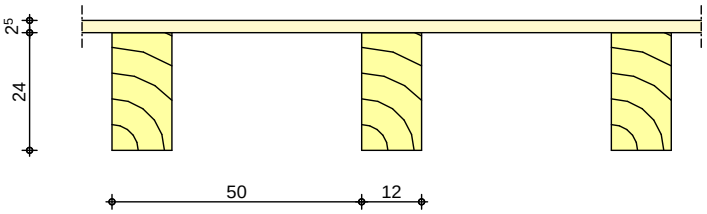
Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
KVH C24	24.0	14.5	21.0	2.5	4.0	11000
Span P5^{Pf}	11.7	7.4	10.3	10.0	1.5	3000

P: Beanspruchung als Platte
f: Lamellenlage flachkant

Querschnittswerte

Bauteil	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
Balken	12.0	24.0	288.0	13824.0

M 1:15



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.75 m)*						
	2.38	3	0.80	8.53	7.41	14.77	0.50*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.00	3	0.80	7.19	0.75	2.46	0.30*

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	7.19	180.0	1.50	0.40	2.31	0.17
Auflager B	3	0.80	7.19	180.0	1.50	0.40	2.31	0.17

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.75 m, NKL 1, k_{def} = 0.60)*						
	2.38	6	w_{inst}	9.0	l/300=	15.8	0.57
	2.38	8	w_{fin}	11.8	l/200=	23.8	0.50
	2.38	10	$w_{net,fin}$	7.6	l/300=	15.8	0.48

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Schwingungen

Nachweis nach F. Colling, 'Holzbau', 07/2012 und P. Hamm, 'Schwingungen bei Holzdecken', 2012

Decke innerhalb einer Nutzungseinheit

Frequenzkriterium

f_1 [Hz]	f_{grenz} [Hz]	G [-]
10.3	6.0	0.58

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

Auflagerkräfte

Charakteristische Auflagerkräfte

- Der Nutzlastanteil ±q wird nicht berücksichtigt.

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	3.26
	B	3.26
Einw. *Qk.N*	A	5.46
	B	5.46

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	2.38	OK	0.50
Querkraft	Feld 1	0.00	OK	0.30
Auflagerpressung	Auflager A		OK	0.17

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

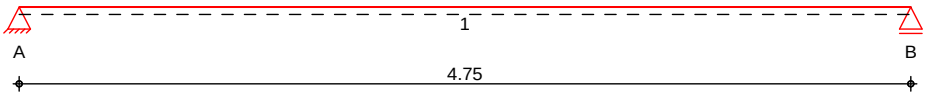
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.38	OK	0.57
Enddurchbiegung	Feld 1	2.38	OK	0.50
gesamte Enddurchb.	Feld 1	2.38	OK	0.48
Schwingung	Feld 1	2.38	OK	0.58

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BE3 Bodenplattenelement

System — Einachsig gespannte Holz-Balkendecke

M 1:40



Abmessungen / Nutzungsklassen

Feld	l [m]	NKL
1	4.75	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.75	12.00	starr	frei

Material/ Querschnitt

Bauteil	Material	Querschnitt [cm]
Balken	*KVH C24*	12/24
Beplankung	*Span P5*	t = 25 mm

Balkenabstand a = 0.40 m
Deckenbreite b = 2.50 m

System in Querrichtung als Einfeldträger

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

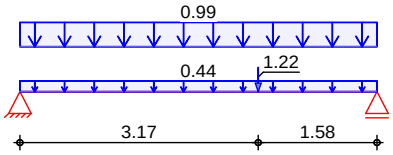
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume — fw

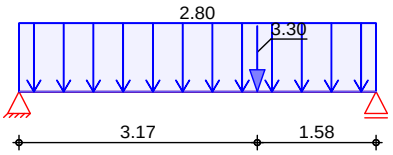
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Flächenlasten in z-Richtung — Gleichflächenlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m²]	q_{re} [kN/m²]
Einw. *Gk*	(a)	1	Eigengew	0.00	4.75		0.44
	(b)	1	G	0.00	4.75		0.99
Einw. *Qk.N*	(c)	1	Nutzlast	0.00	4.75		2.80

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a)	Holzbalken	0.12*0.24*4.2/0.4	=	0.30	kN/m²
	Beplankung	0.025*5.5	=	0.14	kN/m²
			=	0.44	kN/m²
(b)	aus Pos. 'L1' Flächenlast Gk 'gk;SD'	0.992	=	0.99	kN/m²
(c)	Nutzlast q	2.3	=	2.30	kN/m²
	‡q	0.5	=	0.50	kN/m²
			=	2.80	kN/m²

Streckenlasten in z-Richtung

Streckenlasten senkrecht zum Bauteil

	Feld	Komm.	a [m]	q [kN/m]
Einw. *Gk*	1	E2	3.17	1.22
Einw. *Qk.N*	1	E2	3.17	3.30

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

st: ständig
mi: mittel

Bem.-schnittgrößen Bemessungsschnittgrößen

Tabelle Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm/m]	Ek	$M_{y,d,max}$ [kNm/m]	Ek	$V_{z,d,min}$ [kN/m]	Ek	$V_{z,d,max}$ [kN/m]	Ek
Feld 1	0.00	0.00	2	0.00	3	3.81	2	16.76	3
	2.77	5.05	2	22.89	3	-0.21	1	-0.16	4
	4.75	0.00	2	0.00	3	-18.97	3	-4.21	2

Mat./Querschnitt nach DIN EN 1995-1-1

Materialien

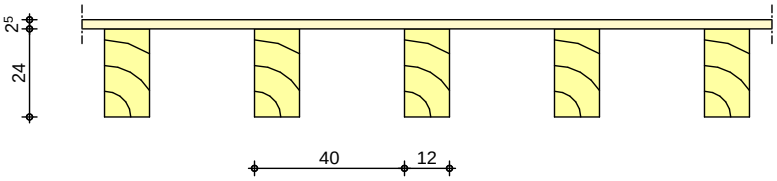
Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
KVH C24	24.0	14.5	21.0	2.5	4.0	11000
Span P5^{Pf}	11.7	7.4	10.3	10.0	1.5	3000

P: Beanspruchung als Platte
f: Lamellenlage flachkant

Querschnittswerte

Bauteil	b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
Balken	12.0	24.0	288.0	13824.0

M 1:20



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 4.75 m)*						
	2.77	3	0.80	9.16	7.95	14.77	0.54*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	4.75	3	0.80	-7.59	0.79	2.46	0.32*

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	6.70	180.0	1.50	0.37	2.31	0.16
Auflager B	3	0.80	7.59	180.0	1.50	0.42	2.31	0.18

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

- Decke innerhalb einer Nutzungseinheit

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.75 m, NKL 1, k_{def} = 0.60)*						
	2.43	6	w_{inst}	9.6	l/300=	15.8	0.60
	2.43	8	w_{fin}	12.6	l/200=	23.8	0.53
	2.42	10	$w_{net,fin}$	8.0	l/300=	15.8	0.51

Negative Verformungen wurden zur Bemessung nicht berücksichtigt.

Schwingungen

Nachweis nach F. Colling, 'Holzbau', 07/2012 und P. Hamm, 'Schwingungen bei Holzdecken', 2012

Decke innerhalb einer Nutzungseinheit

Frequenzkriterium

f_1 [Hz]	f_{grenz} [Hz]	G [-]
10.1	6.0	0.59

Die konstruktiven Mindestanforderungen sind einzuhalten:
Nassestrich oder Trockenestrich mit schwerer Schüttung

Auflagerkräfte

Charakteristische Auflagerkräfte

- Der Nutzlastanteil ‡q wird nicht berücksichtigt.

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN/m]
Einw. *Gk*	A	3.81
	B	4.21
Einw. *Qk.N*	A	6.56
	B	7.66

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	2.77	OK	0.54
Querkraft	Feld 1	4.75	OK	0.32
Auflagerpressung	Auflager B		OK	0.18

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

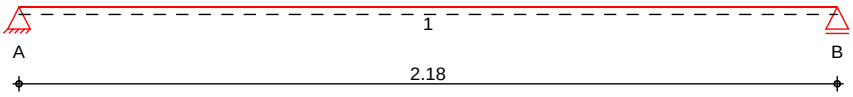
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.43	OK	0.60
Enddurchbiegung	Feld 1	2.43	OK	0.53
gesamte Enddurchb.	Feld 1	2.42	OK	0.51
Schwingung	Feld 1	2.42	OK	0.59

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP4 Zwischenträger, SSV beidseitig

System — Holz-Einfeldträger

M 1:20



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.18	2.18	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.18	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 18/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

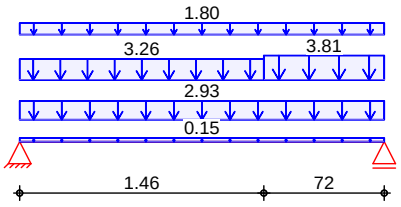
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

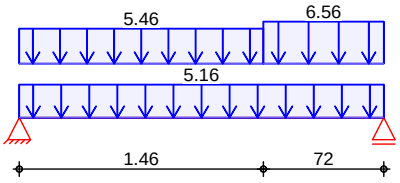
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleich- und Blocklasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	2.18		0.15
	(a)	1	BE1	0.00	2.18		2.93
	(b)	1	BE2	0.00	1.46		3.26
	(c)	1	BE2	1.46	0.72		3.81
		1	Wand EG	0.00	2.18		1.80
Einw. *Qk.N*	(a)	1	BE1	0.00	2.18		5.16
	(b)	1	BE2	0.00	1.46		5.46
	(c)	1	BE2	1.46	0.72		6.56

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

(a) aus Pos. 'BE1', Lager 'B' (Seite 149)

(b) aus Pos. 'BE2', Lager 'A' (Seite 153)

(c) aus Pos. 'BE3', Lager 'A' (Seite 157)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	8.94	2	29.64	3
	1.10	4.91	2	16.31	3	0.00	1	0.07	4
	2.18	0.00	2	0.00	3	-30.79	3	-9.20	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
18.0	24.0	432.0	20736.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\check{\sigma}_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.18 m, k_{crit} = 1.00)*						
	1.10	3	0.80	16.31	9.44	14.77	0.64*

Querkraft
Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	$\check{\tau}_d$ [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	3	0.80	22.10	1.07	2.15	0.50
	1.90	3	0.80	-22.58	1.10	2.15	0.51*

Stabilität
Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.18	2.18

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	$\check{z}_{c90d}$ [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	29.64	270.0	1.75	1.10	2.69	0.41
Auflager B	3	0.80	30.79	270.0	1.75	1.14	2.69	0.42

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.18 m, NKL 1, k_{def} = 0.60)*						
	1.09	6	w_{inst}	2.5	l/300=	7.3	0.34
	1.09	8	w_{fin}	3.4	l/200=	10.9	0.31
	1.09	10	$w_{net,fin}$	2.4	l/300=	7.3	0.33

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	8.94
	B	9.20
Einw. *Qk.N*	A	11.71
	B	12.24

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.10	OK	0.64
Querkraft	Feld 1	1.90	OK	0.51
Auflagerpressung	Auflager B		OK	0.42

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

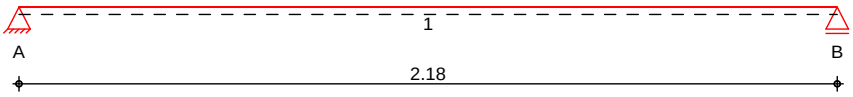
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.09	OK	0.34
Enddurchbiegung	Feld 1	1.09	OK	0.31
gesamte Enddurchb.	Feld 1	1.09	OK	0.33

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP5 Zwischenträger, SSV beidseitig

System — Holz-Einfeldträger

M 1:20



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.18	2.18	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.18	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 18/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

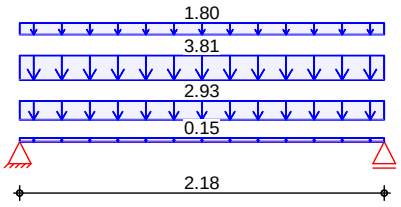
Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

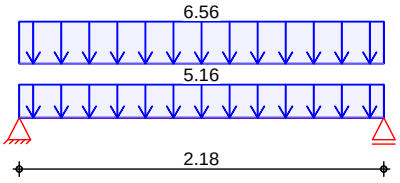
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Gk



Qk.N



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	2.18		0.15
	(a)	1	BE1	0.00	2.18		2.93
	(b)	1	BE3	0.00	2.18		3.81
		1	Wand EG	0.00	2.18		1.80
Einw. *Qk.N*	(a)	1	BE1	0.00	2.18		5.16
	(b)	1	BE3	0.00	2.18		6.56

(a) aus Pos. 'BE1', Lager 'B' (Seite 149)

(b) aus Pos. 'BE3', Lager 'A' (Seite 157)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	Ek	KLED	ĭ (Ă*Ǵ*EW)	
ständig/vorüberg.	3	mi	1.35*Gk	+1.50*Qk.N
selten	6		1.00*Gk	+1.00*Qk.N
	8		1.00*Gk	+1.00*Qk.N
quasi-ständig	10		1.00*Gk	+0.30*Qk.N

mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	9.47	2	31.95	3
	1.09	5.16	2	17.42	3	0.00	3	0.00	2
	2.18	0.00	2	0.00	3	-31.95	3	-9.47	2

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
	[N/mm²]					
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
18.0	24.0	432.0	20736.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$ƷƷ_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.18 m, k_{crit} = 1.00)*						
	1.09	3	0.80	17.42	10.08	14.77	0.68*

Querkraft Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	$ǰ_d$ [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	3	0.80	23.75	1.15	2.15	0.54
	1.90	3	0.80	-23.75	1.15	2.15	0.54*

Stabilität Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.18	2.18

Auflagerpressung Abs. 6.1.5 — Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	$ƷƷ_{c90d}$ [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	3	0.80	31.95	270.0	1.75	1.18	2.69	0.44
Auflager B	3	0.80	31.95	270.0	1.75	1.18	2.69	0.44

f^*_{c90d}: k_{c90} * f_{c90d}

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) — Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen — Nachweise der Verformungen
Abs. 7.2

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.18 m, NKL 1, k_{def} = 0.60)*						
	1.09	6	w_{inst}	2.6	l/300=	7.3	0.36
	1.09	8	w_{fin}	3.6	l/200=	10.9	0.33
	1.09	10	$w_{net,fin}$	2.5	l/300=	7.3	0.35

Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	9.47
	B	9.47
Einw. *Qk.N*	A	12.78
	B	12.78

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.68
Querkraft	Feld 1	1.90	OK	0.54
Auflagerpressung	Auflager A		OK	0.44

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

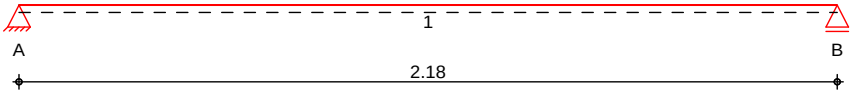
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.09	OK	0.36
Enddurchbiegung	Feld 1	1.09	OK	0.33
gesamte Enddurchb.	Feld 1	1.09	OK	0.35

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP6.1 Randträger, SSV einseitig

System — Holz-Einfeldträger

M 1:20



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.18	2.18	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.18	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 21/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte
Qk.S.A Fall (i)

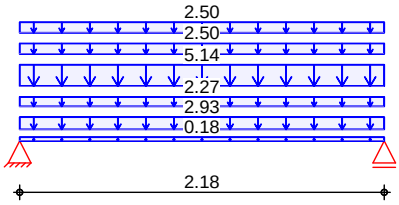
Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte
Qk.W.000 Anstrºmrichtung dž = 0Á
Qk.W.090 Anstrºmrichtung dž = 90Á
Qk.W.180 Anstrºmrichtung dž = 180Á
Qk.W.270 Anstrºmrichtung dž = 270Á

Belastungen — Belastungen auf das System

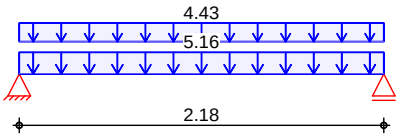
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

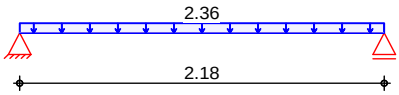
Gk



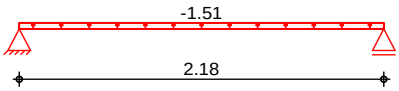
Qk.N



Qk.S.A

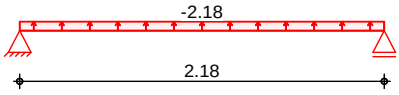


Qk.W.000

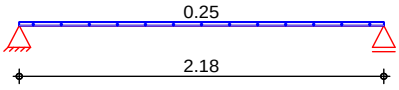


mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

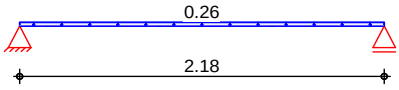
Qk.W.090



Qk.W.180



Qk.W.270



Streckenlasten in z-Richtung

Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	2.18		0.18
	(a)	1	BE1	0.00	2.18		2.93
	(b)	1	E2	0.00	2.18		2.27
	(c)	1	D1.2	0.00	2.18		5.13
		1	Wände	0.00	2.18		2.50
		1	Wände	0.00	2.18		2.50
Einw. *Qk.N*	(a)	1	BE1	0.00	2.18		5.16
	(b)	1	E2	0.00	2.18		4.43
Einw. *Qk.S.A*	(c)	1	D1.2	0.00	2.18		2.36
Einw. *Qk.W.000*	(c)	1	D1.2	0.00	2.18		-1.51
Einw. *Qk.W.090*	(c)	1	D1.2	0.00	2.18		-2.18
Einw. *Qk.W.180*	(c)	1	D1.2	0.00	2.18		0.25
Einw. *Qk.W.270*	(c)	1	D1.2	0.00	2.18		0.26

(a) aus Pos. 'BE1', Lager 'A' (Seite 149)

(b) aus Pos. 'E2', Lager 'A' (Seite 98)

(c) aus Pos. 'D1.2', Lager 'A' (Seite 60)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	2	mi	1.35*Gk	+1.50*Qk.N	
selten	68		1.00*Gk	+1.00*Qk.N	+0.50*Qk.S.A
	70		1.00*Gk	+1.00*Qk.N	+0.50*Qk.S.A
quasi-ständig	72		1.00*Gk	+0.30*Qk.N	

mi: mittel

Bem.-schnittgrößen

Bemessungsschnittgrößen

Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	9	13.34	3	40.45	9
	1.09	7.27	3	22.04	9	0.00	9	0.00	38
	2.18	0.00	3	0.00	9	-40.45	9	-13.34	3

Mat./Querschnitt

nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
			[N/mm²]			
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
21.0	24.0	504.0	24192.0

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	G [-]
Feld 1	*(L = 2.18 m, k_{crit} = 1.00)*						
	1.09	2	0.80	20.99	10.41	14.77	0.70*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	G [-]
Feld 1	0.28	2	0.80	28.62	1.19	2.15	0.55
	1.90	2	0.80	-28.62	1.19	2.15	0.55*

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.18	2.18

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	G [-]
Auflager A	2	0.80	38.52	315.0	1.75	1.22	2.69	0.45
Auflager B	2	0.80	38.52	315.0	1.75	1.22	2.69	0.45

f^*_{c90d}: k_{c90} * f_{c90d}

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 2.18 m, NKL 1, k_{def} = 0.60)*						
	1.09	68	w_{inst}	2.9	l/300=	7.3	0.40
	1.09	70	w_{fin}	4.1	l/200=	10.9	0.38
	1.09	72	$w_{net,fin}$	3.3	l/300=	7.3	0.45

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	16.91
	B	16.91
Einw. *Qk.N*	A	10.46
	B	10.46
Einw. *Qk.S.A*	A	2.58
	B	2.58
Einw. *Qk.W.000*	A	-1.64
	B	-1.64
Einw. *Qk.W.090*	A	-2.38
	B	-2.38

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Einw. *Qk.W.180*	A	0.28
	B	0.28
Einw. *Qk.W.270*	A	0.29
	B	0.29

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.70
Querkraft	Feld 1	1.90	OK	0.55
Auflagerpressung	Auflager A		OK	0.45

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

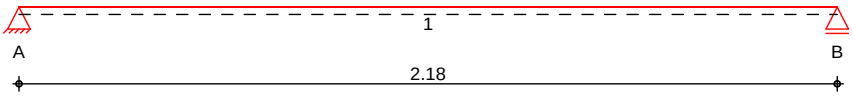
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.09	OK	0.40
Enddurchbiegung	Feld 1	1.09	OK	0.38
gesamte Enddurchb.	Feld 1	1.09	OK	0.45

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP6.2 Randträger, SSV einseitig

System — Holz-Einfeldträger

M 1:20

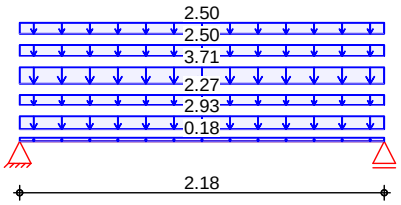


Belastungen — Belastungen auf das System

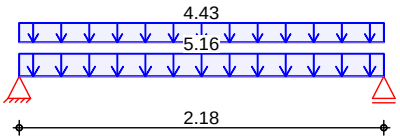
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

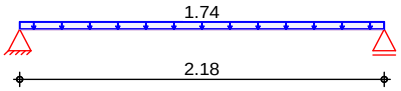
Gk



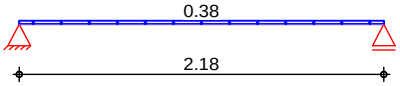
Qk.N



Qk.S.A



Qk.W



Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	15.36
	B	15.36
Einw. *Qk.N*	A	10.46
	B	10.46
Einw. *Qk.S.A*	A	1.89
	B	1.89
Einw. *Qk.W*	A	0.41
	B	0.41

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.67
Querkraft	Feld 1	1.90	OK	0.52
Auflagerpressung	Auflager A		OK	0.43

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

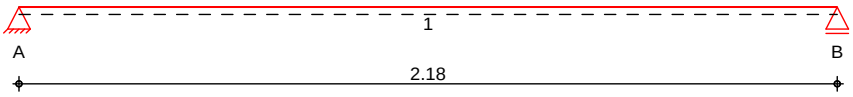
Nachweis	Feld	x [m]		G [-]
Enddurchbiegung	Feld 1	1.09	OK	0.35
gesamte Enddurchb.	Feld 1	1.09	OK	0.41

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP6.3 Randträger, SSV einseitig

System — Holz-Einfeldträger

M 1:20

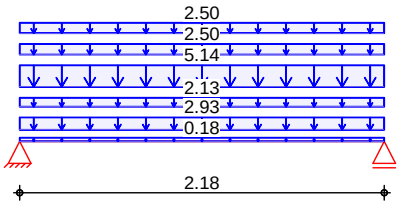


Belastungen — Belastungen auf das System

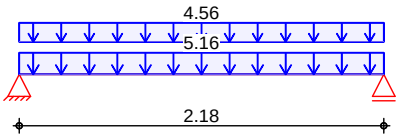
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

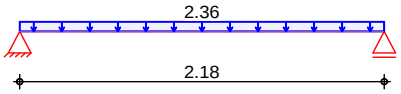
Gk



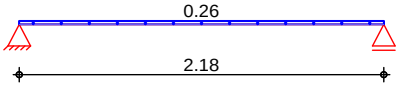
Qk.N



Qk.S.A



Qk.W



Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	16.76
	B	16.76
Einw. *Qk.N*	A	10.60
	B	10.60
Einw. *Qk.S.A*	A	2.58
	B	2.58
Einw. *Qk.W*	A	0.29
	B	0.29

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.70
Querkraft	Feld 1	1.90	OK	0.55
Auflagerpressung	Auflager A		OK	0.45

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

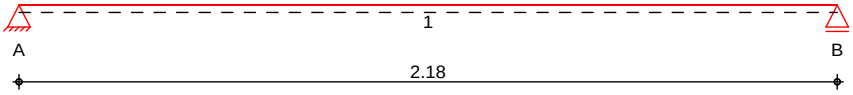
Nachweis	Feld	x [m]		G [-]
Enddurchbiegung	Feld 1	1.09	OK	0.38
gesamte Enddurchb.	Feld 1	1.09	OK	0.45

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP7.1 Randträger, SSV einseitig

System — Holz-Einfeldträger

M 1:20



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	2.18	2.18	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	2.18	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 21/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

Qk.S — Schneeeinwirkung
Schnee- und Eislasten für Orte bis NN + 1000 m
Qk.S min/max Werte
Qk.S.A Fall (i)

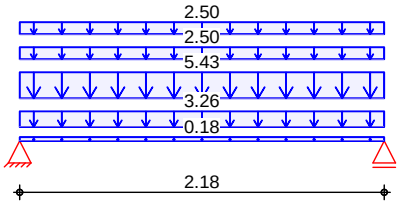
Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte
Qk.W.000 Anstrºmrichtung dž = 0Á
Qk.W.090 Anstrºmrichtung dž = 90Á
Qk.W.180 Anstrºmrichtung dž = 180Á
Qk.W.270 Anstrºmrichtung dž = 270Á

Belastungen — Belastungen auf das System

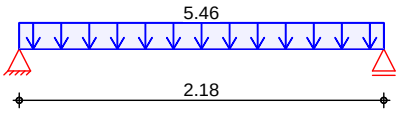
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

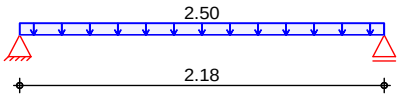
Gk



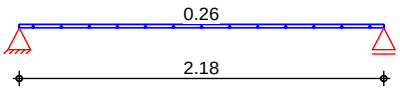
Qk.N



Qk.S.A

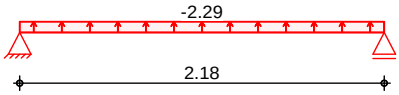


Qk.W.000

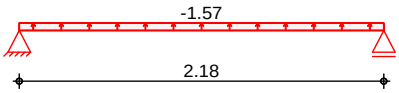


mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

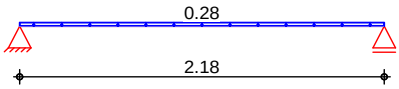
Qk.W.090



Qk.W.180



Qk.W.270



Streckenlasten in z-Richtung — Gleichlasten

		Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*		1	Eigengew	0.00	2.18		0.18
	(a)	1	BE2	0.00	2.18		3.26
	(b)	1	D1.2	0.00	2.18		5.43
		1	Wände	0.00	2.18		2.50
		1	Wände	0.00	2.18		2.50
Einw. *Qk.N*	(a)	1	BE2	0.00	2.18		5.46
Einw. *Qk.S.A*	(b)	1	D1.2	0.00	2.18		2.50
Einw. *Qk.W.000*	(b)	1	D1.2	0.00	2.18		0.26
Einw. *Qk.W.090*	(b)	1	D1.2	0.00	2.18		-2.29
Einw. *Qk.W.180*	(b)	1	D1.2	0.00	2.18		-1.57
Einw. *Qk.W.270*	(b)	1	D1.2	0.00	2.18		0.28

(a) aus Pos. 'BE2', Lager 'B' (Seite 153)

(b) aus Pos. 'D1.2', Lager 'C' (Seite 60)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	2	mi	1.35*Gk	+1.50*Qk.N	
selten	68		1.00*Gk	+1.00*Qk.N	+0.50*Qk.S.A
	70		1.00*Gk	+1.00*Qk.N	+0.50*Qk.S.A
quasi-ständig	72		1.00*Gk	+0.30*Qk.N	

mi: mittel

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	3	0.00	9	11.38	3	31.38	9
	1.09	6.20	3	17.10	9	0.00	59	0.00	7
	2.18	0.00	3	0.00	9	-31.38	9	-11.38	3

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
			[N/mm²]			
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
21.0	24.0	504.0	24192.0

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1

Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 2.18 m, k_{crit} = 1.00)*						
	1.09	2	0.80	15.99	7.93	14.77	0.54*

Querkraft
Abs. 6.1.7

Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.28	2	0.80	21.80	0.91	2.15	0.42*
	1.90	2	0.80	-21.80	0.91	2.15	0.42

Stabilität
Abs. 6.3

Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	2.18	2.18

Auflagerpressung
Abs. 6.1.5

Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	2	0.80	29.33	315.0	1.75	0.93	2.69	0.35
Auflager B	2	0.80	29.33	315.0	1.75	0.93	2.69	0.35

f^*_{c90d}: $k_{c90} * f_{c90d}$

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	η [-]
Feld 1	*(L= 2.18 m, NKL 1, k_{def} = 0.60)*						
	1.09	68	w_{inst}	2.3	l/300=	7.3	0.31
	1.09	70	w_{fin}	3.3	l/200=	10.9	0.30
	1.09	72	$w_{net,fin}$	2.7	l/300=	7.3	0.38

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	15.11
	B	15.11
Einw. *Qk.N*	A	5.95
	B	5.95
Einw. *Qk.S.A*	A	2.73
	B	2.73
Einw. *Qk.W.000*	A	0.28
	B	0.28
Einw. *Qk.W.090*	A	-2.49
	B	-2.49
Einw. *Qk.W.180*	A	-1.71
	B	-1.71
Einw. *Qk.W.270*	A	0.30
	B	0.30

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.54
Querkraft	Feld 1	0.28	OK	0.42
Auflagerpressung	Auflager A		OK	0.35

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

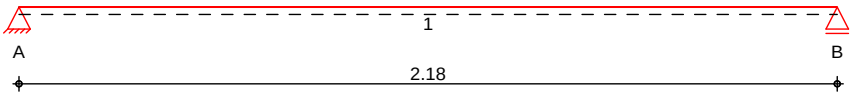
Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	1.09	OK	0.31
Enddurchbiegung	Feld 1	1.09	OK	0.30
gesamte Enddurchb.	Feld 1	1.09	OK	0.38

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP7.2 Randträger, SSV einseitig

System — Holz-Einfeldträger

M 1:20

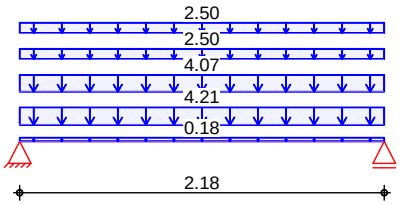


Belastungen — Belastungen auf das System

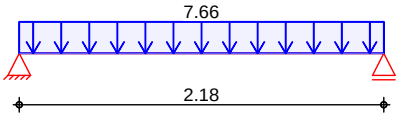
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

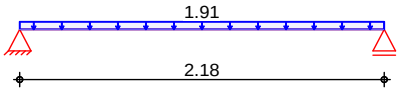
Gk



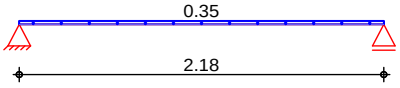
Qk.N



Qk.S.A



Qk.W



Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	14.67
	B	14.67
Einw. *Qk.N*	A	8.35
	B	8.35
Einw. *Qk.S.A*	A	2.08
	B	2.08
Einw. *Qk.W*	A	0.38
	B	0.38

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.59
Querkraft	Feld 1	1.90	OK	0.46
Auflagerpressung	Auflager A		OK	0.38

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

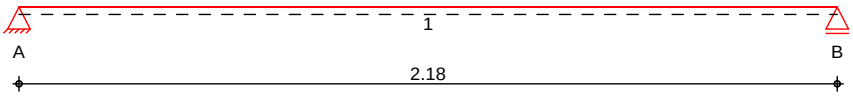
Nachweis	Feld	x [m]		G [-]
Enddurchbiegung	Feld 1	1.09	OK	0.32
gesamte Enddurchb.	Feld 1	1.09	OK	0.38

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP7.3 Zwischenträger, SSV einseitig

System — Holz-Einfeldträger

M 1:20

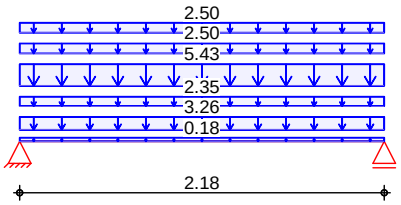


Belastungen — Belastungen auf das System

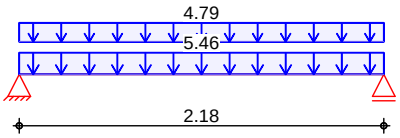
Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen

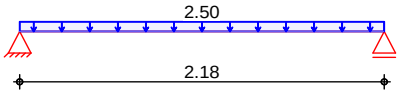
Gk



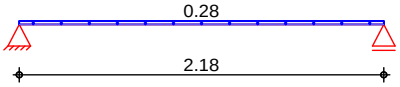
Qk.N



Qk.S.A



Qk.W



Auflagerkräfte — Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	17.67
	B	17.67
Einw. *Qk.N*	A	11.18
	B	11.18
Einw. *Qk.S.A*	A	2.73
	B	2.73
Einw. *Qk.W*	A	0.30
	B	0.30

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 1	1.09	OK	0.74
Querkraft	Feld 1	1.90	OK	0.58
Auflagerpressung	Auflager A		OK	0.48

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

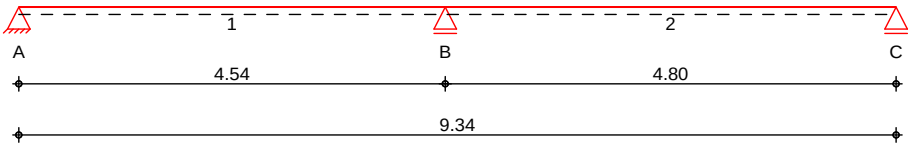
Nachweis	Feld	x [m]		G [-]
Enddurchbiegung	Feld 1	1.09	OK	0.40
gesamte Enddurchb.	Feld 1	1.09	OK	0.47

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. BP8 Randträger

System — Holz-Zweifeldträger

M 1:80



Abmessungen / Nutzungsklassen

Feld	l [m]	$l_{ef,m}$ [m]	NKL
1	4.54	4.54	1
2	4.80	4.80	1

Auflager

Aufl.	x [m]	b [cm]	Transl. [kN/m]	Rotat. [kNm/rad]
A	0.00	12.00	starr	frei
B	4.54	12.00	starr	frei
C	9.34	12.00	starr	frei

Material — *BSH GL24c*

Querschnitt — **b/h = 24/24 cm**

Einwirkungen — Einwirkungen nach DIN EN 1990:2010-12

Gk — Ständige Einwirkung
Ständige Einwirkungen

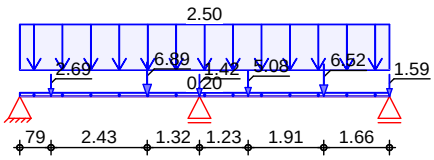
Qk.N — Veränderliche Einwirkung
Kategorie A - Wohn- und Aufenthaltsräume

Qk.W — Windeinwirkung
Windlasten
Qk.W min/max Werte
Qk.W.000 Anstrºmrichtung dž = 0Á
Qk.W.180 Anstrºmrichtung dž = 180Á

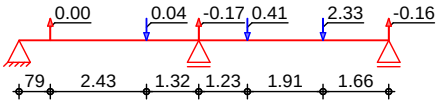
Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

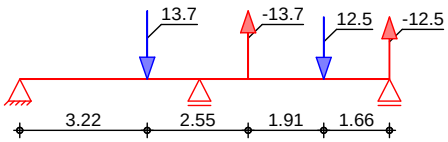
Einwirkungen — Gk



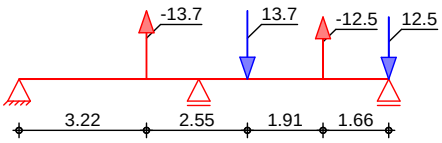
Qk.N



Qk.W.000



Qk.W.180



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Streckenlasten in z-Richtung — Gleichlasten

	Feld	Komm.	a [m]	s [m]	q_{li} [kN/m]	q_{re} [kN/m]
Einw. *Gk*	1	Eigengew	0.00	9.34		0.20
	1	Wand EG	0.00	9.34		2.50

Punktlasten in z-Richtung — Einzellasten

		Feld	Komm.	a [m]	F_z [kN]
Einw. *Gk*	(a)	1	E7	0.79	2.69
	(b)	1	E7	3.22	6.89
	(c)	1	E7	4.54	1.42
	(d)	1	E7	5.77	5.08
	(e)	1	E7	7.68	6.52
	(f)	1	E7	9.34	1.59
Einw. *Qk.N*	(b)	1	E7	3.22	0.04
	(c)	1	E7	4.54	-0.17
	(d)	1	E7	5.77	0.41
	(e)	1	E7	7.68	2.33
	(f)	1	E7	9.34	-0.16
Einw. *Qk.W.000*		1	4.1-AW	3.22	13.74
		1	4.1-AW	5.77	-13.74
		1	4.2-AW	7.68	12.51
		1	4.2-AW	9.34	-12.51
Einw. *Qk.W.180*		1	4.1-AW	3.22	-13.74
		1	4.1-AW	5.77	13.74
		1	4.2-AW	7.68	-12.51
		1	4.2-AW	9.34	12.51

(a) aus Pos. 'E7', Lager 'A' (Seite 117)

(b) aus Pos. 'E7', Lager 'B' (Seite 117)

(c) aus Pos. 'E7', Lager 'C' (Seite 117)

(d) aus Pos. 'E7', Lager 'D' (Seite 117)

(e) aus Pos. 'E7', Lager 'E' (Seite 117)

(f) aus Pos. 'E7', Lager 'F' (Seite 117)

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	1	st	1.35*Gk		
	4	ku/sk	1.35*Gk	+1.05*Qk.N	+1.50*Qk.W.180
	6	ku/sk	1.35*Gk	+1.05*Qk.N	+1.50*Qk.W.000
selten	17		1.00*Gk	+1.00*Qk.W.000	
	18		1.00*Gk	+0.70*Qk.N	+1.00*Qk.W.180
	19		1.00*Gk	+1.00*Qk.W.000	
	20		1.00*Gk	+0.70*Qk.N	+1.00*Qk.W.180
quasi-ständig	21		1.00*Gk		
	22		1.00*Gk	+0.30*Qk.N	
Lagesicherheit	33	ku/sk	0.90*Gk	+1.50*Qk.W.000	
	34	ku/sk	0.90*Gk	+1.50*Qk.W.180	
	35	ku/sk	0.90*Gk	+1.05*Qk.N	+1.50*Qk.W.180
st./vor. Auflagerkr.	43	ku/sk	1.00*Gk	+1.50*Qk.W.000	
	44	ku/sk	1.00*Gk	+1.50*Qk.W.180	
	45	ku/sk	1.00*Gk	+1.05*Qk.N	+1.50*Qk.W.180

st: ständig
ku/sk: kurz/sehr kurz

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Bem.-schnittgrößen — Bemessungsschnittgrößen

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$M_{y,d,min}$ [kNm]	Ek	$M_{y,d,max}$ [kNm]	Ek	$V_{z,d,min}$ [kN]	Ek	$V_{z,d,max}$ [kN]	Ek
Feld 1	0.00	0.00	2	0.00	3	2.26	2	14.02	3
	2.86	-10.16	2	17.69	3	-9.34	4	1.15	5
	4.54	-28.10	6	-8.48	7	-36.34	6	1.26	7
Feld 2	0.00	-28.10	6	-8.48	7	8.20	5	30.00	4
	3.14	1.74	7	26.71	6	-13.06	6	1.19	7
	4.80	0.00	7	0.00	6	-19.12	6	-3.29	7

Mat./Querschnitt — nach DIN EN 1995-1-1

Materialien

Holz	$f_{m,k}$	f_{t0k}	f_{c0k}	f_{c90k}	f_{vk}	E_{0mean}
				[N/mm²]		
BSH GL24c[f]	24.0	17.0	21.5	2.5	3.5	11000

f: Lamellenlage flachkant

Querschnittswerte

b [cm]	h [cm]	A [cm²]	I_y [cm⁴]
24.0	24.0	576.0	27648.0

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Biegung
Abs. 6.1 — Nachweis der Biegetragfähigkeit

	x [m]	Ek	k_{mod} [-]	M_{yd} [kNm]	$\sigma_{m,d}$ [N/mm²]	$f_{m,d}$ [N/mm²]	η [-]
Feld 1	*(L = 4.54 m, k_{crit} = 1.00)*						
	4.54	1	0.60	-20.38	8.84	11.08	0.80*
Feld 2	*(L = 4.80 m, k_{crit} = 1.00)*						
	0.00	1	0.60	-20.38	8.84	11.08	0.80*

Querkraft
Abs. 6.1.7 — Nachweis der Querkrafttragfähigkeit

	x [m]	Ek	k_{mod} [-]	$V_{z,d}$ [kN]	τ_d [N/mm²]	$f_{v,d}$ [N/mm²]	η [-]
Feld 1	0.28	1	0.60	8.47	0.31	1.62	0.19
	4.24	6	1.00	-35.24	1.28	2.69	0.48*
Feld 2	0.30	1	0.60	20.05	0.73	1.62	0.45*
	4.52	1	0.60	-11.00	0.40	1.62	0.25

Stabilität
Abs. 6.3 — Nachweis der Stabilität

Der Einfluss der Stabilität ist im Nachweis der Biegetragfähigkeit enthalten. Folgende Ersatzstablängen werden berücksichtigt.

Ersatzstablängen

	l [m]	$l_{ef,m}$ [m]
Feld 1	4.54	4.54
Feld 2	4.80	4.80

Auflagerpressung
Abs. 6.1.5 — Nachweis der Auflagerpressung

	Ek	k_{mod} [-]	F_d [kN]	A_{ef} [cm²]	k_{c90} [-]	σ_{c90d} [N/mm²]	f^*_{c90d} [N/mm²]	η [-]
Auflager A	1	0.60	9.49	360.0	1.75	0.26	2.02	0.13
Auflager B	1	0.60	43.06	432.0	1.75	1.00	2.02	0.49
Auflager C	4	1.00	28.63	360.0	1.75	0.80	3.37	0.24

f^*_{c90d}: $k_{c90} * f_{c90d}$

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Lagesicherheit
DIN EN 1990, 6.4.2

Lagesicherheitsnachweis in vertikaler Richtung nach NDP zu A1.3.1(3)

Aufl.	Ek [-]	$F_{d,dst}$ [kN]	$F_{d,stb}$ [kN]	G [-]
A	35	-4.77	6.33	0.75
B	34	-8.61	28.71	0.30
C	33	-13.15	9.45	1.39!

ständig/vorüberg.

Zugverankerung

Aufl.	$F_{d,anch}$ [kN]	EK
C	-2.65	43

Nachweise (GZG)

Nachweise im Grenzzustand der Gebrauchstauglichkeit nach DIN EN 1995-1-1

Verformungen
Abs. 7.2

Nachweise der Verformungen

	x [m]	Ek	Norm	w_{vorh} [mm]		w_{zul} [mm]	G [-]
Feld 1	*(L= 4.54 m, NKL 1, k_{def} = 0.60)*						
	2.21	17	w_{inst}	7.8	l/300=	15.1	0.51
	2.21	19	w_{fin}	9.5	l/200=	22.7	0.42
	1.88	21	$w_{net,fin}$	4.7	l/300=	15.1	0.31
Feld 2	*(L= 4.80 m, NKL 1, k_{def} = 0.60)*						
	2.44	18	w_{inst}	8.0	l/300=	16.0	0.50
	2.44	20	w_{fin}	11.8	l/200=	24.0	0.49
	2.74	22	$w_{net,fin}$	10.5	l/300=	16.0	0.66

Auflagerkräfte

Charakteristische Auflagerkräfte

Char. Auflagerkr.

	Aufl.	$F_{z,k}$ [kN]
Einw. *Gk*	A	7.03
	B	31.90
	C	10.50
Einw. *Qk.N*	A	-0.22
	B	1.42
	C	1.25
Einw. *Qk.W.000*	A	3.02
	B	5.74
	C	-8.77
Einw. *Qk.W.180*	A	-3.02
	B	-5.74
	C	8.77

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Feld/Auflager	x [m]		G [-]
Biegung	Feld 2	0.00	OK	0.80
Querkraft	Feld 1	4.24	OK	0.48
Auflagerpressung	Auflager B		OK	0.49
Lagesicherheit			Zugv.	1.39

Zugv.: Für das Auflager C ist eine Zugkraftverankerung erforderlich.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis	Feld	x [m]		G [-]
Anfangsdurchbieg.	Feld 1	2.21	OK	0.51
Enddurchbiegung	Feld 2	2.44	OK	0.49
gesamte Enddurchb.	Feld 2	2.74	OK	0.66

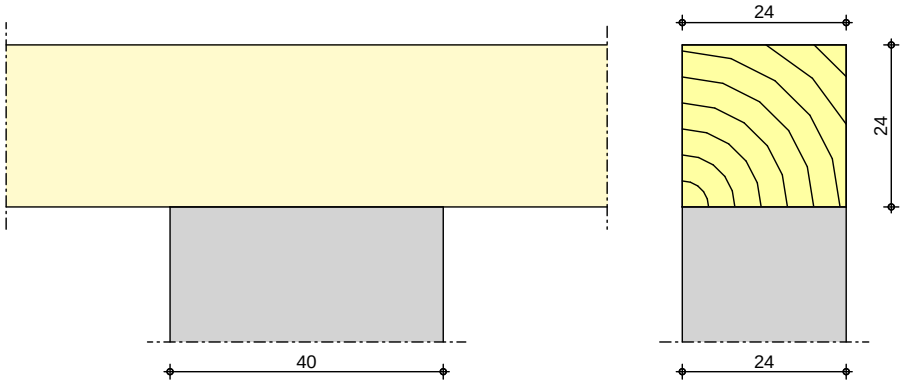
Auf die Zugverankerung kann aufgrund der Auflast der angrenzenden Außenwand verzichtet werden.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. DT_BP Holz-Auflager

Geometrie
M 1:11

Holz-Auflagernachweis nach DIN EN 1995-1-1



Mat./Querschnitt

Bauteil	Material	Querschnitt [cm]
Träger	*NH C24*	**24.0/24.0**
Stütze	-	**40.0/24.0**

Nutzungsklasse 2

Belastungen

Belastungen auf das System

Auflagerlasten

	Komm.	F_z [kN]
Einw. *Gk*	Auflager	9.47
	Auflager	9.20
	Auflager	52.89
Einw. *Qk.N*	Auflager	12.24
	Auflager	12.78
	Auflager	26.96
Einw. *Qk.S*	Auflager	32.58

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)		
ständig/vorüberg.	5	ku	1.35*Gk	+1.05*Qk.N	+1.50*Qk.S

ku: kurz

Mat./Querschnitt

nach DIN EN 1995-1-1

Nachweise (GZT)

Nachweis im Grenzzustand der Tragfähigkeit nach DIN EN 1995-1-1

Querdruck

vertikale Druckkraft

EK	k_{mod} [-]	$F_{c,90,d}$ [kN]	Bauteil	$k_{c,90}$ [-]	$F_{c,90,Rd}$ [kN]	G [-]
5	0.90	200.05	Träger	1.50	286.62	0.70

Zusammenfassung

Zusammenfassung der Nachweise

Nachweise (GZT)

Nachweise im Grenzzustand der Tragfähigkeit

Nachweis	Bauteil		G [-]
Querdruck	Träger	OK	0.70

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Gebäudeaussteifung

Nachweis Mindest-Rippenbreiten

Die Beplankung der Wände erfolgt mit Klammern der Fa. Haubold Typ KG 745 CNK Z12 geharzt mit einer Länge von 45 mm, einem Durchmesser von 1,53 mm und einer Rückenbreite von 11,25 mm. Die Klammern sind um 30° zur Faserrichtung gedreht.

Nach Colling ergibt sich somit bei der Verwendung von Gips eine erforderliche Mindest-Rippenbreite von b_{Ri} = 47,97 mm und bei Verwendung von Holzwerkstoffen (ESB oder DWD) als Beplankungsmaterial eine erforderliche Mindest-Rippenbreite von b_{Ri} = 41,85 mm. Somit sind die tatsächlich vorhandenen Rippenbreiten b_{Ri} = 50 mm sowohl für eine Beplankung aus Gips als auch Holzwerkstoffen ausreichend.

Aussteifung Pergola

Die Aussteifung einer Pergola erfolgt konstruktiv nach Detail DA039 durch zwei Aussteifungswinkel aus Flachstahl 60 x 15 mm.

Aussteifung Balkon

Die Aussteifung eines Balkons erfolgt nach Detail VE022 durch Aussteifungswinkel aus Flachstahl 60 x 15 mm bzw. durch Stahlseile.

Folgende Punkte müssen dabei berücksichtigt werden:
- alle Balkone/Terrassen werden im Werk mit Flachstahlwinkeln versehen (pro Balkonelement 4 Winkel), außer Gartenterrassen
- die Verschraubung erfolgt mit Schmid Rapid Vollgewindeschrauben SK 8x160 (bei Sticher 8/16: SK 8x140)
- wenn ein Balkon um ein Hauseck läuft und an zwei Hausseiten befestigt wird, muss er nicht ausgesteift werden
- wenn mehrere Elemente voreinander montiert werden, müssen alle Elemente separat ausgesteift werden
- falls in mehr als zwei Geschossen übereinander Balkone vorhanden sind, ist eine Rücksprache bezüglich der erforderlichen Aussteifung mit dem Statiker notwendig
- falls eine Sichtschutzwand (statt eines Geländers) an der Balkonkonstruktion befestigt wird, erfolgt die Aussteifung durch Stahlseile anstatt der Winkel

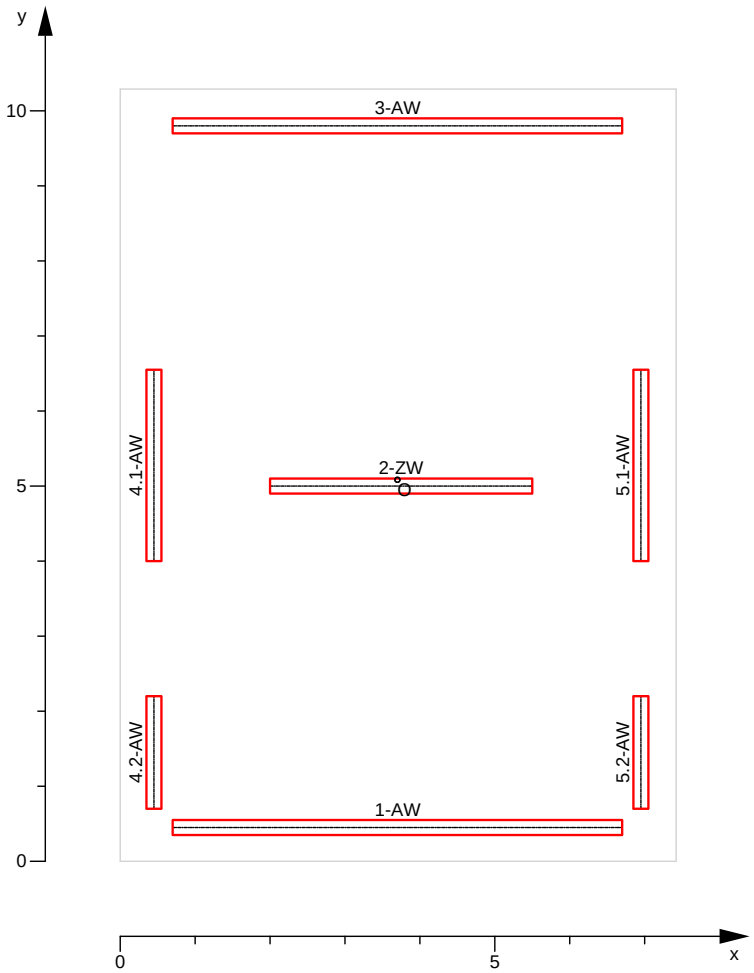
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. HAS Holzaussteifungssystem

Die Lasten werden programmintern für die Außenmaße des Grids am Huaptbaukörper ermittelt. Die Lasten des vorderen Anbaus mit Treppe werden händisch ermittelt und als zusätzliche Lasten in der Berechnung ergänzt.

System
M 1:100

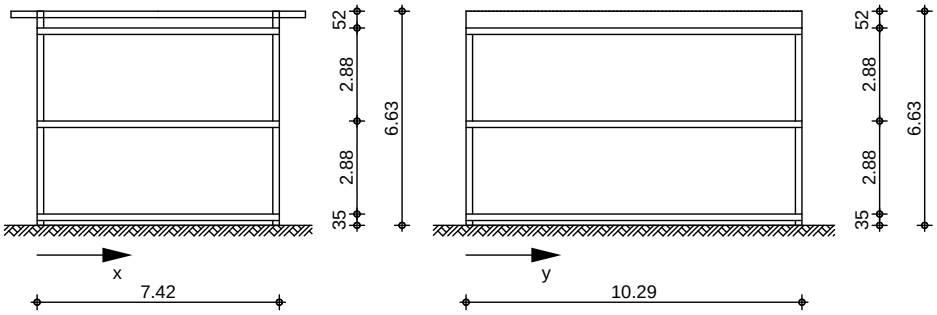
Holz-Aussteifungssystem



Gebäudeabmessungen	Gebäudebreite	B =	7.42	m
	Gebäudelänge	L =	10.29	m
	Gebäudehöhe über GOK	H_G =	6.63	m
	Abstand zur Geländeoberkante	A_{GOK} =	0.35	m
	Dachneigung	ä =	0.00	°
	Drempelhöhe	h_D =	0.52	m

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

M 1:230



Geschosse

Name	Kommentar	Höhe [m]
EG	Dachgeschoss	2.88
OG	Erdgeschoss	2.88

Aussteifungselem.

Wandname	x_a [m]	y_a [m]	x_e [m]	y_e [m]	EI_{eff} [kNm²]	Länge [m]
1-AW	0.70	0.45	6.70	0.45	16766	6.00
2-ZW	2.00	5.00	5.50	5.00	16778	3.50
3-AW	0.70	9.80	6.70	9.80	16766	6.00
4.1-AW	0.45	4.00	0.45	6.55	6132	2.55
4.2-AW	0.45	0.70	0.45	2.20	3282	1.50
5.1-AW	6.95	4.00	6.95	6.55	6132	2.55
5.2-AW	6.95	0.70	6.95	2.20	3282	1.50

Drehpolkoordinaten

	O_x [m]	O_y [m]
EG	3.70	5.08
OG	3.70	5.08

<u>Einwirkungen</u>

Einwirkungen nach DIN EN 1990:2010-12

Qk.W

Windeinwirkung
Windlasten

Qk.W	min/max Werte	
Qk.W.000	Anstrºmrichtung dž = 0Á	exz
Qk.W.090	Anstrºmrichtung dž = 90Á	exz

<u>Windlasten</u>

nach DIN EN 1991-1-4:2010-12
Geschwindigkeitsdruck nach Anhang NA.B
Windzone 2, Geländekategorie III

Basiswindgeschwindigkeit	$v_{b,0}$ =	25.00	m/s
Basisgeschwindigkeitsdruck	$q_{b,0}$ =	0.39	kN/m²
Geschwindigkeitsdruck Anströmrichtung 0° und 90°	$q_p(h)$ =	0.59	kN/m²

Anströmrichtung 0°

Außendruckbeiwerte für vertikale Wände (Tab. NA.1)
Außendruckverlauf nach Bild 7.4 für hÒb
Außendruckbeiwerte für Satteldächer (Tab. 7.4)

Bereich	Breite [m]	Höhe [m]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
D(h)	10.29		0.79	0.46
E(h)	10.29		-0.47	-0.28
F	5.15	0.00	-1.80	-1.05
G	5.15	0.00	-1.20	-0.70
J	10.29	0.00	0.20	0.12

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Anströmrichtung 90°

Außendruckbeiwerte für vertikale Wände (Tab. NA.1)
Außendruckverlauf nach Bild 7.4 für h/b
Außendruckbeiwerte für Satteldächer (Tab. 7.4)

Wind auf den Giebel

Windangriffsfläche links = 0.00 m²
Windangriffsfläche rechts = 0.00 m²

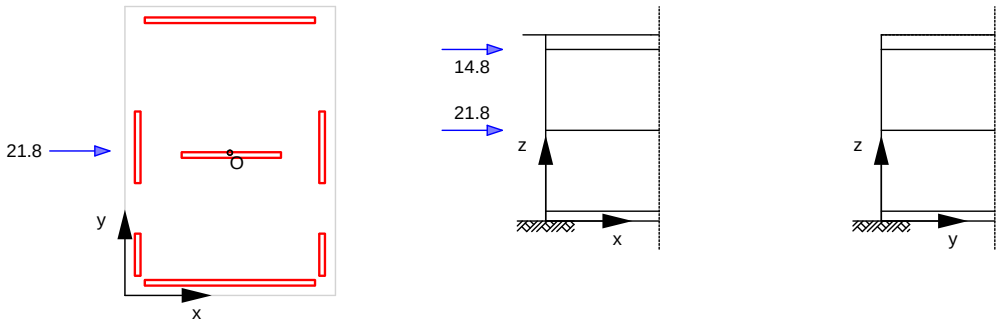
Bereich	Breite [m]	Höhe [m]	$c_{pe,10}$ [-]	$w_{e,10}$ [kN/m²]
D(h)	7.42		0.75	0.44
E(h)	7.42		-0.41	-0.24

Belastungen
Einwirkung
Qk.W.000(z)

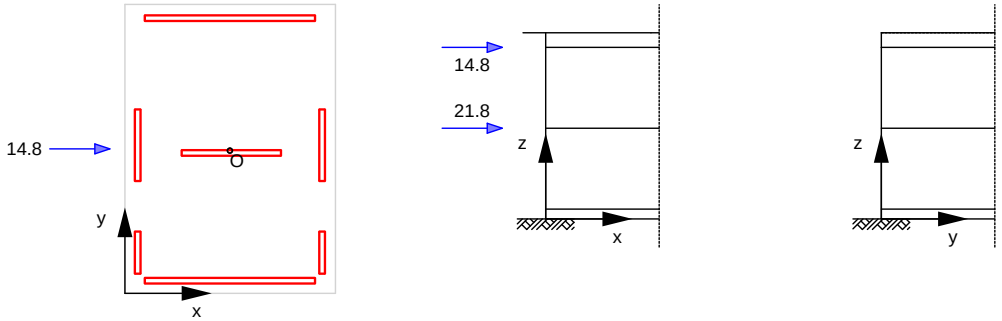
Geschosslasten

	e_y [m]	H_x [kN]	e_x [m]	H_y [kN]
EG	5.14	21.80	-	-
OG	5.14	10.90	-	-
Drempel	5.14	3.94	-	-

Geschoss EG
M 1:265



Geschoss OG
M 1:265



Aussteifungslasten

Geschoss	Aussteifungselement	H_x [kN]	H_y [kN]
EG	1-AW	7.15	0.00
	2-ZW	7.27	0.00
	3-AW	7.38	0.00
	4.1-AW	0.00	0.03
	4.2-AW	0.00	0.02
	5.1-AW	0.00	-0.03
	5.2-AW	0.00	-0.02
OG	1-AW	4.87	0.00

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

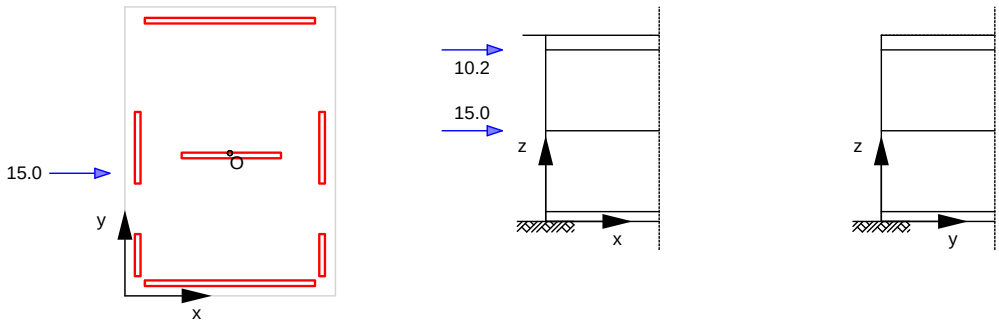
2-ZW	4.95	0.00
3-AW	5.02	0.00
4.1-AW	0.00	0.02
4.2-AW	0.00	0.01
5.1-AW	0.00	-0.02
5.2-AW	0.00	-0.01

Einwirkung
Qk.W.000(n)

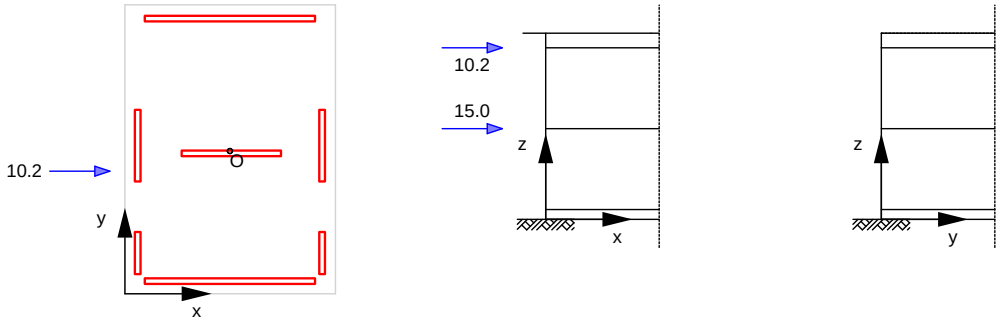
Geschosslasten

	e_y [m]	H_x [kN]	e_x [m]	H_y [kN]
EG	4.37	14.99	-	-
OG	4.37	7.49	-	-
Drempel	4.37	2.71	-	-

Geschoss EG
M 1:265



Geschoss OG
M 1:265



Aussteifungslasten

Geschoss	Aussteifungselement	H_x [kN]	H_y [kN]
EG	1-AW	5.89	0.00
	2-ZW	5.01	0.00
	3-AW	4.08	0.00
	4.1-AW	0.00	-0.23
	4.2-AW	0.00	-0.12
	5.1-AW	0.00	0.23
	5.2-AW	0.00	0.12
OG	1-AW	4.01	0.00
	2-ZW	3.41	0.00
	3-AW	2.78	0.00
	4.1-AW	0.00	-0.16
	4.2-AW	0.00	-0.08
	5.1-AW	0.00	0.16

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

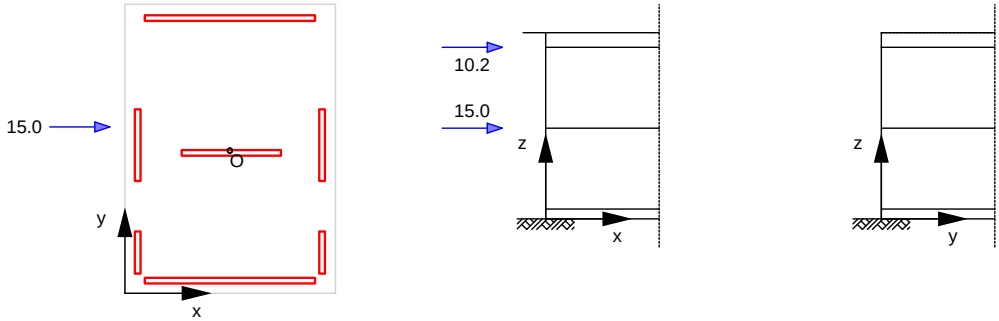
5.2-AW	0.00	0.08

Einwirkung
Qk.W.000(p)

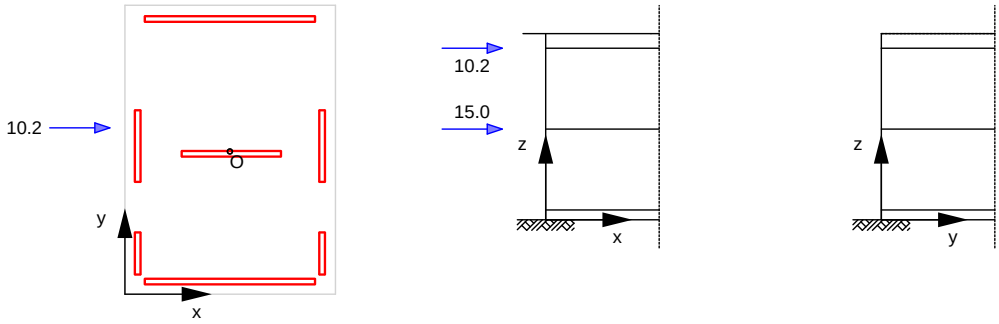
Geschosslasten

	e_y [m]	H_x [kN]	e_x [m]	H_y [kN]
EG	5.92	14.99	-	-
OG	5.92	7.49	-	-
Drempel	5.92	2.71	-	-

Geschoss EG
M 1:265



Geschoss OG
M 1:265



Aussteifungslasten

Geschoss	Aussteifungselement	H_x [kN]	H_y [kN]
EG	1-AW	3.94	0.00
	2-ZW	4.98	0.00
	3-AW	6.06	0.00
	4.1-AW	0.00	0.27
	4.2-AW	0.00	0.14
	5.1-AW	0.00	-0.27
	5.2-AW	0.00	-0.14
OG	1-AW	2.68	0.00
	2-ZW	3.39	0.00
	3-AW	4.13	0.00
	4.1-AW	0.00	0.18
	4.2-AW	0.00	0.10
	5.1-AW	0.00	-0.18
	5.2-AW	0.00	-0.10

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Einwirkung
Qk.W.090(z)

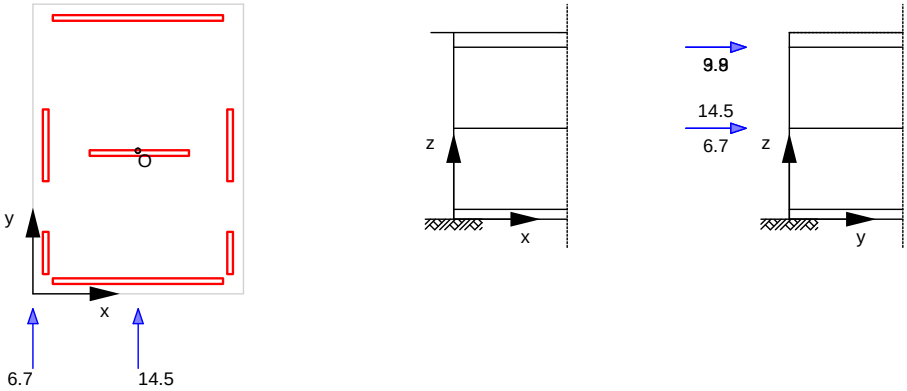
Einzellasten

Richtung		a [m]	H [kN]	e [m]
y	OG	2.88	3.85	0.00
y	EG	2.88	6.66	0.00

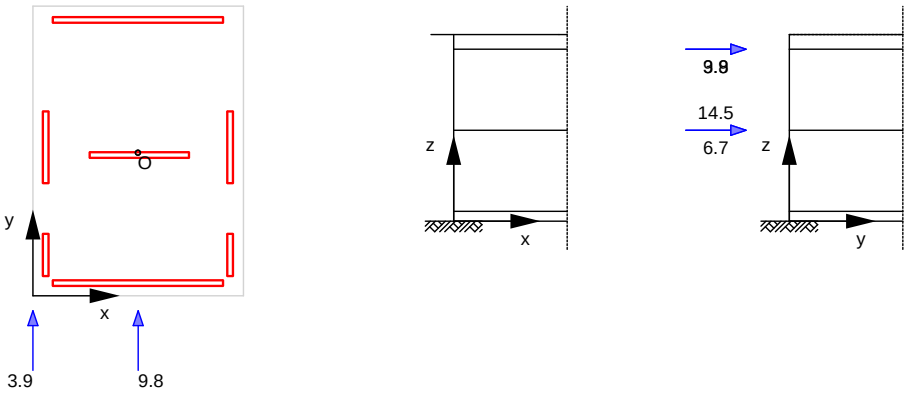
Geschosslasten

	e_y [m]	H_x [kN]	e_x [m]	H_y [kN]
EG	-	-	3.71	14.47
OG	-	-	3.71	7.24
Drempel	-	-	3.71	2.61
OG	-	-	0.00	3.85
EG	-	-	0.00	6.66

Geschoss EG
M 1:265



Geschoss OG
M 1:265



Aussteifungslasten

Geschoss	Aussteifungselement	H_x [kN]	H_y [kN]
EG	1-AW	-2.04	0.00
	2-ZW	-0.04	0.00
	3-AW	2.08	0.00
	4.1-AW	0.00	7.41
	4.2-AW	0.00	3.96
	5.1-AW	0.00	6.36
	5.2-AW	0.00	3.40

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

OG	1-AW	-1.18	0.00
	2-ZW	-0.02	0.00
	3-AW	1.20	0.00
	4.1-AW	0.00	4.76
	4.2-AW	0.00	2.55
	5.1-AW	0.00	4.16
	5.2-AW	0.00	2.23

Einwirkung
Qk.W.090(n)

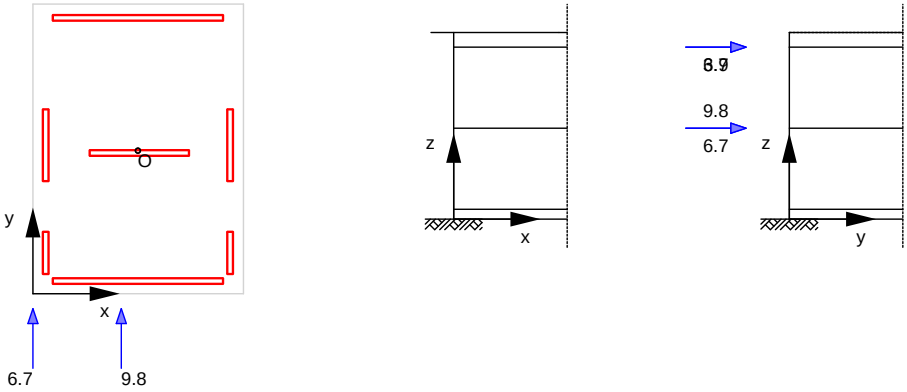
Einzellasten

Richtung		a [m]	H [kN]	e [m]
y	OG	2.88	3.85	0.00
y	EG	2.88	6.66	0.00

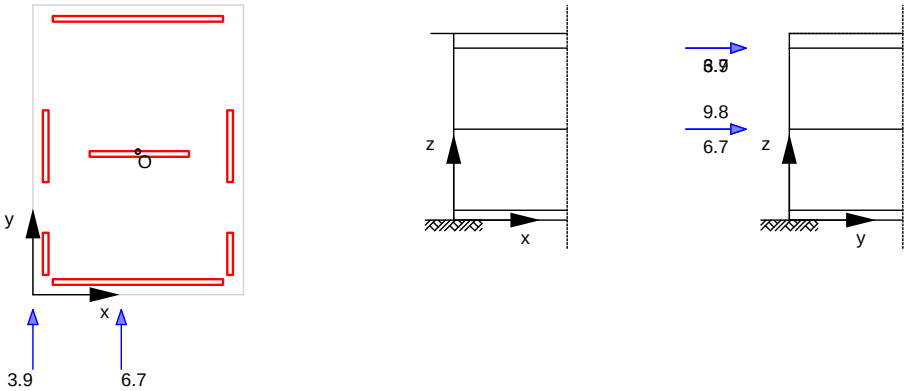
Geschosslasten

	e_y [m]	H_x [kN]	e_x [m]	H_y [kN]
EG	-	-	3.11	9.77
OG	-	-	3.11	4.88
Drempel	-	-	3.11	1.76
OG	-	-	0.00	3.85
EG	-	-	0.00	6.66

Geschoss EG
M 1:265



Geschoss OG
M 1:265



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Aussteifungslasten

Geschoss	Aussteifungselement	H_x [kN]	H_y [kN]
EG	1-AW	-2.53	0.00
	2-ZW	-0.05	0.00
	3-AW	2.58	0.00
	4.1-AW	0.00	6.00
	4.2-AW	0.00	3.21
	5.1-AW	0.00	4.70
	5.2-AW	0.00	2.52
OG	1-AW	-1.51	0.00
	2-ZW	-0.03	0.00
	3-AW	1.54	0.00
	4.1-AW	0.00	3.81
	4.2-AW	0.00	2.04
	5.1-AW	0.00	3.03
	5.2-AW	0.00	1.62

Einwirkung
Qk.W.090(p)

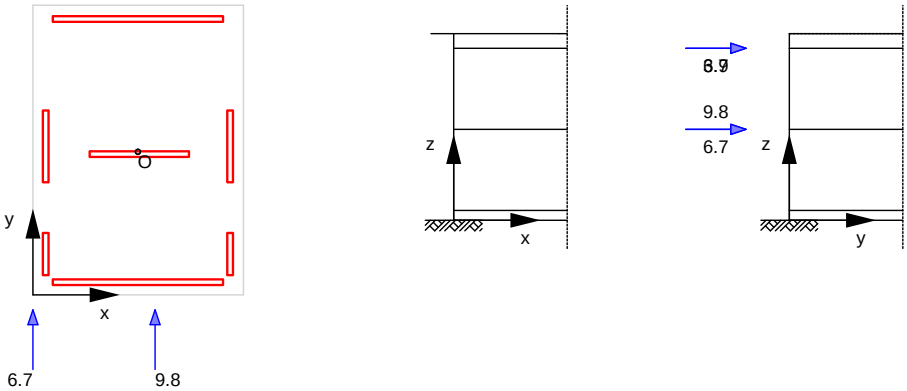
Einzellasten

Richtung		a [m]	H [kN]	e [m]
y	OG	2.88	3.85	0.00
y	EG	2.88	6.66	0.00

Geschosslasten

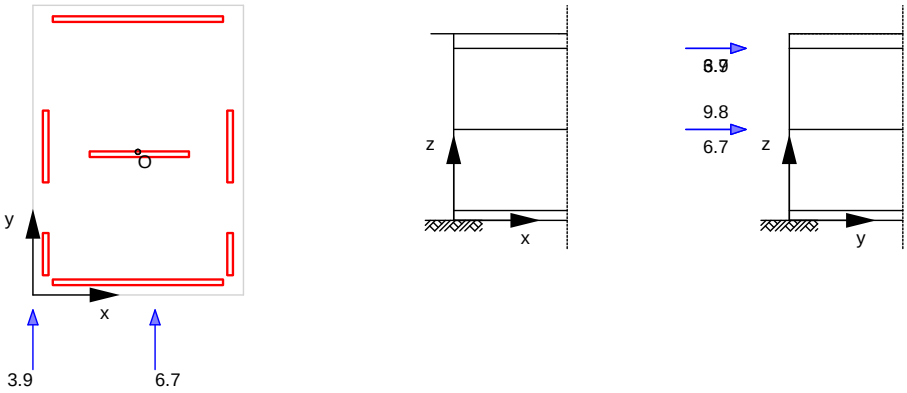
	e_y [m]	H_x [kN]	e_x [m]	H_y [kN]
EG	-	-	4.31	9.77
OG	-	-	4.31	4.88
Drempel	-	-	4.31	1.76
OG	-	-	0.00	3.85
EG	-	-	0.00	6.66

Geschoss EG
M 1:265



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Geschoss OG
M 1:265

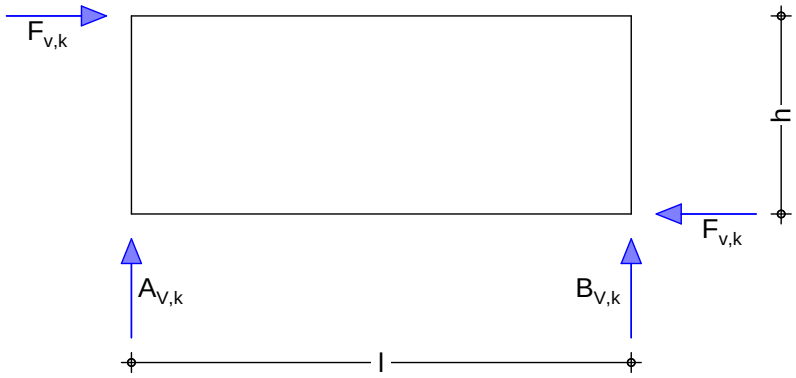


Aussteifungslasten

Geschoss	Aussteifungselement	H_x [kN]	H_y [kN]
EG	1-AW	-1.56	0.00
	2-ZW	-0.03	0.00
	3-AW	1.59	0.00
	4.1-AW	0.00	5.75
	4.2-AW	0.00	3.08
	5.1-AW	0.00	4.95
	5.2-AW	0.00	2.65
OG	1-AW	-0.85	0.00
	2-ZW	-0.02	0.00
	3-AW	0.87	0.00
	4.1-AW	0.00	3.64
	4.2-AW	0.00	1.95
	5.1-AW	0.00	3.20
	5.2-AW	0.00	1.71

Auflagerkräfte

Die Reaktionskräfte greifen im Schubmittelpunkt der Teilquerschnitte an.
Positive (Auflager-)Reaktionen zeigen in negative Koordinatenrichtung.



Einwirkung
Qk.W.000(z)

Geschoss	Aussteifungselement	$F_{v,k}$ [kN]	$A_{V,k}$ [kN]	$B_{V,k}$ [kN]
EG	1-AW	12.02	-8.11	8.11
	2-ZW	12.21	-14.12	14.12

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	3-AW	12.40	-8.36	8.36
	4.1-AW	0.05	-0.08	0.08
	4.2-AW	0.03	-0.07	0.07
	5.1-AW	-0.05	0.08	-0.08
	5.2-AW	-0.03	0.07	-0.07
OG	1-AW	4.87	-2.34	2.34
	2-ZW	4.95	-4.07	4.07
	3-AW	5.02	-2.41	2.41
	4.1-AW	0.02	-0.02	0.02
	4.2-AW	0.01	-0.02	0.02
	5.1-AW	-0.02	0.02	-0.02
	5.2-AW	-0.01	0.02	-0.02

Einwirkung Qk.W.000(n)

Geschoss	Aussteifungselement	$F_{v,k}$ [kN]	$A_{v,k}$ [kN]	$B_{v,k}$ [kN]
EG	1-AW	9.90	-6.68	6.68
	2-ZW	8.43	-9.74	9.74
	3-AW	6.86	-4.63	4.63
	4.1-AW	-0.39	0.61	-0.61
	4.2-AW	-0.21	0.56	-0.56
	5.1-AW	0.39	-0.61	0.61
	5.2-AW	0.21	-0.56	0.56
OG	1-AW	4.01	-1.92	1.92
	2-ZW	3.41	-2.81	2.81
	3-AW	2.78	-1.33	1.33
	4.1-AW	-0.16	0.18	-0.18
	4.2-AW	-0.08	0.16	-0.16
	5.1-AW	0.16	-0.18	0.18
	5.2-AW	0.08	-0.16	0.16

Einwirkung Qk.W.000(p)

Geschoss	Aussteifungselement	$F_{v,k}$ [kN]	$A_{v,k}$ [kN]	$B_{v,k}$ [kN]
EG	1-AW	6.63	-4.47	4.47
	2-ZW	8.37	-9.67	9.67
	3-AW	10.19	-6.87	6.87
	4.1-AW	0.45	-0.72	0.72
	4.2-AW	0.24	-0.65	0.65
	5.1-AW	-0.45	0.72	-0.72
	5.2-AW	-0.24	0.65	-0.65
OG	1-AW	2.68	-1.29	1.29
	2-ZW	3.39	-2.79	2.79
	3-AW	4.13	-1.98	1.98
	4.1-AW	0.18	-0.21	0.21
	4.2-AW	0.10	-0.19	0.19
	5.1-AW	-0.18	0.21	-0.21
	5.2-AW	-0.10	0.19	-0.19

Einwirkung Qk.W.090(z)

Geschoss	Aussteifungselement	$F_{v,k}$ [kN]	$A_{v,k}$ [kN]	$B_{v,k}$ [kN]
EG	1-AW	-3.22	2.11	-2.11
	2-ZW	-0.06	0.07	-0.07
	3-AW	3.28	-2.15	2.15
	4.1-AW	12.17	-19.13	19.13
	4.2-AW	6.51	-17.40	17.40
	5.1-AW	10.52	-16.58	16.58
	5.2-AW	5.63	-15.08	15.08
OG	1-AW	-1.18	0.57	-0.57
	2-ZW	-0.02	0.02	-0.02
	3-AW	1.20	-0.58	0.58
	4.1-AW	4.76	-5.38	5.38
	4.2-AW	2.55	-4.90	4.90
	5.1-AW	4.16	-4.70	4.70

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

5.2-AW	2.23	-4.27	4.27

Einwirkung Qk.W.090(n)

Geschoss	Aussteifungselement	$F_{v,k}$ [kN]	$A_{v,k}$ [kN]	$B_{v,k}$ [kN]
EG	1-AW	-4.04	2.67	-2.67
	2-ZW	-0.07	0.08	-0.08
	3-AW	4.12	-2.71	2.71
	4.1-AW	9.81	-15.38	15.38
	4.2-AW	5.25	-13.99	13.99
	5.1-AW	7.73	-12.16	12.16
	5.2-AW	4.14	-11.06	11.06
OG	1-AW	-1.51	0.73	-0.73
	2-ZW	-0.03	0.02	-0.02
	3-AW	1.54	-0.74	0.74
	4.1-AW	3.81	-4.30	4.30
	4.2-AW	2.04	-3.91	3.91
	5.1-AW	3.03	-3.42	3.42
	5.2-AW	1.62	-3.12	3.12

Einwirkung Qk.W.090(p)

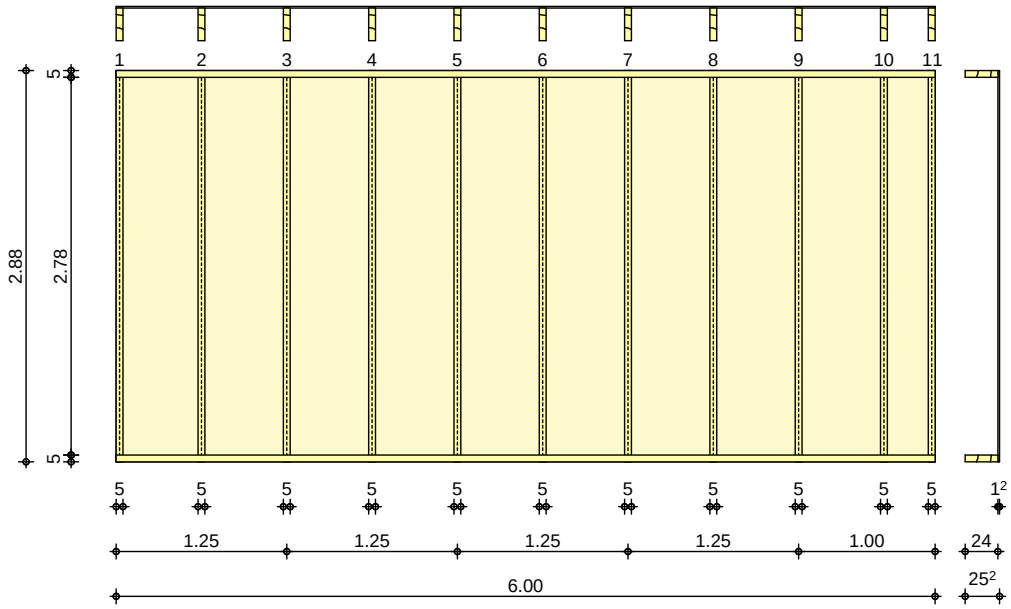
Geschoss	Aussteifungselement	$F_{v,k}$ [kN]	$A_{v,k}$ [kN]	$B_{v,k}$ [kN]
EG	1-AW	-2.41	1.57	-1.57
	2-ZW	-0.04	0.05	-0.05
	3-AW	2.46	-1.60	1.60
	4.1-AW	9.39	-14.71	14.71
	4.2-AW	5.03	-13.39	13.39
	5.1-AW	8.15	-12.82	12.82
	5.2-AW	4.36	-11.67	11.67
OG	1-AW	-0.85	0.41	-0.41
	2-ZW	-0.02	0.01	-0.01
	3-AW	0.87	-0.42	0.42
	4.1-AW	3.64	-4.11	4.11
	4.2-AW	1.95	-3.74	3.74
	5.1-AW	3.20	-3.61	3.61
	5.2-AW	1.71	-3.29	3.29

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. 1-AW.DG Wand 1-AW im Geschoss DG

System
M 1:55

Bemessung einer Holz-Wandscheibe, DIN EN 1995-1-1



Wandabmessungen

Wandlänge	l =	6.00	m
Wandhöhe	h_W =	2.88	m
Rippenabstand	a_R =	0.625	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Vertikale Rippen	5.00	24.00	1
Nadelholz C24			
Horizontale Rippen	5.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5			
einseitig	12.0	1.25	1

Verbindungsmittel

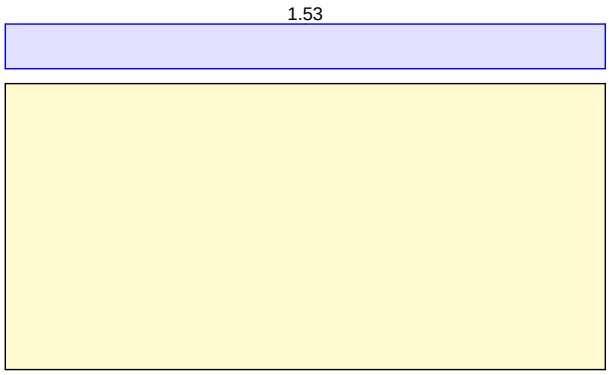
Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Haubold KG700			
einseitig	900	1.53x45	70
beharzte Länge l_H = 45 mm, dž = 30°			

Belastungen
Einwirkung Gk

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
Eigengewicht	0.58				
Gleichlast	0.95				

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

M 1:75



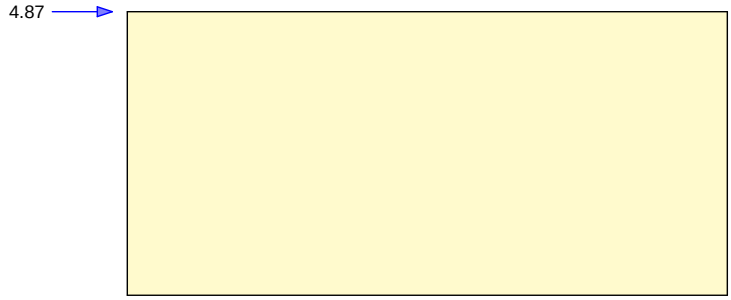
Einwirkung Qk.W.000

Lastart	q_z	F_v	a_x	F_z	q_y
[-]	[kN/m]	[kN]	[m]	[kN]	[kN/m²]
hor. Einzellast		4.87			

Zusammenstellungen

aus Pos. 'HAS - 1-AW.OG' (Seite 192)

M 1:75



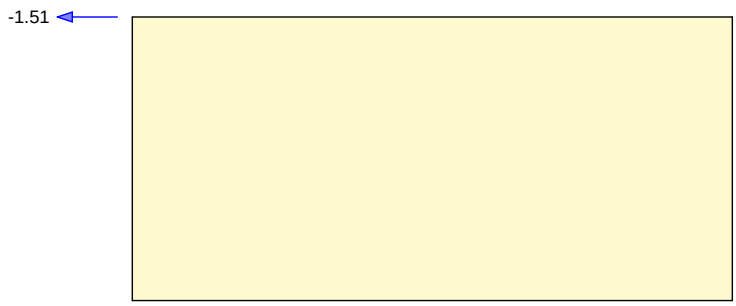
Einwirkung Qk.W.090

Lastart	q_z	F_v	a_x	F_z	q_y
[-]	[kN/m]	[kN]	[m]	[kN]	[kN/m²]
hor. Einzellast		-1.51			

Zusammenstellungen

aus Pos. 'HAS - 1-AW.OG' (Seite 192)

M 1:75



Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	2	ku/sk	1.35*Gk	+1.50*Qk.W.000
	3	ku/sk	1.35*Gk	+1.50*Qk.W.090
Lagesicherheit	11	ku/sk	0.90*Gk	+1.50*Qk.W.000
	12	ku/sk	0.90*Gk	+1.50*Qk.W.090

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

st: ständig
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Rippen

	Material [-]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$E_{0,mean}$ [N/mm²]
vertikal	NH C24	24.0	21.0	2.5	14.5	11000
horizontal	NH C24	24.0	21.0	2.5	14.5	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	7.0	12.7	960

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.53x45	0.69	70

eff. Steifigkeit

im GZ Gebrauchstauglichkeit EI_{ef} = 29404 kNm²
im GZ Tragfähigkeit EI_{ef} = 16766 kNm²

****** WARNUNG **** Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG **** Breite Rippe 5 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG **** Breite Rippe 7 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG **** Breite Rippe 9 b_{VR}=50 mm < erf.Breite=54 mm**

****** WARNUNG **** Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG **** Breite Rippe 5 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG **** Breite Rippe 7 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG **** Breite Rippe 9 b_{VR}=50 mm < erf.Breite=54 mm**

Nachweise (GZT) nach DIN EN 1995-1-1

Imperfektionen der Wand werden nicht berücksichtigt.
Die erforderlichen Randbedingungen nach 9.2.4.2 (NA.18) wurden überprüft.

Scheibenbeanspr.
Abs. 9.2.3

Ri. nr.	EK [-]	k_{mod} [-]	$F_{v,d}$ [kN]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	G [-]
1	2	0.97	7.30	1.22	7.49	0.16
2[1]	2	0.97	7.30	1.22	7.49	0.16
11	2	0.97	7.30	1.22	7.49	0.16

Schwellenpressung
Abs. 6.1.5

Ri. nr.	EK [-]	k_{mod} [-]	$F_{Ri,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ * [N/mm²]	G [-]
1	3	1.00	1.73	192.0	1.25	2.31	0.03
2[1]	1	0.60	1.29	264.0	1.25	1.38	0.03
11	2	1.00	3.89	192.0	1.25	2.31	0.07

*: gem. NCI Zu 9.2.4.2 (NA.21) mit Erhöhung um 20%

Normalspannung
Abs. 6.3.2

Ri. nr.	EK [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c * [-]	$f_{0,d}$ [N/mm²]	G [-]
1	3	1.00	1.73	0.14	0.08	16.15	0.11
2[1]	1	0.60	1.29	0.11	0.08	9.69	0.13
11	2	1.00	3.89	0.32	0.08	16.15	0.24

*: Knicken in Scheibenebene nach DIN EN 1995-1-1/NA, NCI Zu 6.3.1 (NA.5)

[1] maximal beanspruchte Innenrippe

Verformungen
NCI Zu 9.2.4.2

EK [-]	$F_{v,d}$ [kN]	K_{ges} [kN/m]	u_d [mm]	u_{zul} [mm]	G [-]
2	7.30	2106	3.5	28.8	0.12

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Lagesicherheit
DIN EN 1990, 6.4.2
NDP zu A1.3.1(3)

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{z,d}$ [kN]
1	11	4.13	0.00	-3.50	0.62
11	12	4.13	0.00	-1.09	3.04

Keine Zugkräfte vorhanden.

Nachweise (GZG) nach DIN EN 1995-1-1

Verformungen

EK [-]	$F_{v,k}$ [kN]	u_k [mm]	u_{zul} [mm]	G [-]
2	4.87	1.3	19.2	0.07

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.16
Schwellenpressung	OK	0.07
Normalspannung	OK	0.24
Verformungen	OK	0.12

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

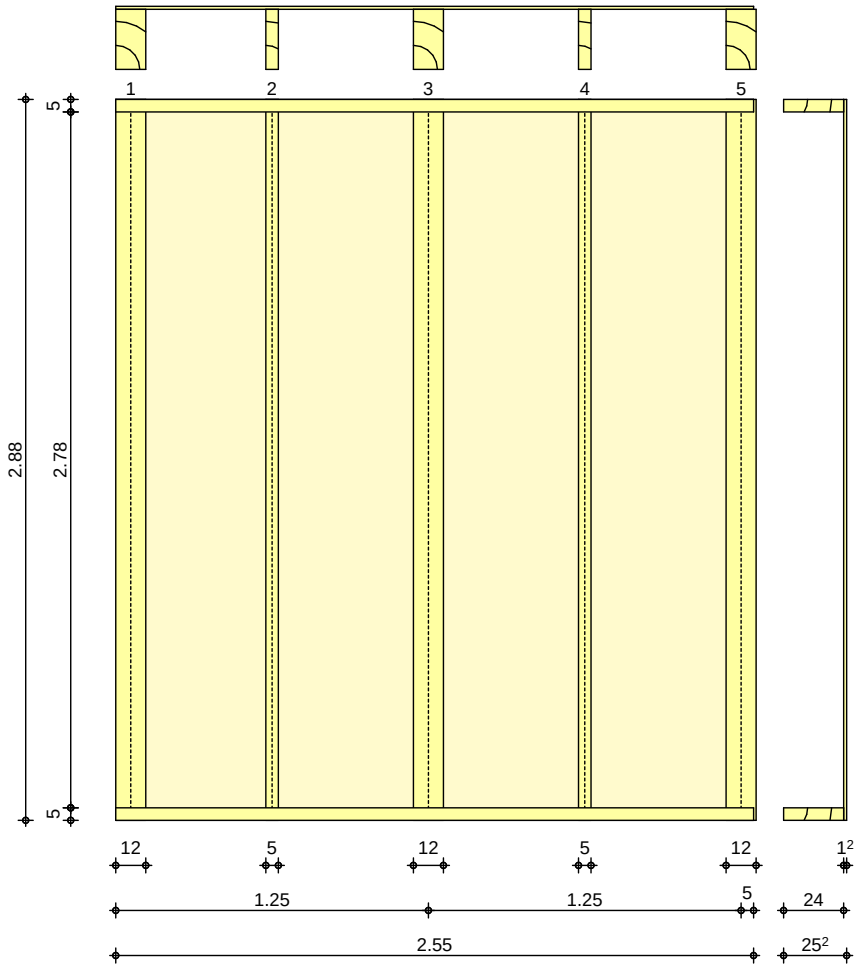
Nachweis		G [-]
Verformungen	OK	0.07

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. 4.1-AW.DG Wand 4.1-AW im Geschoss DG

System
M 1:30

Bemessung einer Holz-Wandscheibe, DIN EN 1995-1-1



Wandabmessungen

Wandlänge	l	=	2.55	m
Wandhöhe	h_W	=	2.88	m
Rippenabstand	a_R	=	0.625	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Vertikale Rippe 1	12.00	24.00	1
Vertikale Rippe 2	5.00	24.00	1
Vertikale Rippe 3	12.00	24.00	1
Vertikale Rippe 4	5.00	24.00	1
Vertikale Rippe 5	12.00	24.00	1
Nadelholz C24			
Horizontale Rippen	5.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5			
einseitig	12.0	1.25	1

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Verbindungsmittel

Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Haubold KG700			
einseitig	900	1.53x45	70

beharzte Länge l_H = 45 mm, dž = 30°

Belastungen

Einwirkung Gk

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
Gleichlast	2.50				
vert. Einzellast			1.25	7.89	

Einwirkung Qk.W.000

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
hor. Einzellast		0.18			

Zusammenstellungen

aus Pos. 'HAS - 4.1-AW.OG' (Seite 192)

Einwirkung Qk.W.090

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
hor. Einzellast		4.76			

Zusammenstellungen

aus Pos. 'HAS - 4.1-AW.OG' (Seite 192)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ä*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	ku/sk	1.35*Gk	+1.50*Qk.W.090
	6	ku/sk	1.00*Gk	+1.50*Qk.W.090
Lagesicherheit	10	st	0.90*Gk	
	12	ku/sk	0.90*Gk	+1.50*Qk.W.090

st: ständig
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Rippen

	Material [-]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$E_{0,mean}$ [N/mm²]
vertikal	NH C24	24.0	21.0	2.5	14.5	11000
horizontal	NH C24	24.0	21.0	2.5	14.5	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	7.0	12.7	960

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.53x45	0.69	70

eff. Steifigkeit

im GZ Gebrauchstauglichkeit EI_{ef} = 11187 kNm²
im GZ Tragfähigkeit EI_{ef} = 6132 kNm²

Nachweise (GZT)

nach DIN EN 1995-1-1

Imperfektionen der Wand werden nicht berücksichtigt.
Die erforderlichen Randbedingungen nach 9.2.4.2 (NA.18) wurden überprüft.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Scheibenbeanspr.
Abs. 9.2.3

Ri. nr.	EK [-]	k_{mod} [-]	$F_{v,d}$ [kN]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	G [-]
1	3	0.97	7.15	2.80	7.49	0.37
2[1]	3	0.97	7.15	2.80	7.49	0.37
5	3	0.97	7.15	2.80	7.49	0.37

Schwellenpressung
Abs. 6.1.5

Ri. nr.	EK [-]	k_{mod} [-]	$F_{Ri,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ * [N/mm²]	G [-]
1	1	0.60	1.05	360.0	1.25	1.38	0.02
3[1]	1	0.60	12.77	432.0	1.25	1.38	0.17
5	3	1.00	9.13	360.0	1.25	2.31	0.09

*: gem. NCI Zu 9.2.4.2 (NA.21) mit Erhöhung um 20%

Normalspannung
Abs. 6.3.2

Ri. nr.	EK [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c * [-]	$f_{0,d}$ [N/mm²]	G [-]
1	3	1.00	-7.02	-0.24	-	11.15	0.02
2[1]	1	0.60	2.11	0.18	0.08	9.69	0.22
5	3	1.00	9.13	0.32	0.42	16.15	0.05

*: Knicken in Scheibenebene nach DIN EN 1995-1-1/NA, NCI Zu 6.3.1 (NA.5)

[1] maximal beanspruchte Innenrippe

Verformungen
NCI Zu 9.2.4.2

EK [-]	$F_{v,d}$ [kN]	K_{ges} [kN/m]	u_d [mm]	u_{zul} [mm]	G [-]
3	7.15	770	9.3	28.8	0.32

Lagesicherheit
DIN EN 1990, 6.4.2
NDP zu A1.3.1(3)

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{z,d}$ [kN]
1	12	6.49	-0.01	-8.07	-1.58!
5	10	6.35	-0.01	-*	6.35

*: Es sind keine destabilisierenden Kräfte vorhanden.

! Zugverankerung erforderlich. Zu verankernde Kraft $F_{anch,d}$.

Zugverankerung

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{anch,d}$ [kN]
1	6	7.21	-0.01	-8.07	-0.86

Nachweise (GZG) nach DIN EN 1995-1-1

Verformungen

EK [-]	$F_{v,k}$ [kN]	u_k [mm]	u_{zul} [mm]	G [-]
3	4.76	3.4	19.2	0.18

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.37
Schwellenpressung	OK	0.17
Normalspannung	OK	0.22
Verformungen	OK	0.32

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

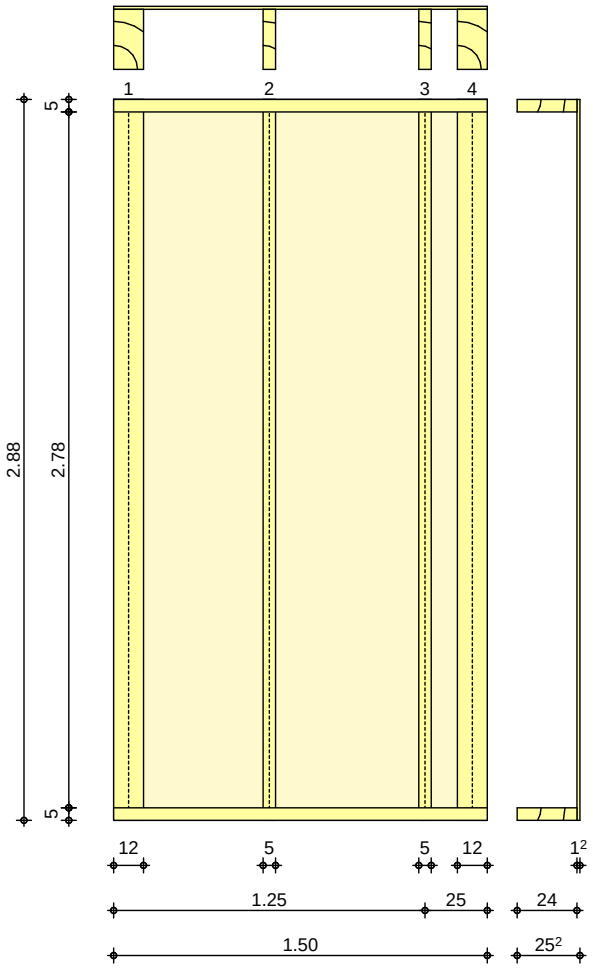
Nachweis		G [-]
Verformungen	OK	0.18

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. 5.2-AW.DG Wand 5.2-AW im Geschoss DG

System
M 1:30

Bemessung einer Holz-Wandscheibe, DIN EN 1995-1-1



Wandabmessungen

Wandlänge	l =	1.50	m
Wandhöhe	h_W =	2.88	m
Rippenabstand	a_R =	0.625	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Vertikale Randrippen	12.00	24.00	1
Nadelholz C24			
Vertikale Innenrippen	5.00	24.00	1
Nadelholz C24			
Horizontale Rippen	5.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5			
einseitig	12.0	1.25	1

Verbindungsmittel

Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_V [mm]
Klammer Haubold KG700			
einseitig	900	1.53x45	70
beharzte Länge l_H = 45 mm, dž = 30°			

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Belastungen

Einwirkung Gk

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
Gleichlast	2.50				

Einwirkung Qk.W.000

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
hor. Einzellast		-0.10			

Zusammenstellungen

aus Pos. 'HAS - 5.2-AW.OG' (Seite 192)

Einwirkung Qk.W.090

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
hor. Einzellast		2.23			

Zusammenstellungen

aus Pos. 'HAS - 5.2-AW.OG' (Seite 192)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	ku/sk	1.35*Gk	+1.50*Qk.W.090
	6	ku/sk	1.00*Gk	+1.50*Qk.W.090
Lagesicherheit	11	ku/sk	0.90*Gk	+1.50*Qk.W.000
	12	ku/sk	0.90*Gk	+1.50*Qk.W.090

st: ständig
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Rippen

	Material [-]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$E_{0,mean}$ [N/mm²]
vertikal Rand	NH C24	24.0	21.0	2.5	14.5	11000
vertikal Innen	NH C24	24.0	21.0	2.5	14.5	11000
horizontal	NH C24	24.0	21.0	2.5	14.5	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	7.0	12.7	960

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.53x45	0.69	70

eff. Steifigkeit

im GZ Gebrauchstauglichkeit EI_{ef} = 5997 kNm²
im GZ Tragfähigkeit EI_{ef} = 3282 kNm²

****** WARNUNG ****** **Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**

****** WARNUNG ****** **Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**

Nachweise (GZT)

nach DIN EN 1995-1-1

Imperfektionen der Wand werden nicht berücksichtigt.
Die erforderlichen Randbedingungen nach 9.2.4.2 (NA.18) wurden überprüft.

Scheibenbeanspr.
Abs. 9.2.3

Ri. nr.	EK [-]	k_{mod} [-]	$F_{v,d}$ [kN]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	γ [-]
1	3	0.97	3.34	2.23	7.49	0.30

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

2[1]	3	0.97	3.34	2.23	7.49	0.30
4	3	0.97	3.34	2.23	7.49	0.30

Schwellenpressung
Abs. 6.1.5

Ri. nr.	EK [-]	k_{mod} [-]	$F_{Ri,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ * [N/mm²]	G [-]
1	1	0.60	1.05	360.0	1.25	1.38	0.02
2[1]	1	0.60	2.11	264.0	1.25	1.38	0.05
4	3	1.00	6.83	360.0	1.25	2.31	0.07

*: gem. NCI Zu 9.2.4.2 (NA.21) mit Erhöhung um 20%

Normalspannung
Abs. 6.3.2

Ri. nr.	EK [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c * [-]	$f_{0,d}$ [N/mm²]	G [-]
1	3	1.00	-5.36	-0.19	-	11.15	0.02
2[1]	1	0.60	2.11	0.18	0.08	9.69	0.22
4	3	1.00	6.83	0.24	0.42	16.15	0.03

*: Knicken in Scheibenebene nach DIN EN 1995-1-1/NA, NCI Zu 6.3.1 (NA.5)

[1] maximal beanspruchte Innenrippe

Verformungen
NCI Zu 9.2.4.2

EK [-]	$F_{v,d}$ [kN]	K_{ges} [kN/m]	u_d [mm]	u_{zul} [mm]	G [-]
3	3.34	412	8.1	28.8	0.28

Lagesicherheit
DIN EN 1990, 6.4.2
NDP zu A1.3.1(3)

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{z,d}$ [kN]
1	12	1.69	0.00	-6.41	-4.72!
4	11	1.69	0.00	-0.28	1.40

! Zugverankerung erforderlich. Zu verankernde Kraft $F_{anch,d}$.

Zugverankerung

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{anch,d}$ [kN]
1	6	1.88	0.00	-6.41	-4.54

Nachweise (GZG) nach DIN EN 1995-1-1

Verformungen

EK [-]	$F_{v,k}$ [kN]	u_k [mm]	u_{zul} [mm]	G [-]
3	2.23	3.0	19.2	0.15

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.30
Schwellenpressung	OK	0.07
Normalspannung	OK	0.22
Verformungen	OK	0.28

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

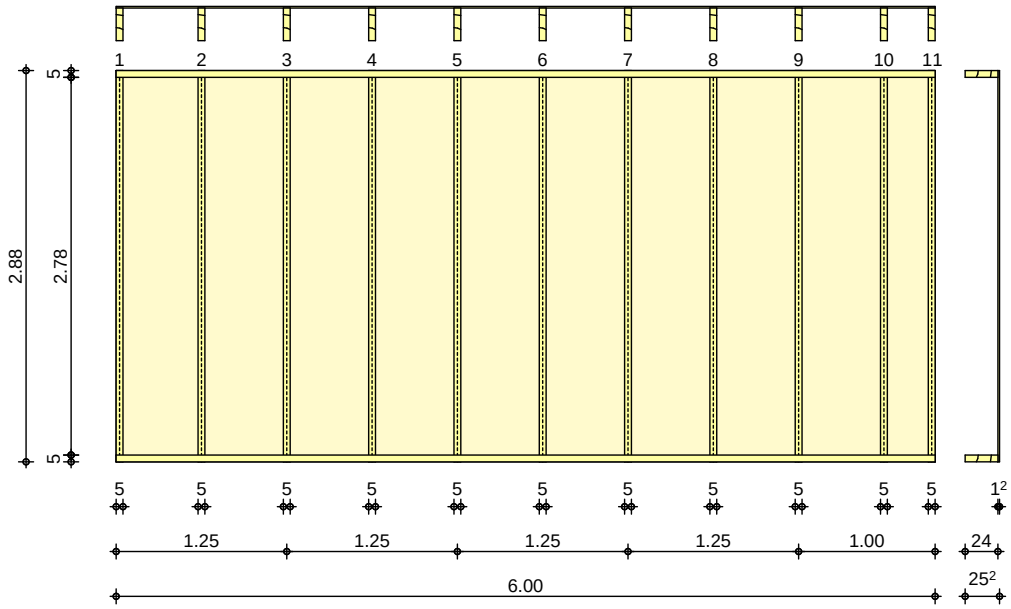
Nachweis		G [-]
Verformungen	OK	0.15

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. 1-AW.EG Wand 1-AW im Geschoss EG

System
M 1:55

Bemessung einer Holz-Wandscheibe, DIN EN 1995-1-1



Wandabmessungen

Wandlänge	l =	6.00	m
Wandhöhe	h_W =	2.88	m
Rippenabstand	a_R =	0.625	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Vertikale Rippen	5.00	24.00	1
Nadelholz C24			
Horizontale Rippen	5.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5			
einseitig	12.0	1.25	1

Verbindungsmittel

Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Haubold KG700			
einseitig	900	1.53x45	70
beharzte Länge l_H = 45 mm, dž = 30°			

Belastungen

Einwirkung Gk

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
Eigengewicht	0.58				
Gleichlast	1.05				
	2.50				
	2.50				

Einwirkung Qk.W.000

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
vert. Einzellast			0.00	-2.34	
			6.00	2.34	
hor. Einzellast		12.02			

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenstellungen

aus Pos. 'HAS - 1-AW.EG' (Seite 192)

Einwirkung Qk.W.090

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
vert. Einzellast			0.00	0.73	
			6.00	-0.73	
hor. Einzellast		-4.04			

Zusammenstellungen

aus Pos. 'HAS - 1-AW.EG' (Seite 192)

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ï (Ä*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	2	ku/sk	1.35*Gk	+1.50*Qk.W.000
	3	ku/sk	1.35*Gk	+1.50*Qk.W.090
	5	ku/sk	1.00*Gk	+1.50*Qk.W.000
Lagesicherheit	11	ku/sk	0.90*Gk	+1.50*Qk.W.000
	12	ku/sk	0.90*Gk	+1.50*Qk.W.090

st: ständig
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Rippen	Material [-]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$E_{0,mean}$ [N/mm²]
vertikal	NH C24	24.0	21.0	2.5	14.5	11000
horizontal	NH C24	24.0	21.0	2.5	14.5	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	7.0	12.7	960

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.53x45	0.69	70

eff. Steifigkeit

im GZ Gebrauchstauglichkeit EI_{ef} = 29404 kNm²
im GZ Tragfähigkeit EI_{ef} = 16766 kNm²

****** WARNUNG ****** **Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG ****** **Breite Rippe 5 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG ****** **Breite Rippe 7 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG ****** **Breite Rippe 9 b_{VR}=50 mm < erf.Breite=54 mm**

****** WARNUNG ****** **Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG ****** **Breite Rippe 5 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG ****** **Breite Rippe 7 b_{VR}=50 mm < erf.Breite=54 mm**
****** WARNUNG ****** **Breite Rippe 9 b_{VR}=50 mm < erf.Breite=54 mm**

Nachweise (GZT)

nach DIN EN 1995-1-1

Imperfektionen der Wand werden nicht berücksichtigt.
Die erforderlichen Randbedingungen nach 9.2.4.2 (NA.18) wurden überprüft.

Scheibenbeanspr.
Abs. 9.2.3

Ri. nr.	EK [-]	k_{mod} [-]	$F_{v,d}$ [kN]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	G [-]
1	2	0.97	18.03	3.01	7.49	0.40
2[1]	2	0.97	18.03	3.01	7.49	0.40

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

11	2	0.97	18.03		3.01	7.49	0.40

Schwellenpressung
Abs. 6.1.5

Ri. nr.	EK [-]	k_{mod} [-]	$F_{Ri,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ * [N/mm²]	G [-]
1	3	1.00	6.80	192.0	1.25	2.31	0.12
2[1]	1	0.60	5.60	264.0	1.25	1.38	0.12
11	2	1.00	13.84	192.0	1.25	2.31	0.25

*: gem. NCI Zu 9.2.4.2 (NA.21) mit Erhöhung um 20%

Normalspannung
Abs. 6.3.2

Ri. nr.	EK [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c * [-]	$f_{0,d}$ [N/mm²]	G [-]
1	3	1.00	6.80	0.57	0.08	16.15	0.43
2[1]	1	0.60	5.60	0.47	0.08	9.69	0.58
11	2	1.00	13.84	1.15	0.08	16.15	0.87

*: Knicken in Scheibenebene nach DIN EN 1995-1-1/NA, NCI Zu 6.3.1 (NA.5)

[1] maximal beanspruchte Innenrippe

Verformungen
NCI Zu 9.2.4.2

EK [-]	$F_{v,d}$ [kN]	K_{ges} [kN/m]	u_d [mm]	u_{zul} [mm]	G [-]
2	18.03	2106	8.6	28.8	0.30

Lagesicherheit
DIN EN 1990, 6.4.2
NDP zu A1.3.1(3)

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{z,d}$ [kN]
1	11	14.41	0.59	-8.65	5.75
11	12	16.82	-0.18	-2.91	13.91

Keine Zugkräfte vorhanden.

Nachweise (GZG) nach DIN EN 1995-1-1

Verformungen

EK [-]	$F_{v,k}$ [kN]	u_k [mm]	u_{zul} [mm]	G [-]
2	12.02	3.3	19.2	0.17

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.40
Schwellenpressung	OK	0.25
Normalspannung	OK	0.87
Verformungen	OK	0.30

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

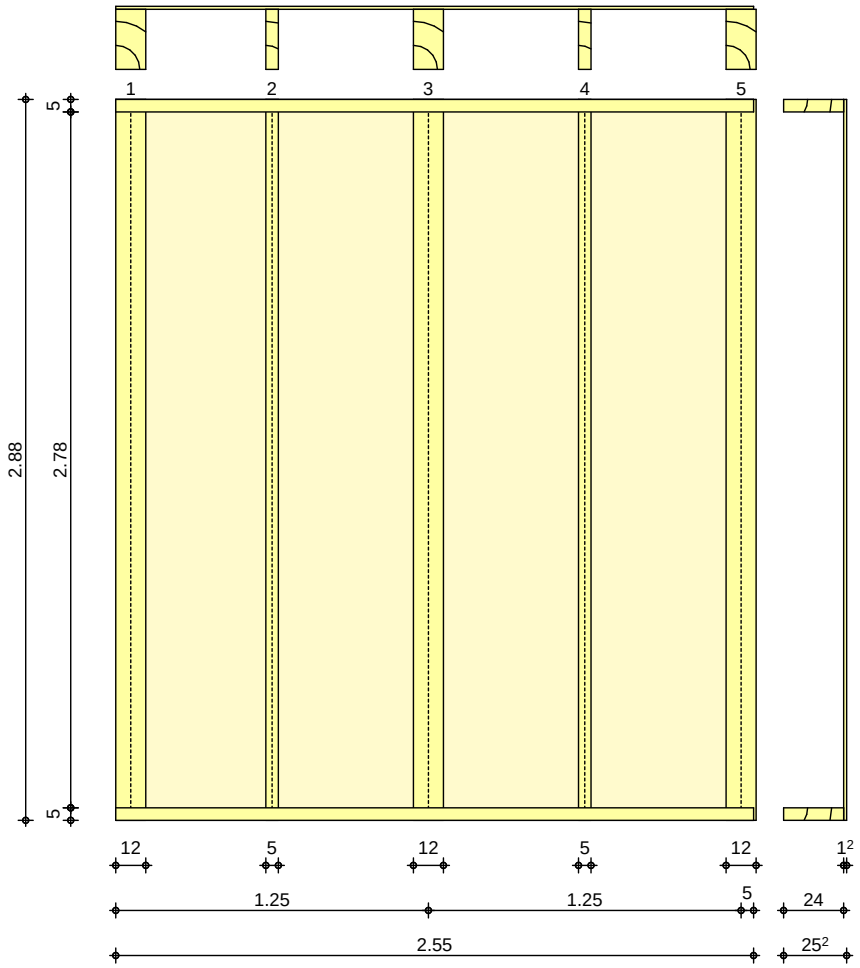
Nachweis		G [-]
Verformungen	OK	0.17

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. 4.1-AW.EG Wand 4.1-AW im Geschoss EG

System
M 1:30

Bemessung einer Holz-Wandscheibe, DIN EN 1995-1-1



Wandabmessungen

Wandlänge	l	=	2.55	m
Wandhöhe	h_W	=	2.88	m
Rippenabstand	a_R	=	0.625	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Vertikale Rippe 1	12.00	24.00	1
Vertikale Rippe 2	5.00	24.00	1
Vertikale Rippe 3	12.00	24.00	1
Vertikale Rippe 4	5.00	24.00	1
Vertikale Rippe 5	12.00	24.00	1
Nadelholz C24			
Horizontale Rippen	5.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5			
einseitig	12.0	1.25	1

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Verbindungsmittel

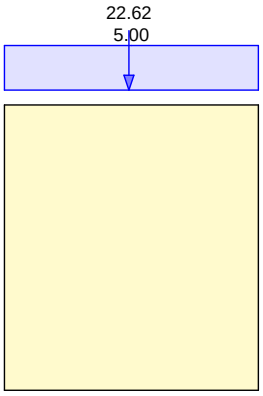
Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Haubold KG700			
einseitig	900	1.53x45	70
beharzte Länge l_H = 45 mm, dž = 30°			

Belastungen

Einwirkung Gk

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
Gleichlast	2.50				
	2.50				
vert. Einzellast			1.25	7.89	
			1.25	14.72	

M 1:75



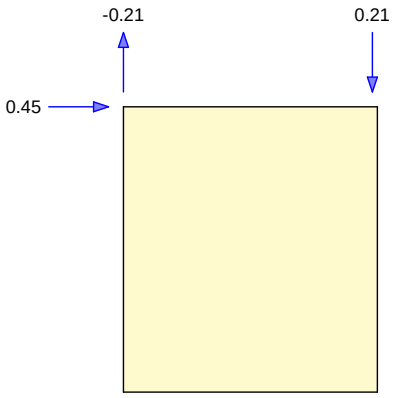
Einwirkung Qk.W.000

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
vert. Einzellast			0.00	-0.21	
			2.50	0.21	
hor. Einzellast		0.45			

Zusammenstellungen

aus Pos. 'HAS - 4.1-AW.EG' (Seite 192)

M 1:75



Einwirkung Qk.W.090

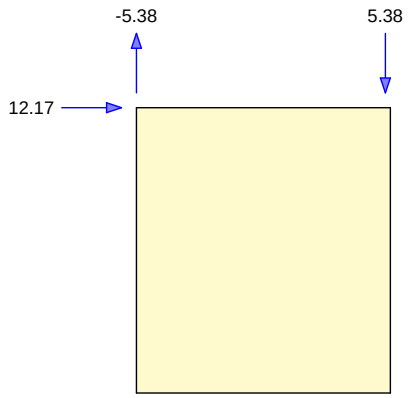
Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
vert. Einzellast			0.00	-5.38	
			2.50	5.38	
hor. Einzellast		12.17			

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenstellungen

aus Pos. 'HAS - 4.1-AW.EG' (Seite 192)

M 1:75



Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	ku/sk	1.35*Gk	+1.50*Qk.W.090
	6	ku/sk	1.00*Gk	+1.50*Qk.W.090
Lagesicherheit	10	st	0.90*Gk	
	12	ku/sk	0.90*Gk	+1.50*Qk.W.090

st: ständig
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Rippen	Material [-]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$E_{0,mean}$ [N/mm²]
vertikal	NH C24	24.0	21.0	2.5	14.5	11000
horizontal	NH C24	24.0	21.0	2.5	14.5	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	7.0	12.7	960

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.53x45	0.69	70

eff. Steifigkeit

im GZ Gebrauchstauglichkeit EI_{ef} = 11187 kNm²
im GZ Tragfähigkeit EI_{ef} = 6132 kNm²

Nachweise (GZT)

nach DIN EN 1995-1-1

Imperfektionen der Wand werden nicht berücksichtigt.
Die erforderlichen Randbedingungen nach 9.2.4.2 (NA.18) wurden überprüft.

Scheibenbeanspr.
Abs. 9.2.3

Ri. nr.	EK [-]	k_{mod} [-]	$F_{v,d}$ [kN]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	G [-]
1	3	0.97	18.26	7.16	7.49	0.96
2[1]	3	0.97	18.26	7.16	7.49	0.96
5	3	0.97	18.26	7.16	7.49	0.96

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Schwellenpressung
Abs. 6.1.5

Ri. nr.	EK [-]	k_{mod} [-]	$F_{Ri,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ * [N/mm²]	G [-]
1	1	0.60	2.11	360.0	1.25	1.38	0.03
3[1]	1	0.60	34.76	432.0	1.25	1.38	0.46
5	3	1.00	30.80	360.0	1.25	2.31	0.30

*: gem. NCI Zu 9.2.4.2 (NA.21) mit Erhöhung um 20%

Normalspannung
Abs. 6.3.2

Ri. nr.	EK [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c * [-]	$f_{0,d}$ [N/mm²]	G [-]
1	3	1.00	-26.58	-0.92	-	11.15	0.08
2[1]	1	0.60	4.22	0.35	0.08	9.69	0.44
5	3	1.00	30.80	1.07	0.42	16.15	0.16

*: Knicken in Scheibenebene nach DIN EN 1995-1-1/NA, NCI Zu 6.3.1 (NA.5)

[1] maximal beanspruchte Innenrippe

Verformungen
NCI Zu 9.2.4.2

EK [-]	$F_{v,d}$ [kN]	K_{ges} [kN/m]	u_d [mm]	u_{zul} [mm]	G [-]
3	18.26	770	23.7	28.8	0.82

Lagesicherheit
DIN EN 1990, 6.4.2
NDP zu A1.3.1(3)

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{z,d}$ [kN]
1	12	8.20	0.62	-20.62	-12.42!
5	10	15.72	-0.02	-*	15.72

*: Es sind keine destabilisierenden Kräfte vorhanden.

! Zugverankerung erforderlich. Zu verankernde Kraft $F_{anch,d}$.

Zugverankerung

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{anch,d}$ [kN]
1	6	9.99	0.55	-20.62	-10.63

Nachweise (GZG) nach DIN EN 1995-1-1

Verformungen

EK [-]	$F_{v,k}$ [kN]	u_k [mm]	u_{zul} [mm]	G [-]
3	12.17	8.7	19.2	0.45

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.96
Schwellenpressung	OK	0.46
Normalspannung	OK	0.44
Verformungen	OK	0.82

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

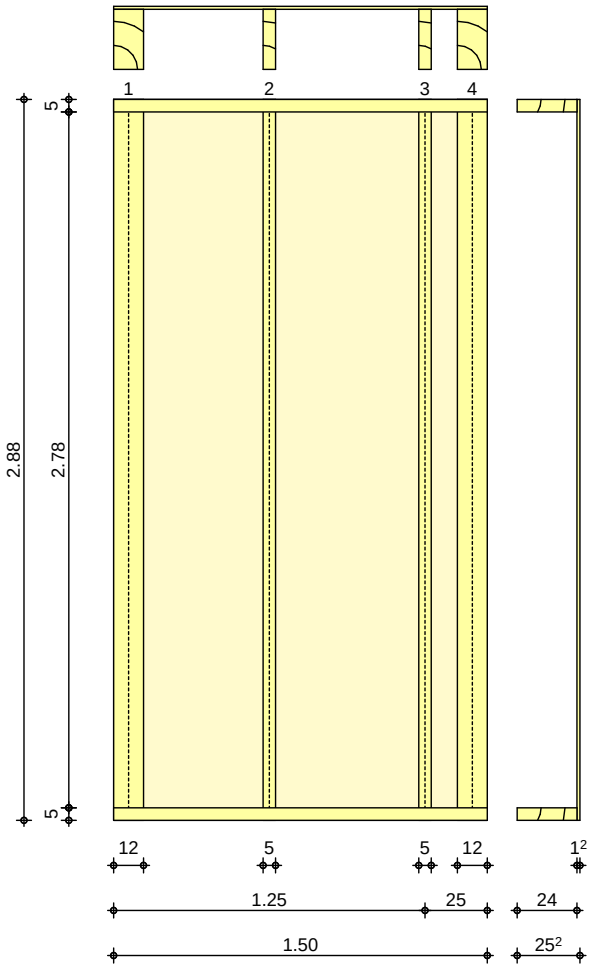
Nachweis		G [-]
Verformungen	OK	0.45

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. 5.2-AW.EG Wand 5.2-AW im Geschoss EG

System
M 1:30

Bemessung einer Holz-Wandscheibe, DIN EN 1995-1-1



Wandabmessungen

Wandlänge	l =	1.50	m
Wandhöhe	h_W =	2.88	m
Rippenabstand	a_R =	0.625	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24 Vertikale Randrippen	12.00	24.00	1
Nadelholz C24 Vertikale Innenrippen	5.00	24.00	1
Nadelholz C24 Horizontale Rippen	5.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5 einseitig	12.0	1.25	1

Verbindungsmittel

Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Haubold KG700 einseitig	900	1.53x45	70

beharzte Länge l_H = 45 mm, dž = 30°

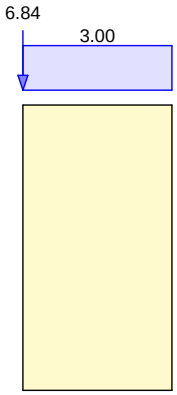
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Belastungen

Einwirkung Gk

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
Gleichlast	3.00				
vert. Einzellast			0.00	6.84	

M 1:75



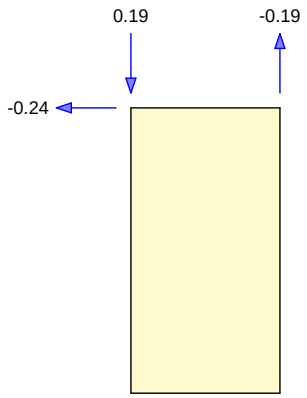
Einwirkung Qk.W.000

Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
vert. Einzellast			0.00	0.19	
			1.50	-0.19	
hor. Einzellast		-0.24			

Zusammenstellungen

aus Pos. 'HAS - 5.2-AW.EG' (Seite 192)

M 1:75



Einwirkung Qk.W.090

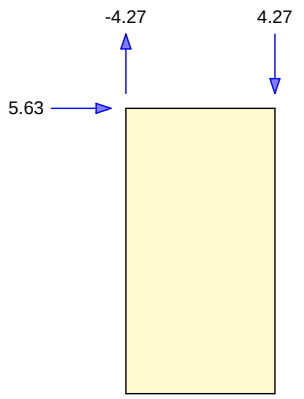
Lastart [-]	q_z [kN/m]	F_v [kN]	a_x [m]	F_z [kN]	q_y [kN/m²]
vert. Einzellast			0.00	-4.27	
			1.50	4.27	
hor. Einzellast		5.63			

Zusammenstellungen

aus Pos. 'HAS - 5.2-AW.EG' (Seite 192)

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

M 1:75



Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)	
ständig/vorüberg.	1	st	1.35*Gk	
	3	ku/sk	1.35*Gk	+1.50*Qk.W.090
	6	ku/sk	1.00*Gk	+1.50*Qk.W.090
Lagesicherheit	11	ku/sk	0.90*Gk	+1.50*Qk.W.000
	12	ku/sk	0.90*Gk	+1.50*Qk.W.090

st: ständig
ku/sk: kurz/sehr kurz

Mat./Querschnitt

Rippen	Material [-]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	$f_{c,90,k}$ [N/mm²]	$f_{t,0,k}$ [N/mm²]	$E_{0,mean}$ [N/mm²]
vertikal Rand	NH C24	24.0	21.0	2.5	14.5	11000
vertikal Innen	NH C24	24.0	21.0	2.5	14.5	11000
horizontal	NH C24	24.0	21.0	2.5	14.5	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	7.0	12.7	960

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.53x45	0.69	70

eff. Steifigkeit

im GZ Gebrauchstauglichkeit EI_{ef} = 5997 kNm²
im GZ Tragfähigkeit EI_{ef} = 3282 kNm²

****** WARNUNG ****** **Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**

****** WARNUNG ****** **Breite Rippe 3 b_{VR}=50 mm < erf.Breite=54 mm**

Nachweise (GZT)

nach DIN EN 1995-1-1

Imperfektionen der Wand werden nicht berücksichtigt.
Die erforderlichen Randbedingungen nach 9.2.4.2 (NA.18) wurden überprüft.

Scheibenbeanspr.
Abs. 9.2.3

Ri. nr.	EK [-]	k_{mod} [-]	$F_{v,d}$ [kN]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	G [-]
1	3	0.97	8.44	5.63	7.49	0.75
2[1]	3	0.97	8.44	5.63	7.49	0.75
4	3	0.97	8.44	5.63	7.49	0.75

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Schwellenpressung
Abs. 6.1.5

Ri. nr.	EK [-]	k_{mod} [-]	$F_{Ri,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ * [N/mm²]	G [-]
1	1	0.60	10.50	360.0	1.25	1.38	0.17
2[1]	3	1.00	5.77	264.0	1.25	2.31	0.08
4	3	1.00	23.13	360.0	1.25	2.31	0.22

*: gem. NCI Zu 9.2.4.2 (NA.21) mit Erhöhung um 20%

Normalspannung
Abs. 6.3.2

Ri. nr.	EK [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c * [-]	$f_{0,d}$ [N/mm²]	G [-]
1	1	0.60	10.50	0.36	0.42	9.69	0.09
2[1]	1	0.60	2.53	0.21	0.08	9.69	0.26
4	3	1.00	23.13	0.80	0.42	16.15	0.12

*: Knicken in Scheibenebene nach DIN EN 1995-1-1/NA, NCI Zu 6.3.1 (NA.5)

[1] maximal beanspruchte Innenrippe

Verformungen
NCI Zu 9.2.4.2

EK [-]	$F_{v,d}$ [kN]	K_{ges} [kN/m]	u_d [mm]	u_{zul} [mm]	G [-]
3	8.44	412	20.5	28.8	0.71

Lagesicherheit
DIN EN 1990, 6.4.2
NDP zu A1.3.1(3)

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{z,d}$ [kN]
1	12	1.77	0.49	-16.21	-14.44!
4	11	1.74	-0.49	-0.70	1.04

! Zugverankerung erforderlich. Zu verankernde Kraft $F_{anch,d}$.

Zugverankerung

Ri. nr.	EK [-]	$F_{stb,d}$ [kN]	e [m]	$F_{dst,d}$ [kN]	$F_{anch,d}$ [kN]
1	6	2.68	0.40	-16.21	-13.53

Nachweise (GZG) nach DIN EN 1995-1-1

Verformungen

EK [-]	$F_{v,k}$ [kN]	u_k [mm]	u_{zul} [mm]	G [-]
3	5.63	7.5	19.2	0.39

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.75
Schwellenpressung	OK	0.22
Normalspannung	OK	0.26
Verformungen	OK	0.71

Nachweise (GZG) Nachweise im Grenzzust. der Gebrauchstauglichkeit

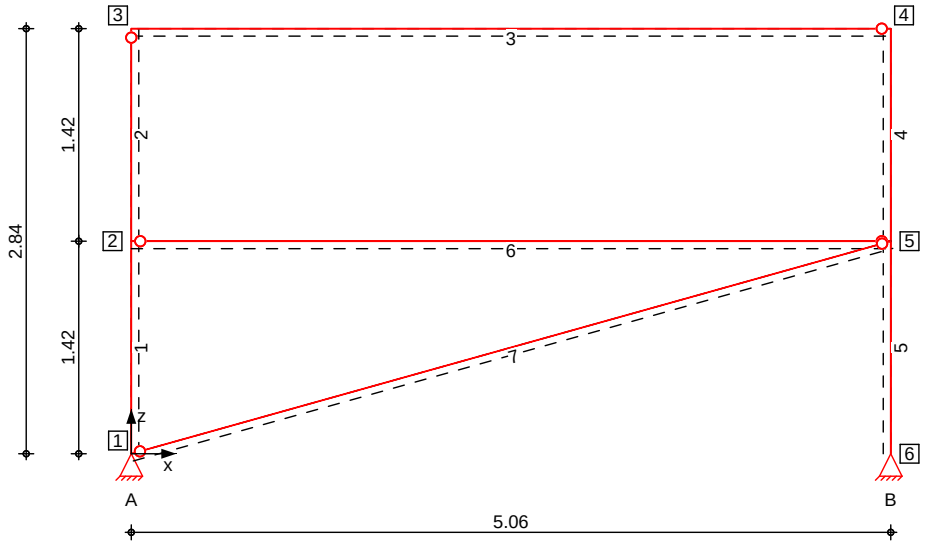
Nachweis		G [-]
Verformungen	OK	0.39

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. SWK1 Holz-Bemessung, ebenes Stabwerk

System Stabwerk

M 1:50



Knotendefinition

Knoten	x [m]	z [m]
1	0.00	0.00
2	0.00	1.42
3	0.00	2.84
4	5.06	2.84
5	5.06	1.42
6	5.06	0.00

Stabdefinition

Stab	von Kn.	bis Kn.	l [m]	Material	Querschnitt
1	1	2	1.42	BSH GL24c	b/h=16/28cm
2	2	3	1.42	BSH GL24c	b/h=16/28cm
3	3	4	5.06	BSH GL24c	b/h=16/28cm
4	4	5	1.42	BSH GL24c	b/h=16/28cm
5	5	6	1.42	BSH GL24c	b/h=16/28cm
6	2	5	5.06	BSH GL24c	b/h=16/28cm
7	1	5	5.26	BSH GL24c	b/h=4.5/5cm

Stabendgelenke

Stab	$N_{x,Anf}$	$V_{z,Anf}$	$M_{y,Anf}$	$N_{x,End}$	$V_{z,End}$	$M_{y,End}$
2, 3	fest	fest	fest	fest	fest	frei
6, 7	fest	fest	frei	fest	fest	frei

Nutzungsklasse

Stab	NKL
1-7	2

Auflagerdefinition global

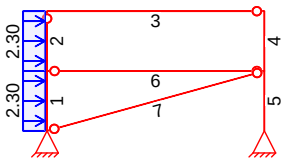
Lager	Kn.	$K_{T,x}$ [kN/m]	$K_{T,z}$ [kN/m]	$K_{R,y}$ [kNm/rad]
A	1	fest	fest	frei
B	6	fest	fest	frei

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Qk.W



Streckenlasten in x-Richtung — Streckenlasten am Stab

Einw. *Qk.W*

Stab	Kommentar	a [m]	s [m]	$q_{x,li}$ [kN/m]	$q_{x,re}$ [kN/m]
1	Wind	0.00	1.42		2.30
2	Wind	0.00	1.42		2.30

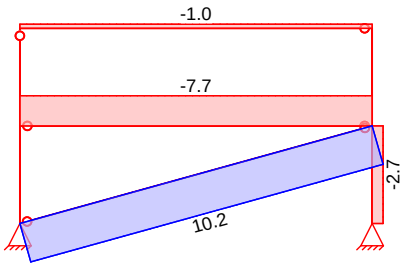
Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	ĭ (Ā*Ǵ*EW)
ständig/vorüberg.	1	1.50*Qk.W
selten, w_{inst}	2	1.00*Qk.W
selten, w_{fin}	3	1.00*Qk.W

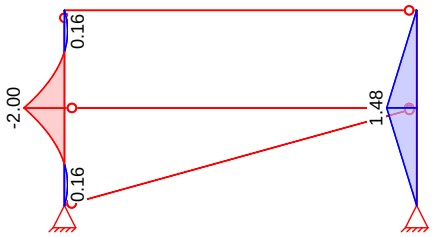
Bem.-schnittgrößen — Bemessungsschnittgrößen Theorie I. Ordnung

Grafik — Schnittgrößen (Umhüllende)

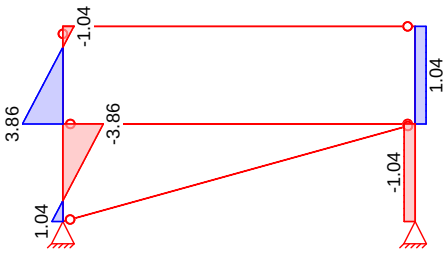
Normalkraft $N_{x,d}$[kN]



Moment $M_{y,d}$[kNm]



Querkraft $V_{z,d}$[kN]

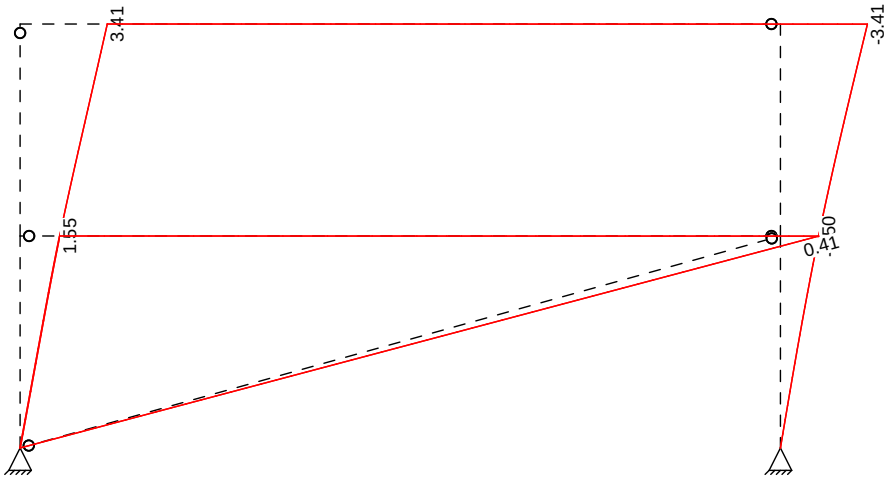


mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Bem.-verformungen — Bemessungsverformungen Theorie I. Ordnung

Grafik — Verformungen (Umhüllende)

Verschiebung $w_{z,d}$ [mm]



Auflagerkräfte — Charakteristische Auflagerkräfte (global)

Char. Auflagerkr.

Einw. *Qk.W*

Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]
A	7.23	-1.83
B	-0.70	1.83

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Biegung	OK	0.35
Querkraft	OK	0.07

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

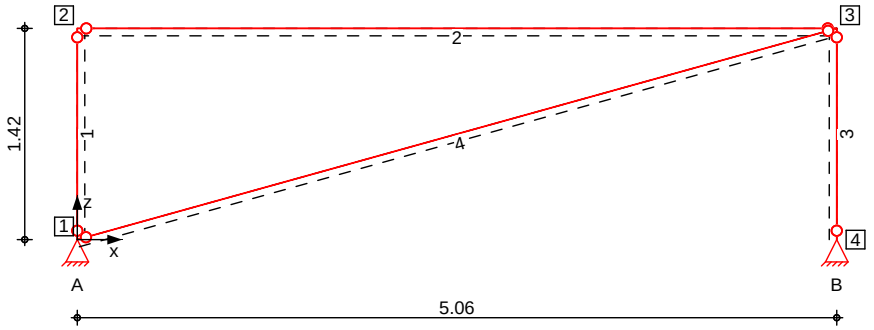
Nachweis		G [-]
elast. Durchbieg.	OK	0.72
Enddurchbiegung	OK	0.48

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. SK0 Stahlkreuz, Aussteifung

System Stabwerk

M 1:50



Knotendefinition

Knoten	x [m]	z [m]
1	0.00	0.00
2	0.00	1.42
3	5.06	1.42
4	5.06	0.00

Stabdefinition

Stab	von Kn.	bis Kn.	l [m]	Lage [°]	Achse	Material	Querschnitt
1	1	2	1.42	0.0	fest	S 235	HEA 100
2	2	3	5.06	0.0	fest	S 235	HEA 100
3	3	4	1.42	0.0	fest	S 235	HEA 100
4	1	3	5.26	0.0	fest	S 355	RD 12

Stabendgelenke

Stab	$N_{x,Anf}$	$V_{z,Anf}$	$M_{y,Anf}$	$N_{x,End}$	$V_{z,End}$	$M_{y,End}$
1-4	fest	fest	frei	fest	fest	frei

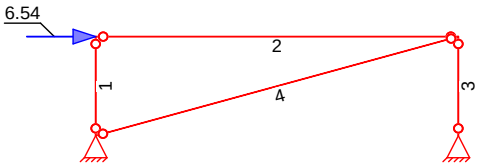
Auflagerdefinition global

Lager	Kn.	$K_{T,x}$ [kN/m]	$K_{T,z}$ [kN/m]	$K_{R,y}$ [kNm/rad]
A	1	fest	fest	frei
B	4	fest	fest	frei

Belastungen Belastungen auf das System

Grafik Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen Qk.W



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Punktlasten in x-/z-Richtung

Einzellasten am Knoten

	Knoten	Kommentar	F_x [kN]	F_z [kN]
Einw. *Qk.W*	2		6.54	

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	ĭ (Ā*Ǵ*EW)
ständig/vorüberg.	1	1.50*Qk.W
selten	2	1.00*Qk.W

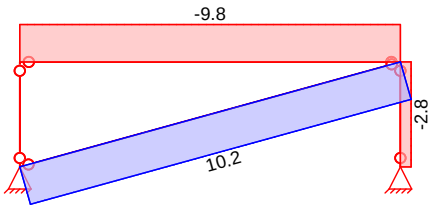
Bem.-schnittgrößen

Bemessungsschnittgrößen Theorie I. Ordnung

Grafik

Schnittgrößen (Umhüllende)

Normalkraft $N_{x,d}$[kN]



Tabelle

Schnittgrößen (Umhüllende)

	x [m]	$N_{x,d,min}$ [kN]	Ek	$N_{x,d,max}$ [kN]	Ek
Stab *1*	0.00	0.00	1	0.00	1
	1.42	0.00	1	0.00	1
Stab *2*	0.00	-9.81	1	-9.81	1
	5.06	-9.81	1	-9.81	1
Stab *3*	0.00	-2.75	1	-2.75	1
	1.42	-2.75	1	-2.75	1
Stab *4*	0.00	10.19	1	10.19	1
	5.26	10.19	1	10.19	1

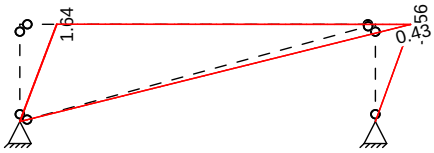
Bem.-verformungen

Bemessungsverformungen Theorie I. Ordnung

Grafik

Verformungen (Umhüllende)

Verschiebung $w_{z,d}$[mm]



Auflagerkräfte

Charakteristische Auflagerkräfte (global)

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]
Einw. *Qk.W*	A	6.54	-1.84

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

B	0.00	1.84

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Nachweis E-E	OK	0.25

Nachweise (GZG) — Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis		G [-]
Verformung	OK	0.35

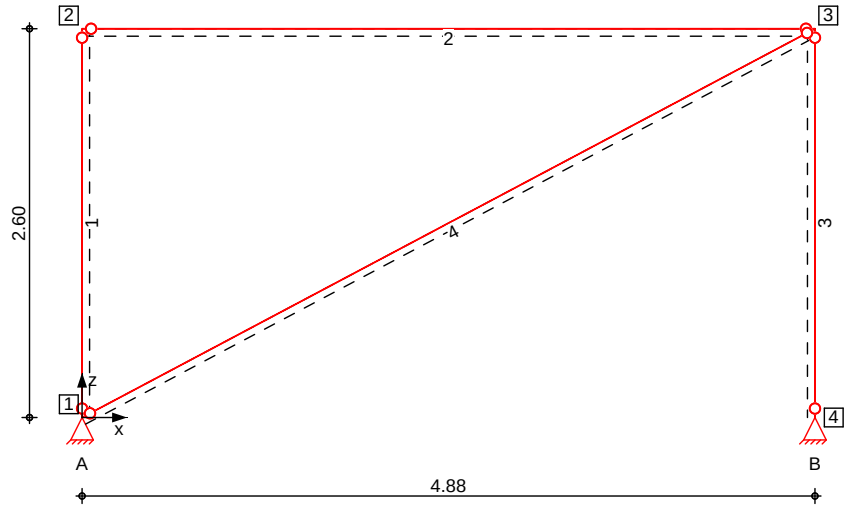
Es wird eine Spannbare Seilkonstruktion nach ETA-10/0358 mit einem Seildurchmesser von 12 mm gewählt.
Die zulässige Zugkraft beträgt nach Zulassung 85,95*1570*0,82*0,88*1/(1,5*1,1) = 59.014 N = 59 kN

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. SK1 Stahlkreuz, Aussteifung Dach

System Stabwerk

M 1:50



Knotendefinition

Knoten	x [m]	z [m]
1	0.00	0.00
2	0.00	2.60
3	4.88	2.60
4	4.88	0.00

Stabdefinition

Stab	von Kn.	bis Kn.	l [m]	Lage [°]	Achse	Material	Querschnitt
1	1	2	2.60	0.0	fest	S 235	HEA 100
2	2	3	4.88	0.0	fest	S 235	HEA 100
3	3	4	2.60	0.0	fest	S 235	HEA 100
4	1	3	5.53	0.0	fest	S 355	RD 8

Stabendgelenke

Stab	$N_{x,Anf}$	$V_{z,Anf}$	$M_{y,Anf}$	$N_{x,End}$	$V_{z,End}$	$M_{y,End}$
1-4	fest	fest	frei	fest	fest	frei

Auflagerdefinition global

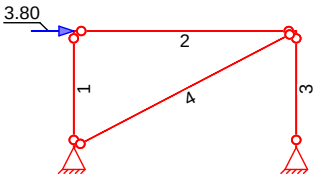
Lager	Kn.	$K_{T,x}$ [kN/m]	$K_{T,z}$ [kN/m]	$K_{R,y}$ [kNm/rad]
A	1	fest	fest	frei
B	4	fest	fest	frei

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Belastungen — Belastungen auf das System

Grafik — Belastungsgrafiken (einwirkungsbezogen)

Einwirkungen — Qk.W



Punktlasten in x-/z-Richtung — Einzellasten am Knoten

	Knoten	Kommentar	F_x [kN]	F_z [kN]
Einw. *Qk.W*	2		3.80	

Kombinationen — Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	ĭ (Ā*Ǵ*EW)
ständig/vorüberg.	1	1.50*Qk.W
selten	2	1.00*Qk.W

Bem.-schnittgrößen — Bemessungsschnittgrößen Theorie I. Ordnung

Tabelle — Schnittgrößen (Umhüllende)

	x [m]	$N_{x,d,min}$ [kN]	Ek	$N_{x,d,max}$ [kN]	Ek
Stab *1*	0.00	0.00	1	0.00	1
	2.60	0.00	1	0.00	1
Stab *2*	0.00	-5.70	1	-5.70	1
	4.88	-5.70	1	-5.70	1
Stab *3*	0.00	-3.04	1	-3.04	1
	2.60	-3.04	1	-3.04	1
Stab *4*	0.00	6.46	1	6.46	1
	5.53	6.46	1	6.46	1

Auflagerkräfte — Charakteristische Auflagerkräfte (global)

Char. Auflagerkr.

	Aufl.	$F_{x,k}$ [kN]	$F_{z,k}$ [kN]
Einw. *Qk.W*	A	3.80	-2.02
	B	0.00	2.02

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Nachweis E-E	OK	0.36

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Nachweise (GZG)

Nachweise im Grenzzust. der Gebrauchstauglichkeit

Nachweis		G [-]
Verformung	OK	0.30

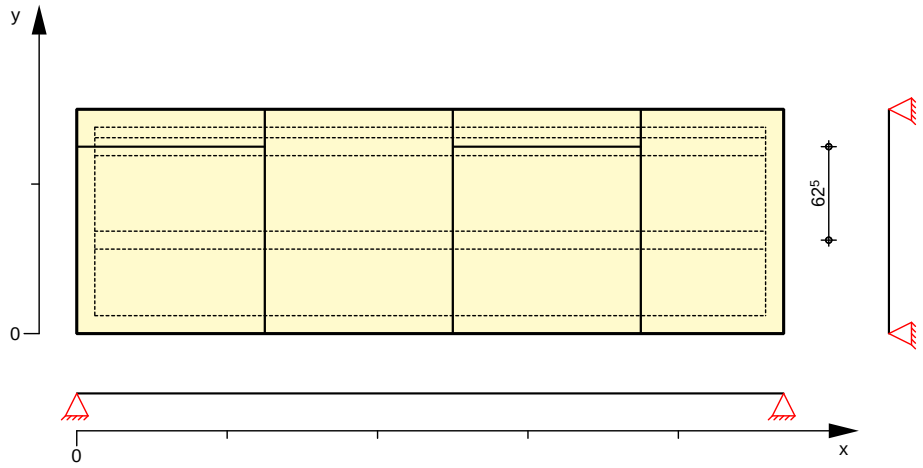
Es wird eine Spannbare Seilkonstruktion nach ETA-10/0358 mit einem Seildurchmesser von 8 mm gewählt.
Die zulässige Zugkraft beträgt nach Zulassung 29,7*0,9/1,5 = 17,8 kN

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. DE-T Deckenscheibe Traufe

System
M 1:50

Bemessung Holz-Deckenscheibe, DIN EN 1995-1-1



Deckenabmessungen

Deckenbreite	B	=	4.70	m
Deckenlänge	L	=	1.50	m
Rippenabstand	a_R	=	0.625	m
effektive Höhe in x-Richtung	$h_{ef,x}$	=	4.70	m
effektive Höhe in y-Richtung	$h_{ef,y}$	=	1.50	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Rippen/Gurte	12.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	l_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5f				
einseitig	25.0	1.25	2.50	1
f: Lamellenlage flachkant				

Die Plattenränder quer zu den Innenrippen sind frei.
Die Platten sind auf allen Rippen mit
Verbindungsmitteln im Abstand a_v anzuschließen.

Verbindungsmittel

Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Benutzerdef Standardklammer			
einseitig	800	1.80x65a	70.0

beharzte Länge l_H = 33 mm, dž = 30°

Einwirkungen

Einwirkungen nach DIN EN 1990:2010-12

Qk.W

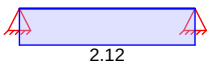
Windeinwirkung
Windlasten
Qk.W min/max Werte

Belastungen
Einwirkung Qk.W

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Gleich	y	2.12	2.12			

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

in y-Richtung



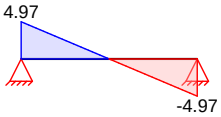
in x-Richtung

Char. Schnittgrößen

Einwirkung Qk.W

Ort [-]	V_k [kN]	M_k [kNm]	$F_{c,k}$ [kN]	$F_{t,k}$ [kN]
Randrippe li.	4.97		4.97	
Randrippe re.	-4.97		4.97	
Gurt oben		5.84	3.90	
Gurt unten		5.84		3.90
Beplankung	-4.97			

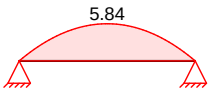
V_k [kN]



V_k [kN]

M_k [kNm]

M_k [kNm]



Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ	(Ā*Ǵ*EW)
ständig/vorüberg.	1	ku/sk	1.50	*Qk.W

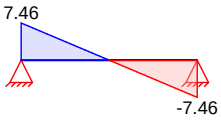
ku/sk: kurz/sehr kurz

Bem.-schnittgrößen

EK 1

Ort [-]	V_d [kN]	M_d [kNm]	$F_{c,d}$ [kN]	$F_{t,d}$ [kN]
Randrippe li.	7.46		7.46	
Randrippe re.	-7.46		7.46	
Gurt oben		8.76	5.84	
Gurt unten		8.76		5.84
Beplankung	-7.46			

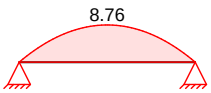
V_d [kN]



V_d [kN]

M_d [kNm]

M_d [kNm]



mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Mat./Querschnitt
Rippen

Material [-]	ρ_k [kg/m³]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	E_{0mean} [N/mm²]
NH C24	350	24.0	21.0	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	5.9	10.3	860

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.80x65a	0.87	70.0

Nachweise (GZT) nach DIN EN 1995-1-1

Scheibenbeanspr.
Abs. 9.2.3

EK [-]	k_{mod} [-]	Ri. [-]	V_d [kN]	h_{ef} [m]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	η [-]
1	0.99	x	0.00	4.70	0.00	6.22	0.00
		y	-7.46	1.50	4.97	6.22	0.80

Zwischenwerte Schubfestigkeit

EK [-]	VBM: $f_{v,0,d}$ [N/mm]	Platten: $f_{v,0,d}$ [N/mm]	Beulen: $f_{v,0,d}$ [N/mm]
1	**6.22**	24.09	33.73

Schwellenpressung
Abs. 6.1.5

EK [-]	k_{mod} [-]	$F_{c,90,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ [N/mm²]	η [-]
1	1.00	1.86	360	1.25	1.92	0.02

Normalspannung
Abs. 6.3.2

EK [-]	Ort [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c [-]	$f_{0,d}$ [N/mm²]	η [-]
1	Go	1.00	5.84	0.20	1.00	16.15	0.01
	Gu	1.00	5.84	0.20	1.00	16.15	0.01
	Rl	1.00	7.46	0.26	1.00	16.15	0.02
	Rr	1.00	7.46	0.26	1.00	16.15	0.02

Go/Gu = Gurt oben/unten, Rl/Rr = Randrippe links /rechts

Zusammenfassung Zusammenfassung der Nachweise

Nachweise (GZT) Nachweise im Grenzzustand der Tragfähigkeit

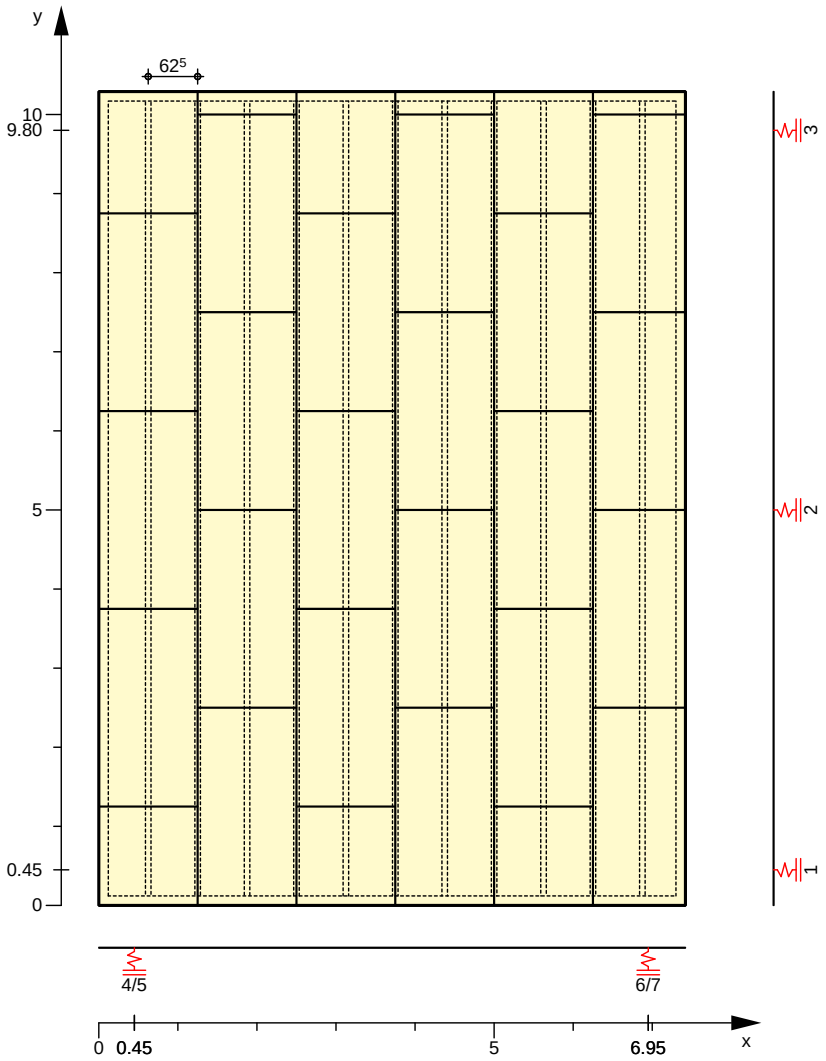
Nachweis		η [-]
Scheibenbeanspruchung	OK	0.80
Schwellenpressung	OK	0.02
Normalspannung	OK	0.02

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Pos. DA Dachscheibe

System
M 1:95

Bemessung Holz-Deckenscheibe, DIN EN 1995-1-1



Deckenabmessungen

Deckenbreite	B	=	7.42	m
Deckenlänge	L	=	10.29	m
Rippenabstand	a_R	=	0.625	m
effektive Höhe in x-Richtung	$h_{ef,x}$	=	5.15	m
effektive Höhe in y-Richtung	$h_{ef,y}$	=	10.29	m

Rippen

Material [-]	b [cm]	h [cm]	NKL [-]
Nadelholz C24			
Randrippen/Gurte	12.00	24.00	1
Nadelholz C24			
Innenrippen	7.00	24.00	1

Beplankung

Material [-]	t [mm]	b_T [m]	l_T [m]	NKL [-]
kunstharzgebundene Spanplatten P5^f				
einseitig	25.0	1.25	2.50	1

f: Lamellenlage flachkant

Die Plattenränder quer zu den Innenrippen sind frei.

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Die Platten sind auf allen Rippen mit Verbindungsmitteln im Abstand a_v anzuschließen.

Verbindungsmittel

Art [-]	$f_{u,k}$ [N/mm²]	dn x ln [mm]	a_v [mm]
Klammer Haubold HD7900			
einseitig	900	1.80x65	70.0
beharzte Länge l_H = 65 mm, dž = 30°			

Belastungen

Einwirkung Qk.W.000(z)

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Trapez	x	1.44	1.44	(5.14)	(14.84)	*
Auflager	x			0.45	-4.87	1-AW
	x			5.00	-4.95	2-ZW
	x			9.80	-5.02	3-AW
	y			0.45	-0.02	4.1-AW
	y			0.45	-0.01	4.2-AW
	y			6.95	0.02	5.1-AW
	y			6.95	0.01	5.2-AW

* Die Einzellast wurde in eine Streckenlast umgerechnet.

Einwirkung Qk.W.000(n)

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Trapez	x	1.44	0.54	(4.37)	(10.20)	*
Auflager	x			0.45	-4.01	1-AW
	x			5.00	-3.41	2-ZW
	x			9.80	-2.78	3-AW
	y			0.45	0.16	4.1-AW
	y			0.45	0.08	4.2-AW
	y			6.95	-0.16	5.1-AW
	y			6.95	-0.08	5.2-AW

* Die Einzellast wurde in eine Streckenlast umgerechnet.

Einwirkung Qk.W.000(p)

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Trapez	x	0.54	1.44	(5.92)	(10.20)	*
Auflager	x			0.45	-2.68	1-AW
	x			5.00	-3.39	2-ZW
	x			9.80	-4.13	3-AW
	y			0.45	-0.18	4.1-AW
	y			0.45	-0.10	4.2-AW
	y			6.95	0.18	5.1-AW
	y			6.95	0.10	5.2-AW

* Die Einzellast wurde in eine Streckenlast umgerechnet.

Einwirkung Qk.W.090(z)

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Trapez	y	3.40	0.29	(2.67)	(13.70)	*
Auflager	x			0.45	1.18	1-AW
	x			5.00	0.02	2-ZW
	x			9.80	-1.20	3-AW
	y			0.45	-4.76	4.1-AW
	y			0.45	-2.55	4.2-AW
	y			6.95	-4.16	5.1-AW
	y			6.95	-2.23	5.2-AW

* Die Einzellast wurde in eine Streckenlast umgerechnet.

Einwirkung Qk.W.090(n)

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Trapez	y	3.40	-0.57	(1.97)	(10.50)	*
Auflager	x			0.45	1.51	1-AW
	x			5.00	0.03	2-ZW

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

	x		9.80	-1.54	3-AW
	y		0.45	-3.81	4.1-AW
	y		0.45	-2.04	4.2-AW
	y		6.95	-3.03	5.1-AW
	y		6.95	-1.62	5.2-AW

* Die Einzellast wurde in eine Streckenlast umgerechnet.

Einwirkung
Qk.W.090(p)

Lastart [-]	Ri. [-]	q_1 [kN/m]	q_2 [kN/m]	a [m]	F_v [kN]	Komment. [-]
Trapez	y	2.54	0.29	(2.73)	(10.50)	*
Auflager	x			0.45	0.85	1-AW
	x			5.00	0.02	2-ZW
	x			9.80	-0.87	3-AW
	y			0.45	-3.64	4.1-AW
	y			0.45	-1.95	4.2-AW
	y			6.95	-3.20	5.1-AW
	y			6.95	-1.71	5.2-AW

* Die Einzellast wurde in eine Streckenlast umgerechnet.

Kombinationen

Kombinationsbildung nach DIN EN 1990
Darstellung der maßgebenden Kombinationen

	Ek	KLED	ĭ (Ā*Ǵ*EW)
ständig/vorüberg.	1	ku/sk	1.50*Qk.W.000 (z)

z: zentrischer Lastangriff
ku/sk: kurz/sehr kurz

Mat./Querschnitt
Rippen

Material [-]	ρ_k [kg/m³]	$f_{my,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	E_{0mean} [N/mm²]
Rand/Gurte NH C24	350	24.0	21.0	11000
Innen NH C24	350	24.0	21.0	11000

Beplankung

Material [-]	$f_{v,k}$ [N/mm²]	$f_{c,0,k}$ [N/mm²]	G_{mean} [N/mm²]
Span P5	5.9	10.3	860

Verbindungsmittel

Typ [-]	$F_{v,Rk}$ [kN]	a_v [mm]
Klammer 1.80x65	0.90	70.0

Nachweise (GZT) nach DIN EN 1995-1-1

Scheibenbeanspr.
Abs. 9.2.3

EK [-]	k_{mod} [-]	Ri. [-]	V_d [kN]	h_{ef} [m]	$s_{v,0,d}$ [N/mm]	$f_{v,0,d}$ [N/mm]	η [-]
1	0.99	x	6.47	5.15	1.26	6.45	0.20
		y	0.05	10.29	0.00	6.45	0.00

Schwellenpressung
Abs. 6.1.5

EK [-]	k_{mod} [-]	$F_{c,90,d}$ [kN]	A_{ef} [cm²]	$k_{c,90}$ [-]	$f_{c,90,d}$ [N/mm²]	η [-]
1	1.00	1.85	360	1.25	1.92	0.02

Normalspannung
Abs. 6.3.2

EK [-]	Ort [-]	k_{mod} [-]	$F_{0,d}$ [kN]	$\sigma_{0,d}$ [N/mm²]	k_c [-]	$f_{0,d}$ [N/mm²]	η [-]
1	Gl	1.00	1.85	0.06	1.00	16.15	0.00
	Gr	1.00	1.85	0.06	1.00	16.15	0.00
	Ro	1.00	0.00	0.00	1.00	16.15	0.00
	Ru	1.00	0.00	0.00	1.00	16.15	0.00

Gl/Gr = Gurt links/rechts, Ro/Ru = Randrippe oben/unten

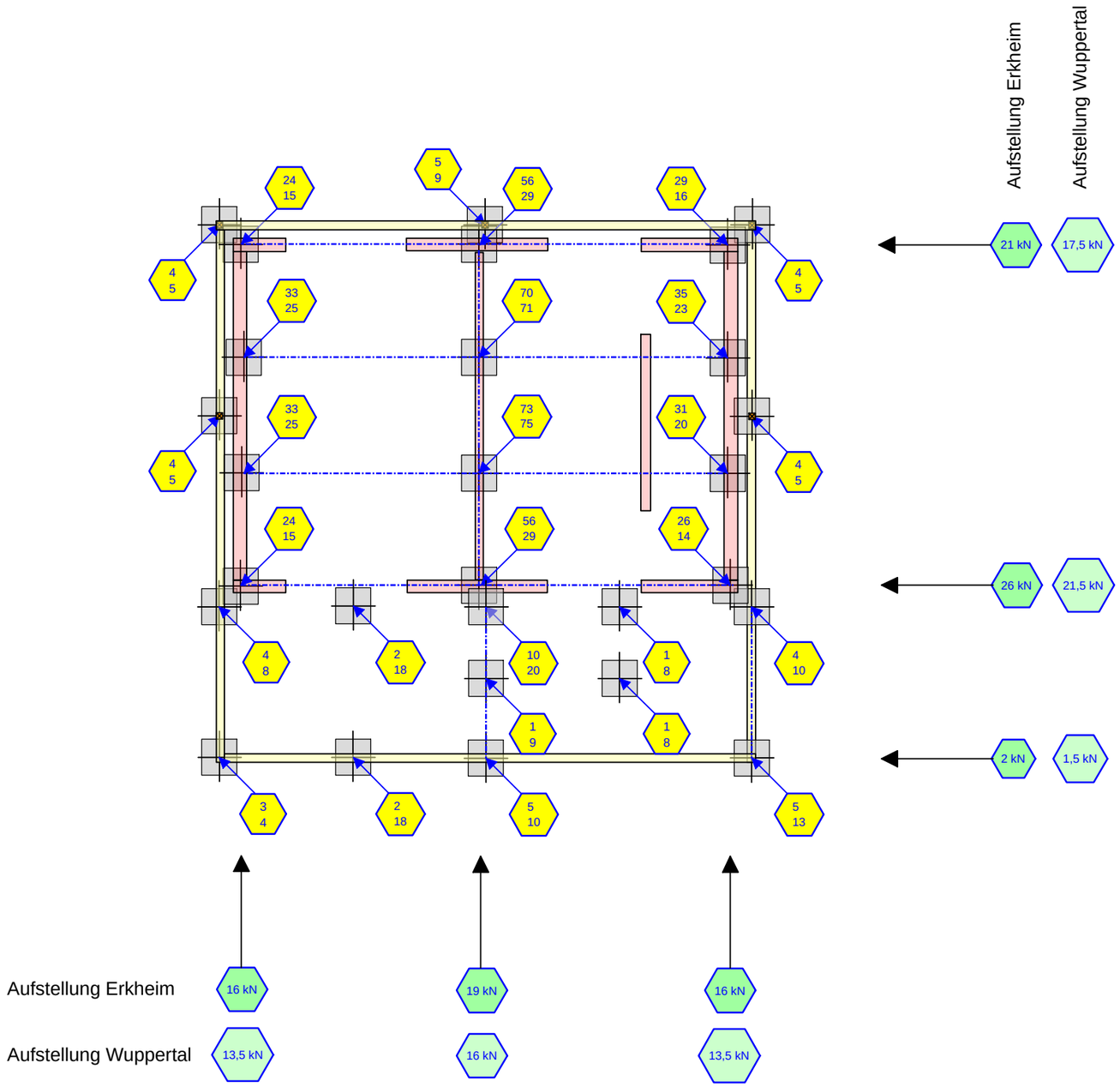
mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH

Zusammenfassung — Zusammenfassung der Nachweise

Nachweise (GZT) — Nachweise im Grenzzustand der Tragfähigkeit

Nachweis		G [-]
Scheibenbeanspruchung	OK	0.20
Schwellenpressung	OK	0.02
Normalspannung	OK	0.00

mb-Viewer Version 2021 - Copyright 2020 - mb AEC Software GmbH



Angabe als charakteristische Lasten (ohne Sicherheit)

g [in kN/m]
q [in kN/m]

G [in kN]
Q [in kN]

Wind [kN]

Lastenplan

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

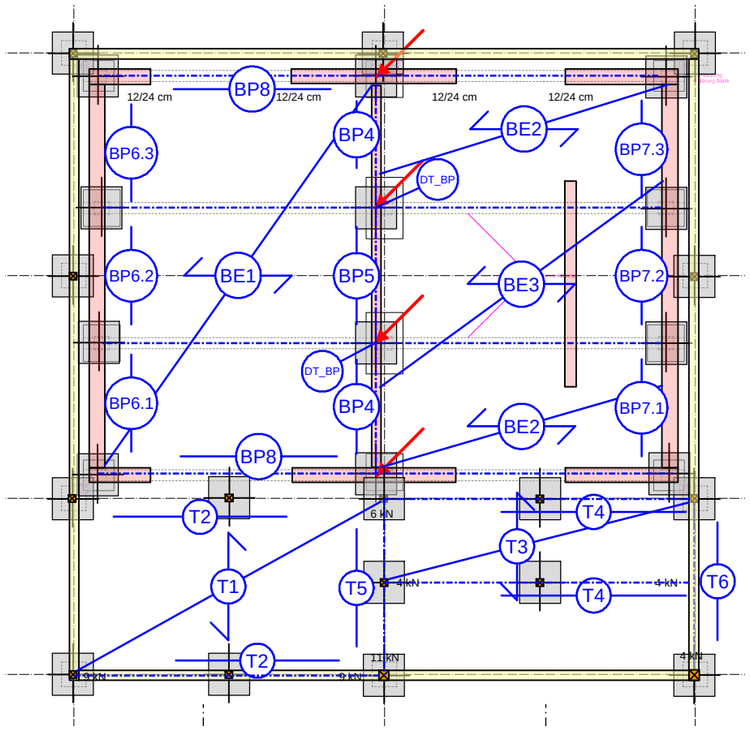
BAUFRITZ
WIR BAUEN GESUNDHEIT

Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim

Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER

48-2021-7



Position	Positionsbeschreibung
BE1	Bodenplattenelement b/h = 7/24 cm, a = 0.40 m, KVH C24, NKL1
BE2	Bodenplattenelement b/h = 12/24 cm, a = 0.50 m, KVH C24, NKL1
BE3	Bodenplattenelement b/h = 12/24 cm, a = 0.40 m, KVH C24, NKL1
BP4	Zwischenträger, SSV beidseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP5	Zwischenträger, SSV beidseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP6.1	Randträger, SSV einseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP6.2	Randträger, SSV einseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP6.3	Randträger, SSV einseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP7.1	Randträger, SSV einseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP7.2	Randträger, SSV einseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP7.3	Zwischenträger, SSV einseitig b/h = 24/24 cm, BSH GL24c, NKL1
BP8	Randträger b/h = 24/24 cm, BSH GL24c, NKL1
DT_BP	Holz-Auflager erforderliches Auflager, b = 24 cm, Länge > 40 cm, ,
T1	Terrasse EG b/h = 8/16 cm, a = 0.625 m, BSH GL24c, NKL2
T2	Randbalken mit SSV b/h = 16/16 cm , BSH GL24c, NKL2
T3	Terrasse EG b/h = 8/16 cm, a = 0.625 m, BSH GL24c, NKL2
T4	Randbalken mit SSV b/h = 16/16 cm , BSH GL24c, NKL2
T5	Randbalken b/h = 16/16 cm , BSH GL24c, NKL2
T6	Randbalken b/h = 16/16 cm , BSH GL24c, NKL2

Schneelastzone:	1a
Windzone:	2
Geländekategorie:	III
Erdbebenzone:	-

Positionsplan EG

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

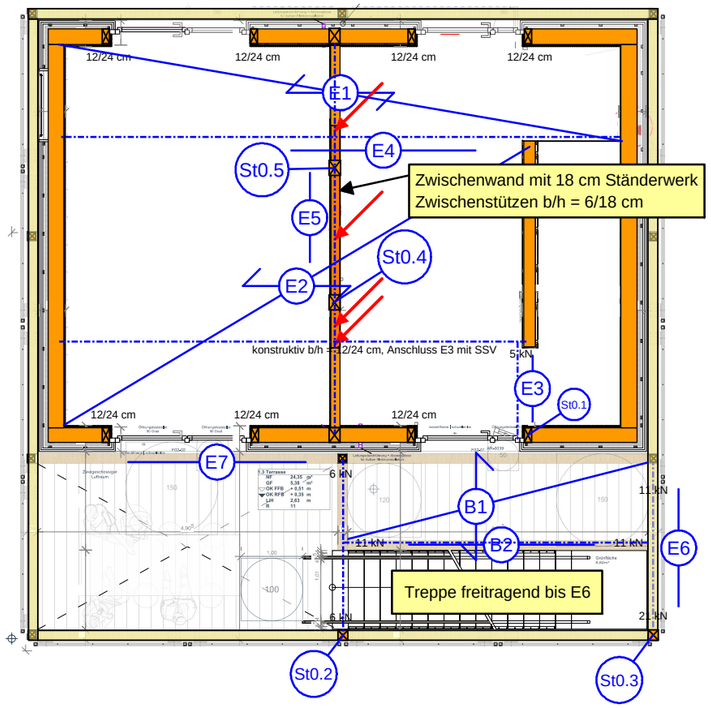
Legende

Sparren-, Balkonbalken- oder Balkenlage
Pfette, Wandgurt, Wandzange, Unterzug oder Träger
Stütze
Tragwand
Konsole
Abhängung
Fundament oder Isokorb
Balkonlast
Last aus darüberliegendem Geschoss
Einzellast aus darüberliegendem Geschoss

BAUFRITZ
WIR BAUEN GESUNDHEIT
Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim
Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER
48-2021-4

Position	Positionsbeschreibung
B1	Balkon b/h = 8/16 cm, a = 0.625 m, BSH GL24c, NKL2
B2	Randbalken, SSV einseitig b/h = 16/28 cm, BSH GL24c, NKL2
E1	geschlossene Decke b/h = 7/24 cm, a = 0.45 m, KVH C24, NKL1
E2	geschlossene Decke b/h = 7/24 cm, a = 0.55 m, KVH C24, NKL1
E3	Treppenwechsel, SSV einseitig b/h = 12/24 cm, BSH GL24c, NKL1
E4	Treppenwechsel b/h = 18/24 cm, BSH GL24c, NKL1
E5	Wandgurt b/h = 18/28 cm, BSH GL24c, NKL1
E6	Gridträger mit Treppe b/h = 16/28 cm, BSH GL24c, NKL2
E7	Wandgurt b/h = 24/24 cm, BSH GL24c, NKL1
St0.1	Holzstütze Aussenwand b/h = 12/24 cm, Trio C24, NKL1
St0.2	Holzstütze Außenbereich b/h = 16/16 cm, BSH GL24c, NKL3
St0.3	Holzstütze Außenbereich b/h = 16/16 cm, BSH GL24c, NKL3
St0.4	Holzstütze Zwischenwand b/h = 36/18 cm, NH C24, NKL1
St0.5	Holzstütze Zwischenwand b/h = 32/18 cm, NH C24, NKL1



	Aufstellung Erkheim	Aufstellung Wuppertal
Schneelastzone:	1a	1
Windzone:	2	1
Geländekategorie:	III	III
Erdbebenzone:	-	-

Positionsplan EG

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

Legende

- Sparren-, Balkonbalken- oder Balkenlage
- Pfette, Wandgurt, Wandzange, Unterzug oder Träger
- Stütze
- Tragwand
- Konsole
- Abhängung
- Fundament oder Isokorb
- Balkonlast
- Last aus darüberliegendem Geschoss
- Einzellast aus darüberliegendem Geschoss

BAUFRITZ
WIR BAUEN GESUNDHEIT

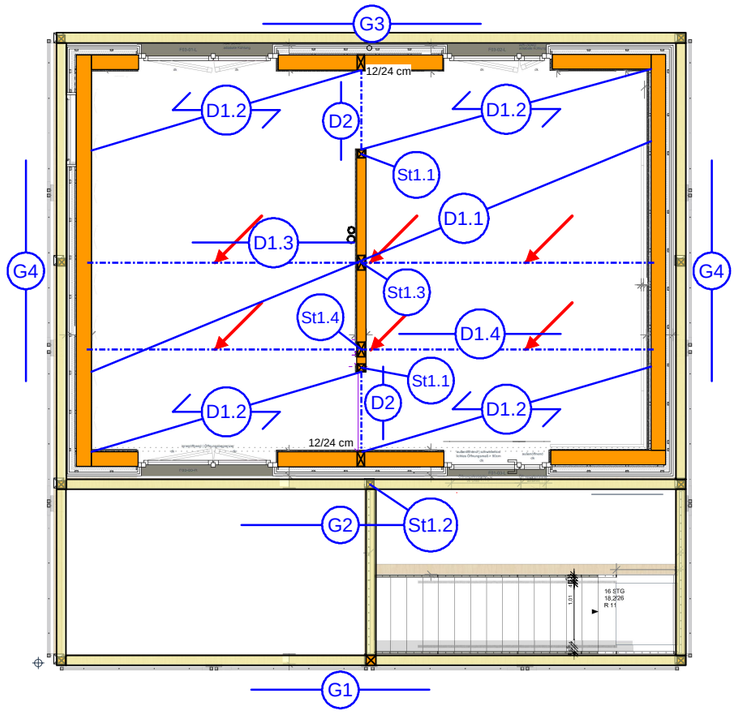
Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim

Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER

48-2021-3

Position	Positionsbeschreibung
D1.1	Sparren b/h = 7/24 cm,a = 0.52 m, NH C24, NKL1
D1.2	Sparren b/h = 7/24 cm,a = 0.40 m, NH C24, NKL1
D1.3	Sparren mit Zusatzlasten b/h = 18/24 cm, BSH GL24c, NKL1
D1.4	Sparren mit Zusatzlasten b/h = 18/24 cm, BSH GL24c, NKL1
D2	Unterzug deckengleich (beidseitig SSV) b/h = 18/24 cm, BSH GL24c, NKL1
G1	Grid Randträger b/h = 16/16 cm, BSH GL24c, NKL2
G2	Grid Randträger b/h = 16/24 cm, BSH GL24c, NKL2
G3	Grid Randträger b/h = 16/20 cm, BSH GL24c, NKL2
G4	Grid Randträger b/h = 16/16 cm, BSH GL24c, NKL2
St1.1	Holzstütze Zwischenwand b/h = 12/12 cm, NH C24, NKL1
St1.2	Holzstütze Außenbereich b/h = 16/16 cm, BSH GL24c, NKL3
St1.3	Holzstütze Zwischenwand b/h = 24/12 cm, NH C24, NKL1
St1.4	Holzstütze Zwischenwand b/h = 12/12 cm, NH C24, NKL1



Begrünung auf
Flachdach
max. 120 kg/m²

Alle Stützen des Grids b/h = 16/16 cm
konstruktiv ausreichend.

Legende

- Sparren-, Balkonbalken- oder Balkenlage
- Pfette, Wandgurt, Wandzange, Unterzug oder Träger
- Stütze
- Tragwand
- Konsole
- Abhängung
- Fundament oder Isokorb
- Balkonlast
- Last aus darüberliegendem Geschoss
- Einzellast aus darüberliegendem Geschoss

Positionsplan DG

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

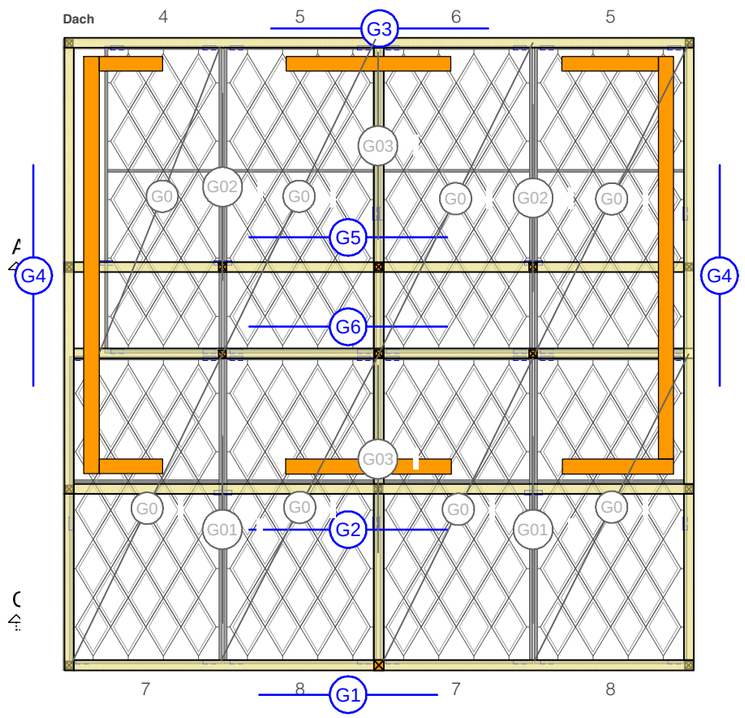
BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

BAUFRITZ
WIR BAUEN GESUNDHEIT
Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim
Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER
48-2021-2

Position	Positionsbeschreibung
G0	Lastermittlung Solarnetz
G01	Lastermittlung Solarnetz
G1	Grid Randträger b/h = 16/16 cm, BSH GL24c, NKL2
G02	Lastermittlung Solarnetz
G2	Grid Randträger b/h = 16/24 cm, BSH GL24c, NKL2
G03	Lastermittlung Solarnetz
G3	Grid Randträger b/h = 16/20 cm, BSH GL24c, NKL2
G4	Grid Randträger b/h = 16/16 cm, BSH GL24c, NKL2
G5	Grid Dachträger b/h = 16/16 cm, BSH GL24c, NKL2
G6	Grid Dachträger b/h = 16/16 cm, BSH GL24c, NKL2



Alle Stützen des Grids b/h = 16/16 cm konstruktiv ausreichend.

Legende

- Sparren-, Balkonbalken- oder Balkenlage
- Pfette, Wandgurt, Wandzange, Unterzug oder Träger
- Stütze
- Tragwand
- Konsole
- Abhängung
- Fundament oder Isokorb
- Balkonlast
- Last aus darüberliegendem Geschoss
- Einzellast aus darüberliegendem Geschoss

Positionsplan GR

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

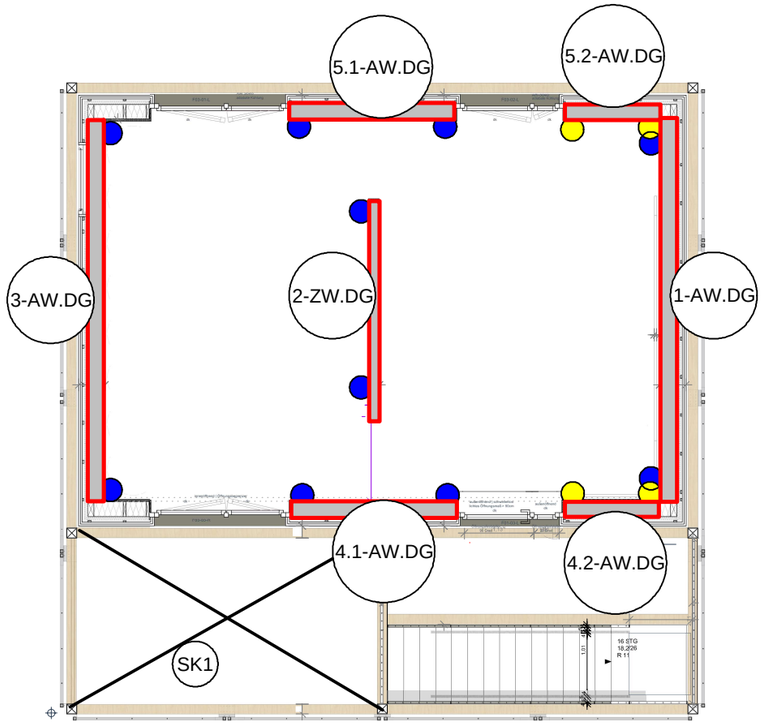
DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

BAUFRITZ
WIR BAUEN GESUNDHEIT
Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim
Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER

48-2021-1

Position	Positionsbeschreibung
1-AW.DG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
2-ZW.DG	Zwischenwand: beidseitig: GKF 18 mm, Klammer 1,5 mm, a = 70 mm
3-AW.DG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
4.1-AW.DG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
4.2-AW.DG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
5.1-AW.DG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
5.2-AW.DG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
DA	Dachscheibe oben: Spanplatte P5 25 mm, Klammer 1,5 mm, a = 70 mm
SK1	Stahlseilaussteifung analog VE022, Seildurchmesser 8 mm , Verankerung mit je vier Schrauben 8.0 x 100



●	1x BMF Winkelverbinder 90 + Schmid Star Drive GPR, 8,0 x 120	Last:	Fd = 2,00 kN
●	1x Simpson Strong Tie HD2P2 L/R + Vollgewindeschraube Schmid Rapid 8,0 x 200	Last:	Fd = 5,99 kN
	Alternativ: Stexon RG 40 + Stockschraube 12,0 x 200/100		
●	2x Simpson Strong Tie HD2P1 L/R + Vollgewindeschraube Schmid Rapid 8,0 x 200	Last gesamt:	Fd = 17,0 kN
	Alternativ: Stexon RL 40 + Stockschraube 12,0 x 300/200		
●	2x Simpson Strong Tie HTT5 + Vollgewindeschraube Schmid Rapid 8,0 x 200	Last gesamt:	Fd = 25,48 kN
●	2 x Stexon RL 40 + Stockschraube 12,0 x 300/200	Last gesamt:	Fd = 32,3 kN
▭	innen mit 12 mm ESB-P5-Platte beplankt		

Verankerungsplan DG

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

BAUFRITZ
WIR BAUEN GESUNDHEIT

Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim

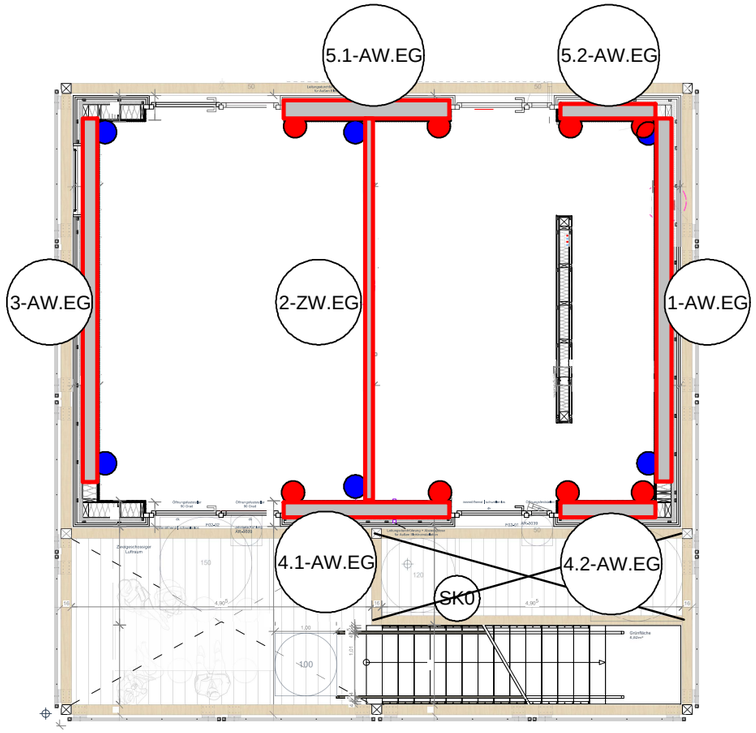
Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER

48-2021-5

Die Aussteifung der Balkonelemente erfolgt nach Detail VE 022. (Stahlkreuz)

Achtung bei der Deckenscheibe muss der Klammerabstand am Treppenpodest auf a = 60 mm reduziert werden.



Position	Positionsbeschreibung
1-AW.EG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
2-ZW.EG	Zwischenwand: beidseitig: GKF 18 mm, Klammer 1,5 mm, a = 70 mm
3-AW.EG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
4.1-AW.EG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
4.2-AW.EG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
5.1-AW.EG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
5.2-AW.EG	Außenwand: innen: Spanplatte P5 12 mm, Klammer 1,5 mm, a = 70 mm
DE	Deckenscheibe oben: Spanplatte P5 25 mm, Klammer 1,5 mm, a = 70 mm
SK0	Stahlseilaussteifung analog VE022, Seildurchmesser 12 mm , Verankerung mit je vier Schrauben 8.0 x 160

	1x BMF Winkelverbinder 90 + Schmid Star Drive GPR, 8,0 x 120	Last:	Fd = 2,00 kN
	1x Simpson Strong Tie HD2P2 L/R + Vollgewindeschraube Schmid Rapid 8,0 x 200	Last:	Fd = 5,99 kN
	Alternativ: Stexon RG 40 + Stockschraube 12,0 x 200/100		
	2x Simpson Strong Tie HD2P1 L/R + Vollgewindeschraube Schmid Rapid 8,0 x 200	Last gesamt:	Fd = 17,0 kN
	Alternativ: Stexon RL 40 + Stockschraube 12,0 x 300/200		
	2x Simpson Strong Tie HTT5 + Vollgewindeschraube Schmid Rapid 8,0 x 200	Last gesamt:	Fd = 25,48 kN
	2 x Stexon RL 40 + Stockschraube 12,0 x 300/200	Last gesamt:	Fd = 32,3 kN
	innen mit 12 mm ESB-P5-Platte beplankt		

Verankerungsplan EG

BAUHERR: Bau-Fritz GmbH & Co. KG
Alpenweg 25
87746 Erkheim

BAUVORHABEN: Einfamilienhaus
Alpenweg 25
87746 Erkheim

DATUM: 02.02.2022
GEZEICHNET: Müller
MASSSTAB: 1 : 100

BAUFRITZ
WIR BAUEN GESUNDHEIT

Bau-Fritz GmbH & Co. KG
seit 1896
Alpenweg 25
D-87746 Erkheim

Tel: +49 (0) 8336 - 900-0, Fax: +49 (0) 8336 - 900-777
E-Mail: tobias.mueller@baufritz.de, http://www.Baufritz.de

PLANNUMMER

48-2021-6

Zusätzlich ist eine Verankerung auf den Streifenfundamenten erforderlich.

Appendix C – OPV façade

SOLAR DECATHLON
FASSADENSYSTEM

Statischer Bericht

„STR-Solar_Decathlon-Statischer Bericht-R0“

Revision R0
Datum 26.11.2021

Ingenieurbüro: str.ucture GmbH
Lindenspürstraße 32
70176 Stuttgart

str.ucture GmbH
Lindenspürstaße 32
70176 Stuttgart

T +49 (0)711 286 937-0
F +49 (0)711 286 937-49
info@str-ucture.com
www.str-ucture.com

Geschäftsführer:
Prof. Dr. Michael Herrmann
Prof. Dr. Alexander Michalski

Amtsgericht:
Stuttgart: HRB 740135
Umsatzsteuer-ID:
DE284574577

Revision Table:

R0	Basis-Report	26.11.2021	LS

These calculations, drawings, photographs and all information contained herein are the property of str.ucture and their use is authorized only in connection with the product for which they were provided. Neither these drawings nor their contents thereof shall be disclosed to any other party for their use without the written consent of str.ucture.
The use or disclosure of these drawings or the contents thereof for any other purpose is prohibited, anyone doing so will be held liable therefore.

© str.ucture *2021*

Inhalt:

1 Allgemein 1-1
2 Planungsgrundlage 2-1
2.1 Normen 2-1
2.2 Sicherheitskonzept 2-1
2.3 Teilsicherheitsbeiwerte Stahlbau 2-1
2.4 Kombinationsbeiwerte 2-1
3 Statisches System 3-1
3.1 Beschreibung 3-1
3.2 FEM Modell 3-3
4 Materialien und Querschnitte 4-1
4.1 Übersicht 4-1
4.2 Gruppennummern 4-1
4.3 Materialien 4-3
4.4 Querschnitte 4-4
5 Lasten 5-1
5.1 Ständige Lasten 5-1
5.2 Veränderliche Lasten 5-1
5.3 Lastfälle und Kombinationen 5-2
5.4 Aufgebrachte Lasten 5-3
6 Auflagerkräfte 6-1
7 Nachweis im GZG 7-4
7.1 Großer Fassadenrahmen 7-5
8 Nachweis im GZT 8-8
8.1 Schnittgrößen Rahmen 8-8
8.2 Schnittgrößen Druckstab 8-14
8.3 Bemessung Rahmen 8-15
8.4 Bemessung Druckstab 8-17
8.5 Seilnetz 8-19
9 Details 9-1
9.1 Anschluss Rahmen – Grid 9-1
9.2 Anschluss Druckstab 9-3

1 Allgemein

Dieser Report beinhaltet die statischen Untersuchungen der beiden maßgebenden Fassadenrahmen für den Solar Decathlon. Dabei werden die maßgebenden Schnittgrößen und Auflagerkräfte unter Eigengewicht, Windlast sowie Temperaturbeanspruchung bestimmt und die Haupttragglieder mit diesen Einwirkungen bemessen.

Zusätzlich ist der Anschluss des Fassadenrahmens an die Holzunterkonstruktion Teil dieses Berichts.

2 Planungsgrundlage

2.1 Normen

Die im Folgenden genannten Normen werden der statischen Berechnung zugrunde gelegt:

- DIN EN 1990 - Grundlagen der Tragwerksplanung
- DIN EN 1991 - Eurocode 1 - Einwirkungen auf Tragwerke
- DIN EN 1993 - Eurocode 3 - Bemessung und Konstruktion von Stahlbauten
- DIN EN 1995 - Eurocode 5 - Bemessung und Konstruktion von Bauten aus Holz

2.2 Sicherheitskonzept

Im Rahmen der statischen Untersuchung werden folgende Lasten angesetzt:

- Eigengewicht
- Vorspannung
- Windlasten
- Eislasten
- Temperaturbeanspruchungen

2.3 Teilsicherheitsbeiwerte Stahlbau

Einwirkungsgrößen und Teilsicherheitsbeiwerte:

- Eigengewicht: $\gamma_F = 1{,}35$
- Vorspannung: $\gamma_F = 1{,}0$
- Wind: $\gamma_F = 1{,}5$
- Schnee: $\gamma_F = 1{,}5$
- Temperatur: $\gamma_F = 1{,}5$

2.4 Kombinationsbeiwerte

Für die Lastkombination aus Wind und Temperatur werden die folgenden Kombinationsbeiwerte angesetzt:

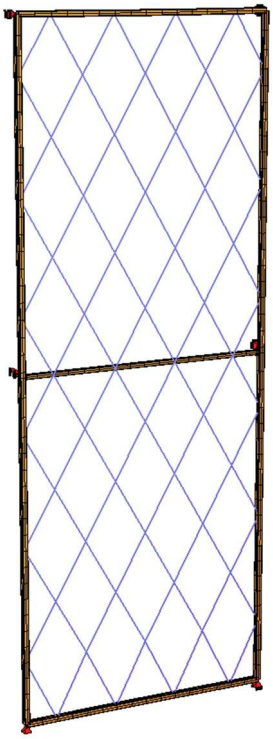
- $\psi_{Wind} = 0{,}6$
- $\psi_{Temperatur} = 0{,}6$

3 Statisches System

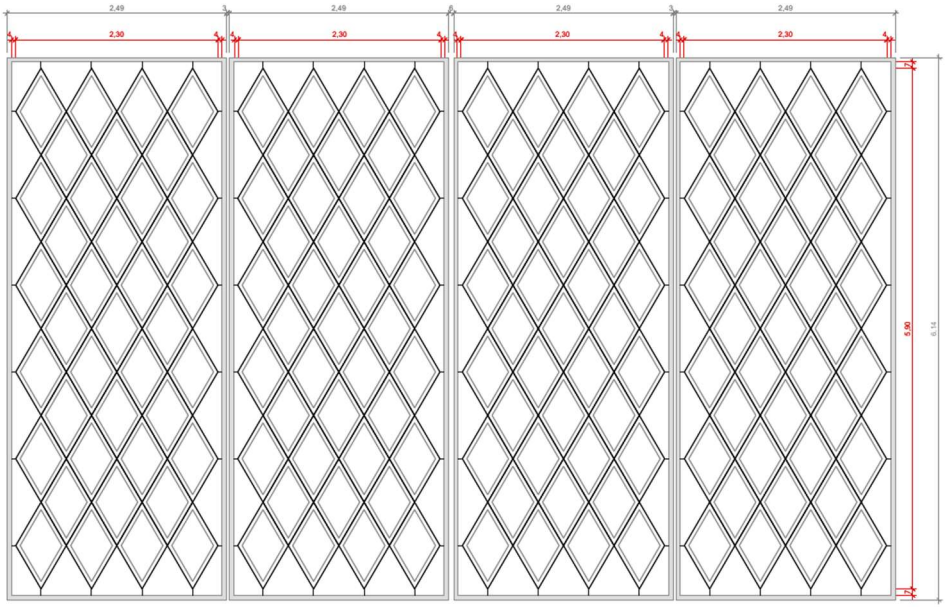
3.1 Beschreibung

Die Fassadenrahmen bestehen aus einem biegesteif geschweißten Rahmen aus quadratischen Stahlhohlprofilen, welcher mit einem Seilnetz ausgefacht wird. In der folgenden Berechnung wird dabei die maßgebende Rahmengeometrie untersucht. Auf der folgenden Seite sind die beiden Rahmengeometrien dargestellt.

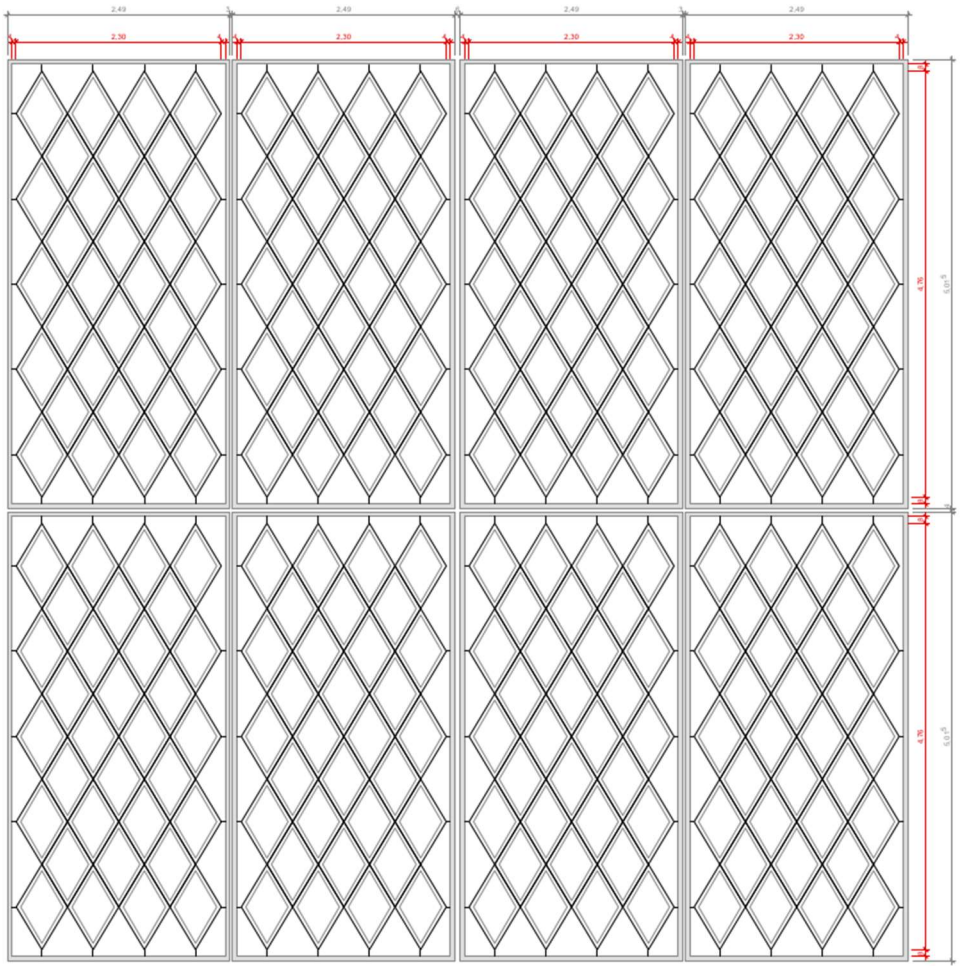
Auf Grund der größeren Abmessung ist der Fassadenrahmen der vertikalen Fassade maßgebend. Um zu große Durchbiegungen infolge Vorspannung zu vermeiden und den Querschnitt des Rahmenprofils möglichst klein zu halten wir mittig im Rahmen ein horizontaler Druckstab eingebaut.



Vertikale Fassade:



Fassade auf dem Dach:



3.2 FEM Modell

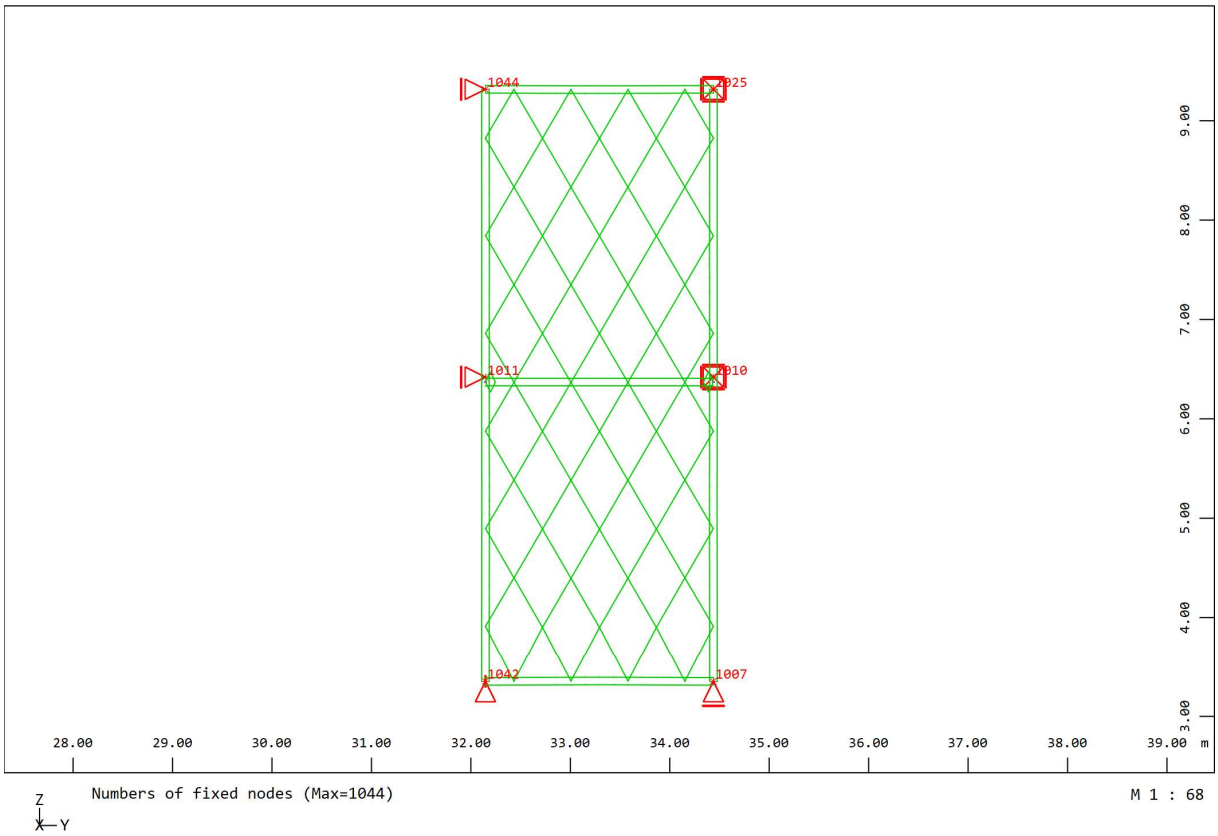
3.2.1 Allgemein

Die statische Berechnung erfolgt mit dem Programmmodul ASE 2020 der SOFISTIK AG. ASE berechnet die statischen Systemreaktionen eines dreidimensionalen Finiten Element Systems und hat sich in den vergangenen Jahren bereits bei verschiedenen Berechnungen im Bereich der Stahl-Tragwerke bewährt.

Das statische System ist aus dreidimensionalen Balken- und Seilelementen aufgebaut. Die Stahlelemente werden mit isotrop, linear elastischen Materialeigenschaften. Die Schnittgrößen werden nach Theorie 2. Ordnung ermittelt.

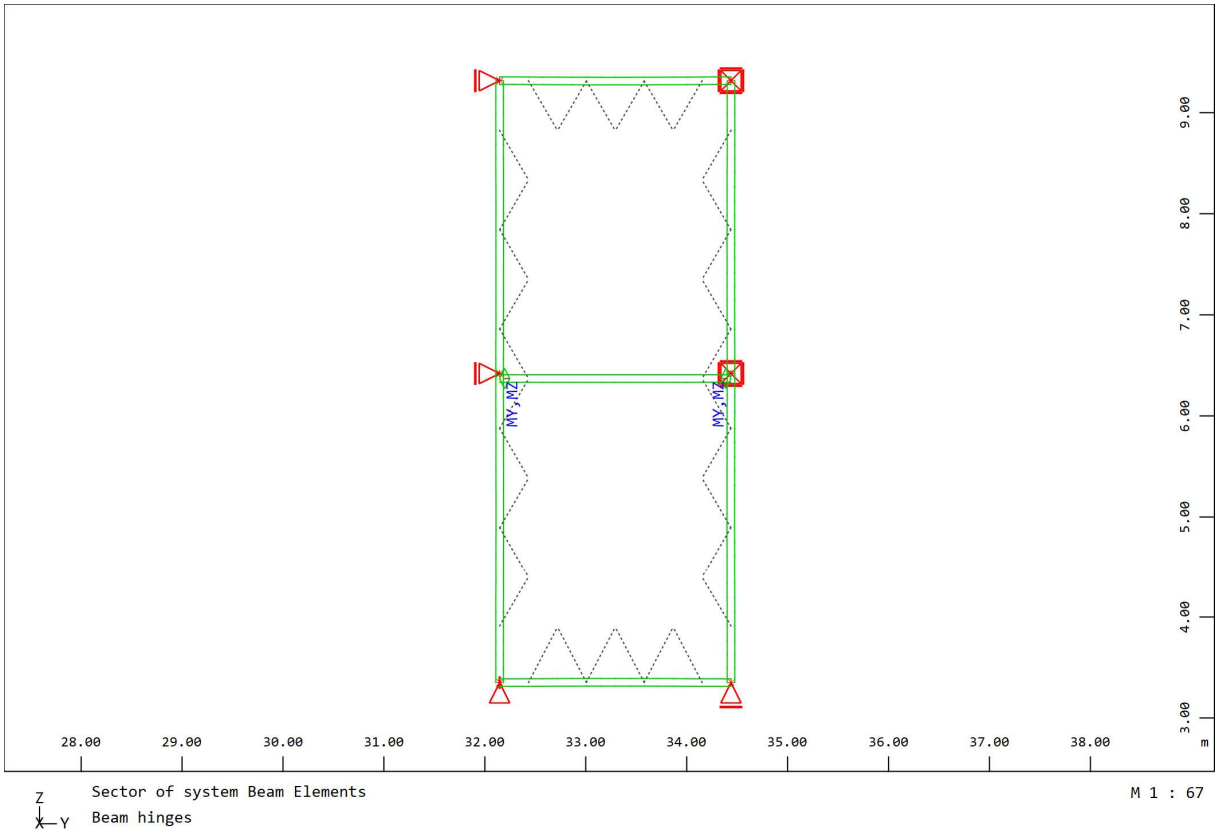
3.2.2 Lagerung

Um die Entstehung großer Kräfte infolge verhinderter Ausdehnung unter Temperaturbeanspruchung zu verhindern, werden die einzelnen Rahmen statisch bestimmt an die Holzkonstruktion angeschlossen. Aus diesem Grund werden auch keine Temperaturlasten auf das System angesetzt.



3.2.3 Stabgelenke

Der Fassadenrahmen in sich ist in den Ecken biegesteif verbunden, die Druckstäbe dazwischen gelenkig eingehängt.



4 Materialien und Querschnitte

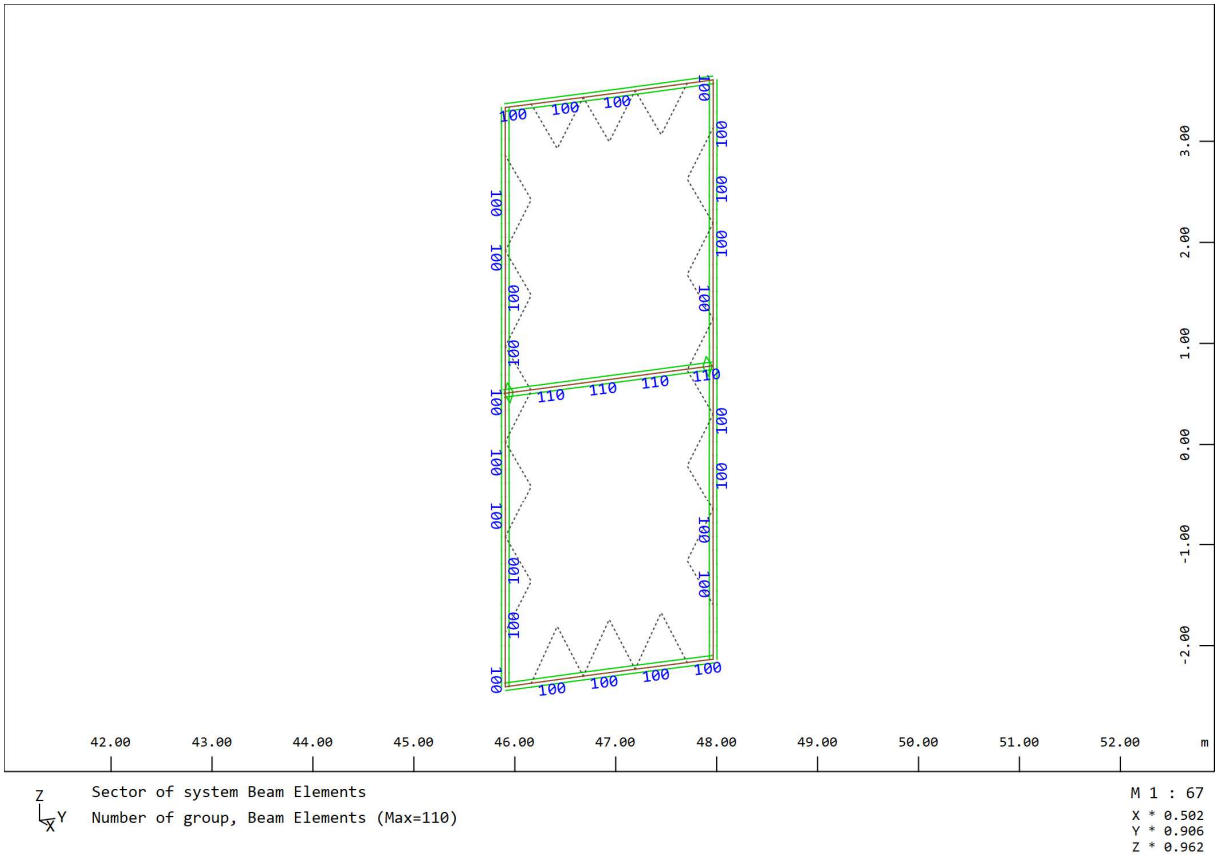
4.1 Übersicht

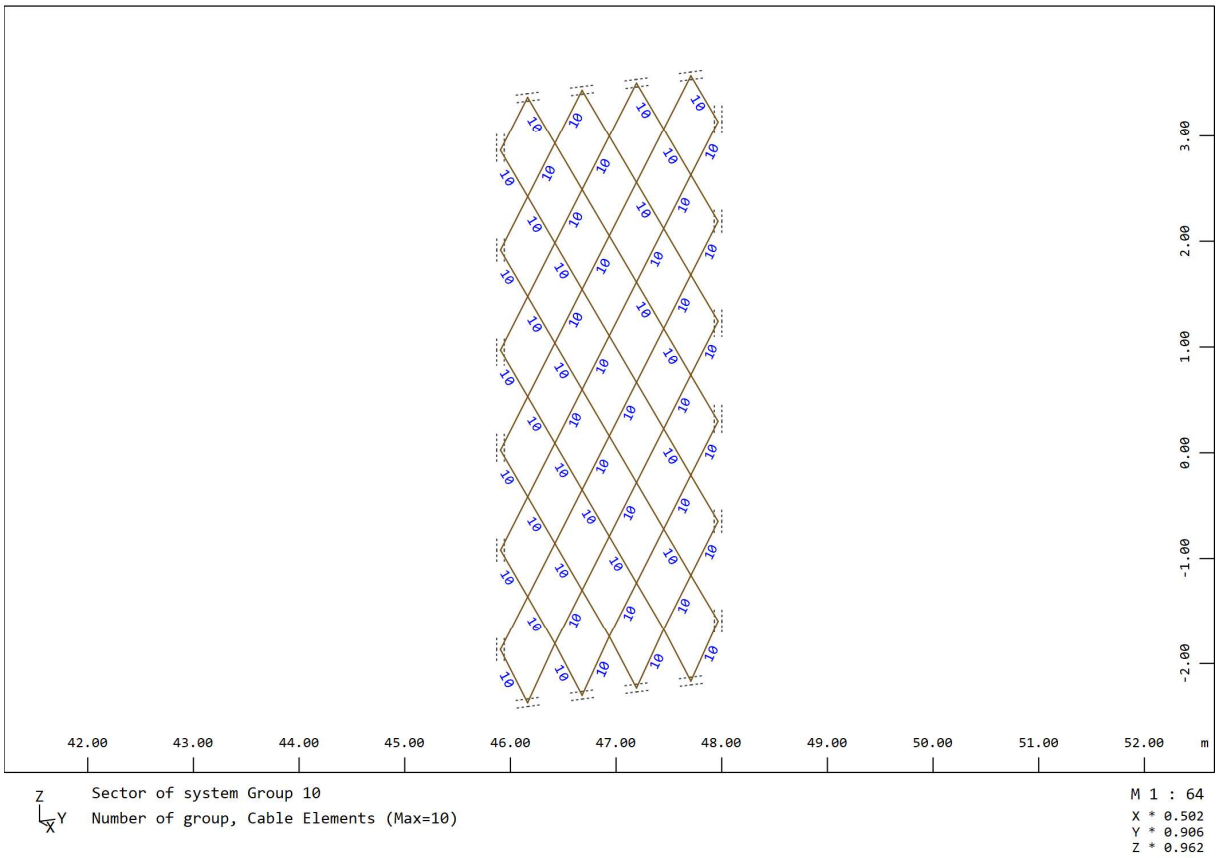
Die Querschnitts-, Gruppen- und Materialnummern sind in folgender Tabelle und folgenden Grafiken beschrieben:

	Gruppe	Materialnummer	Querschnittsnummer
Seilnetz	10	10	10
Stahlrahmen	100	100	100
Druckstäbe	110	100	110

4.2 Gruppennummern

Auf den folgenden Seiten sind die Gruppennummern der einzelnen Profile des Rahmens mit Druckstäben dargestellt. Da die Zuordnung für beide Rahmen identisch ist werden diese nicht nochmals gesondert gezeigt.


42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00
51.00
52.00
m
3.00
2.00
1.00
0.00
-1.00
-2.00
Z
Y
X
Sector of system Beam Elements
Number of group, Beam Elements (Max=110)
M 1 : 67
X * 0.502
Y * 0.906
Z * 0.962


42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00
51.00
52.00
m
3.00
2.00
1.00
0.00
-1.00
-2.00
Z
Y
X
Sector of system Group 10
Number of group, Cable Elements (Max=10)
M 1 : 64
X * 0.502
Y * 0.906
Z * 0.962

4.3 Materialien

Stahltragwerk

Mat100 S 235 (EN 1993)

Young's modulus	E	210000	[N/mm2]	Safetyfactor		1.00	[-]
Poisson's ratio	μ	0.30	[-]	Yield stress	fy	235.00	[MPa]
Shear modulus	G	80769	[N/mm2]	Compressive yield	fyc	235.00	[MPa]
Compression modulus	K	175000	[N/mm2]	Tensile strength	ft	360.00	[MPa]
Nominal Weight	γ	78.5	[kN/m3]	Compressive strength	fc	360.00	[MPa]
Mean density	ρ	7850.0	[kg/m3]	Ultimate strain		100.00	[o/oo]
Elongation coefficient	α	1.20E-05	[1/K]	relative bond coeff.		0.00	[-]
max. thickness	t-max	40.00	[mm]	EN 1992 bond coeff.	k1	0.00	[-]
Safety sectional design	γ-M0	1.00	[-]	Hardening modulus	Eh	0.00	[MPa]
Safety stability design	γ-M1	1.00	[-]	Proportional limit	fp	235.00	[MPa]
Safety rupture	γ-M2	1.25	[-]	Dynamic allowance	σ-dyn	0.00	[MPa]

Seile

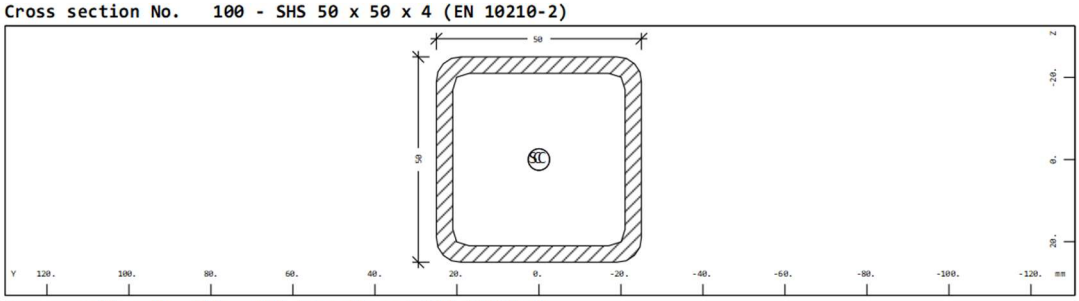
Mat 10 Y 1570 C (EN 1992) Seile

Young's modulus	E	130000	[N/mm2]	Safetyfactor		1.15	[-]
Poisson's ratio	μ	0.30	[-]	Yield stress	fy	1300.00	[MPa]
Shear modulus	G	50000	[N/mm2]	Compressive yield	fyc	1300.00	[MPa]
Compression modulus	K	108333	[N/mm2]	Tensile strength	ft	1570.00	[MPa]
Nominal Weight	γ	78.5	[kN/m3]	Compressive strength	fc	1570.00	[MPa]
Mean density	ρ	7850.0	[kg/m3]	Ultimate strain		60.00	[o/oo]
Elongation coefficient	α	1.20E-05	[1/K]	relative bond coeff.		0.50	[-]
max. thickness	t-max	10.00	[mm]	EN 1992 bond coeff.	k1	1.60	[-]
Relaxation	EN-1992	Class	2	Hardening modulus	Eh	0.00	[MPa]
Relaxation	ρ(1000h)	2.50	[%]	Proportional limit	fp	1300.00	[MPa]
				Dynamic allowance	σ-dyn	160.87	[MPa]

4.4 Querschnitte

Rahmenprofil – Vierkantrohr

Cross section No. 100 - SHS 50 x 50 x 4 (EN 10210-2)



Cross section No. 100 - SHS 50 x 50 x 4 (EN 10210-2)

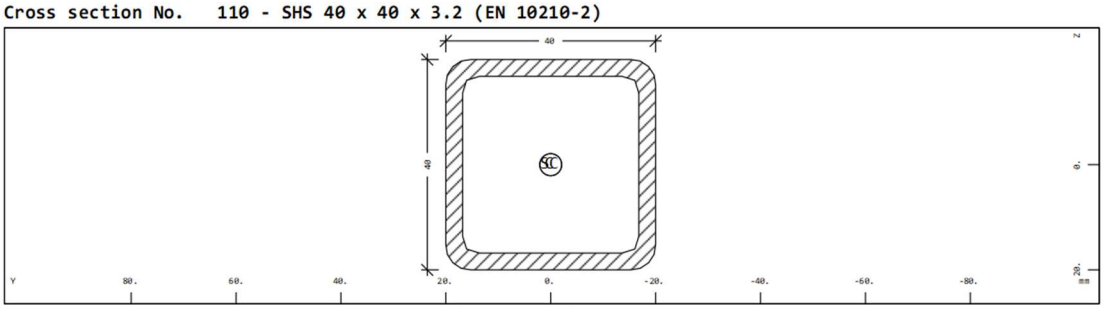
Static properties of cross section

SNo	Mat MRf	A[m2] It[m4]	Ay[m2] Az[m2] Ayz[m2]	Iy[m4] Iz[m4] Iyz[m4]	yc[mm] zc[mm]	ysc[mm] zsc[mm]	E[N/mm2] G[N/mm2]	g[kg/m]	I-1[m4] I-2[m4] α[°]
100	100	7.2000E-04	3.267E-04	2.502E-07	0.0	0.0	210000	5.7	
		4.151E-07	3.267E-04	2.502E-07	0.0	0.0	80769	(CENTR)	
= SHS 50 x 50 x 4 (EN 10210-2)									

SNo	section number	yc[mm],zc[mm]	ordinate of elastic centroid
Mat	material number	ysc[mm],zsc[mm]	ordinate of shear centre
A[m2]	sectional area	E[N/mm2]	Young's modulus
Ay[m2],Az[m2],Ayz[m2]	transverse shear deformation area	g[kg/m]	weight per length
Iy[m4],Iz[m4],Iyz[m4]	bending moment of inertia		
I-1[m4],I-2[m4],α[°]	principal moments of inertia and angle of the principal axes		
MRf	reinforcement material number		
It[m4]	torsional moment of inertia		
G[N/mm2]	Shear modulus		

Druckstab

Cross section No. 110 - SHS 40 x 40 x 3.2 (EN 10210-2)



Cross section No. 110 - SHS 40 x 40 x 3.2 (EN 10210-2)

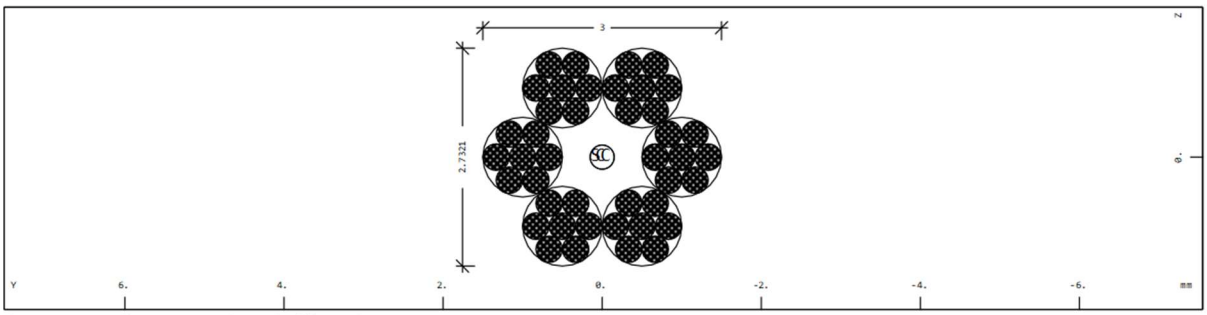
Static properties of cross section

SNo	Mat MRf	A[m2] It[m4]	Ay[m2] Az[m2] Ayz[m2]	Iy[m4] Iz[m4] Iyz[m4]	yc[mm] zc[mm]	ysc[mm] zsc[mm]	E[N/mm2] G[N/mm2]	g[kg/m]	I-1[m4] I-2[m4] α[°]
110	100	4.6080E-04	2.091E-04	1.025E-07	0.0	0.0	210000	3.6	
		1.700E-07	2.091E-04	1.025E-07	0.0	0.0	80769	(CENTR)	
= SHS 40 x 40 x 3.2 (EN 10210-2)									

SNo	section number	yc[mm],zc[mm]	ordinate of elastic centroid
Mat	material number	ysc[mm],zsc[mm]	ordinate of shear centre
A[m2]	sectional area	E[N/mm2]	Young's modulus
Ay[m2],Az[m2],Ayz[m2]	transverse shear deformation area	g[kg/m]	weight per length
Iy[m4],Iz[m4],Iyz[m4]	bending moment of inertia		
I-1[m4],I-2[m4],α[°]	principal moments of inertia and angle of the principal axes		
MRf	reinforcement material number		
It[m4]	torsional moment of inertia		
G[N/mm2]	Shear modulus		

Seile

Cross section No. 10 - Seil D=3mm



Cross section No. 10 - Seil D=3mm

Static properties of cross section

SNo	Mat MRf	A[m2] It[m4]	Ay[m2] Az[m2] Ayz[m2]	Iy[m4] Iz[m4] Iyz[m4]	yc[mm] zc[mm]	ysc[mm] zsc[mm]	E[N/mm2] G[N/mm2]	g[kg/m]	I-1[m4] I-2[m4] α[°]
10	10	3.3210E-06		1.868E-12	0.0	0.0	130000	0.0	
		0.000E+00		1.868E-12	0.0	0.0	50000	(CABLE)	

= Seil D=3mm

SNo	section number	yc[mm],zc[mm]	ordinate of elastic centroid
Mat	material number	ysc[mm],zsc[mm]	ordinate of shear centre
A[m2]	sectional area	E[N/mm2]	Young's modulus
Ay[m2],Az[m2],Ayz[m2]	transverse shear deformation area	g[kg/m]	weight per length
Iy[m4],Iz[m4],Iyz[m4]	bending moment of inertia		
I-1[m4],I-2[m4],α[°]	principal moments of inertia and angle of the principal axes		
MRf	reinforcement material number		
It[m4]	torsional moment of inertia		
G[N/mm2]	Shear modulus		

5 Lasten

Im Folgenden sind die angesetzten Lasten dargestellt.

5.1 Ständige Lasten

Stahl
Das Eigengewicht der Stahlbauteile ist mit einer Wichte von 7850 kg/m³ ermittelt.

Vorspannung
Die Vorspannung der Seile beträgt **V=0,5 kN**

Ausbaulasten
Das Eigengewicht der Photovoltaik-Module beträgt **0,2 kN/m²**

5.2 Veränderliche Lasten

Windlasten

Grundwerte

Die Einwirkungen infolge Winds werden nach DIN EN 1991-1-4/NA:2010-12 ermittelt.

Basiswerte:	Stadt:	Wuppertal / Erkheim (maßgebend)
	Windzone:	2
	Geländekategorie:	III

Böengeschwindigkeitsdruck unter genauer Berücksichtigung der Bodenrauigkeit gem. DIN EN 1991-1-/NA.B Tab. NA.B.2:

$$q_p = 1{,}5 \times 0{,}39 = \mathbf{0{,}58\ kN/m^2}$$

cp-Werte

Die anzusetzenden cp-Werte ergeben sich für vertikale Wände rechteckiger Gebäude nach DIN EN 1991-1-4, Abschnitt 7.2.2 Bild 7.5 und Tabelle 7.1 Dabei sind positive Werte als Druck- und negative Werte als Sogbeiwerte zu verstehen.

Bereich C:	**-1,2**
Bereich D:	**+0,8**

Auf der sicheren Seite werden die maßgebenden Werte auf den gesamten Rahmen angesetzt.

5.3 Lastfälle und Kombinationen

5.3.1 Basislastfälle

- LF 1: Vorspannung
- LF 10: Eigengewicht
- LF 20: Winddruck
- LF 30: Windsog

5.3.2 Lastfallkombinationen im GZG

Für die Nachweise im Grenzzustand der Gebrauchstauglichkeit (GZG, SLS) wird die vertikale bzw. horizontale Verformung des Rahmens als maßgebend angenommen. Hierfür wird, gemäß DIN EN 1990/NA, A.1.4.3, die charakteristische Kombination als maßgebend angenommen.

$$\sum_{j\geq 1} G_{k,j} \text{ "+" } P_k \text{ "+" } Q_{k,1} \text{ "+" } \sum_{i>1} \Psi_{0,i}\, Q_{k,i}$$

Sämtliche Lastkombinationen im GZG sind im Folgenden dargestellt.

- LF 100: 1,0 x Eigengewicht
- LF 200: 1,0 x Eigengewicht + 1,0 x Winddruck
- LF 300: 1,0 x Eigengewicht + 1,0 x Windsog

5.3.3 Lastfallkombinationen im GZT

Der Bemessungswert der Beanspruchungen im Grenzzustand der Tragfähigkeit (GZT, ULS) errechnet sich nach DIN EN 1990/NA in der Grundkombination zu:

$$\sum_{j\geq 1} \gamma_{G,j}\, G_{k,j} \text{"+"} \gamma_P\, P \text{"+"} \gamma_{Q,1}\, Q_{k,1} \text{"+"} \sum_{i>1} \gamma_{Q,i}\, \psi_{0,i}\, Q_{k,i}$$

Sämtliche Lastkombinationen im GZT sind im Folgenden dargestellt.

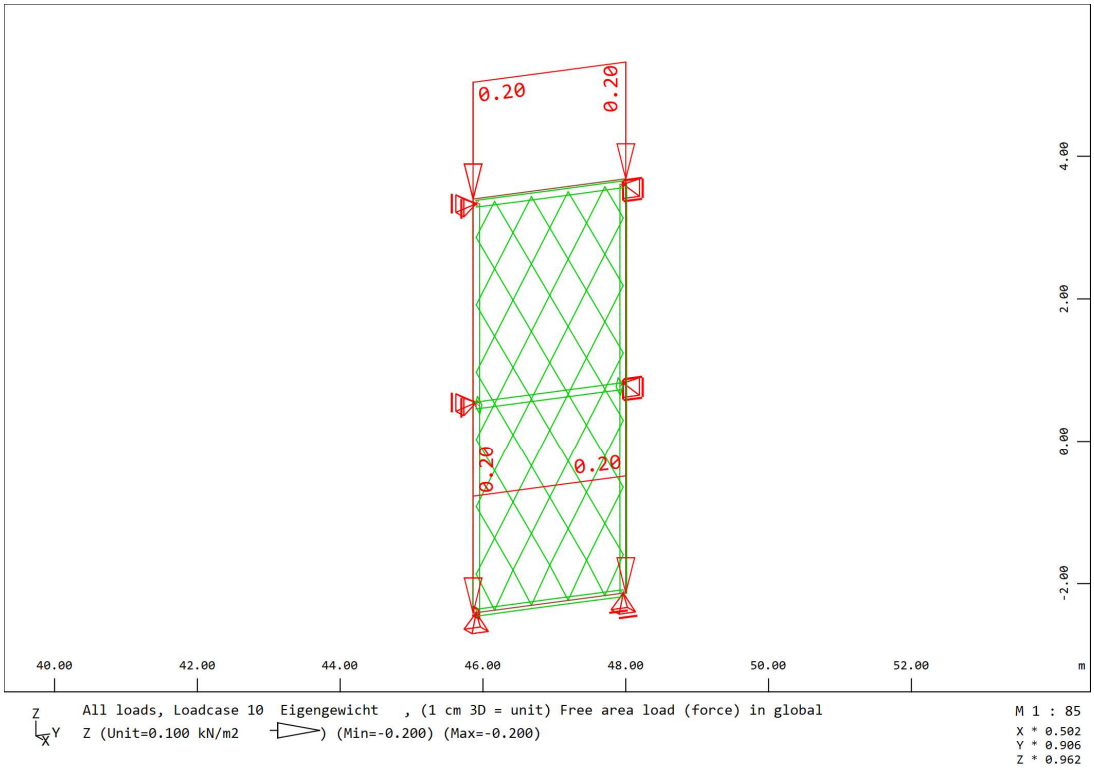
- LF 100: 1,35 x Eigengewicht
- LF 200: 1, 35 x Eigengewicht + 1,5 x Winddruck
- LF 300: 1, 35 x Eigengewicht + 1,5 x Windsog

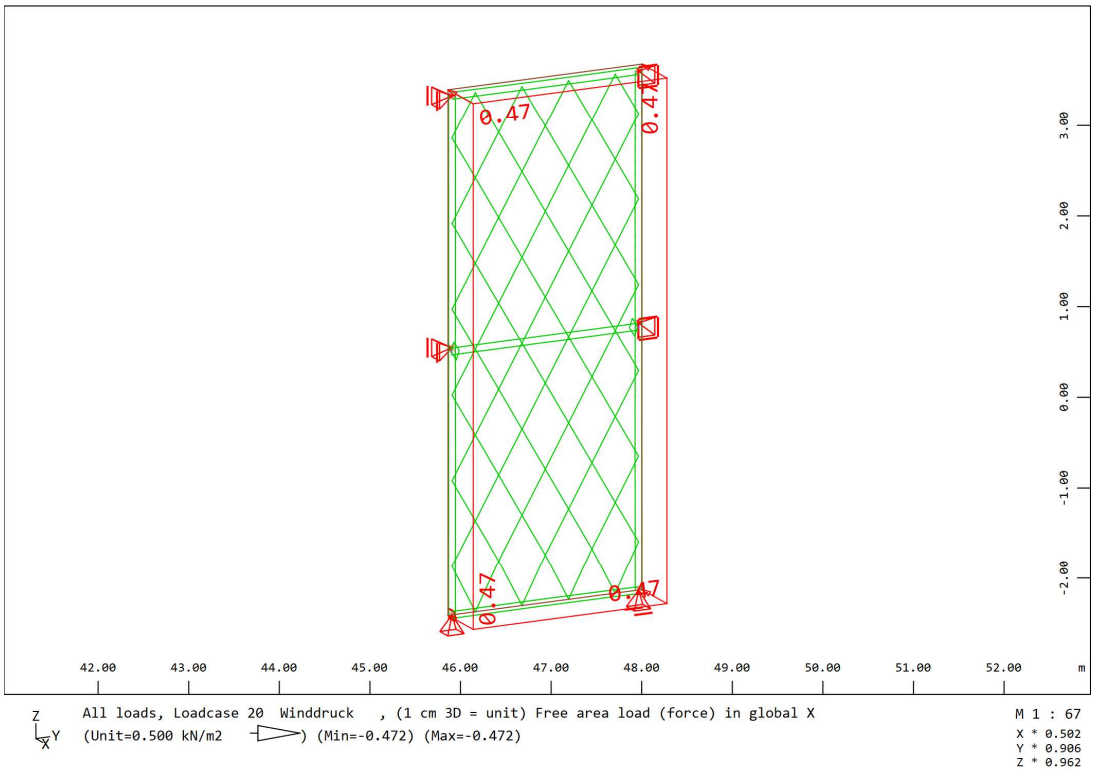
5.3.4 Maxima Lastfälle

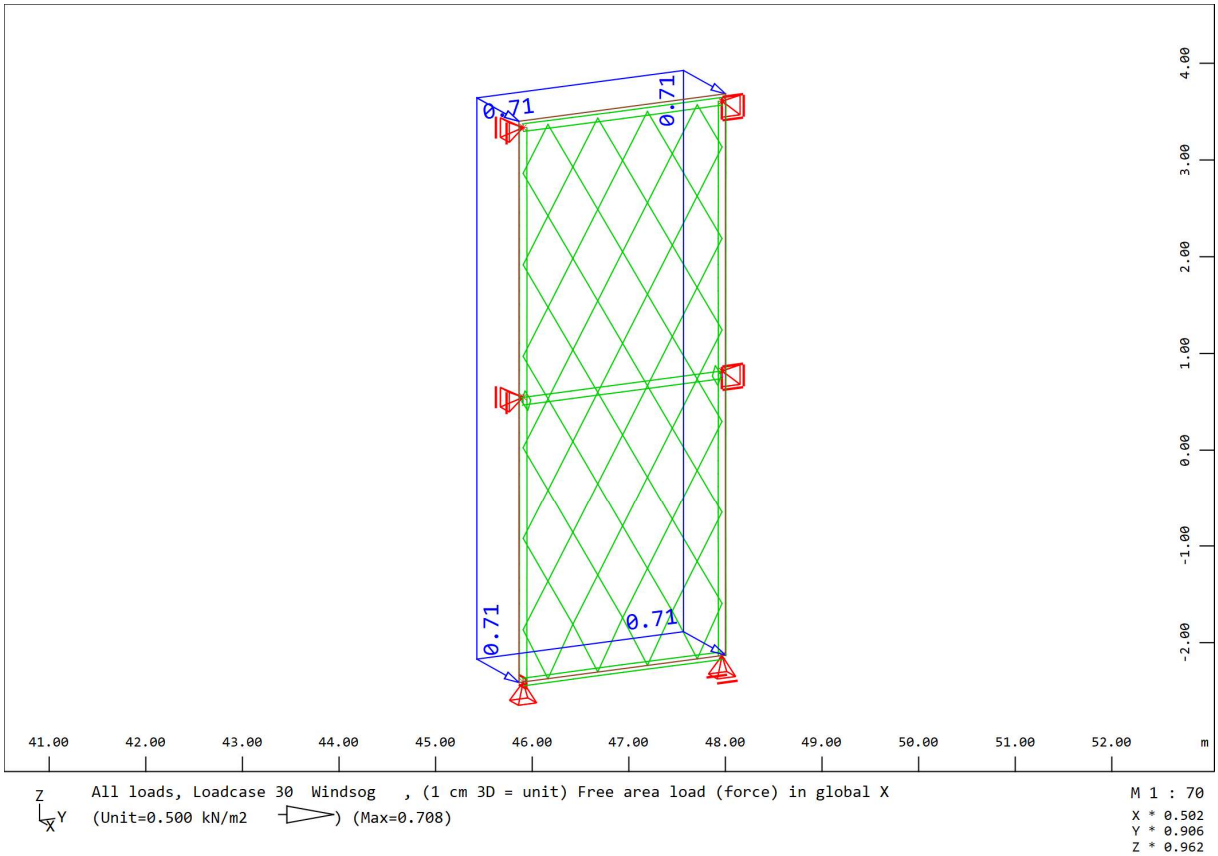
LF 8000: Maximale Stabschnittgrößen
LF 8500: Maximale Seilschnittgrößen
LF 9000: Maximale Auflagerkräfte

5.4 Aufgebrachte Lasten

Auch hier werden nur die Lasten auf den Rahmen mit Druckstab gezeigt. Für den Fall ohne Druckstab sind diese identisch.

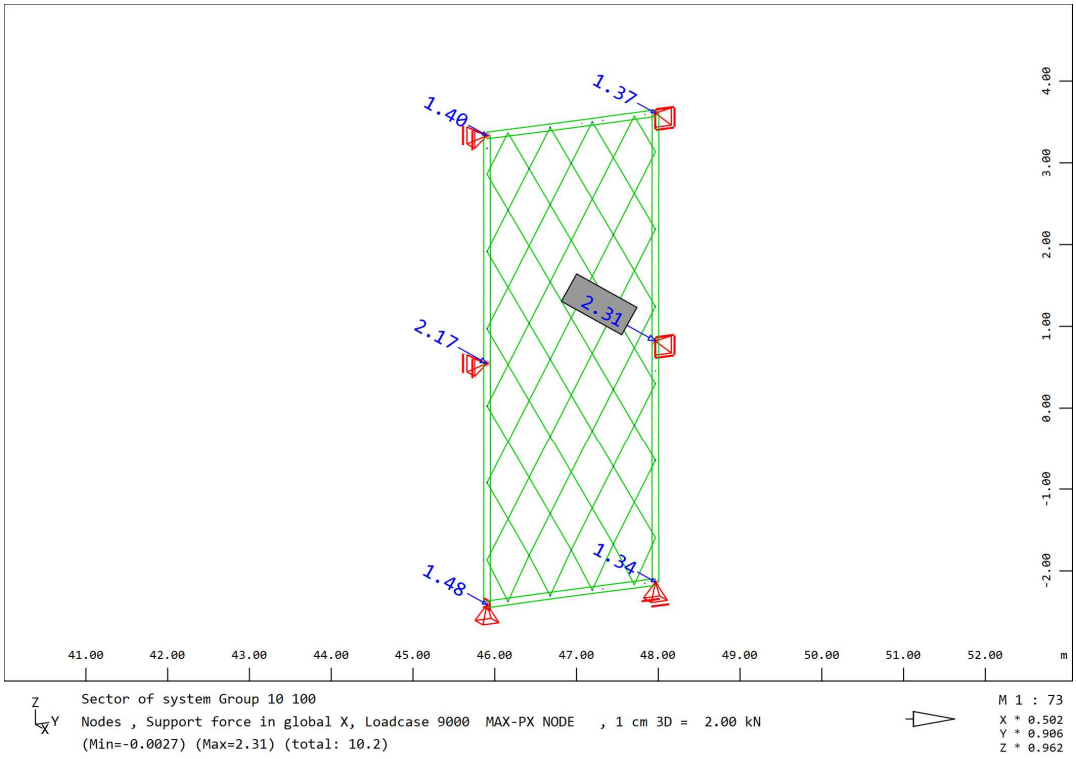


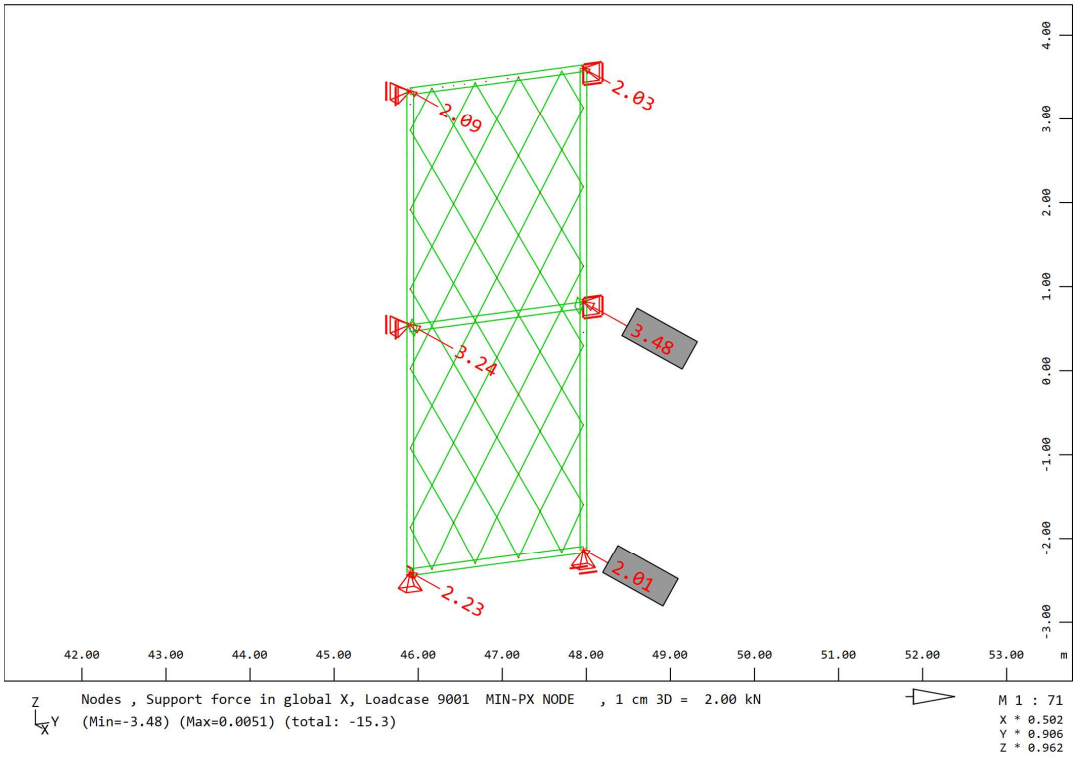


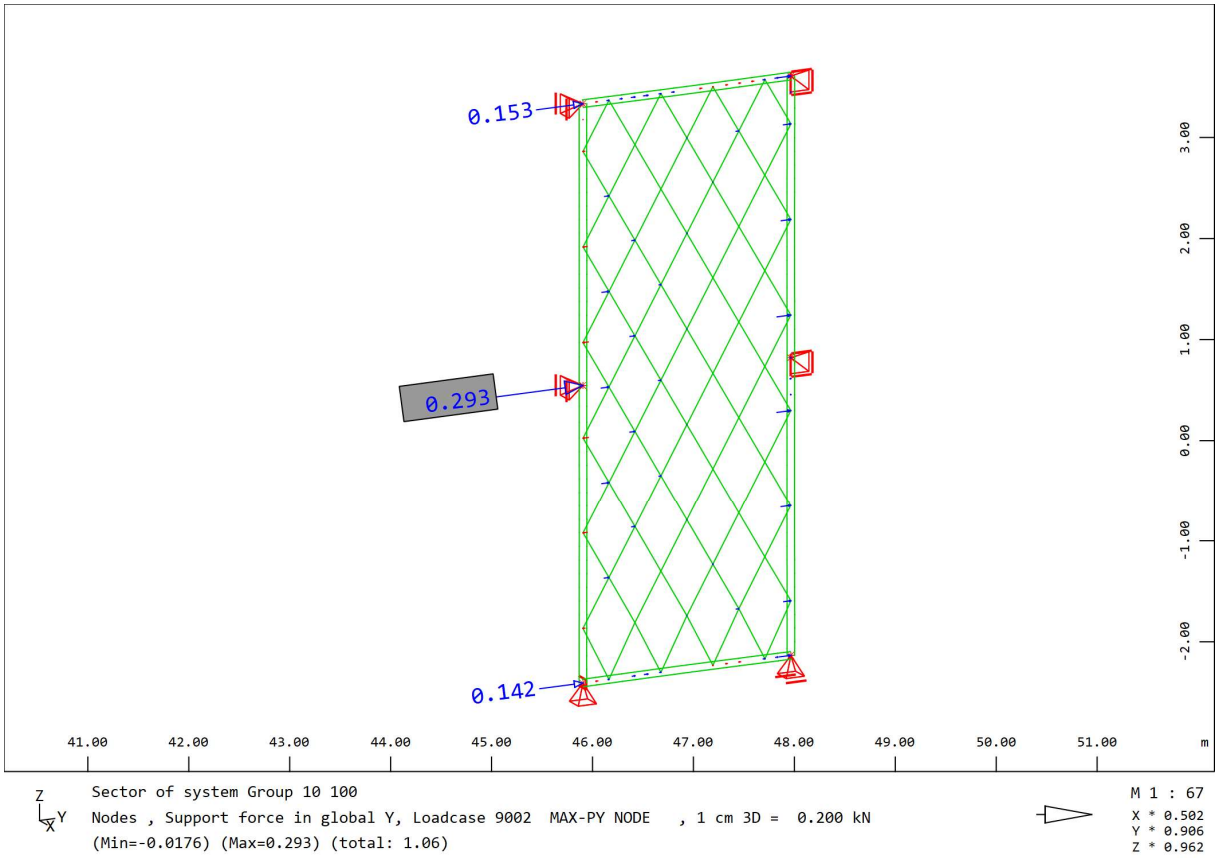

0.71
0.71
0.71
0.71
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
41.00
42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00
51.00
52.00
m
Z
Y
X
All loads, Loadcase 30 Windsog , (1 cm 3D = unit) Free area load (force) in global X
(Unit=0.500 kN/m2) (Max=0.708)
M 1 : 70
X * 0.502
Y * 0.906
Z * 0.962

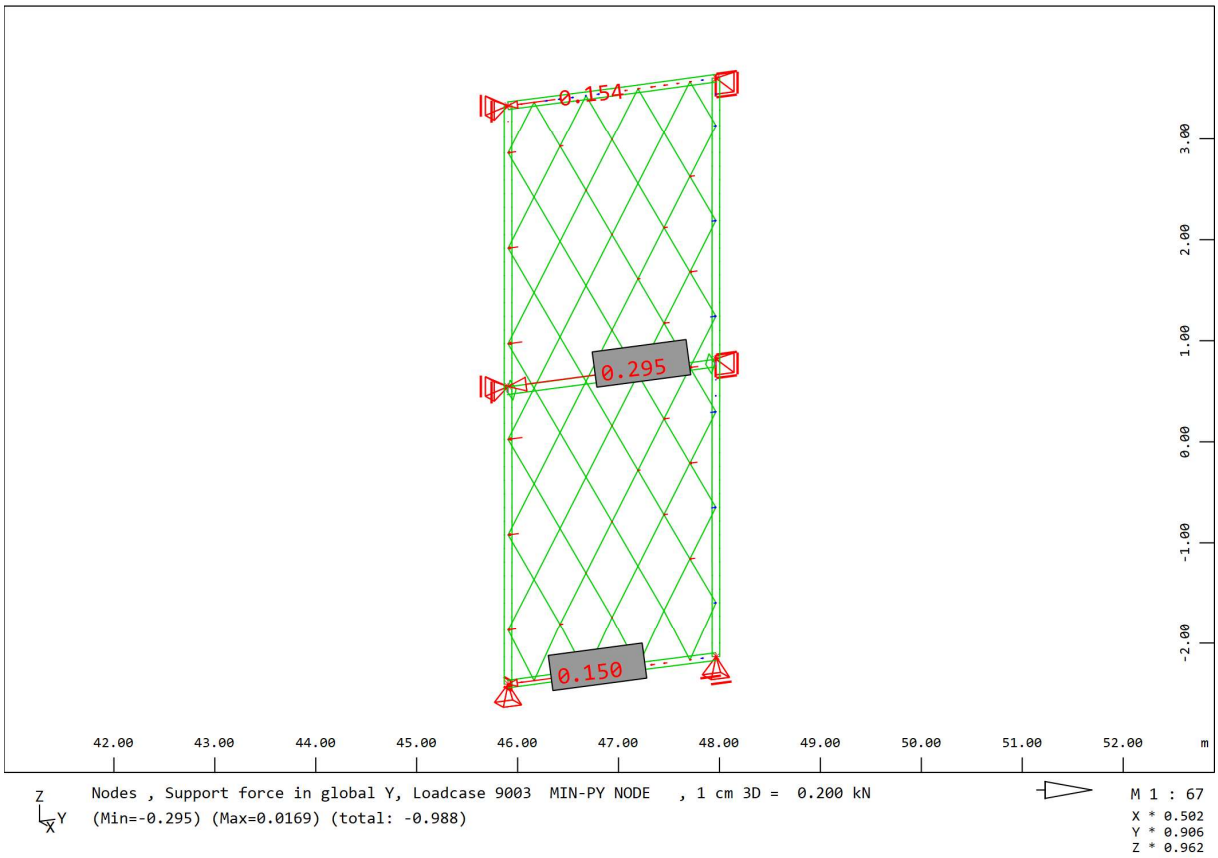
6 Auflagerkräfte

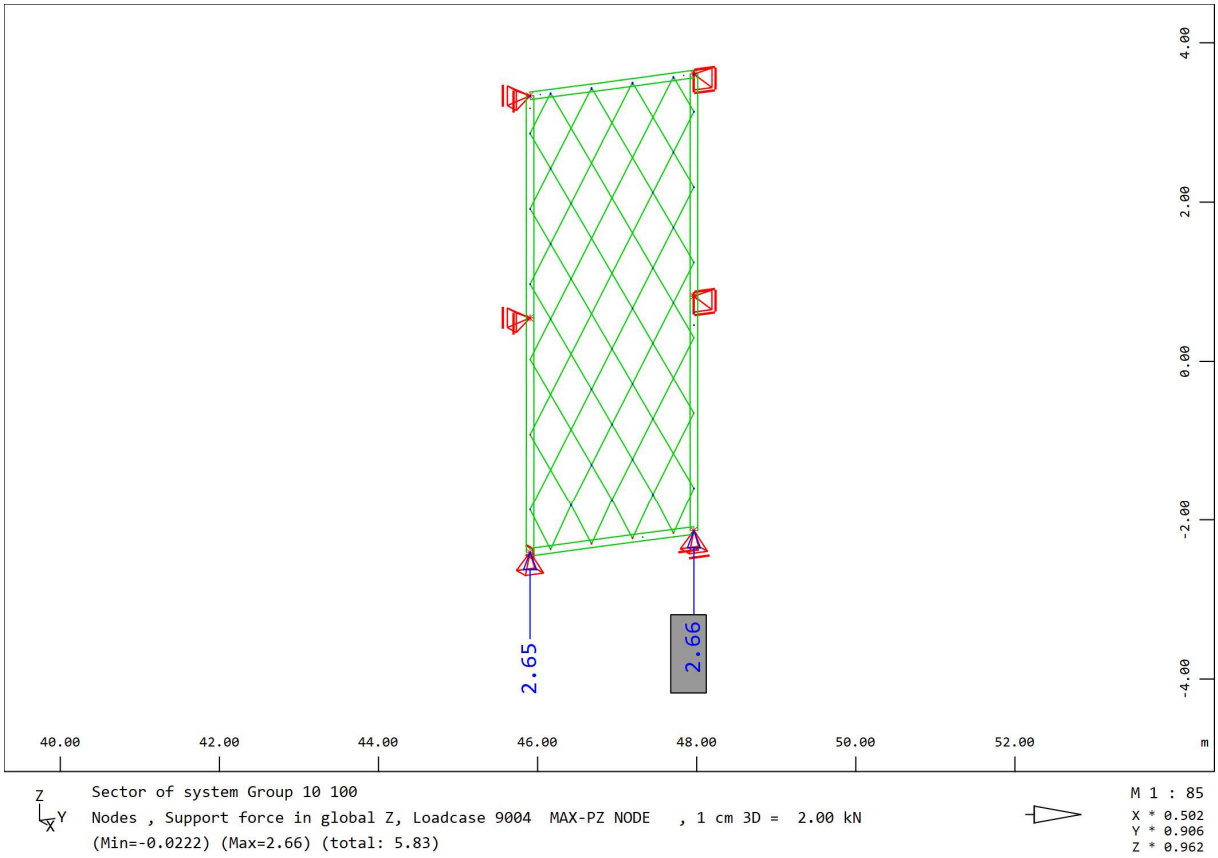
Auf den folgenden Seiten sind die maximalen, einhüllenden Auflagerkräfte bezogen auf das **globale** Koordinatensystem dargestellt.

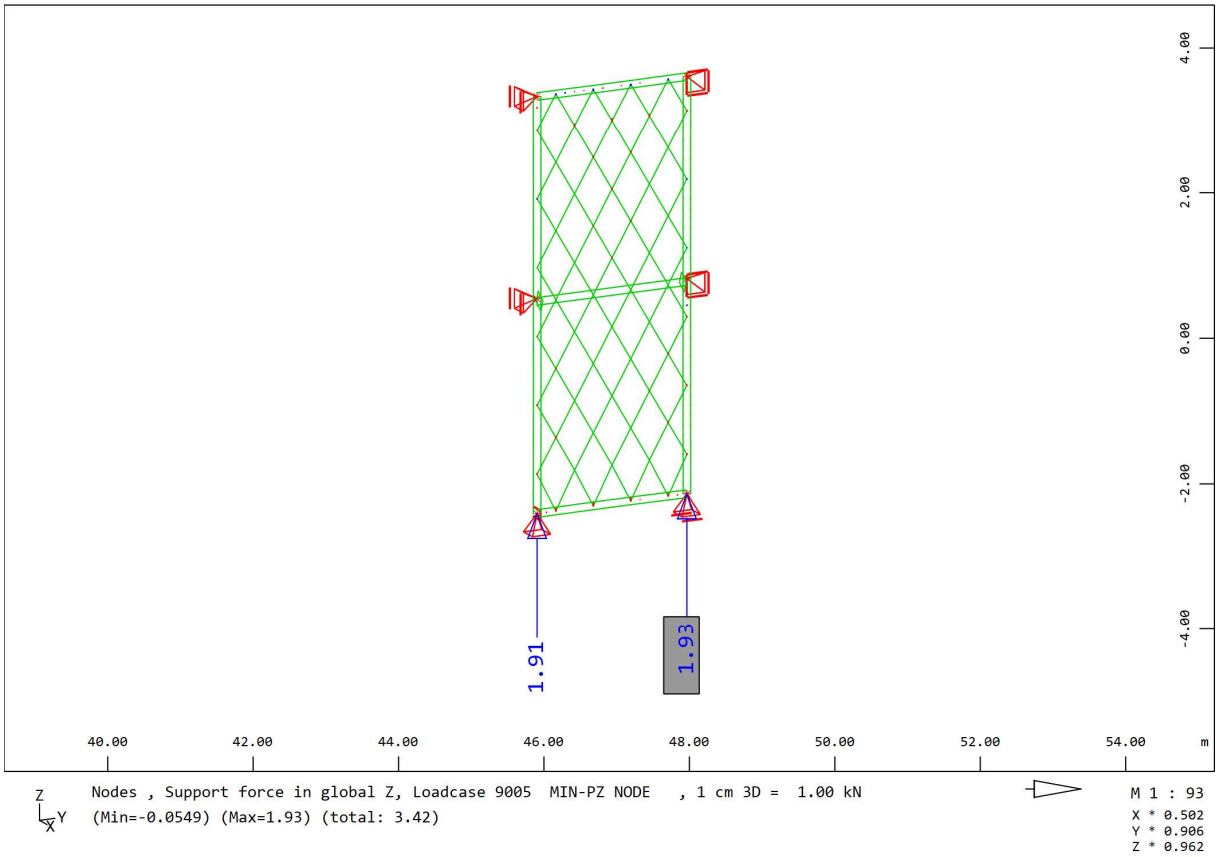





0.153
0.293
0.142
41.00
42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00
51.00
m
3.00
2.00
1.00
0.00
-1.00
-2.00
Z
Y
X
Sector of system Group 10 100
Nodes , Support force in global Y, Loadcase 9002 MAX-PY NODE , 1 cm 3D = 0.200 kN
(Min=-0.0176) (Max=0.293) (total: 1.06)
M 1 : 67
X * 0.502
Y * 0.906
Z * 0.962


0.154
0.295
0.150
42.00
43.00
44.00
45.00
46.00
47.00
48.00
49.00
50.00
51.00
52.00
m
3.00
2.00
1.00
0.00
-1.00
-2.00
Z
Y
X
Nodes , Support force in global Y, Loadcase 9003 MIN-PY NODE , 1 cm 3D = 0.200 kN
(Min=-0.295) (Max=0.0169) (total: -0.988)
M 1 : 67
X * 0.502
Y * 0.906
Z * 0.962


2.65
2.66
40.00
42.00
44.00
46.00
48.00
50.00
52.00
m
4.00
2.00
0.00
-2.00
-4.00
Z
Y
X
Sector of system Group 10 100
Nodes , Support force in global Z, Loadcase 9004 MAX-PZ NODE , 1 cm 3D = 2.00 kN
(Min=-0.0222) (Max=2.66) (total: 5.83)
M 1 : 85
X * 0.502
Y * 0.906
Z * 0.962


1.91
1.93
40.00
42.00
44.00
46.00
48.00
50.00
52.00
54.00
m
4.00
2.00
0.00
-2.00
-4.00
Z
Y
X
Nodes , Support force in global Z, Loadcase 9005 MIN-PZ NODE , 1 cm 3D = 1.00 kN
(Min=-0.0549) (Max=1.93) (total: 3.42)
M 1 : 93
X * 0.502
Y * 0.906
Z * 0.962

7 Nachweis im GZG

Nach DIN EN 1990 darf die Begrenzung der Durchbiegung nach folgendem Ansatz erfolgen: „Wenn das Erscheinungsbild des Tragwerks betroffen ist, sollte die quasi-ständige Kombination nach Gleichung (6.16b) verwendet werden“ (DIN EN 1990 A.1.4.3.(4)).

Daraus folgt:

$$\sum_{j\geq 1} G_{k,j} \text{ "+" } P \text{ "+" } \sum_{i\geq 1} \psi_{2,i}\, Q_{k,i} \qquad (6.16b)$$

Mit:

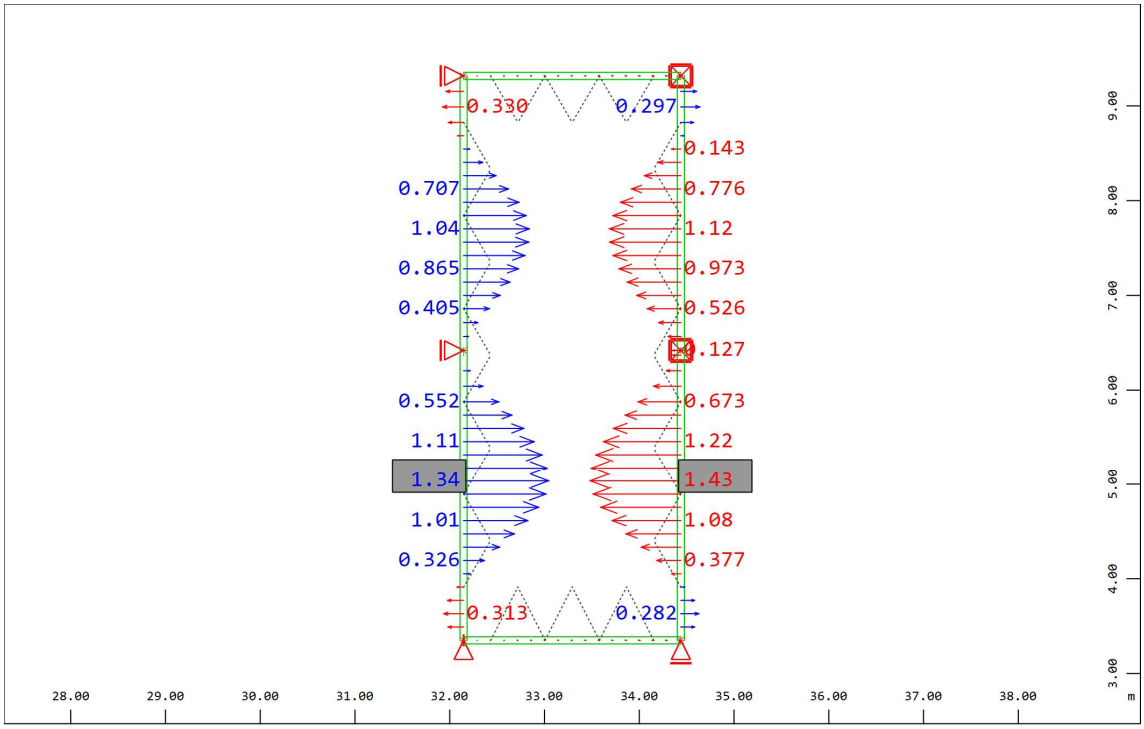
Einwirkung	ψ_0	ψ_1	ψ_2
Nutzlasten im Hochbau (siehe EN 1991-1-1)			
Kategorie A: Wohngebäude	0,7	0,5	0,3
Kategorie B: Bürogebäude	0,7	0,5	0,3
Kategorie C: Versammlungsbereiche	0,7	0,7	0,6
Kategorie D: Verkaufsflächen	0,7	0,7	0,6
Kategorie E: Lagerflächen	1,0	0,9	0,8
Fahrzeugverkehr im Hochbau Kategorie F: Fahrzeuggewicht ≤ 30kN	0,7	0,7	0,6
Kategorie G: 30kN < Fahrzeuggewicht ≤ 160kN	0,7	0,5	0,3
Kategorie H : Dächer	0	0	0
Schneelasten im Hochbau (siehe EN 1991-1-3)[a]			
— Finnland, Island, Norwegen, Schweden	0,7	0,5	0,2
— Für Orte in CEN-Mitgliedsstaaten mit einer Höhe über 1000 m ü. NN	0,7	0,5	0,2
— Für Orte in CEN-Mitgliedsstaaten mit einer Höhe niedriger als 1000 m ü. NN	0,5	0,2	0
Windlasten im Hochbau (siehe EN 1991-1-4)	0,6	0,2	0
Temperaturanwendungen (ohne Brand) im Hochbau, siehe EN 1991-1-5	0,6	0,5	0
ANMERKUNG Die Festlegung der Kombinationsbeiwerte erfolgt im Nationalen Anhang.			
[a] Bei nicht ausdrücklich genannten Ländern sollten die maßgebenden örtlichen Bedingungen betrachtet werden.			

Für die veränderliche Last aus Windund Temperatur wird in diesem Fall ein Beiwert $\psi_2 = 0$ empfohlen, sodass nur die Kombination aus Eigengewicht und Vorspannung maßgebend ist.

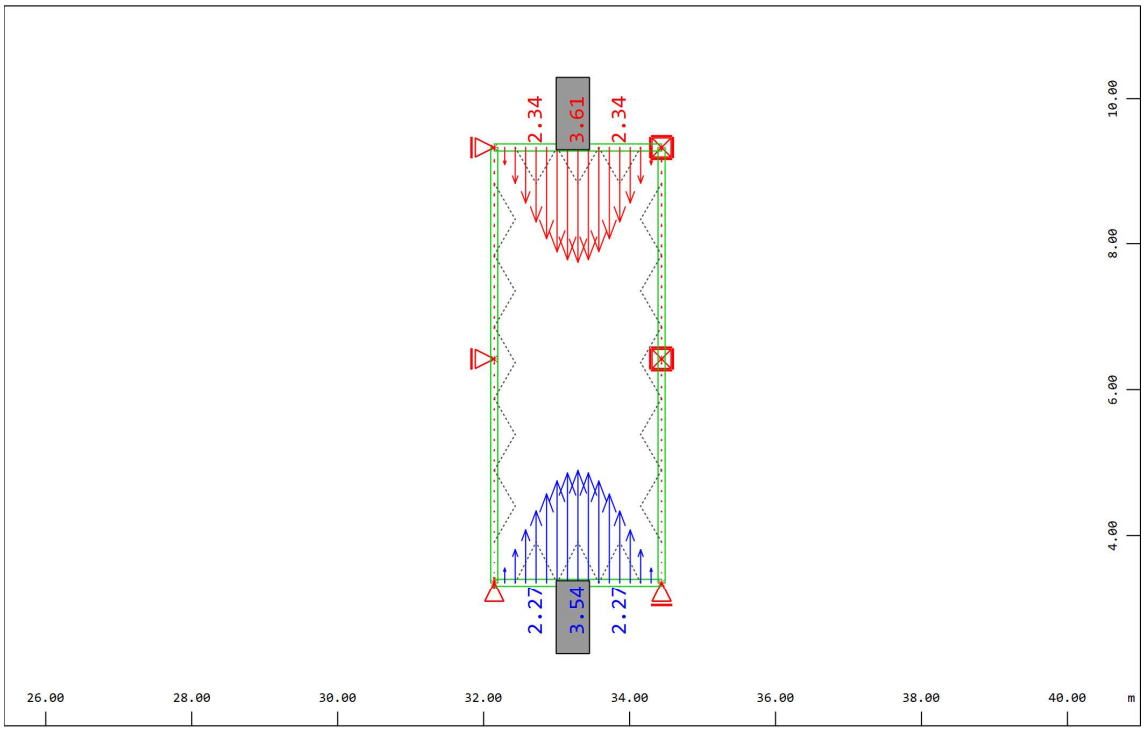
Auf den folgenden Abbildungen sind die Verformungen der Rahmen für die beiden Lastfälle abgebildet.

7.1 Großer Fassadenrahmen

Verformung infolge Vorspannung

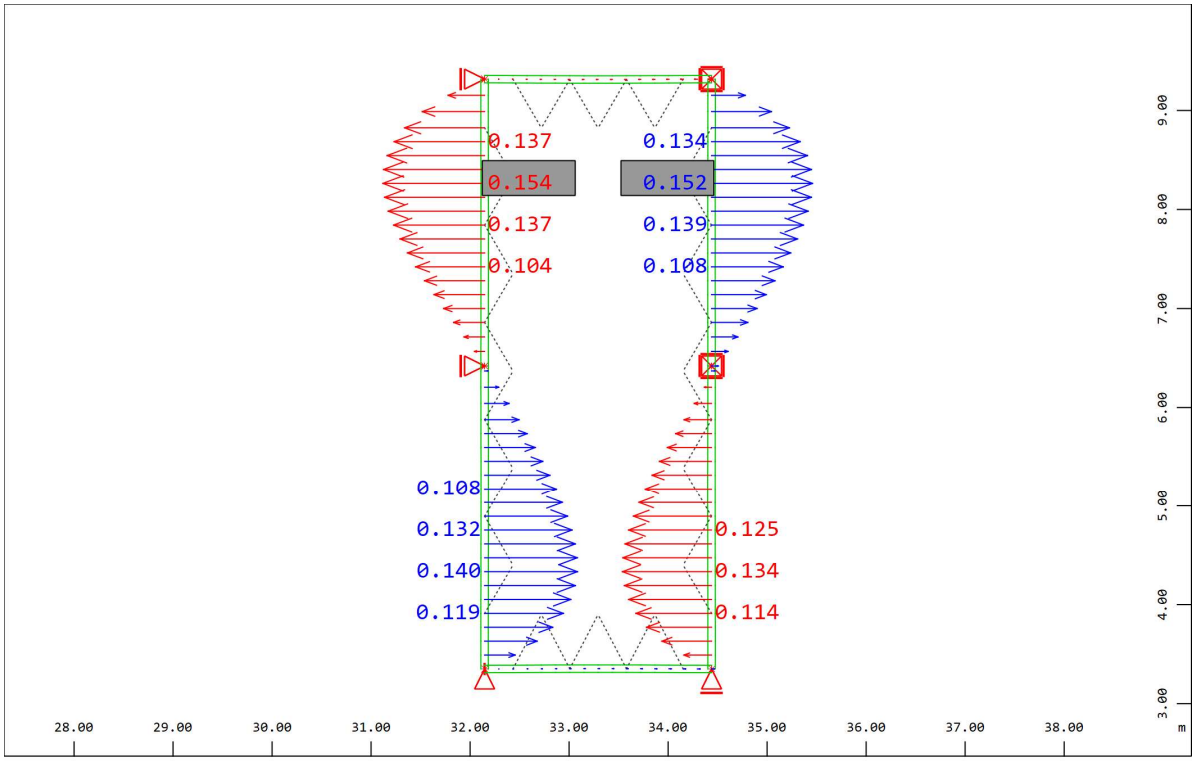


Sector of system Group 100 M 1 : 67
Nodal displacement in global Y, nonlinear Loadcase 1 FORMFINDING , 1 cm 3D = 1.00 mm
(Min=-1.43) (Max=1.34)

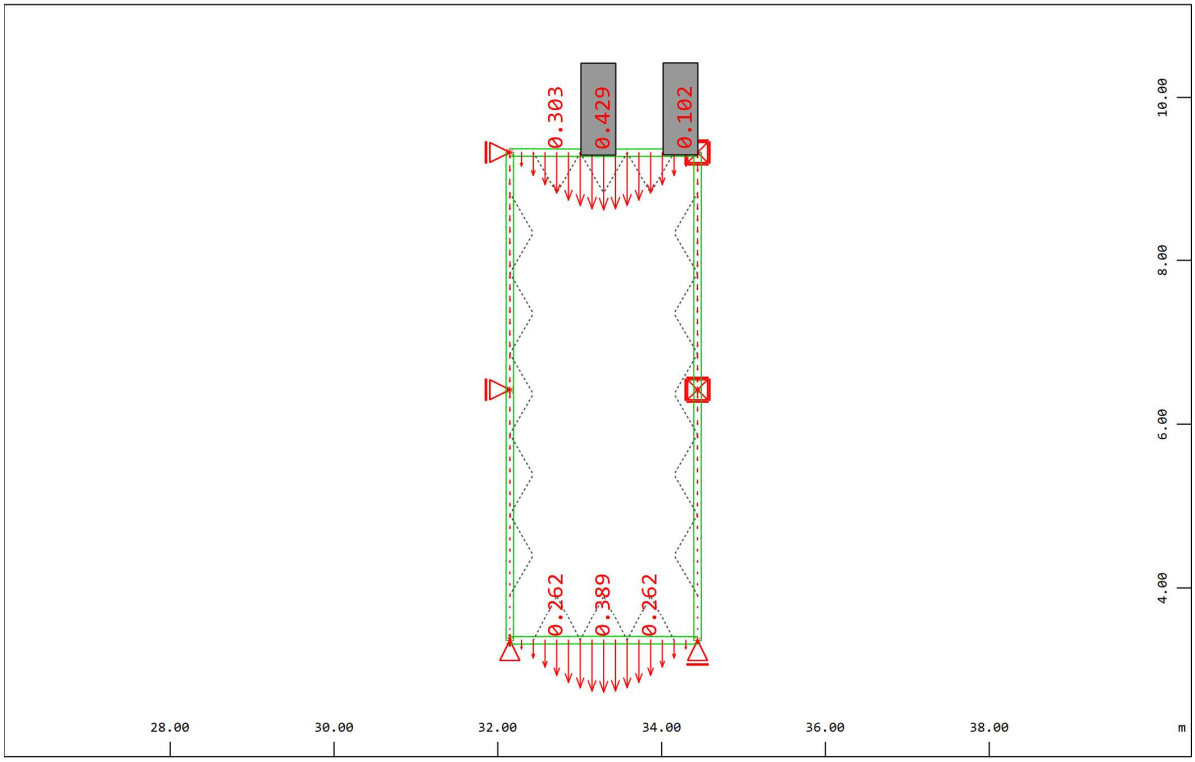


Sector of system Group 100 M 1 : 87
Nodal displacement in global Z, nonlinear Loadcase 1 FORMFINDING , 1 cm 3D = 2.00 mm
(Min=-3.61) (Max=3.54)

Verformung infolge Eigengewicht



Sector of system Group 100 M 1 : 67
Nodal displacement in global Y, nonlinear Loadcase 100 SLS 100 , 1 cm 3D = 0.100 mm
(Min=-0.154) (Max=0.152)



Sector of system Group 100 M 1 : 81
Nodal displacement in global Z, nonlinear Loadcase 100 SLS 100 , 1 cm 3D = 0.500 mm
(Min=-0.429) (Max=0)

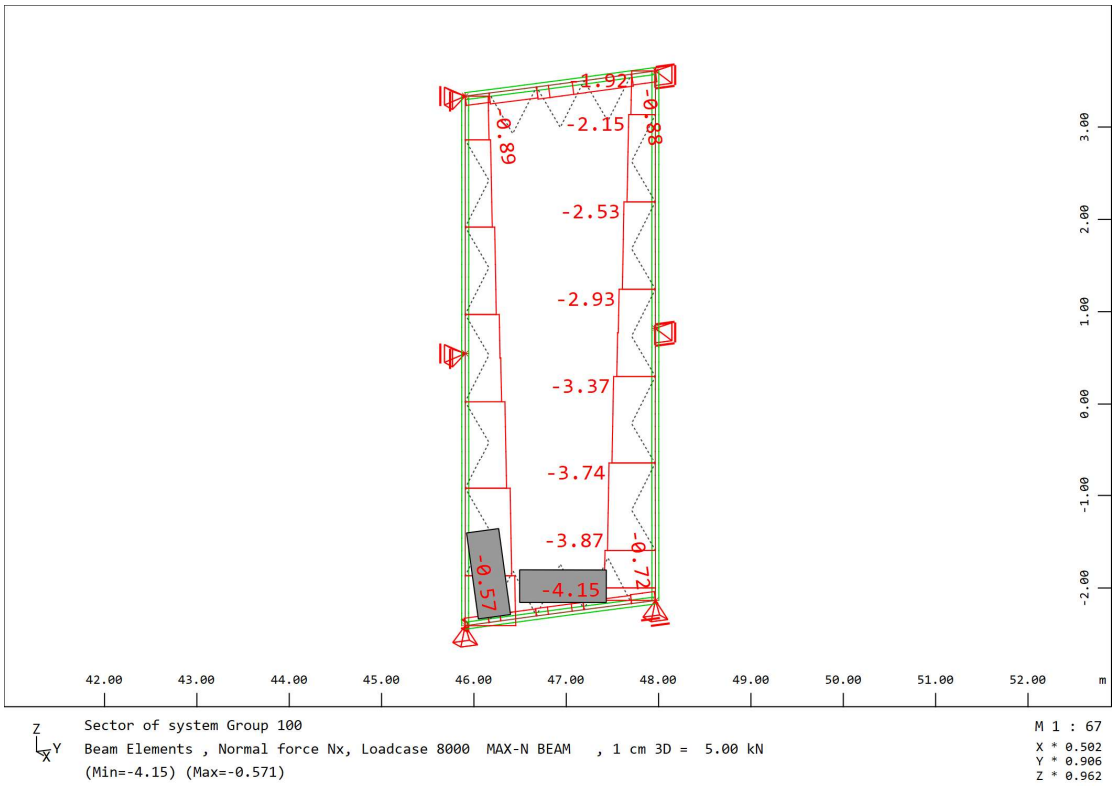
Die maßgebende Verformung des Rahmens stellt sich an der horizontalen Seite mit insgesamt

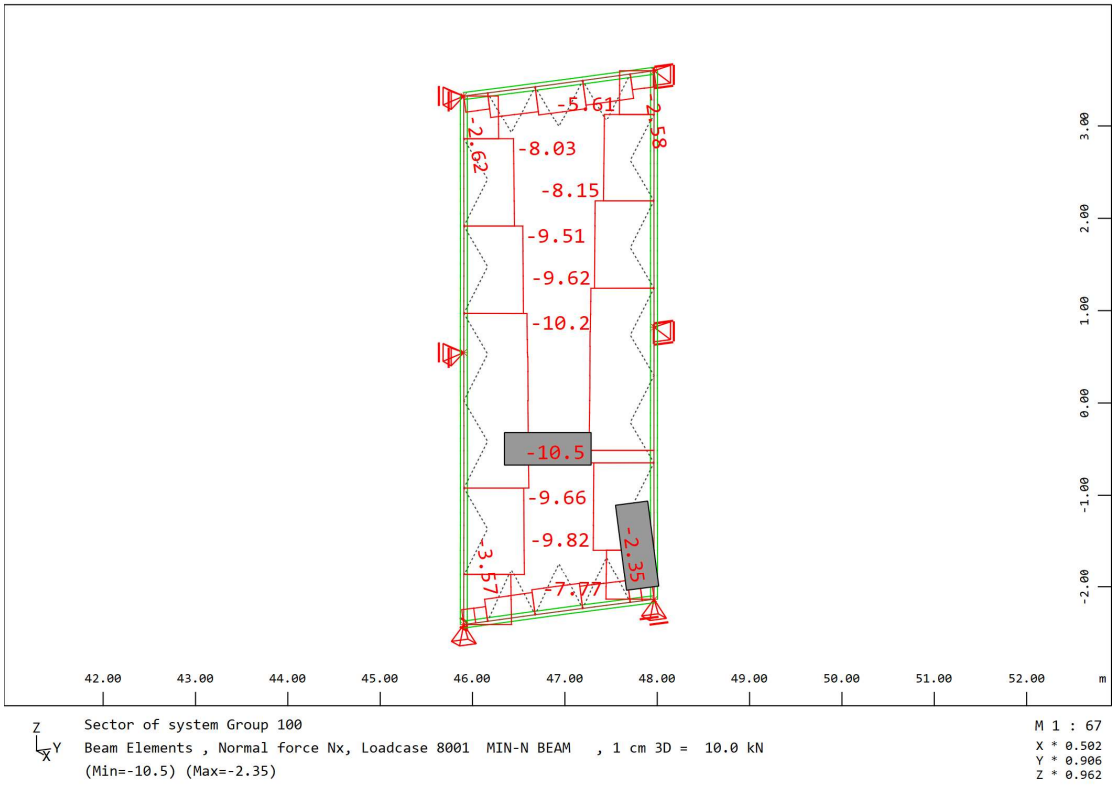
$$3{,}6 \text{ mm} + 0{,}4 \text{ mm} = 4 \text{ mm}$$

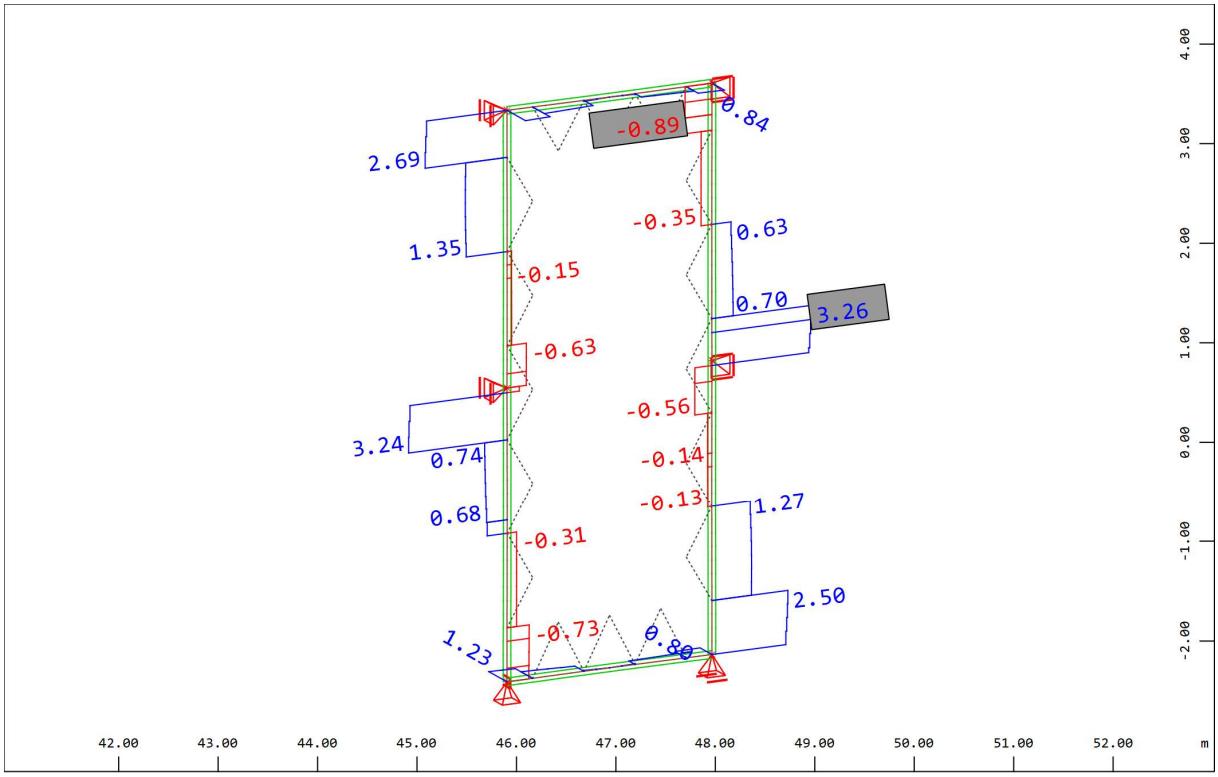
ein. Dieser Wert liegt deutlich unter dem zulässigen Grenzwert von l/300 = 8 mm.

8 Nachweis im GZT

8.1 Schnittgrößen Rahmen



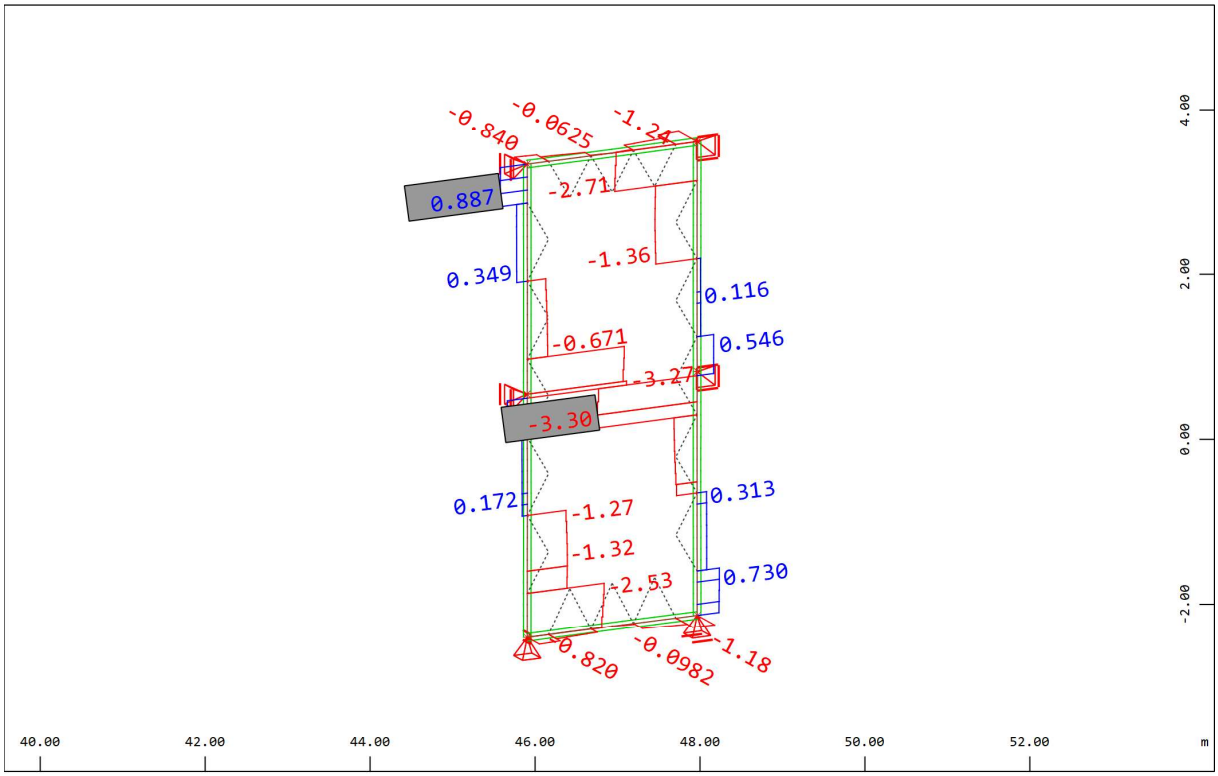




Z
Y
X

Sector of system Group 100
Beam Elements , Shear force Vy, Loadcase 8002 MAX-VY BEAM , 1 cm 3D = 2.00 kN
(Min=-0.888) (Max=3.26)

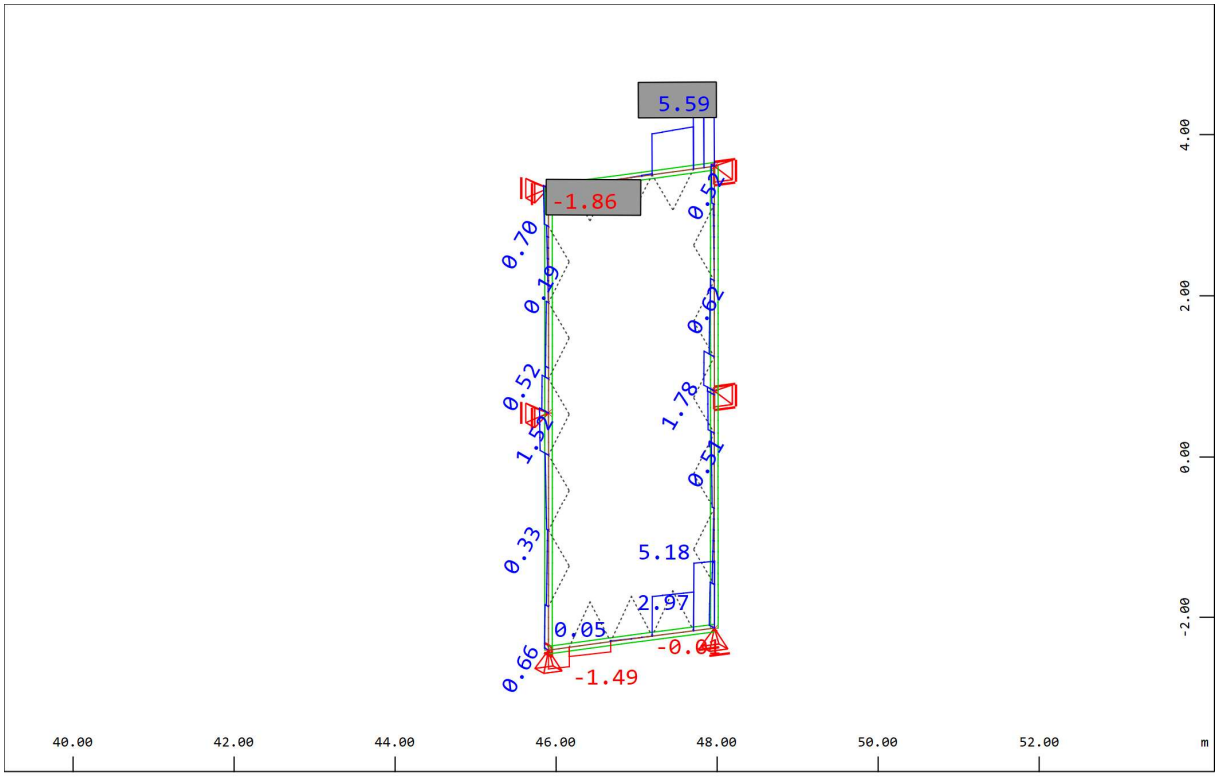
M 1 : 68
X * 0.502
Y * 0.906
Z * 0.962



Z
Y
X

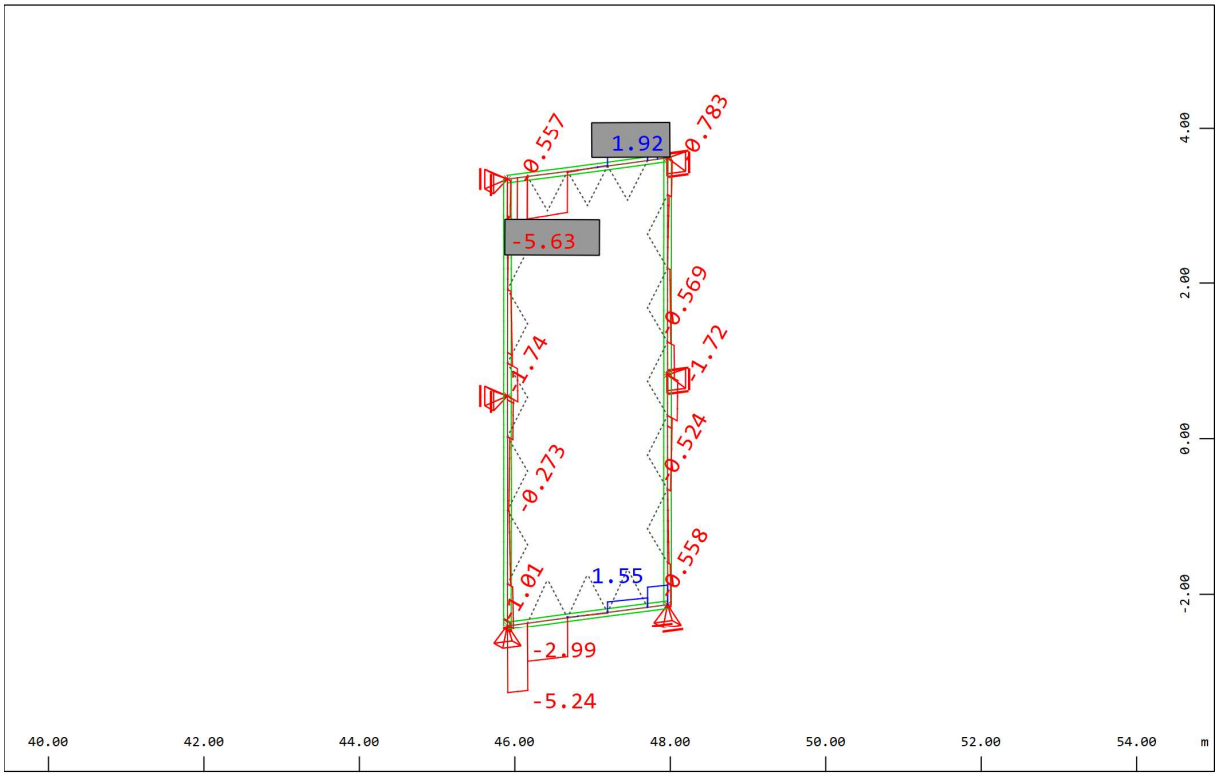
Sector of system Group 100
Beam Elements , Shear force Vy, Loadcase 8003 MIN-VY BEAM , 1 cm 3D = 2.00 kN
(Min=-3.30) (Max=0.887)

M 1 : 82
X * 0.502
Y * 0.906
Z * 0.962



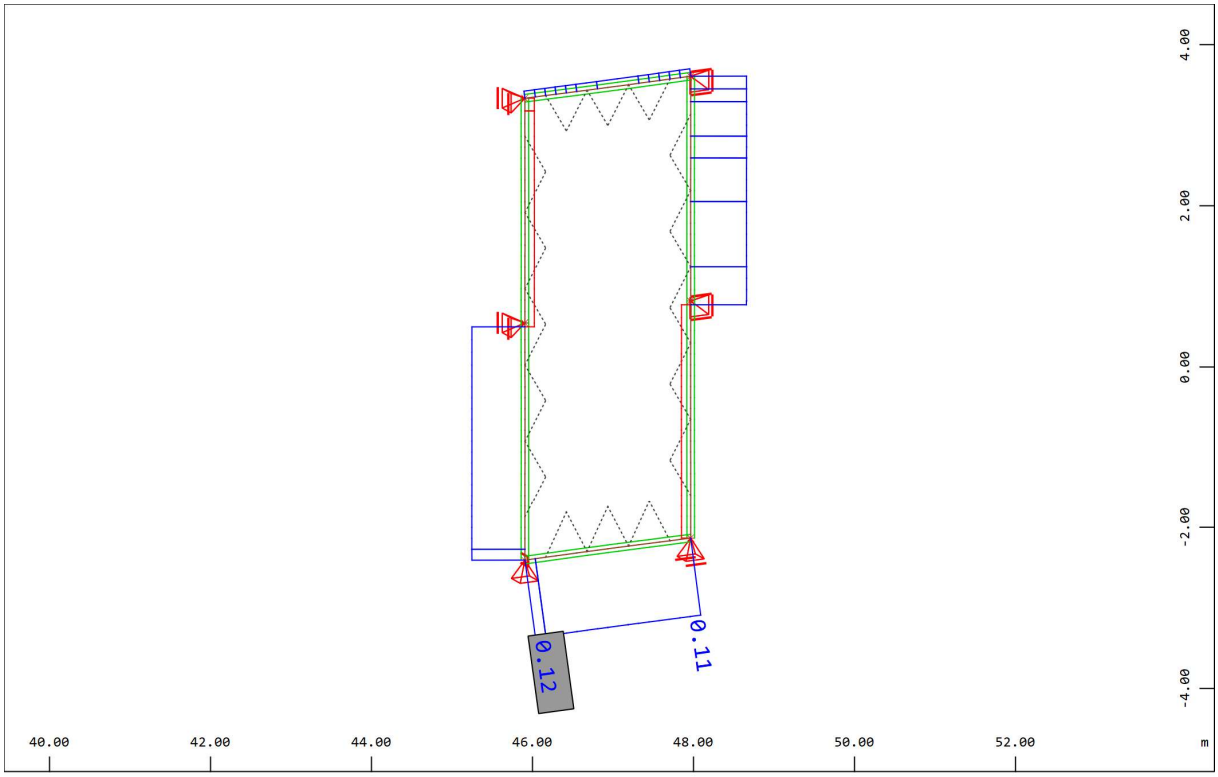
Sector of system Group 100
Beam Elements , Shear force Vz, Loadcase 8004 MAX-VZ BEAM , 1 cm 3D = 5.00 kN
(Min=-1.86) (Max=5.59)

M 1 : 84
X * 0.502
Y * 0.906
Z * 0.962



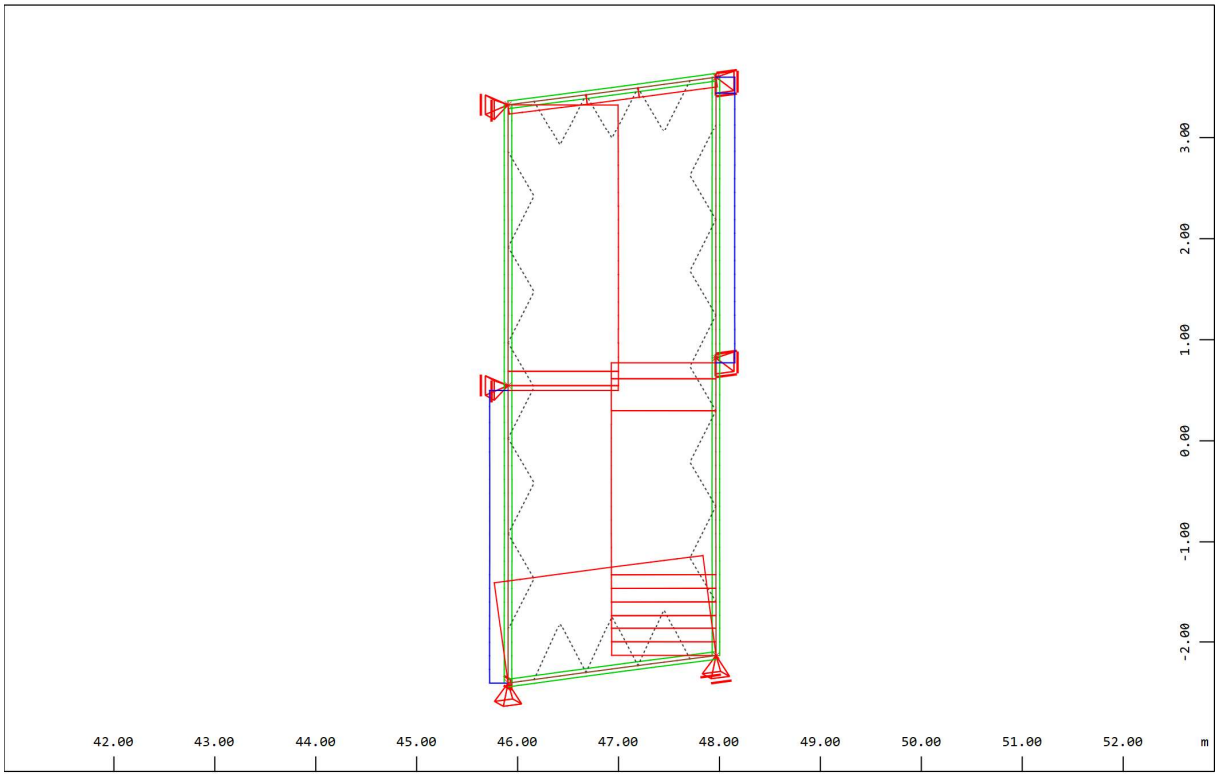
Sector of system Group 100
Beam Elements , Shear force Vz, Loadcase 8005 MIN-VZ BEAM , 1 cm 3D = 5.00 kN
(Min=-5.63) (Max=1.92)

M 1 : 87
X * 0.502
Y * 0.906
Z * 0.962



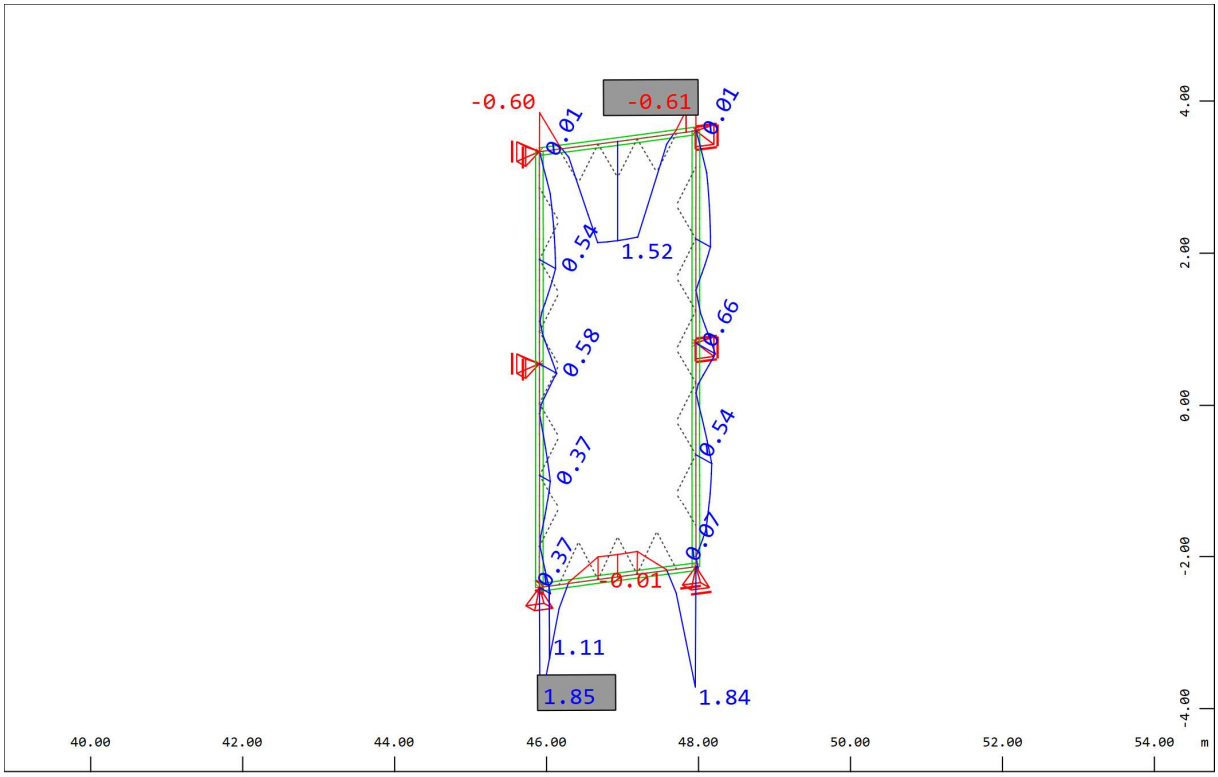
Sector of system Group 100
Beam Elements , Torsional moment Mt, Loadcase 8006 MAX-MT BEAM , 1 cm 3D = 0.100 kNm
(Min=-0.0139) (Max=0.115)

M 1 : 84
X * 0.502
Y * 0.906
Z * 0.962



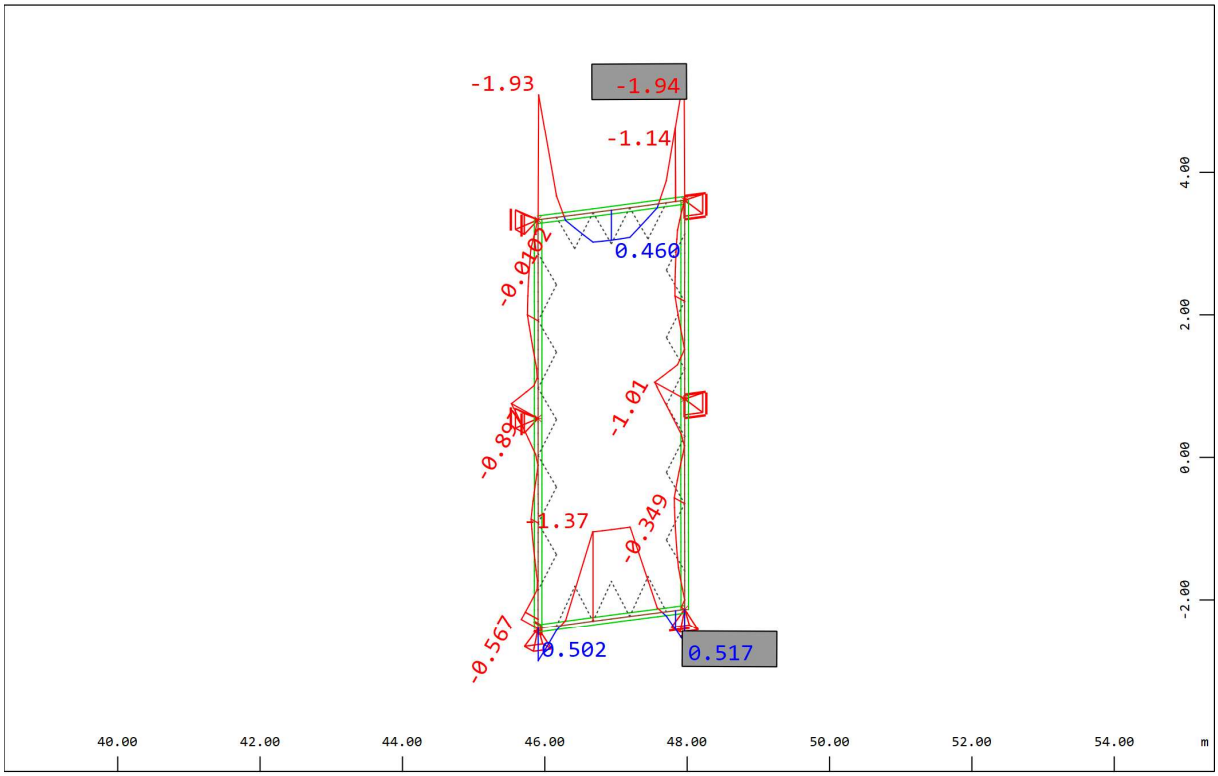
Sector of system Group 100
Beam Elements , Torsional moment Mt, Loadcase 8007 MIN-MT BEAM , 1 cm 3D = 0.0500 kNm
(Min=-0.0816) (Max=0.0139)

M 1 : 67
X * 0.502
Y * 0.906
Z * 0.962



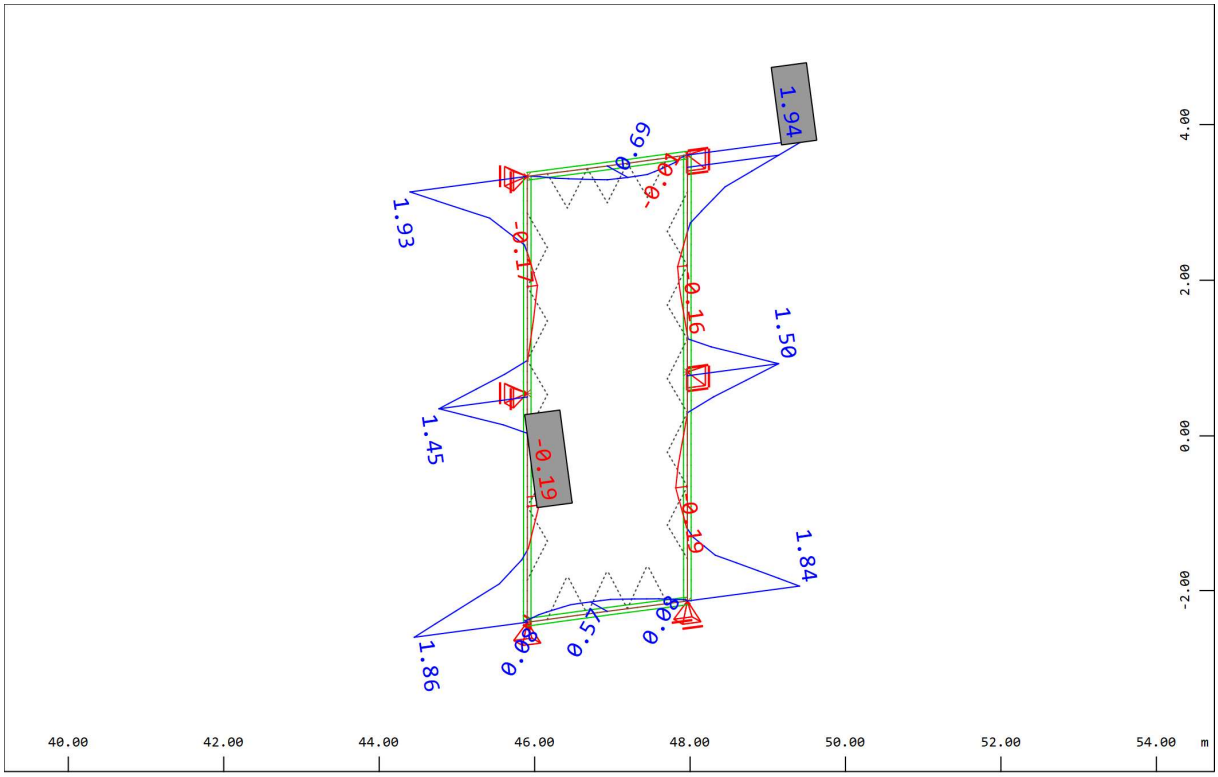
Sector of system Group 100
Beam Elements , Bending moment My, Loadcase 8008 MAX-MY BEAM , 1 cm 3D = 1.00 kNm
(Min=-0.614) (Max=1.85)

M 1 : 89
X * 0.502
Y * 0.906
Z * 0.962



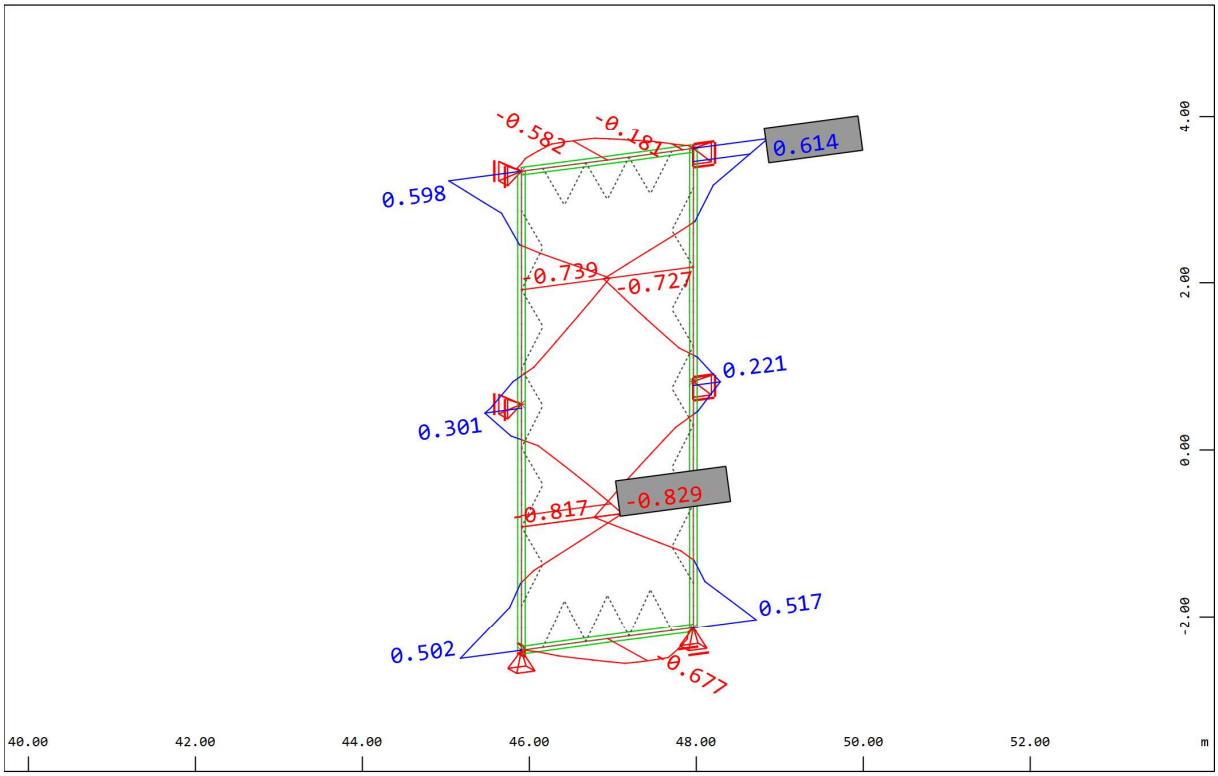
Sector of system Group 100
Beam Elements , Bending moment My, Loadcase 8009 MIN-MY BEAM , 1 cm 3D = 1.00 kNm
(Min=-1.94) (Max=0.517)

M 1 : 95
X * 0.502
Y * 0.906
Z * 0.962



Z Y X
Sector of system Group 100
Beam Elements , Bending moment Mz, Loadcase 8010 MAX-MZ BEAM , 1 cm 3D = 1.00 kNm
(Min=-0.194) (Max=1.94)

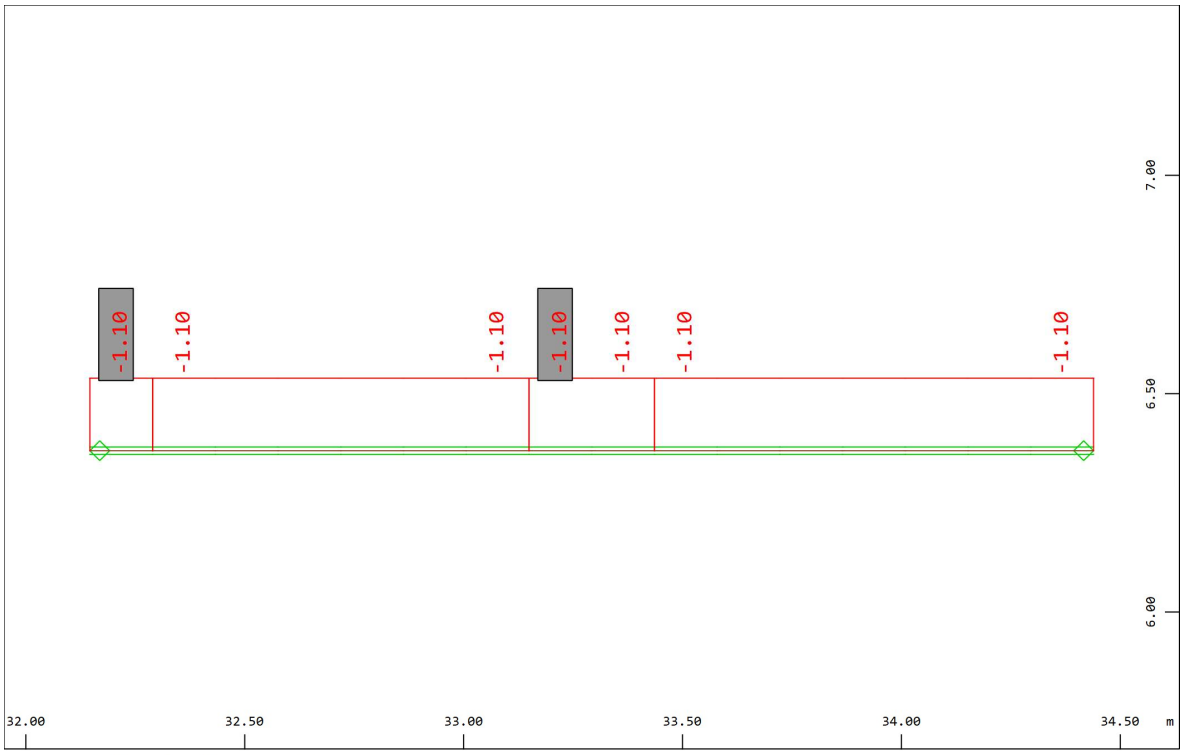
M 1 : 87
X * 0.502
Y * 0.906
Z * 0.962



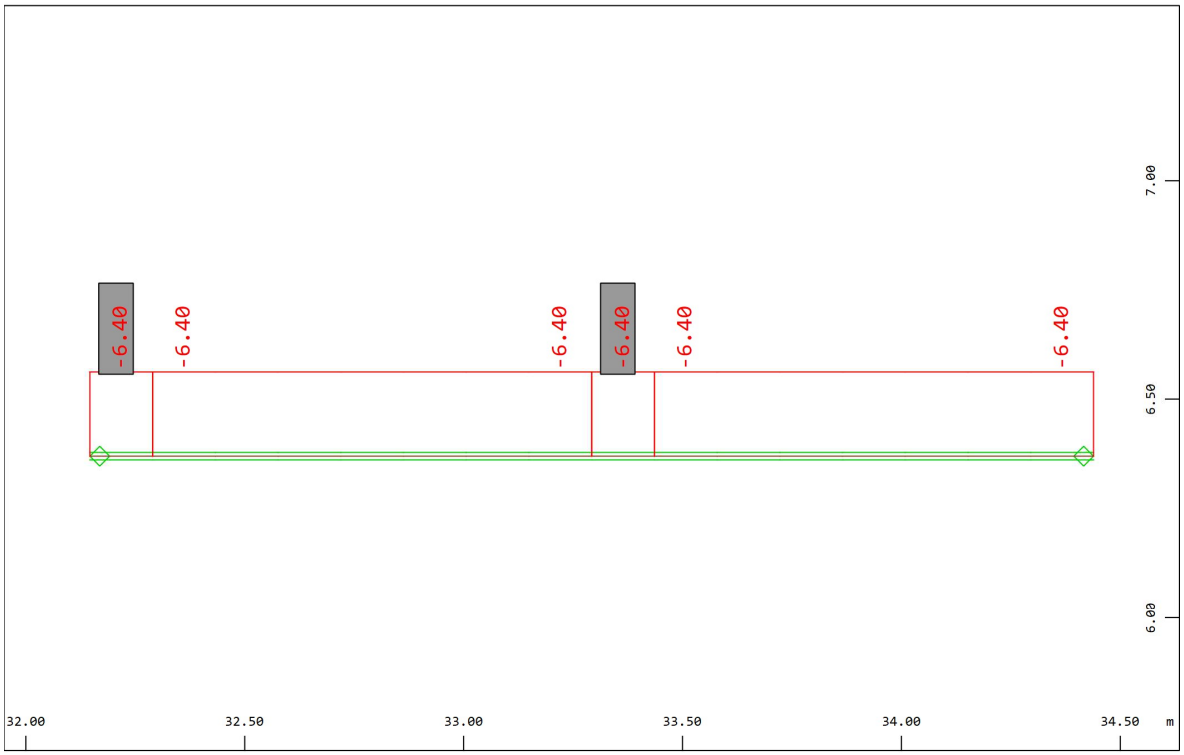
Z Y X
Sector of system Group 100
Beam Elements , Bending moment Mz, Loadcase 8011 MIN-MZ BEAM , 1 cm 3D = 0.500 kNm
(Min=-0.829) (Max=0.614)

M 1 : 81
X * 0.502
Y * 0.906
Z * 0.962

8.2 Schnittgrößen Druckstab

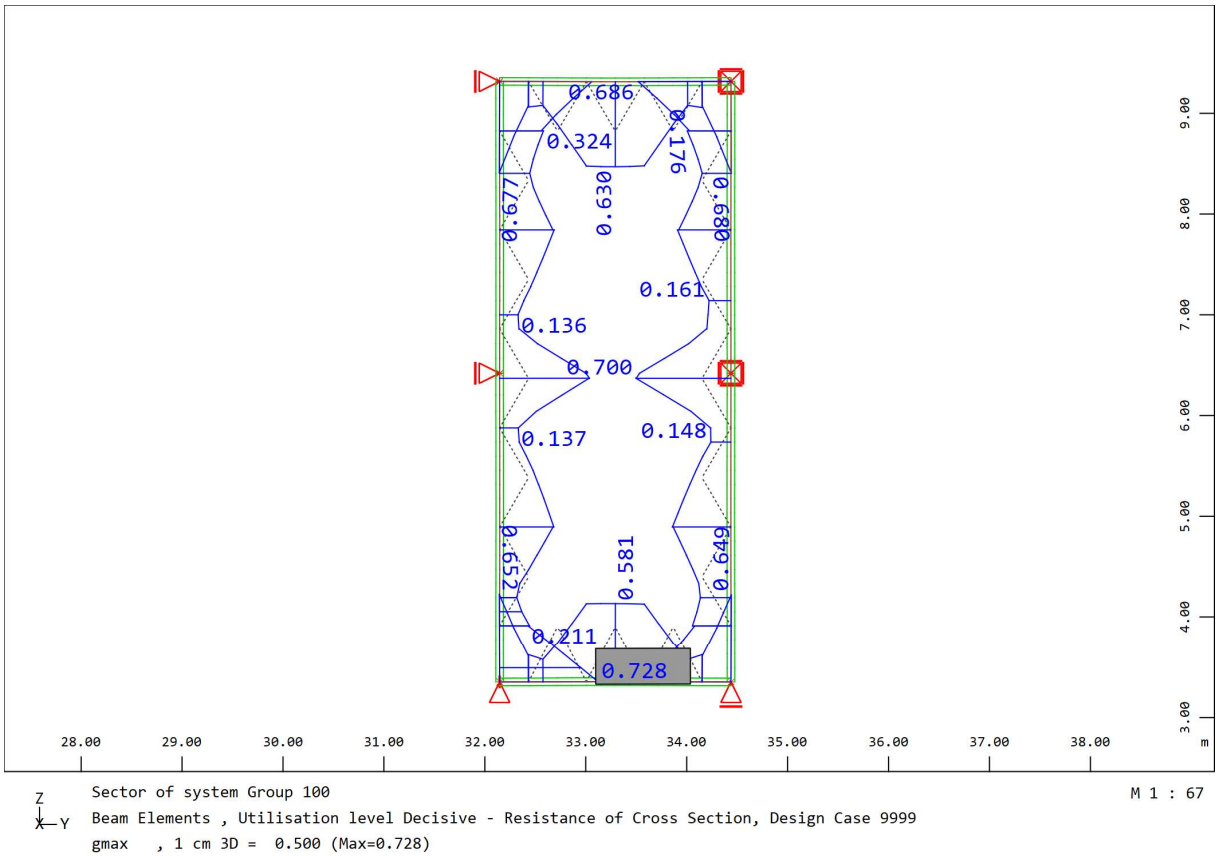


Sector of system Group 110 M 1 : 15
Beam Elements , Normal force Nx, Loadcase 8000 MAX-N BEAM , 1 cm 3D = 1.00 kN
(Min=-1.10) (Max=-1.10)



Sector of system Group 110 M 1 : 15
Beam Elements , Normal force Nx, Loadcase 8001 MIN-N BEAM , 1 cm 3D = 5.00 kN
(Min=-6.40) (Max=-6.40)

8.3 Bemessung Rahmen



Mit der maßgebenden Druck-Normalkraft von 10,5 kN wird der Stabilitätsnachweis geführt.

Der Nachweis wird mit dem Frilo Modul STX geführt.

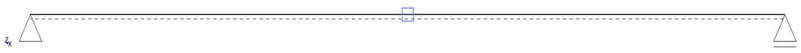
Stabilitätsnachweis STX+ 02/21 (FRILO R-2021-2/P09)

Grundparameter

Bemessungsnorm	:	DIN EN 1993-1-1/NA:2015-08
Sicherheitskonzept/Lastkombinatorik	:	DIN EN 1990/NA:2010-12
Querschnittsbemessung	:	plastisch
Stabilitätsnachweis nach	:	6.3.3 - Anhang B

System

Systemgrafik



Trägerlänge	:	3.10 m
Material	:	S235
Querschnitt	:	QRO 50X4

Lagerbedingungen - Verschiebungen,Verdrehungen

		Verschiebungen*)			Verdrehungen*)		
Nr	x [m]	ux [kN/m]	uy [kN/m]	uz [kN/m]	Φ_x [kNm/rad]	Φ_y [kNm/rad]	Φ_z [kNm/rad]
1	0.00	-1	-1	-1	-1	0.0	0.0
2	3.10	0.00	-1	-1	-1	0.0	0.0

*)-1 = starr, 0 = frei, > 0 = elastisch

Belastung

Belastung

Schnittgrößen

x [m]	N_{Ed} [kN]	$V_{z,Ed}$ [kN]	$M_{y,Ed}$ [kNm]	$V_{y,Ed}$ [kN]	$M_{z,Ed}$ [kNm]
0.00	-11.0	0.0	0.00	0.0	0.00
3.10	-11.0	0.0	0.00	0.0	0.00

Ergebnisse

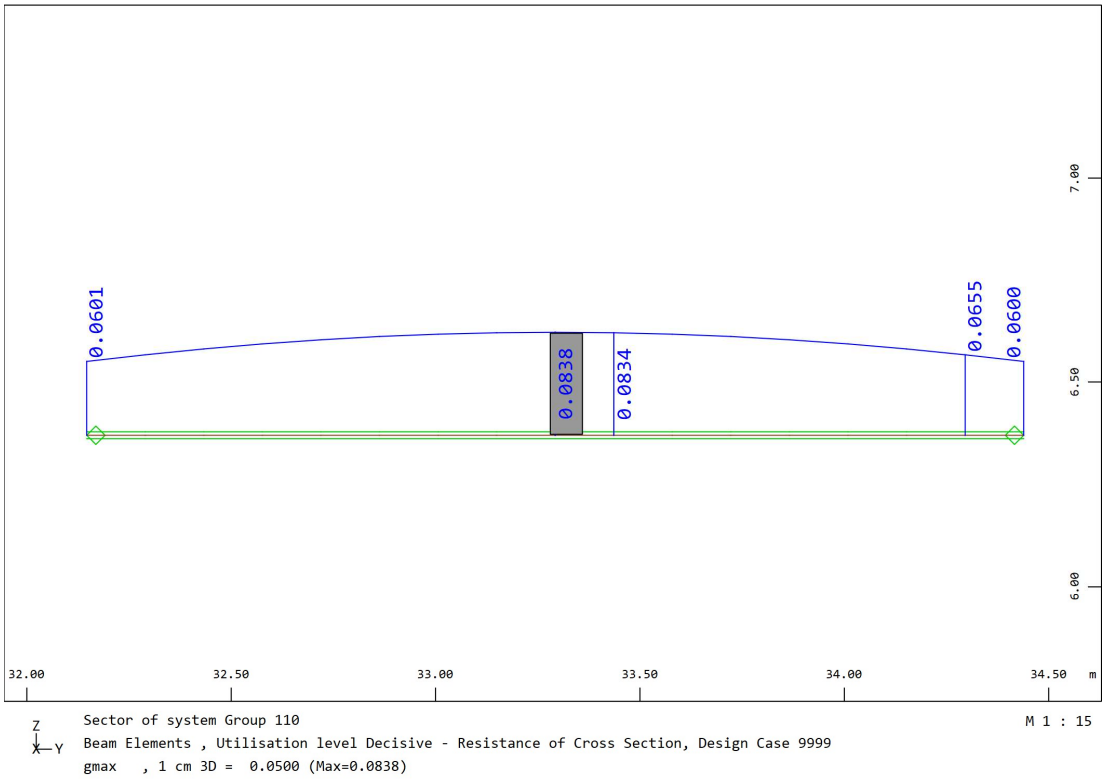
Stabilitätsnachweis zentrische Normalkraft (Gl. 6.46)

$N_{Ed}/ (\chi_y * N_{Rd}) =$ **0.25** $N_{Ed}/ (\chi_z * N_{Rd}) =$ **0.25**

N_{Ed}	=	11.0 kN	N_{Rk}	=	169.7 kN
s_{ky}	=	3.10 m	s_{kz}	=	3.10 m
λ_y	=	1.76	λ_z	=	1.76
$N_{cr,y}$	=	54.8 kN	$N_{cr,z}$	=	54.8 kN
χ_y	=	0.28	χ_z	=	0.28
γ_{M1}	=	1.10			

Nachweis bei x = 0.00 m nach Gl. (6.46) erfüllt.

8.4 Bemessung Druckstab



Mit der maßgebenden Druck-Normalkraft von 6,5 kN wird der Stabilitätsnachweis geführt.

Der Nachweis wird mit dem Frilo Modul STX geführt.

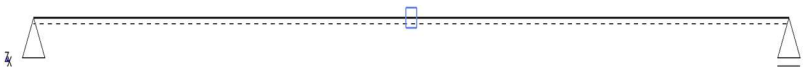
Stabilitätsnachweis STX+ 02/21 (FRILO R-2021-2/P09)

Grundparameter

Bemessungsnorm	:	DIN EN 1993-1-1/NA:2015-08
Sicherheitskonzept/Lastkombinatorik	:	DIN EN 1990/NA:2010-12
Querschnittsbemessung	:	plastisch
Stabilitätsnachweis nach	:	6.3.3 - Anhang B

System

Systemgrafik



Trägerlänge	:	2.50 m
Material	:	S235
Querschnitt	:	QRO 40X3.2

Lagerbedingungen - Verschiebungen,Verdrehungen

		Verschiebungen*)			Verdrehungen*)		
Nr	x [m]	ux [kN/m]	uy [kN/m]	uz [kN/m]	Φ_x [kNm/rad]	Φ_y [kNm/rad]	Φ_z [kNm/rad]
1	0.00	-1	-1	-1	-1	0.0	0.0
2	2.50	0.00	-1	-1	-1	0.0	0.0

*)-1 = starr, 0 = frei, > 0 = elastisch

Belastung

Belastung

Schnittgrößen

x [m]	N_{Ed} [kN]	$V_{z,Ed}$ [kN]	$M_{y,Ed}$ [kNm]	$V_{y,Ed}$ [kN]	$M_{z,Ed}$ [kNm]
0.00	-7.0	0.0	0.00	0.0	0.00
2.50	-7.0	0.0	0.00	0.0	0.00

Ergebnisse

Stabilitätsnachweis zentrische Normalkraft (Gl. 6.46)

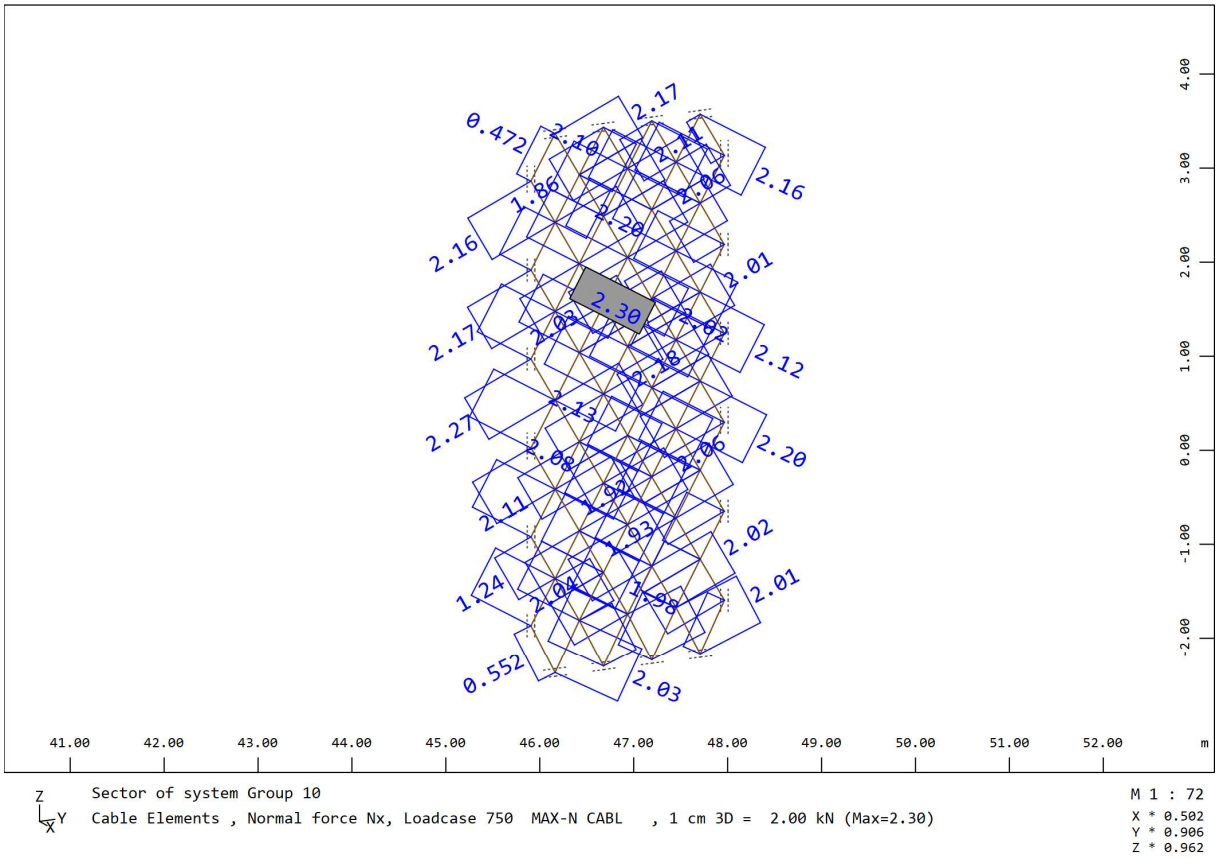
$N_{Ed}/ (\chi_y * N_{Rd}) =$ **0.26** $N_{Ed}/ (\chi_z * N_{Rd}) =$ **0.26**

N_{Ed}	=	7.0 kN	N_{Rk}	=	108.6 kN
s_{ky}	=	2.50 m	s_{kz}	=	2.50 m
λ_y	=	1.77	λ_z	=	1.77
$N_{cr,y}$	=	34.5 kN	$N_{cr,z}$	=	34.5 kN
χ_y	=	0.28	χ_z	=	0.28
γ_{M1}	=	1.10			

Nachweis bei x = 0.00 m nach Gl. (6.46) erfüllt.

8.5 Seilnetz

Folgend sind die maximalen Seilkräfte der beiden Rahmenvarianten dargestellt.



Die Grenzzugkraft der Seile berechnet sich aus der Mindestbruchkraft und dem Verlustfaktor nach EC3 sowie dem Teilsicherheitsbeiwert:

$$F_{Rd} = (5{,}12 \times 0{,}8) / 1{,}5 = 2{,}73 \text{ kN}$$

Somit ist der Seilwiderstand größer als die maximale Einwirkung von 2,3 kN.

Der angesetzte Verlustfaktor ist auf Grund aktuell fehlender Testergebnisse im Nachgang zu bestätigen oder die Grenzzugkraft der Seile entsprechend anzupassen.

9 Details

9.1 Anschluss Rahmen – Grid

Für den Anschluss der Rahmen an die Holz-Unterkonstruktion werden Stahllaschen an die Rahmen angeschweißt und mit der Verankerungskonsole verschraubt. Das entsprechende Gegenstück aus einer Stahlplatte mit angeschweißter Stahllaschen wird im dahinterliegenden Holzgrid befestigt. Im Folgenden werden die Detailnachweise der Anschlüsse geführt.

Max. Auflagerkräfte gem. Abschnitt 6:

$P_x = 3{,}5$ kN
$P_y = 0{,}5$ kN
$P_z = 2{,}7$ kN

Damit ergeben sich die folgenden maßgebenden Einwirkungen auf die Schrauben

$F_{t,Ed} = 4$ kN
$F_{v,Ed} = 6$ kN

Schraubennachweise nach DIN EN 1993-1-8 3.6.1

Querschnittswerte							
Schraubengröße	M 10						
Festigkeitsklasse	8.8						
	d=	10 [mm]	f_{yb}=	640 [N/mm²]	e_1=	15 [mm]
Lochspiel	Δd=	1 [mm]	f_{ub}=	800 [N/mm²]	e_2=	15 [mm]
Lochdurchmesser	d_0=	11 [mm]			p_1=	15 [mm]
	A=	79 [mm²]	f_y=	S 235 [N/mm²]	p_2=	0 [mm]
	A_s=	58 [mm²]	f_u=	360 [N/mm²]		
Bauteildicke	t=	5 [mm]				
Einwirkungen						
Abscherkraft	$F_{v,Ed}$=	6 [kN]				
Zugkraft	$F_{t,Ed}$=	4 [kN]				

Nachweise

Abscheren	Scherfuge im Gewinde	α_v=	0,6		
	Grenzabscherkraft	$F_{v,Rd}$=	22,27 [kN]		
	Nachweis	$\frac{F_{v,Ed}}{F_{v,Rd}}$ =	0,27	≤ 1,0	**Nachweis erbracht**
Zug	Grenzzugkraft	$F_{t,Rd}$=	33,408 [kN]	mit k_2= 0,9	
	Nachweis	$\frac{F_{v,Ed}}{F_{v,Rd}}$ =	0,12	≤ 1,0	**Nachweis erbracht**
Zug und Abscheren	Nachweis	$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1{,}4 \cdot F_{t,Rd}}$ =	0,36	≤ 1,0	**Nachweis erbracht**
Lochleibung	Randschraube quer zur Kraftrichtung	α_b=	0,45		
		k_1=	2,50		
	Grenzlochleibungskraft	$F_{b,Rd}$=	9,72 [kN]	Abminderungsfaktor für Langloch: 0,6	
	Nachweis	$\frac{F_{b,Ed}}{F_{b,Rd}}$ =	0,62	≤ 1,0	**Nachweis erbracht**

Nachweis der Laschen

Abmessung	50 mm x 50 mm x 10 mm	
Fläche	$A = 0{,}05 \times 0{,}01 = 5e\text{-}4\ m^2$	
Widerstand	$I_y = 0{,}05 \times 0{,}01^2 / 6 = 8{,}3e\text{-}7\ m^3$	
Moment	$M_e = 2{,}7 \times 0{,}025 = 0{,}0675\ kN/m$	
Normalspannung	$\sigma = N/A + M/W = 87\ N/mm^2$	$< 235\ N/mm^2$
Schubspannung	$\tau = sqrt(3{,}5^2 + 0{,}2^2) / A = 7{,}5\ N/mm^2$	$< 135{,}6\ N/mm^2$
Vergleichsspannung	$\sigma_v = 88\ N/mm^2$	$< 235\ N/mm^2$

Nachweis der Schweißnaht Lasche – Rahmen/Konsolenplatte

Die Schweißnaht wird als HV-Naht mit a = t ausgeführt. Mit dem Querschnittsnachweis gilt diese Schweißnaht somit ebenfalls als nachgewiesen.

Nachweis der Holzschrauben

Auf der kommenden Seite ist eine Skizze zu Schraubenabständen in der Konsolenplatte dargestellt.

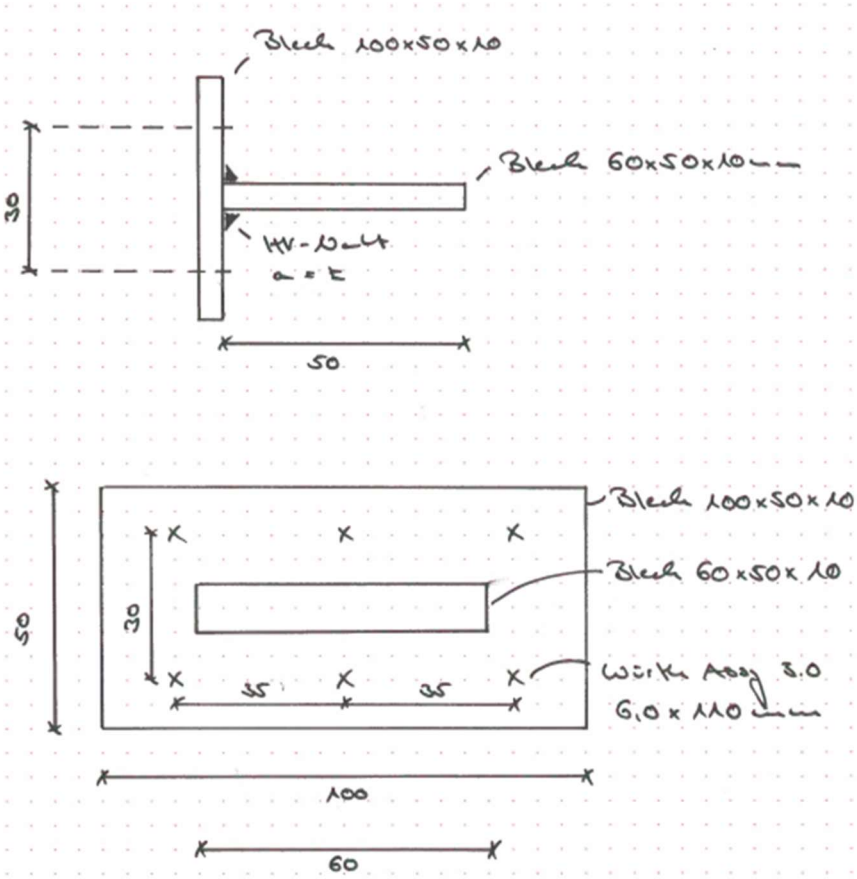
Moment	$M_{max} = 0{,}1\ kNm$
Kräftepaar	$Z = 0{,}1/0{,}03 = 3{,}3\ kN$

$F_{t,Ed} = (3{,}5 + 3{,}3)/3 = 2{,}3\ kN$
$F_{v,Ed} = 1\ kN$

Würt Assy 3.0: 6,0 x 110 mm

6x100 mm	2,55	2,02	2,55	2,02	2,55	2,02	2,55	2,02	2,55	2,02	2,55	2,02	2,55	2,02
		2,39		2,39		2,39		2,39		2,39		2,39		2,39
ASSY 3.0 6x110 mm	4,83	3,46	4,83	3,46	4,83	3,46	4,83	3,46	4,83	3,46	4,83	3,46	4,83	3,46
		4,06		4,06		4,06		4,06		4,06		4,06		4,06
	2,97	2,13	2,97	2,13	2,97	2,13	2,97	2,13	2,97	2,13	2,97	2,13	2,97	2,13
		2,50		2,50		2,50		2,50		2,50		2,50		2,50

$F_{t,Rd} = 4{,}83 \times 0{,}75/1{,}3 = 2{,}8\ kN$	OK.
$F_{v,Rd} = 3{,}46 \times 0{,}75/1{,}3 = 2{,}0\ kN$	OK.



Nachweis der „Kralle“

Mit den vorangegangenen Nachweisen sind die Nachweise der „Kralle“ ebenfalls erfüllt unter der Voraussetzung, dass eine Blechstärke von 10 mm vorhanden ist.
Die Konsolenplatte verbreitert sich auf 120 mm, um so ein Verschrauben der Konsolenplatte mit der Holzunterkonstruktion zu ermöglichen. Dabei entfällt die mittlere Schraubenreihe und der Schraubenabstand horizontal erhöht sich auf 80 mm.

9.2 Anschluss Druckstab

Das Druckstabprofil wird zwischen den Fassadenrahmen mit einer HV-Naht a=t geschweißt (Rückseite bündig). Die entstehende Exzentrizität zwischen Rahmen und Druckstab wurde im Modell berücksichtigt.
Ein zusätzlicher Nachweis der Schweißnaht ist nicht erforderlich.

Appendix D – Ramp construction and handrail

Ingenieure für Ihre Visionen
- Zuverlässig
- Sicher
- Schnell

EXPO Engineering

Statische Berechnung

Static Analysis

Datum:	15.09.2015
Lieferschein-Nr.:	2015091502
Kunden-Nr.:	80940
Sachbearbeiter/-in:	ML

Auftraggeber:
Customer:

Podestbau Kleu GmbH
Dornaper Straße 16-18
42327 Wuppertal

Projekt:
Project:

2015-0820
KLEU - Typenstatik

Dokumentation: Rapid

Nur gültig und rechtsverbindlich als Original mit Stempel und Unterschrift - Kopien sind rechtswidrig!
Only valid and binding as an original document with stamp and signature - copies are illegal!

Expo Engineering GmbH
Suerkamp 14
D-59302 Oelde
Fon: +49 (0) 2520-93162-0
Fax: +49 (0) 2520-93162-210
www.expo-engineering.de

Inhaltsverzeichnis

1 Aufbau- und Betriebshinweise 3
2 Objektbeschreibung 4
3 Berechnungsgrundlagen 6
4 Verwendete Materialien 6
5 Lastannahmen 7
5.1 Schneelasten / Windlasten 7
5.2 Eigengewichte 7
5.3 Verkehrslasten 8
5.3.1 Vertikale Verkehrslasten 8
5.3.2 Horizontale Verkehrslasten 9
6 Schnittgrößenermittlung 10
7 Bauteilnachweise 11
7.1 Trägerplatte 11
7.1.1 Flächenlast 11
7.1.2 Punktlast 13
7.2 Aluminium Struktur 15
7.2.1 Rahmenprofil 15
7.2.2 Podestfuß 18
7.2.3 Bemessung der Eckelemente 20
8 Schlussfolgerungen 20

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de

Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

1 Aufbau- und Betriebshinweise

Eine fachgerechte Montage und Betrieb der Konstruktion ist Voraussetzung für diese statische Berechnung.
Unbeachtet allgemein gültiger Sicherheitsanforderungen sind aus statischer Hinsicht folgende Hinweise zu beachten:

- Maximale Nutzlast (1,0m Höhe) 750 kg / m^2
- Fußprofil 40x4 (EN AW-6063 T66), oder stärker
- Fußeinspannung mit 10Nm von Hand festziehen
- Es wurden Tests gemäß DIN 15921 durchgeführt, die die Berechnungen bestätigen. Eine FEM Analyse des Eckelementes konnte nicht durchgeführt werden.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

2 Objektbeschreibung

Gegenstand der Nachweise ist ein Steckfuß-Podestsystem, welches im Wesentlichen aus folgenden Komponenten besteht:

- Trägerplatte aus Holzwerkstoff
- Umrandungsprofile aus extrudiertem Aluminium
- Eck-Bein-Verbinder aus Zink Druckguss
- Stiele (Füße) aus extrudiertem Aluminium

Hersteller:	Podestbau Kleu GmbH
Typ:	Rapid
Dimensionen:	2x1m
Maximale Aufbauhöhe ohne Aussteifungen:	1,0m

Die folgenden Berechnungen sind nur gültig in Verbindung mit einer positiven Belastungsprüfung der Gesamtkonstruktion gemäß den Vorgaben aus DIN 15921. Die Prüfung ist zu dokumentieren und den Unterlagen beizufügen. Profile und Material des im Belastungstest verwendeten Podestes müssen mit denen der Berechnungen übereinstimmen.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

Basisdaten:

Hersteller	Podestbau Kleu GmbH	
Typ	Rapid	
Artikel Nr.	-	
Podestdaten		
Länge x Breite	2000x1000	mm
Prüf-Podesthöhe	1000	mm
Prüf-Verkehrslast	750	kg/m^2
horizontale Verkehrslast	1/20 * V	
Masse ohne Füße	38	kg
Masse gesamt	41	kg
Podestfuß		
Material	EN AW 6063 T66	
Typ	Steckfuß	
Querschnitt	40x40	mm
Materialdicke	4	mm
Rahmenprofil		
Material	EN AW 6063 T66	
Rahmenhöhe	80	mm
CAD File liegt vor	ja	
Platte		
Plattenart	Sperrholz / Multiplex	
Holzart	Buche	
Dicke	22	mm
Eckeelement		
Material	ZL0410	
für Fußweiten	40	mm
Art der Fixierung	Klemmwinkel mit Flügelschraube	
Klemmkraft	5 kN (10 Nm)	
3D Volumenkörper liegt vor	nein	
Dokumente		
Prüfbericht nach DIN 15921	ja	
mit Messwerten		

Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

3 Berechnungsgrundlagen

Grundlagen des konstruktiven Ingenieurwesens:

- DIN EN 1993-1 Eurocode 3: Bemessung und Konstruktion von Stahlbauten (12/2010)
- DIN EN 1995-1 Eurocode 5: Bemessung und Konstruktion von Holzbauten (12/2010)
- DIN EN 1999-1 Eurocode 9: Bemessung und Konstruktion von Aluminiumtragwerken (05/2010)
- DIN 15921 Veranstaltungstechnik - Podeste und Zargen aus Aluminium - Sicherheitstechnische Anforderungen und Prüfung
- TÜV EK 5 / AK 5 11-01:2012

4 Verwendete Materialien

<u>Aluminiumlegierung</u>
EN AW 6063 T66 Rahmenprofil und Podestfüße

<u>Zink Druckguss</u>
ZL0410 Eckverbinder

		Legierungsbestandteile Druckguss-Stücke				
Werkstoff-Nr.	**Kurz-bezeichnung**	**Bezeichnung gem. DIN 1743**	**Al**	**Cu**	**Mg**	**Zn**
ZL 0410	**ZL 5**	GD- ZnAl4Cu1	3,8 - 4,2	0,7 - 1,1	0,035-0,06	Rest
ZL 0430	**ZL 2**	GD- ZnAl4Cu3	3,8 - 4,2	2,7 - 3,3	0,035-0,06	Rest

Legierung	**Zugfestigkeit Rm (N/mm²)**	**0,2 Grenze $R_{p0,2}$ (N/mm²)**	**Bruchdehnung A_5 (%)**	**Brinellhärte HB (10/1000 / 30)**
ZL 0410	280 - 350	220 - 250	2 - 5	85 - 105
ZL 0430	330 - 380	310 - 350	5 - 10	100 - 130

<u>Schrauben</u>
Festigkeitsklasse 8.8

<u>Holz</u>
Multiplex alternativ Stabsperrholz
F20/10

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

5 Lastannahmen

5.1 Schneelasten / Windlasten

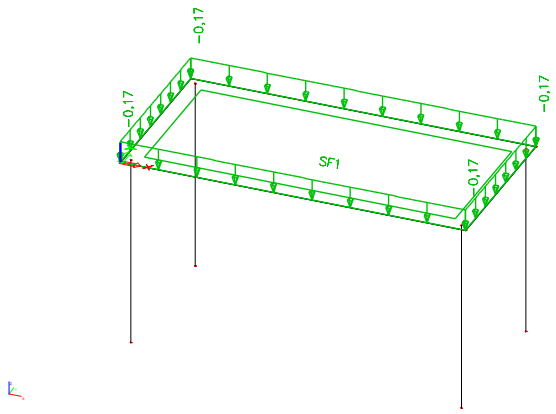
keine

Die Podeste werden ohne Wettereinflüsse berechnet.

5.2 Eigengewichte

<u>Profile</u>
Werden vom Programm anhand ihrer Material- und Querschnittseigenschaften berücksichtigt.

<u>Holzplatte</u> max g = 0,17 kN / m^2



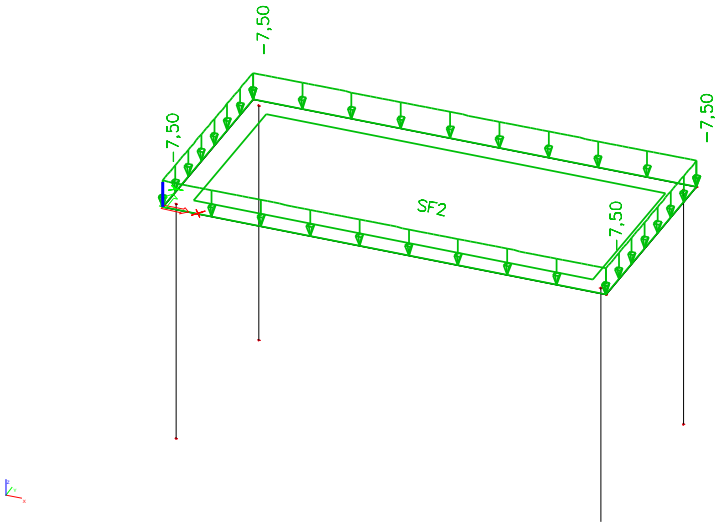
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

5.3 Verkehrslasten

5.3.1 Vertikale Verkehrslasten

<u>Flächenlast:</u>
Gemäß DIN 15921 wird eine Last von 500 kg/m^2 gefordert.
Auf Kundenwunsch erfolgt der Nachweis über 750 kg/m^2 (Tribünen).

p = 7,5 kN / m^2



<u>Punktbelastung:</u> *(Nachweis für Holzplatte)*

P = 1,5 kN auf 5x5cm gemäß DIN 15921

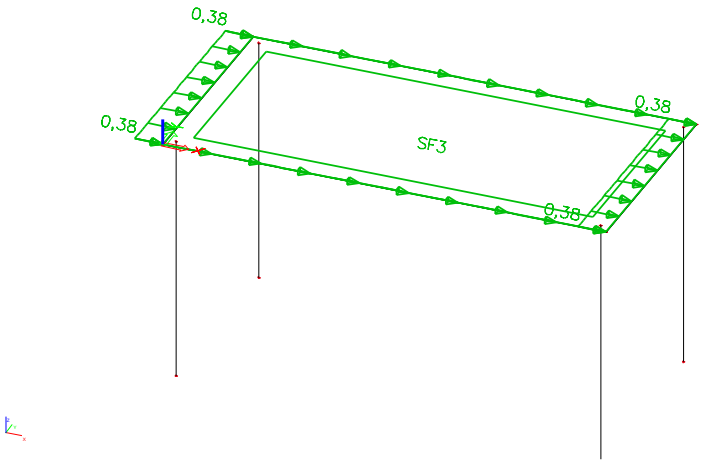
EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

5.3.2 Horizontale Verkehrslasten

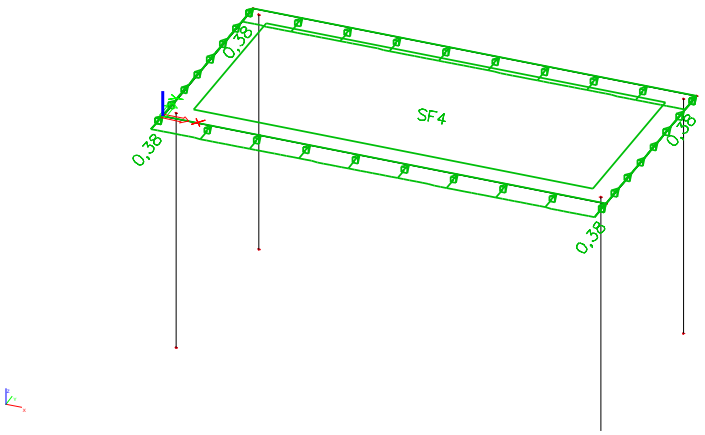
Es wird gemäß DIN 15921 eine horizontale Ersatzlast von V/20 angesetzt:

h = 7,5 / 20 = 0,375 kN / m^2

X:



Y:



Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

6 Schnittgrößenermittlung

Die Schnittgrößen werden in einer dreidimensionalen Stabwerkberechnung mit Hilfe der Software SCIA Engineer ermittelt. Die Eingabe der Struktur und der Belastungen sowie die Ausgabe der Ergebnisse sind im Anhang als EDV-Ausdruck beigefügt.

Die Berechnungen erfolgen nach Th. 2. Ordnung.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

7 Bauteilnachweise

7.1 Trägerplatte

7.1.1 Flächenlast

t = 22mm

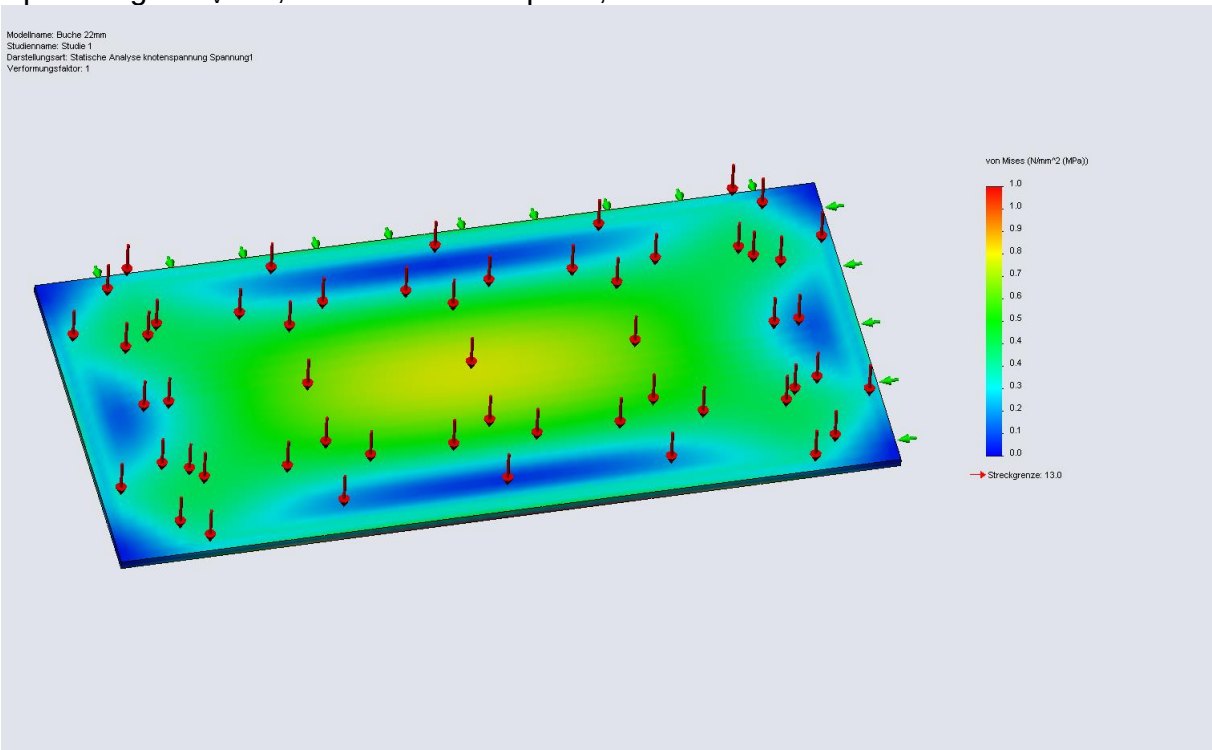
Wy = 100 * $2{,}2^2$ / 6 = 80,67 cm^3

Multiplex Buche
ρ = 775 kg / m^3
g = 7,75 * 0,022 = 0,171 kN / m^2

Multiplex Birke
ρ = 690 kg / m^3
g = 6,9 * 0,022 = 0,152 kN / m^2

Tischlerplatte Stab Buche
ρ = 455 kg / m^3
g = 4,55 * 0,022 = 0,100 kN / m^2

Spannungen σ_v = 0,8 N / mm^2 mit p = 1,0 kN / m^2



EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

Bemessungsspannung aus Flächenlast
σ_{Ed} = 1,5 * (5,0 + 0,171) / 1,00 * 0,8 = 6,205 N / mm^2

Mindest-Festigkeitsklasse F20/10 bzw. E40/20

Lasteinwirkungsdauer: KLED = kurz
Nutzungsklasse bedachte offene Bauwerke: NKL = 2
$f_{m,k}$ = 10,0 N/mm^2 - konservativer Ansatz
$f_{v,k}$ = 0,6 N/mm^2 - konservativer Ansatz

Biegung:
min. $f_{m,d}$ = 0,9 * 10,0 / 1,30 = 6,92 N / mm^2

Schub:
min. $f_{v,d}$ = 0,9 * 0,6 / 1,30 = 0,42 N / mm^2

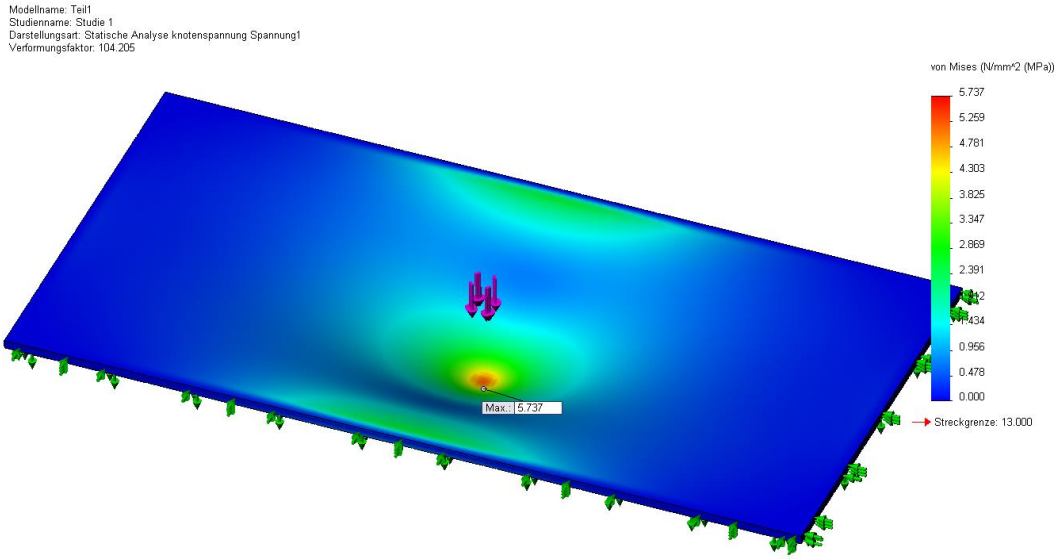
η = 6,205 / 6,92 = 0,9 < 1,0 ✓

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

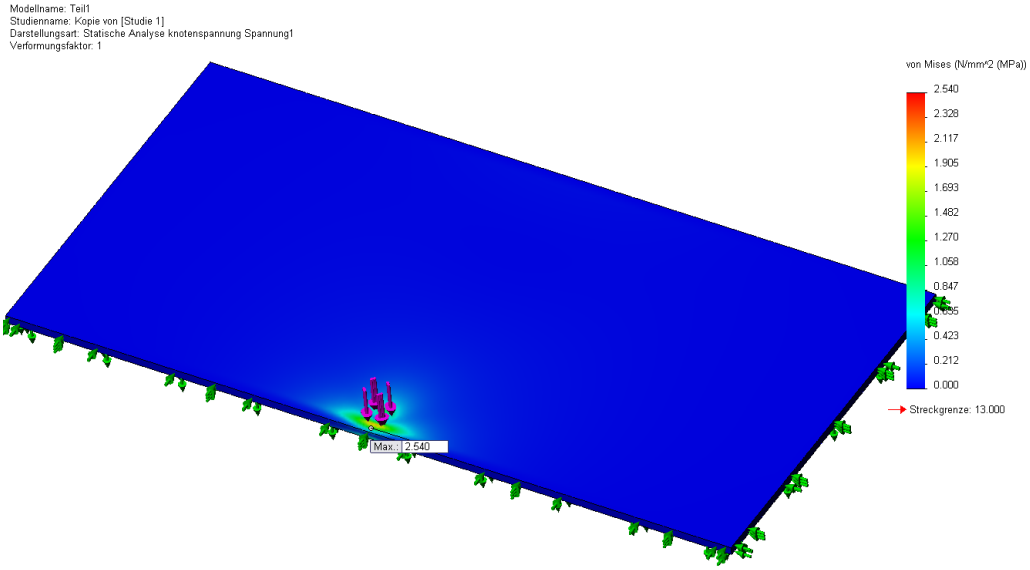
7.1.2 Punktlast

Last: 150 kg
Fläche: 50mm x 50mm

In Plattenmitte:



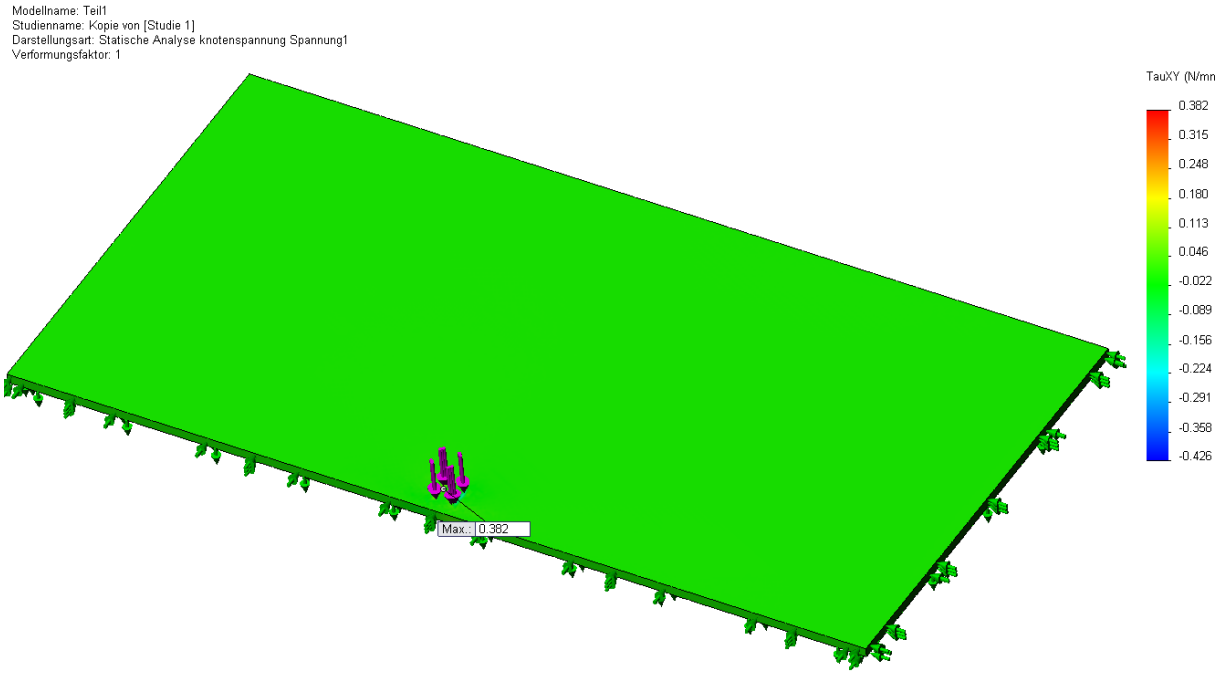
am Plattenrand:



Biegung:
min. $f_{m,d}$ = 0,9 * 10,0 / 1,30 = 6,92 N / mm^2

η = 5,74 / 6,92 = 0,83 < 1,0 ✓

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.



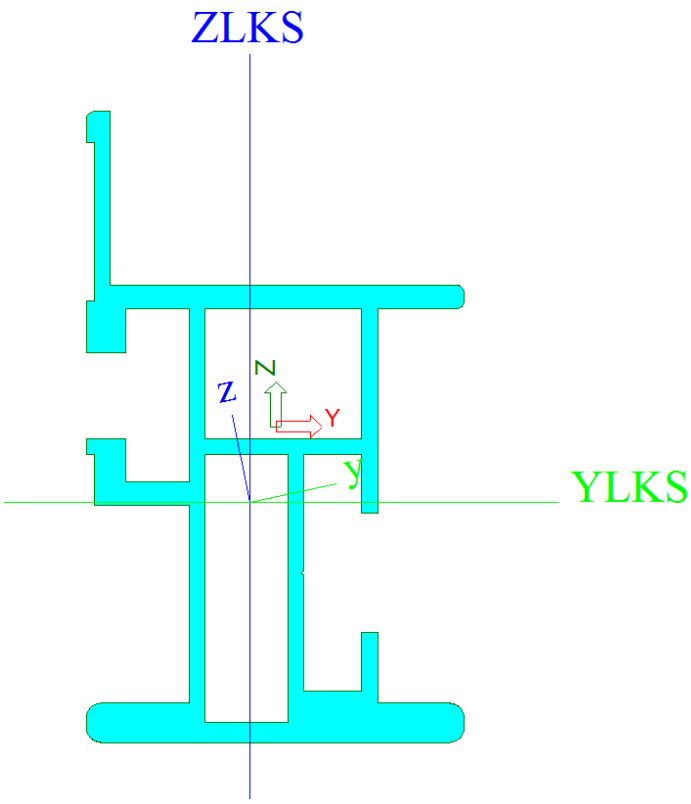
Schub:
min. $f_{v,d}$ = 0,9 * 0,6 / 1,30 = 0,42 N / mm^2

η = 0,38 / 0,42 = 0,90 < 1,0 ✓

Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

7.2 Aluminium Struktur

7.2.1 Rahmenprofil

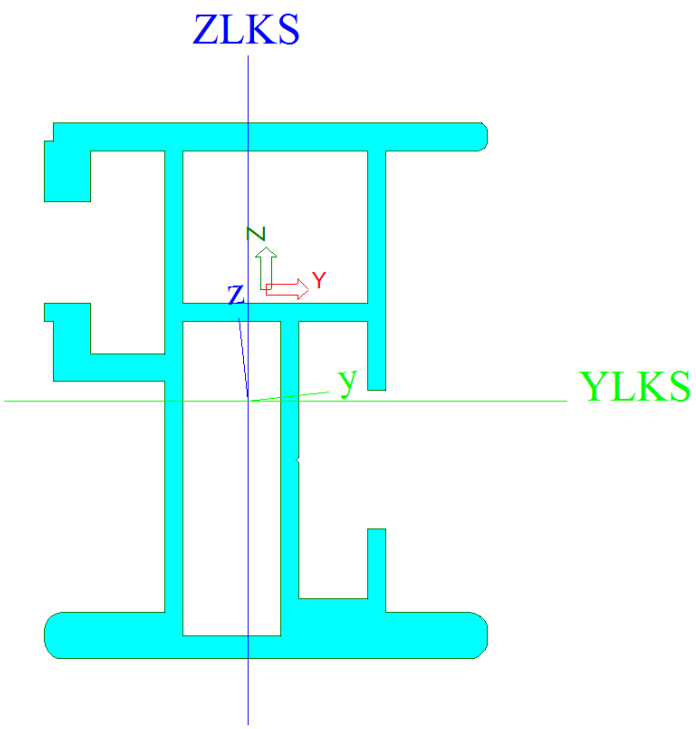


Parameter	
Mat 1	EN-AW 6063 (EP,ET,E
Bearbeiten	
Allgemein	
Anzeigefarbe	Normalfarbe
Farben	
Fasertext zoomen	1.0
Eigenschaften bearbeiten	☐
Knick bearbeiten	☒
Knick y-y	c
Knick z-z	c
Herstellung	allgemein
FEM-Analyse	☒
Netzdichte [mm]	0,0
Mindest-Punktabstand [mm]	0,1
Genannte Objekte bearbeit...	
Reduktionsbeiwerte d...	
Reduktionsbeiwerte verw...	☐
Eigenschaft	
A [cm^2]	7,71
Ay [cm^2]	6,53
Az [cm^2]	3,81
AL [m^2/m]	3,9845e-01
It [cm^4]	4,48
Iy [cm^4]	42,32
Iz [cm^4]	12,93
IYZLKS [cm^4]	-5,95
IYLCS [cm^4]	41,07
IZLCS [cm^4]	14,19
Iw [cm^6]	56,80
Alpha [deg]	11,95
Wely [cm^3]	8,05
Welz [cm^3]	4,02
Wply [cm^3]	15,72
Wplz [cm^3]	8,51
cYLKS [mm]	-3,3
cZLKS [mm]	-9,6
dy [mm]	-0,7
dz [mm]	0,0
Mply+ [Ncm]	314491,37
Mply- [Ncm]	314491,37
Mplz+ [Ncm]	170296,47
Mplz- [Ncm]	170296,47

Der obere Steg stützt nur die Holzplatte. Ein Beulen wird toleriert und beeinflusst den Restquerschnitt nicht.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

Effektiver Querschnitt



Parameter	
Mat 1	EN-AW 6063 (EP,ET,E
Bearbeiten	
Allgemein	
Anzeigefarbe	Normalfarbe
Farben	
Fasertext zoomen	1,0
Eigenschaften bearbeiten	☐
Knick bearbeiten	☒
Knick y-y	c
Knick z-z	c
Herstellung	allgemein
FEM-Analyse	☒
Netzdichte [mm]	0,0
Mindest-Punktabstand [mm]	0,1
Genannte Objekte bearbeit...	
Reduktionsbeiwerte d...	
Reduktionsbeiwerte verw...	☐
Eigenschaft	
A [cm^2]	7,23
Ay [cm^2]	4,97
Az [cm^2]	3,10
AL [m^2/m]	3,5288e-01
It [cm^4]	4,52
Iy [cm^4]	33,26
Iz [cm^4]	12,15
IYZLKS [cm^4]	-2,19
IYLCS [cm^4]	33,03
IZLCS [cm^4]	12,38
Iw [cm^6]	53,56
Alpha [deg]	5,98
Wely [cm^3]	10,34
Welz [cm^3]	4,20
Wply [cm^3]	13,89
Wplz [cm^3]	8,16
cYLKS [mm]	-2,0
cZLKS [mm]	-12,1
dy [mm]	-2,8
dz [mm]	1,3
Mply+ [Ncm]	277807,70
Mply- [Ncm]	277807,70
Mplz+ [Ncm]	163140,37
Mplz- [Ncm]	163140,37

W_{ely} = 10,34 cm^3

Die Aluminium Struktur wird mittels Stabwerksprogramm berechnet.

Versatz der Podestfußachsen zu den Stabachsen der Rahmenprofile:

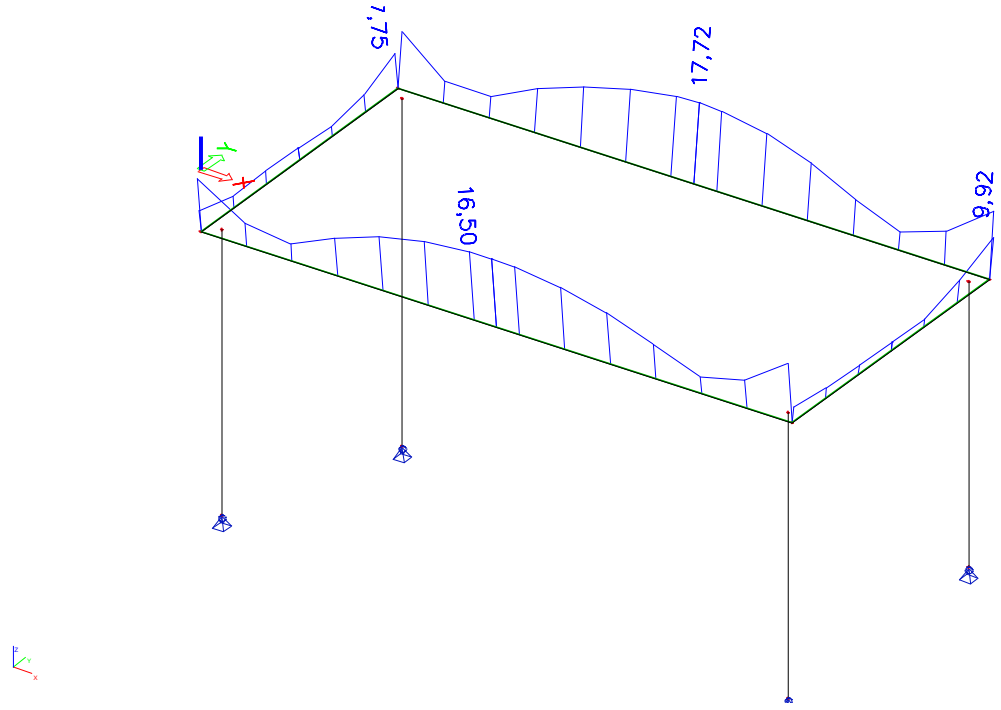
$e_{y,z}$ = 42,5mm

Das Stabwerk wird mit den Außenmaßen der Struktur berechnet, um volle Last zur generieren.

Als Höhe wird 1,0m (vom AG vorgegeben) gesetzt.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

Bemessung der Umrandungsprofile



max σ_{Ed} = 17,72 kN / cm^2 = 177,2 N / mm^2

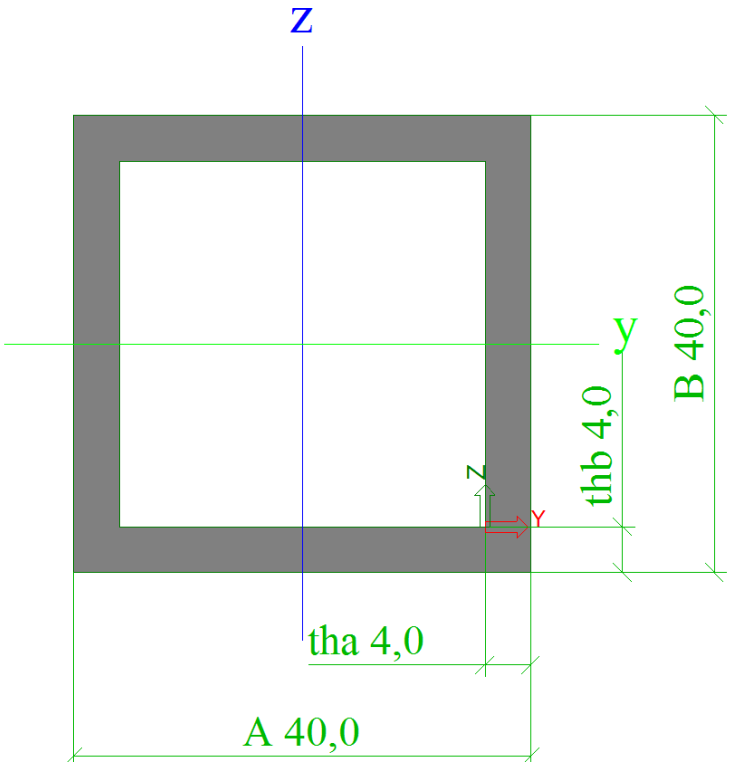
(1) $\sigma_{o,Rd}$ = 200,0 / 1,1 = 181,82 N / mm^2
(2) $\sigma_{u,Rd}$ = 245,0 / 1,25 = 196,0 N / mm^2

Ausnutzungsgrad
η = 177,2 / 181,82 = 0,97 < 1,0

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

7.2.2 Podestfuß

Profil: QRO 40x4
Material: EN AW 6063 T66

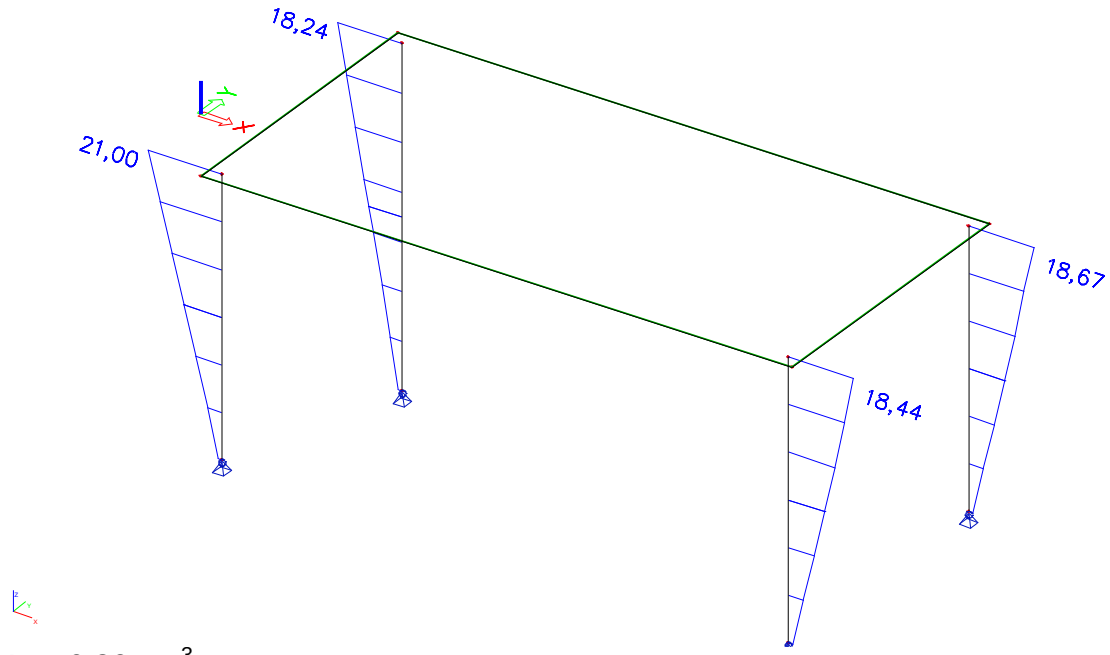


Parameter	
Material	EN-AW 6063 (EP,ET,E
A [mm]	40,0
tha [mm]	4,0
B [mm]	40,0
thb [mm]	4,0
Allgemein	
Anzeigefarbe	Normalfarbe
Farben	
Fasertext zoomen	1.0
Eigenschaften bearbeiten	☐
Knick bearbeiten	☒
Knick y-y	b
Knick z-z	b
Herstellung	allgemein
FEM-Analyse	☐
Genannte Objekte bearbeit...	
AutoDesign Beschränkung...	
Reduktionsbeiwerte d...	
Reduktionsbeiwerte verw...	☐
Eigenschaft	
A [cm^2]	5,76
Ay [cm^2]	2,88
Az [cm^2]	2,88
AL [m^2/m]	1,6000e-01
It [cm^4]	16,80
Iy [cm^4]	12,60
Iz [cm^4]	12,60
Iw [cm^6]	0,00
Alpha [deg]	0,00
Wely [cm^3]	6,30
Welz [cm^3]	6,30
Wply [cm^3]	7,81
Wplz [cm^3]	7,81
cYLKS [mm]	-16,0
cZLKS [mm]	16,0
dy [mm]	0,0
dz [mm]	0,0

Gedrückte innenliegende Querschnittsteile:
Querschnittsklassifizierung: KL 1

Die Spannungen werden mit SCIA Engineer mittels der elastischen Widerstandsmomente und nach Theorie 2. Ordnung berechnet.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.



W_{el} = 6,30 cm^3
W_{pl} = 7,81 cm^3

α_{pl} = 1,24

Elastischer Nachweis:

f_o = 20,0 kN/cm^2
$\sigma_{o,Rd}$ = 20,0 / 1,1 * 1,24 = 22,55 kN/cm^2

η = 21,0 / 22,55 = 0,93 < 1,0 ✓

Plastischer Nachweis nach EC9 - 6.2.9.2:

N_{Rd} = 5,76 * 20,0 / 1,1 = 104,7 kN
M_{Rd} = 6,30 * 24,5 / 1,25 = 123,5 kNcm

NC5:
N = 5,14 kN
My = 0,89 kNm
Mz = 0,38 kNm

$\eta = (5{,}14 / 104{,}7)^{1,3} + [(89/123{,}5)^{1,7} + (38/123{,}5)^{1,7}]^{0,6} = 0{,}833 < 1{,}0$ ✓

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

7.2.3 Bemessung der Eckelemente

Die Berechnungen konnten aufgrund fehlender Daten nicht durchgeführt werden.

8 Schlussfolgerungen

Die Konstruktion wurde gemäß den derzeit gültigen Normen und Bestimmungen berechnet und für die im Kapitel „Lastannahmen“ beschriebenen Belastungen als ausreichend tragfähig nachgewiesen, sofern die Anforderungen und Hinweise in diesem Dokument – insbesondere die in Kapitel 1 – beachtet werden.

Es wurden Tests gemäß DIN 15921 durchgeführt, die die Berechnungen bestätigen. Eine FEM Analyse des Eckelementes konnte nicht durchgeführt werden.

EXPO Engineering ©
Expo Engineering GmbH, Suerkamp 14, D-59302 Oelde
Tel.: +49 (0)2520 / 912 921 1 Fax: +49 (0)2520 / 912 921 3
www.expo-engineering.de
Dieses Dokument ist nur als Original (mit Stempel und Unterschrift) gültig.

1. Inhalt

1. Inhalt	1
2. Projekt	3
3. Querschnitt	4
3.1. Querschnitte	4
3.1.1. Querschnitte - CS3	4
3.1.2. Querschnitte - CS4	5
3.2. Material	5
4. Lasten	6
4.1. Lastfälle	6
4.1.1. Lastfälle - E1	6
4.1.1.1. Lasten	6
4.1.2. Lastfälle - E2	7
4.1.2.1. Lasten	7
4.1.2.2. Flächenlasten	8
4.1.3. Lastfälle - V1	9
4.1.3.1. Lasten	9
4.1.3.2. Flächenlasten	10
4.1.4. Lastfälle - H1	11
4.1.4.1. Lasten	11
4.1.4.2. Flächenlasten	11
4.1.5. Lastfälle - H2	12
4.1.5.1. Lasten	12
4.1.5.2. Flächenlasten	12
4.2. Lastgruppen	13
4.3. Nichtlineare LF-Kombinationen	13
4.4. Ergebnisklassen	14
5. Struktur	15
5.1. Knoten	15
5.2. 1D-Teil	15
5.3. Gelenke	15
5.4. Stab-Nichtlinearität	15
5.5. Stabschnitt	15
5.6. Knotenauflager	15
5.7. Knoten	16
5.8. Stäbe	17
6. Ergebnisse	18
6.1. Schnittgrößen	18
6.1.1. Schnittgrößen - CS3	18
6.1.1.1. Stabschnittgrößen	18
6.1.1.2. Spannungen	19
6.1.2. Schnittgrößen - CS4	20
6.1.2.1. Stabschnittgrößen	20
6.1.2.2. Spannungen	20
6.2. Resultierende der Lastfälle	22
6.2.1. Resultierende der Lastfälle - E1	22
6.2.1.1. Resultierende	22
6.2.1.2. res Reaktion	22
6.2.2. Resultierende der Lastfälle - E2	23
6.2.2.1. Resultierende	23
6.2.2.2. res Reaktion	23
6.2.3. Resultierende der Lastfälle - V1	24
6.2.3.1. Resultierende	24
6.2.3.2. res Reaktion	24
6.2.4. Resultierende der Lastfälle - H1	25
6.2.4.1. Resultierende	25
6.2.4.2. res Reaktion	25
6.2.5. Resultierende der Lastfälle - H2	26

6.2.5.1. Resultierende	26
6.2.5.2. res Reaktion	26
6.3. Ergebnisklassen	28
6.3.1. Ergebnisklassen - RC1	28
6.3.1.1. Reaktionen	28
6.3.1.2. Auflager	29
6.3.2. Ergebnisklassen - RC2	30
6.3.2.1. Reaktionen	30
6.3.2.2. Auflager	30
6.3.3. Ergebnisklassen - RC3	31
6.3.3.1. Reaktionen	31
6.3.3.2. Auflager	31

2. Projekt

Lizenzname	Expo Engineering
Staatsnorm	EC-EN
Struktur	Rahmen XYZ
Anzahl Knoten:	12
Anzahl Stäbe:	8
Anzahl 2D-Teile:	0
Anzahl verwendete Profile:	2
Anzahl Lastfälle:	5
Anzahl Materialien:	2
Name der Projektdatei	2015-0820 KLEU - Typenstatik Rapid - nL.esa
Pfad der Projektdatei	C:\Users\ ekte\KLEU\2015-0820KLEU Rapid + Rapid V\Berechnungen\
Projekt	KLEU
Teil	Podest: Rapid
Beschreibung	2015-0820
Bearbeiter	ML
Datum	15.09.2015
Erdbeschleunigung [m/sec^2]	9,810
Version	Scia Engineer 11.0.1223
Funktionalität	Nichtlinearität Vorverformungen und Vorkrümmungen Geometrische Nichtlinearität (Th.II.O.)

3. Querschnitt

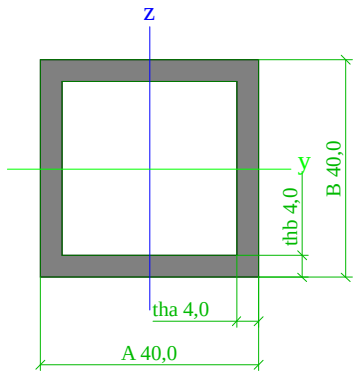
3.1. Querschnitte

3.1.1. Querschnitte - CS3

Name	CS3
Typ	O
Detailliert	40,0; 4,0; 40,0; 4,0
Materialangabe	EN-AW 6063 (EP,ET,ER/B) T66 (0-10)
Herstellung	allgemein
Knick y-y	b
Knick z-z	b
FEM-Analyse	×

A [cm²]	5,76	
A y, z [cm²]	2,88	2,88
I y, z [cm⁴]	12,60	12,60
It [cm⁴]	16,80	
Iw [cm⁶]	0,00	
Wel y, z [cm³]	6,30	6,30
Wt [cm³]	0,00	
Wpl y, z [cm³]	7,81	7,81
d y, z [mm]	0,0	0,0
c YLKS, ZLKS [mm]	-16,0	16,0
Alpha [deg]	0,00	
AL [m²/m]	1,6000e-01	
i y, z [cm]	1,48	1,48

Bild

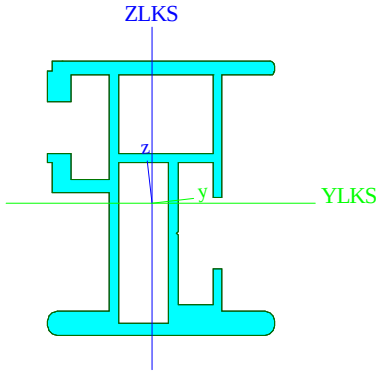


3.1.2. Querschnitte - CS4

Name	CS4
Typ	Allgemeiner Querschnitt
Materialangabe	EN-AW 6063 (EP,ET,ER/B) T66 (0-10)
Herstellung	allgemein
Knick y-y	c
Knick z-z	c
FEM-Analyse	✓

A [cm²]	7,23	
A y, z [cm²]	4,97	3,10
I y, z [cm⁴]	33,26	12,15
It [cm⁴]	4,52	
I YLCS, ZLCS [cm⁴]	33,03	12,38
Iw [cm⁶]	53,56	
Wel y, z [cm³]	10,34	4,20
Wt [cm³]	1,81	
Wpl y, z [cm³]	13,89	8,16
d y, z [mm]	-2,8	1,3
c YLKS, ZLKS [mm]	-2,0	-12,1
Alpha [deg]	5,98	
IYZLKS [cm⁴]	-2,19	
AL [m²/m]	3,5288e-01	
i y, z [cm]	2,14	1,31

Bild



3.2. Material

Name	Typ	Massendichte [kg/m³]	E-Mod [kN/cm²]	Querdehnzahl	G-Mod [kN/cm²]	T-Dehnzahl [m/mK]
EN-AW 5083 (Sheet) O/H111 (0-50)	Aluminium	2700,00	7000,00	0,3	2692,31	0,00
EN-AW 6063 (EP,ET,ER/B) T66 (0-10)	Aluminium	2700,00	7000,00	0,3	2692,31	0,00

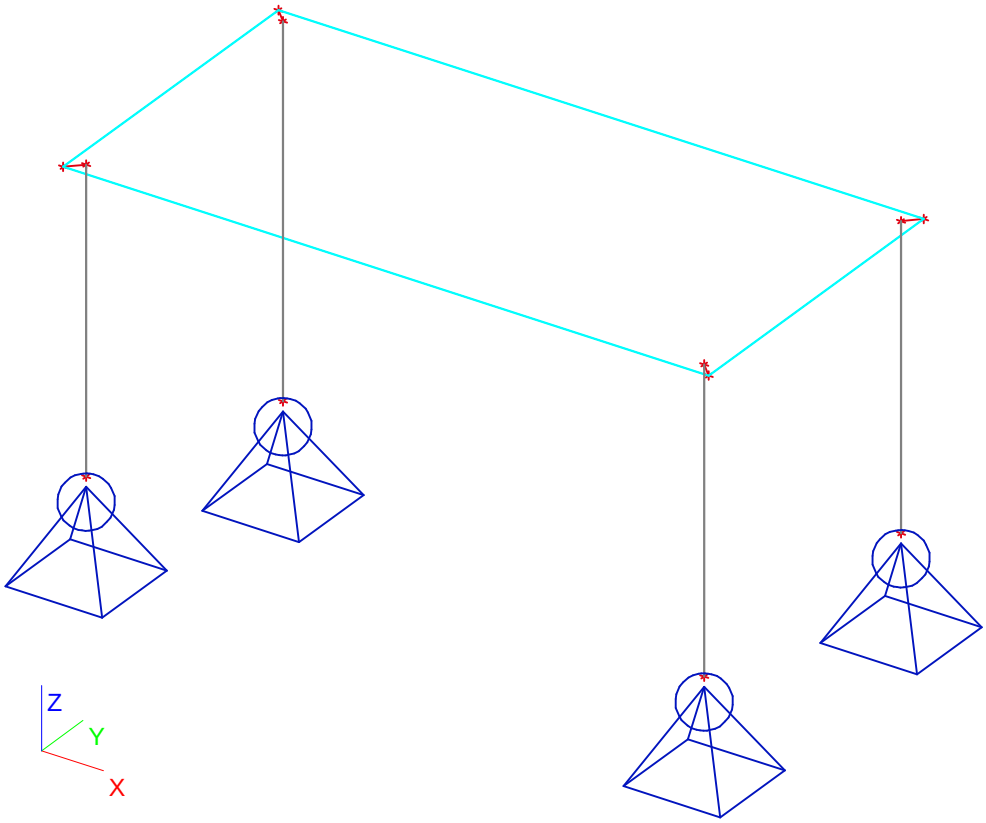
4. Lasten

4.1. Lastfälle

4.1.1. Lastfälle - E1

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Richtung
E1	Profile	Ständig	LG1	Eigengewicht	-Z

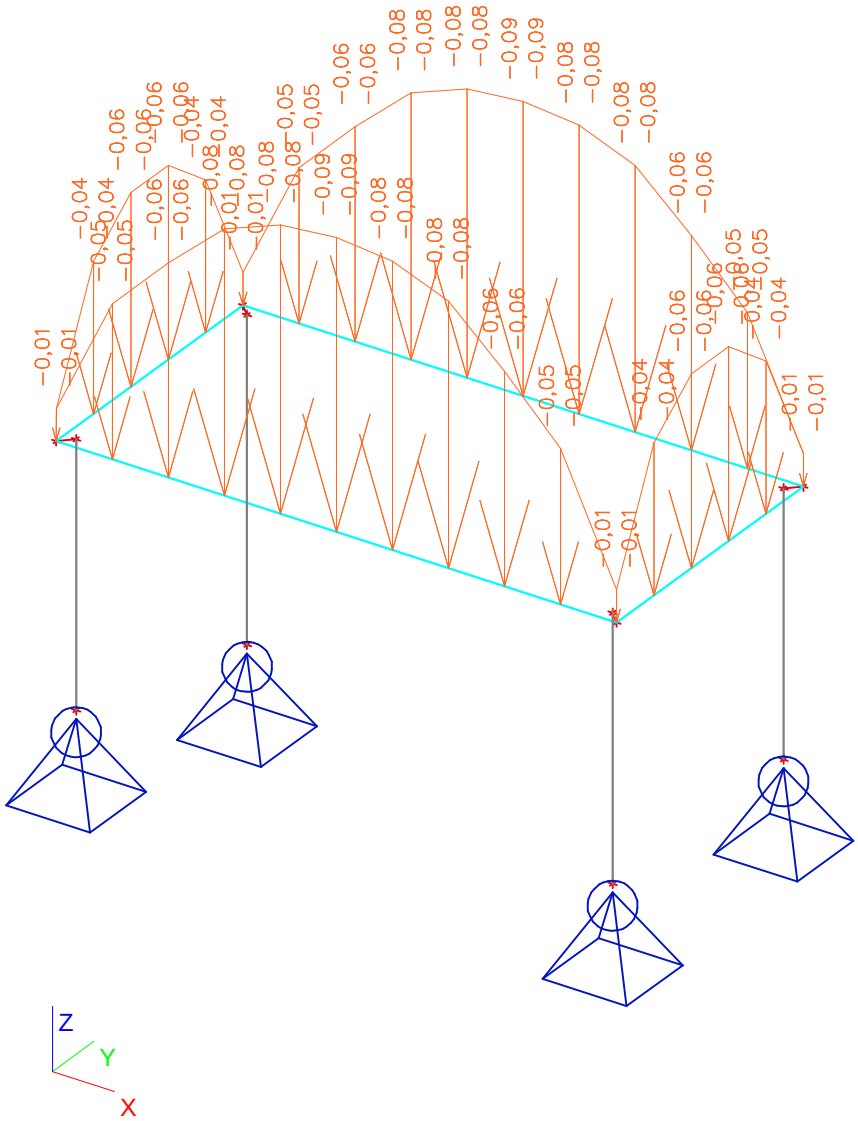
4.1.1.1. Lasten



4.1.2. Lastfälle - E2

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp
E2	Holzplatte	Ständig	LG1	Standard

4.1.2.1. Lasten



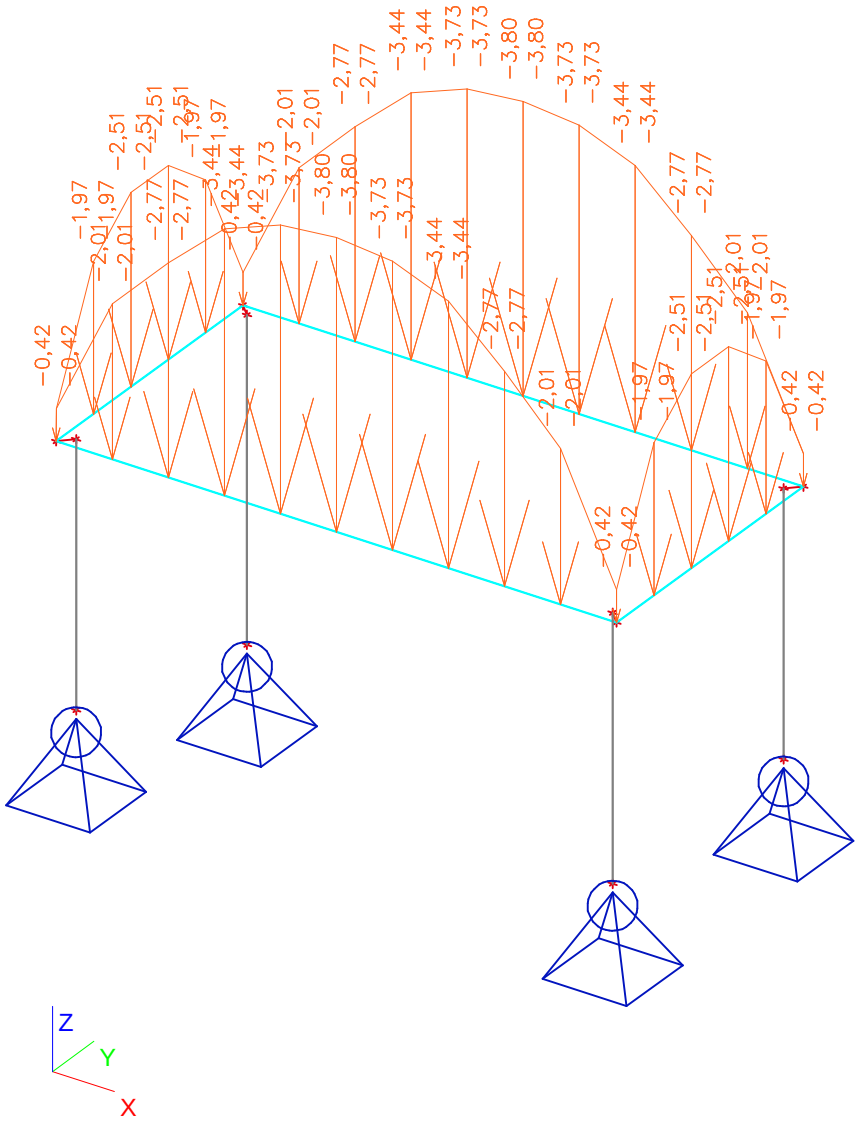
4.1.2.2. Flächenlasten

Name	Rich	Typ	Wert [kN/m²]	Lastfall	System	Pos
SF1	Z	Kraft	-0,17	E2 - Holzplatte	LKS	Länge

4.1.3. Lastfälle - V1

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Spez	Dauer	Vorherrschender Lastfall
V1	Flächenlast	Variabel	LG2	Statisch	Standard	Kurz	Nein

4.1.3.1. Lasten



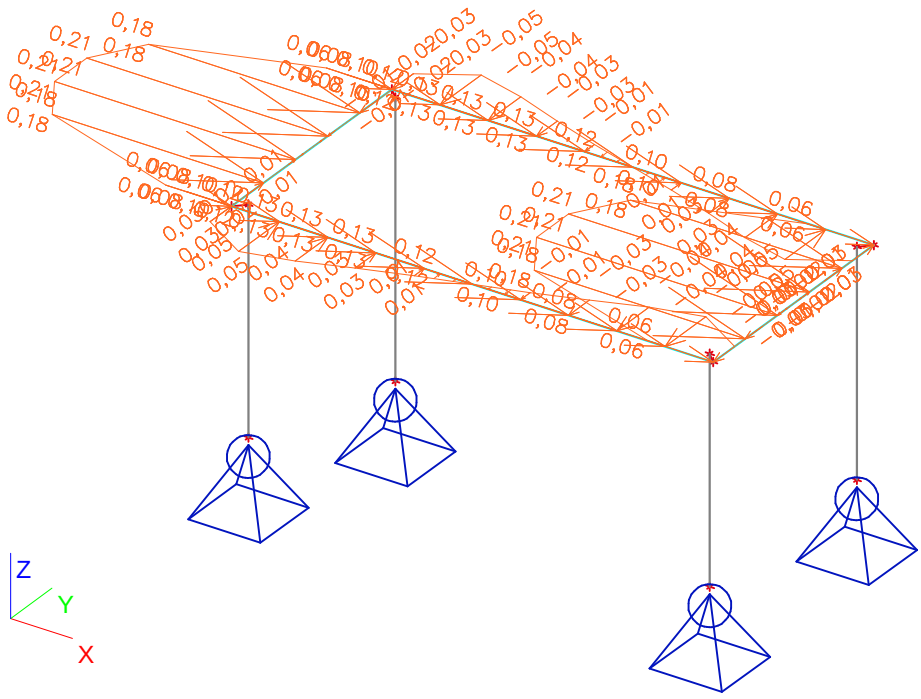
4.1.3.2. Flächenlasten

Name	Rich	Typ	Wert [kN/m²]	Lastfall	System	Pos
SF2	Z	Kraft	-7,50	V1 - Flächenlast	LKS	Länge

4.1.4. Lastfälle - H1

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Spez	Dauer	Vorherrschender Lastfall
H1	V/20 - X	Variabel	LG3	Statisch	Standard	Kurz	V1 - Flächenlast

4.1.4.1. Lasten



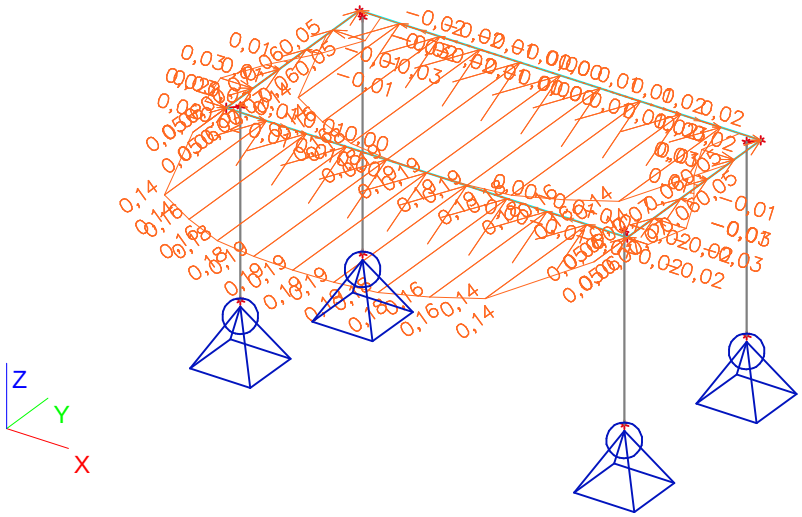
4.1.4.2. Flächenlasten

Name	Rich	Typ	Wert [kN/m²]	Lastfall	System	Pos
SF3	X	Kraft	0,38	H1 - V/20 - X	GKS	Länge

4.1.5. Lastfälle - H2

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Spez	Dauer	Vorherrschender Lastfall
H2	V/20 - Y	Variabel	LG3	Statisch	Standard	Kurz	V1 - Flächenlast

4.1.5.1. Lasten



4.1.5.2. Flächenlasten

Name	Rich	Typ	Wert [kN/m²]	Lastfall	System	Pos
SF4	Y	Kraft	0,38	H2 - V/20 - Y	GKS	Länge

4.2. Lastgruppen

Name	Belastung	Status	Typ
LG1	Ständig		
LG2	Variabel	Exklusiv	Kat.E: Lagerräume
LG3	Variabel	Exklusiv	Kat.E: Lagerräume

4.3. Nichtlineare LF-Kombinationen

Name	Typ	Lastfälle	Beiwert [-]	f	1/f
NC1	GZT	E1 - Profile	1,35	0,005	200
		E2 - Holzplatte	1,35		
NC2	GZT	E1 - Profile	1,00	0,005	200
		E2 - Holzplatte	1,00		
NC3	GZT	E1 - Profile	1,35	0,005	200
		E2 - Holzplatte	1,35		
		V1 - Flächenlast	1,50		
NC4	GZT	E1 - Profile	1,35	0,005	200
		E2 - Holzplatte	1,35		
		V1 - Flächenlast	1,50		
		H1 - V/20 - X	1,50		
NC5	GZT	E1 - Profile	1,35	0,005	200
		E2 - Holzplatte	1,35		
		V1 - Flächenlast	1,50		
		H2 - V/20 - Y	1,50		
NC6	GZT	E1 - Profile	1,00	0,005	200
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,50		
NC7	GZT	E1 - Profile	1,00	0,005	200
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,50		
		H1 - V/20 - X	1,50		
NC8	GZT	E1 - Profile	1,00	0,005	200
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,50		
		H2 - V/20 - Y	1,50		
NC9	GZG	E1 - Profile	1,00		
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,00		
NC10	GZG	E1 - Profile	1,00		
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,00		
		H1 - V/20 - X	1,00		
NC11	GZG	E1 - Profile	1,00		
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,00		
		H2 - V/20 - Y	1,00		
NC13	GZG	E1 - Profile	1,00		
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,70		
NC14	GZG	E1 - Profile	1,00		
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,70		
		H1 - V/20 - X	1,70		
NC15	GZG	E1 - Profile	1,00		
		E2 - Holzplatte	1,00		
		V1 - Flächenlast	1,70		
		H2 - V/20 - Y	1,70		

4.4. Ergebnisklassen

Name	Liste
RC1	NC1
	NC2
	NC3
	NC4
	NC5
	NC6
	NC7
	NC8
RC2	NC9
	NC10
	NC11
RC3	NC13
	NC14
	NC15

5. Struktur

5.1. Knoten

Name	Koord X [m]	Koord Y [m]	Koord Z [m]
N1	0,000	0,000	-0,200
N2	2,000	0,000	-0,200
N3	0,000	1,000	-0,200
N4	2,000	1,000	-0,200
N5	0,043	0,043	-1,120
N6	0,043	0,043	-0,200
N7	0,043	0,958	-1,320
N8	0,043	0,958	-0,200
N9	1,958	0,043	-1,120
N10	1,958	0,043	-0,200
N11	1,958	0,958	-1,120
N12	1,958	0,958	-0,200

5.2. 1D-Teil

Name	Querschnitt	Länge [m]	Form	Anf.Kn	Endkn	Typ	FEM-Typ	Layer
B1	CS4 - Allgemeiner Querschnitt	2,000	Linie	N1	N2	allgemein (0)	Standard	Layer1
B2	CS4 - Allgemeiner Querschnitt	2,000	Linie	N4	N3	allgemein (0)	Standard	Layer1
B3	CS4 - Allgemeiner Querschnitt	1,000	Linie	N3	N1	allgemein (0)	Standard	Layer1
B4	CS4 - Allgemeiner Querschnitt	1,000	Linie	N2	N4	allgemein (0)	Standard	Layer1
B5	CS3 - O (40,0; 4,0; 40,0; 4,0)	0,920	Linie	N6	N5	allgemein (0)	Standard	Layer1
B6	CS3 - O (40,0; 4,0; 40,0; 4,0)	1,120	Linie	N8	N7	allgemein (0)	Standard	Layer1
B7	CS3 - O (40,0; 4,0; 40,0; 4,0)	0,920	Linie	N10	N9	allgemein (0)	Standard	Layer1
B8	CS3 - O (40,0; 4,0; 40,0; 4,0)	0,920	Linie	N12	N11	allgemein (0)	Standard	Layer1

5.3. Gelenke

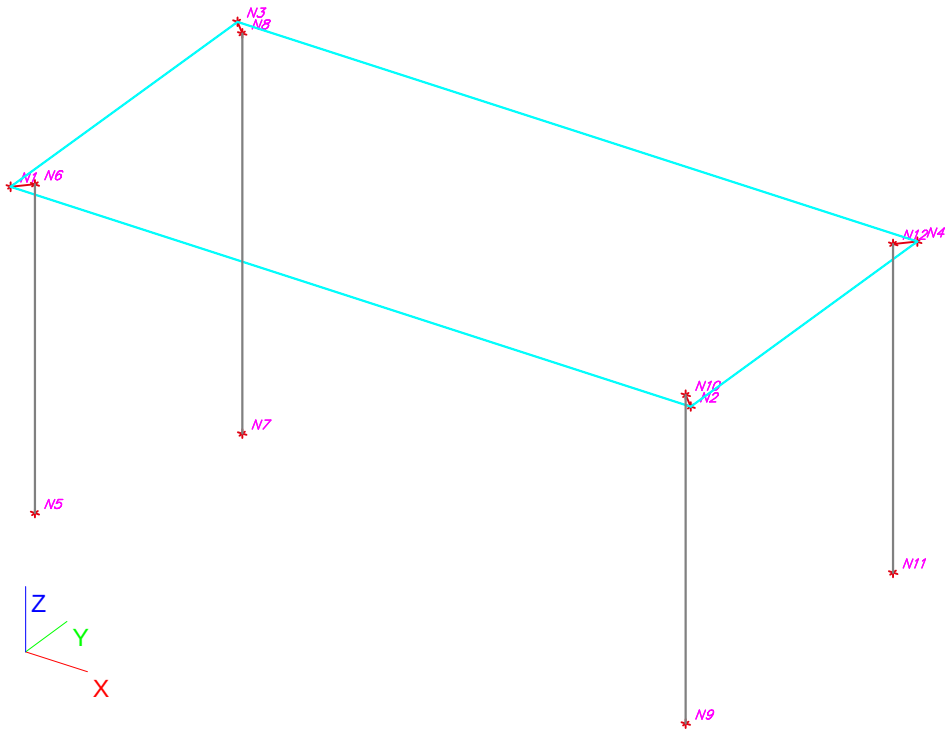
5.4. Stab-Nichtlinearität

5.5. Stabschnitt

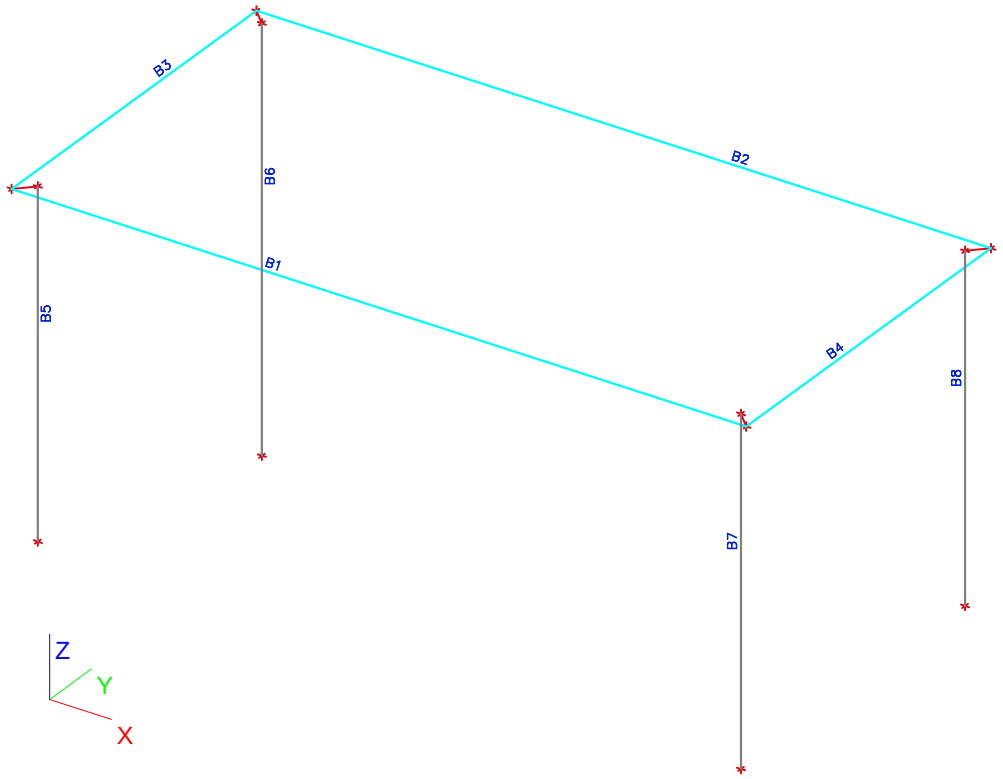
5.6. Knotenauflager

Name	Knoten	System	Typ	X	Y	Z	Rx	Ry	Rz
Sn1	N5	GKS	Standard	Starr	Starr	Starr	Frei	Frei	Frei
Sn2	N7	GKS	Standard	Starr	Starr	Starr	Frei	Frei	Frei
Sn3	N9	GKS	Standard	Starr	Starr	Starr	Frei	Frei	Frei
Sn4	N11	GKS	Standard	Starr	Starr	Starr	Frei	Frei	Frei

5.7. Knoten



5.8. Stäbe



6. Ergebnisse

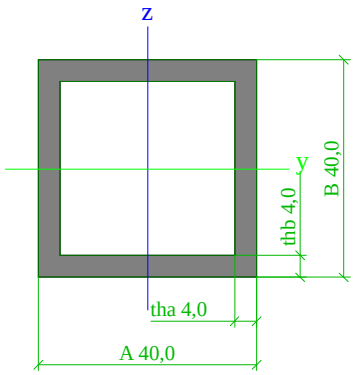
6.1. Schnittgrößen

6.1.1. Schnittgrößen - CS3

Name	CS3
Typ	O
Detailliert	40,0; 4,0; 40,0; 4,0
Materialangabe	EN-AW 6063 (EP,ET,ER/B) T66 (0-10)
Herstellung	allgemein
Knick y-y	b
Knick z-z	b
FEM-Analyse	×

A [cm²]	5,76	
A y, z [cm²]	2,88	2,88
I y, z [cm⁴]	12,60	12,60
It [cm⁴]	16,80	
Iw [cm⁶]	0,00	
Wel y, z [cm³]	6,30	6,30
Wt [cm³]	0,00	
Wpl y, z [cm³]	7,81	7,81
d y, z [mm]	0,0	0,0
c YLKS, ZLKS [mm]	-16,0	16,0
Alpha [deg]	0,00	
AL [m²/m]	1,6000e-01	
i y, z [cm]	1,48	1,48

Bild



6.1.1.1. Stabschnittgrößen

Stabschnittgrößen
Stabschnittgrößen
Nichtlineare Analyse, Extremwerte : Querschnitt, System : Hauptsystem
Auswahl : Alle
LFK-Klasse : RC1
Querschnitt : CS3 - O (40,0; 4,0; 40,0; 4,0)

LF	Teil	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
NC5	B6	0,000	**-6,58**	-0,33	0,59	-0,01	-0,77	0,31
NC2	B7	0,000	**-0,11**	0,00	0,02	0,00	-0,01	0,00
NC5	B5	0,000	-5,14	**-0,45**	0,91	**-0,01**	-0,89	**0,38**
NC5	B8	0,000	-6,57	**0,47**	0,71	**0,01**	-0,69	**-0,39**
NC2	B6	1,120	-0,13	0,00	**0,01**	0,00	0,00	0,00
NC4	B7	0,613	-6,06	-0,04	**1,23**	0,00	-0,37	0,03
NC4	B7	0,000	-6,11	0,13	1,07	0,00	**-1,09**	0,00
NC8	B5	0,920	-5,07	-0,33	0,93	0,00	**0,00**	0,00

6.1.1.2. Spannungen

Nichtlineare Analyse, Extremwerte : Teil
Auswahl : Alle
LFK-Klasse : RC1
Querschnitt : CS3 - O (40,0; 4,0; 40,0; 4,0)

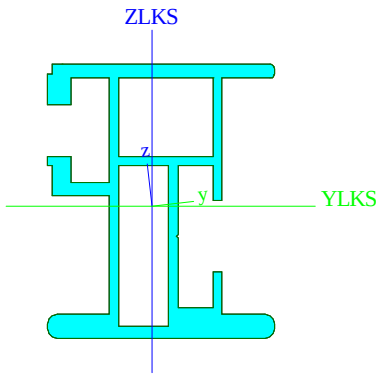
Teil	Typname	LF	dx [m]	Normal - [kN/cm²]	Normal + [kN/cm²]	Schub [kN/cm²]	von Mises [kN/cm²]
B5	Spannungen	RC1	0,000	**-21,00**	**19,22**	**0,49**	**21,00**
B5	Spannungen	RC1	0,920	**-1,03**	**0,00**	**0,36**	**1,20**
B6	Spannungen	RC1	0,000	**-18,24**	**15,96**	0,33	**18,24**
B6	Spannungen	RC1	1,120	**-1,14**	**0,00**	**0,27**	**1,23**
B6	Spannungen	RC1	0,320	-13,35	11,07	**0,33**	13,35
B7	Spannungen	RC1	0,000	**-18,44**	**16,48**	**0,43**	**18,44**
B7	Spannungen	RC1	0,920	**-1,05**	**0,00**	0,46	**1,32**
B7	Spannungen	RC1	0,613	-7,37	5,26	**0,48**	7,37
B7	Spannungen	RC1	0,307	-13,28	11,17	0,46	13,28
B8	Spannungen	RC1	0,000	**-18,67**	**16,53**	**0,42**	**18,67**
B8	Spannungen	RC1	0,920	**-1,14**	**0,00**	0,46	**1,33**
B8	Spannungen	RC1	0,613	-7,26	5,14	**0,48**	7,26
B8	Spannungen	RC1	0,307	-13,06	10,93	0,46	13,06

6.1.2. Schnittgrößen - CS4

Name	CS4
Typ	Allgemeiner Querschnitt
Materialangabe	EN-AW 6063 (EP,ET,ER/B) T66 (0-10)
Herstellung	allgemein
Knick y-y	c
Knick z-z	c
FEM-Analyse	✓

A [cm²]	7,23	
A y, z [cm²]	4,97	3,10
I y, z [cm⁴]	33,26	12,15
It [cm⁴]	4,52	
I YLCS, ZLCS [cm⁴]	33,03	12,38
Iw [cm⁶]	53,56	
Wel y, z [cm³]	10,34	4,20
Wt [cm³]	1,81	
Wpl y, z [cm³]	13,89	8,16
d y, z [mm]	-2,8	1,3
c YLKS, ZLKS [mm]	-2,0	-12,1
Alpha [deg]	5,98	
IYZLKS [cm⁴]	-2,19	
AL [m²/m]	3,5288e-01	
i y, z [cm]	2,14	1,31

Bild



6.1.2.1. Stabschnittgrößen

Stabschnittgrößen
Stabschnittgrößen
Nichtlineare Analyse, Extremwerte : Querschnitt, System : Hauptsystem
Auswahl : Alle
LFK-Klasse : RC1
Querschnitt : CS4 - Allgemeiner Querschnitt

LF	Teil	dx [m]	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
NC5	B1	1,000	**-1,03**	0,04	0,08	0,00	1,58	0,09
NC5	B3	1,000	**0,11**	0,02	-0,71	0,00	0,16	-0,01
NC5	B2	2,000	-0,46	**-0,69**	-4,35	0,00	-1,04	-0,18
NC5	B2	0,000	-0,46	**0,74**	4,26	0,00	-0,95	**-0,23**
NC4	B1	2,000	-0,89	-0,52	**-4,67**	0,00	**-1,34**	-0,15
NC4	B2	0,000	-0,83	0,55	**4,67**	**0,00**	-1,34	-0,18
NC5	B1	2,000	-0,89	-0,15	-4,30	**0,00**	-0,95	-0,01
NC3	B2	1,000	-0,74	0,03	-0,05	0,00	**1,59**	0,15
NC5	B2	1,000	-0,57	0,03	-0,05	0,00	1,57	**0,21**

6.1.2.2. Spannungen

Nichtlineare Analyse, Extremwerte : Teil
Auswahl : Alle

LFK-Klasse : RC1
Querschnitt : CS4 - Allgemeiner Querschnitt

Teil	Typname	LF	dx [m]	Normal - [kN/cm²]	Normal + [kN/cm²]	Schub [kN/cm²]	von Mises [kN/cm²]
B1	Spannungen	RC1	0,923	**-16,50**	**14,80**	0,39	**16,50**
B1	Spannungen	RC1	1,692	**-3,48**	**2,89**	2,30	**3,99**
B1	Spannungen	RC1	1,000	-16,48	14,77	**0,23**	16,48
B1	Spannungen	RC1	2,000	-13,26	14,36	**2,75**	14,37
B1	Spannungen	RC1	0,308	-4,28	3,80	2,03	4,28
B1	Spannungen	RC1	0,000	-11,70	12,79	2,48	12,79
B2	Spannungen	RC1	1,000	**-17,72**	**15,85**	**0,22**	**17,72**
B2	Spannungen	RC1	0,308	**-3,10**	**2,86**	2,28	**3,96**
B2	Spannungen	RC1	0,000	-13,78	15,03	**2,73**	15,03
B2	Spannungen	RC1	1,692	-4,76	4,21	2,20	4,77
B2	Spannungen	RC1	0,462	-7,85	7,05	1,91	7,86
B3	Spannungen	RC1	0,000	**-6,89**	**7,74**	**1,45**	**7,75**
B3	Spannungen	RC1	0,333	**-2,09**	**2,16**	0,96	**2,16**
B3	Spannungen	RC1	0,667	-2,93	2,81	**0,56**	2,93
B3	Spannungen	RC1	0,833	-2,60	2,49	0,83	2,60
B3	Spannungen	RC1	0,500	-2,64	2,70	0,59	2,70
B4	Spannungen	RC1	1,000	**-8,78**	**9,92**	**1,35**	**9,92**
B4	Spannungen	RC1	0,667	**-1,81**	**1,91**	0,88	**1,91**
B4	Spannungen	RC1	0,333	-2,37	2,20	**0,36**	2,37
B4	Spannungen	RC1	0,000	-3,36	3,81	0,81	3,81
B4	Spannungen	RC1	0,500	-2,19	2,18	0,52	2,19

6.2. Resultierende der Lastfälle

6.2.1. Resultierende der Lastfälle - E1

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Richtung
E1	Profile	Ständig	LG1	Eigengewicht	-Z

6.2.1.1. Resultierende

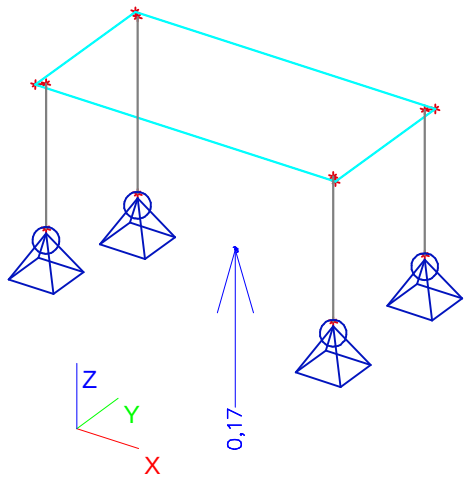
Resultierende

LF	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
E1	**0,00**	**0,00**	**0,17**	**0,00**	**0,00**	**0,00**

Zentralpunkt

X [m]	Y [m]	Z [m]
1,000	0,500	-1,170

6.2.1.2. res Reaktion



6.2.2. Resultierende der Lastfälle - E2

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp
E2	Holzplatte	Ständig	LG1	Standard

6.2.2.1. Resultierende

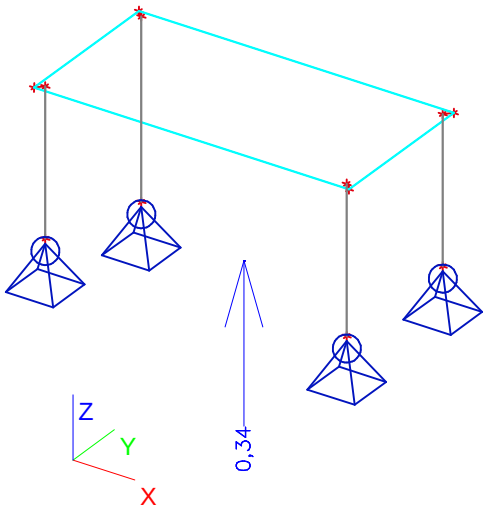
Resultierende

LF	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
E2	**0,00**	**0,00**	**0,34**	**0,00**	**0,00**	**0,00**

Zentralpunkt

X [m]	Y [m]	Z [m]
1,000	0,500	-1,170

6.2.2.2. res Reaktion



6.2.3. Resultierende der Lastfälle - V1

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Spez	Dauer	Vorherrschender Lastfall
V1	Flächenlast	Variabel	LG2	Statisch	Standard	Kurz	Nein

6.2.3.1. Resultierende

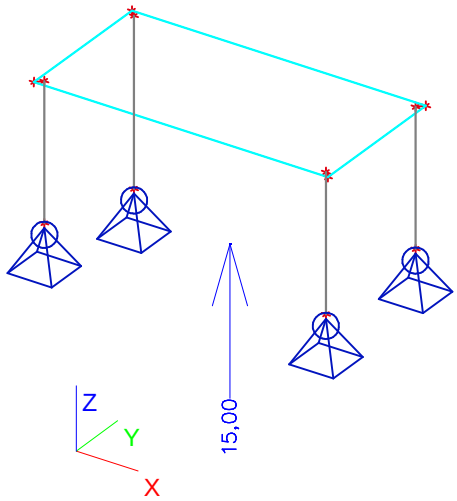
Resultierende

LF	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
V1	**0,00**	**0,00**	**15,00**	**0,00**	**0,00**	**0,00**

Zentralpunkt

X [m]	Y [m]	Z [m]
1,000	0,500	-1,170

6.2.3.2. res Reaktion



6.2.4. Resultierende der Lastfälle - H1

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Spez	Dauer	Vorherrschender Lastfall
H1	V/20 - X	Variabel	LG3	Statisch	Standard	Kurz	V1 - Flächenlast

6.2.4.1. Resultierende

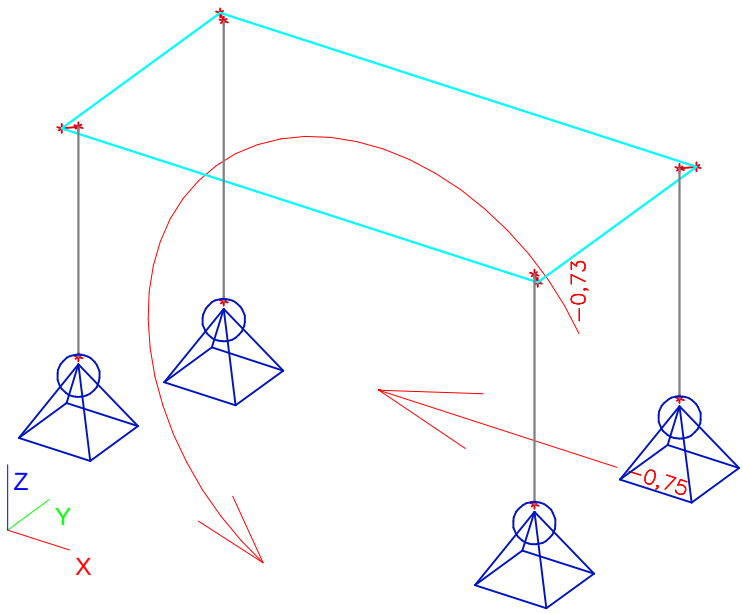
Resultierende

LF	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
H1	**-0,75**	**0,00**	**0,00**	**0,00**	**-0,73**	**0,00**

Zentralpunkt

X [m]	Y [m]	Z [m]
1,000	0,500	-1,170

6.2.4.2. res Reaktion



6.2.5. Resultierende der Lastfälle - H2

Name	Beschreibung	Einwirkungstyp	Lastgruppe	Lasttyp	Spez	Dauer	Vorherrschender Lastfall
H2	V/20 - Y	Variabel	LG3	Statisch	Standard	Kurz	V1 - Flächenlast

6.2.5.1. Resultierende

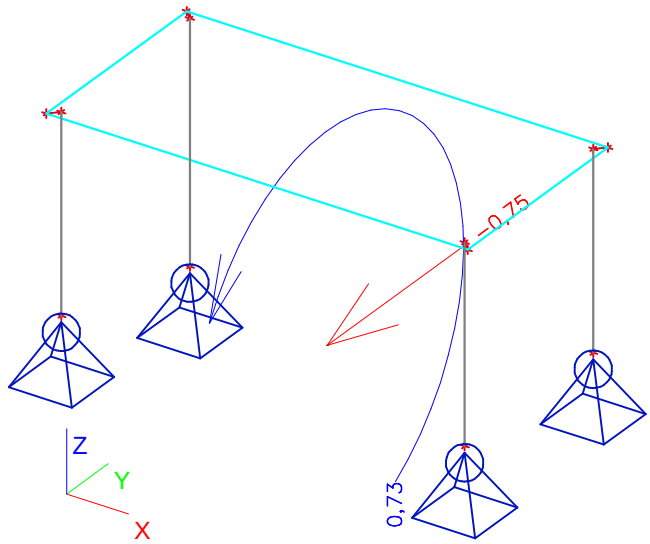
Resultierende

LF	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
H2	**0,00**	**-0,75**	**0,00**	**0,73**	**0,00**	**0,00**

Zentralpunkt

X [m]	Y [m]	Z [m]
1,000	0,500	-1,170

6.2.5.2. res Reaktion



6.3. Ergebnisklassen

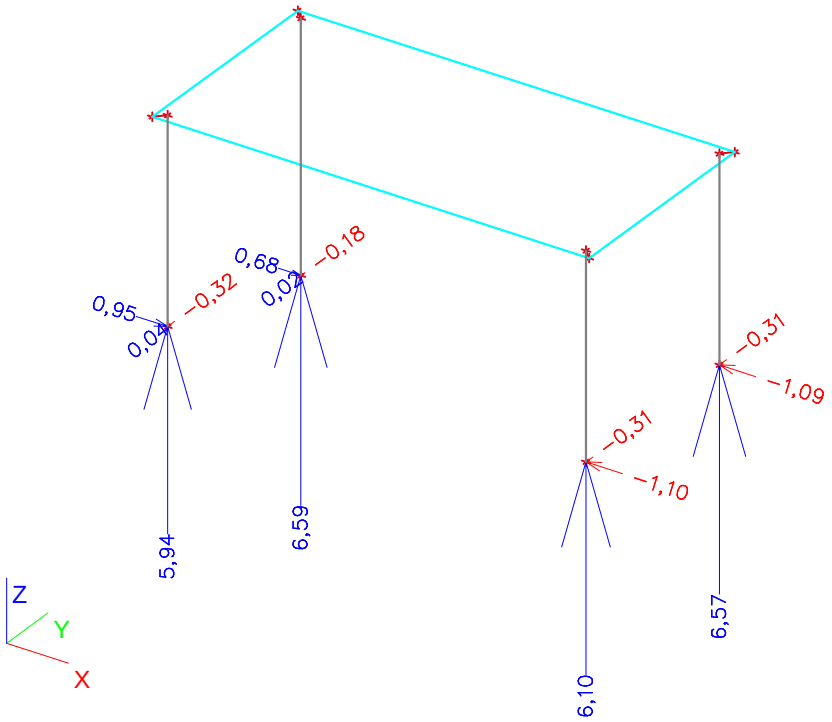
6.3.1. Ergebnisklassen - RC1

Name	Liste
RC1	NC1
	NC2
	NC3
	NC4
	NC5
	NC6
	NC7
	NC8

6.3.1.1. Reaktionen

LF	Auflager	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
NC2	Sn1/N5	**0,02**	0,00	**0,13**	0,00	0,00	0,00
NC5	Sn1/N5	**0,95**	-0,32	5,13	0,00	0,00	0,00
NC8	Sn1/N5	0,94	**-0,32**	5,09	0,00	0,00	0,00
NC3	Sn1/N5	0,92	**0,04**	**5,94**	0,00	0,00	0,00
NC1	Sn1/N5	0,02	0,00	0,18	**0,00**	**0,00**	**0,00**
NC2	Sn2/N7	**0,01**	0,00	**0,13**	0,00	0,00	0,00
NC3	Sn2/N7	**0,68**	**0,02**	5,79	0,00	0,00	0,00
NC8	Sn2/N7	0,65	**-0,18**	6,54	0,00	0,00	0,00
NC5	Sn2/N7	0,66	-0,18	**6,59**	0,00	0,00	0,00
NC1	Sn2/N7	0,02	0,00	0,18	**0,00**	**0,00**	**0,00**
NC4	Sn3/N9	**-1,10**	-0,01	**6,10**	0,00	0,00	0,00
NC2	Sn3/N9	**-0,02**	**0,00**	**0,13**	0,00	0,00	0,00
NC5	Sn3/N9	-0,82	**-0,31**	4,90	0,00	0,00	0,00
NC1	Sn3/N9	-0,02	0,00	0,17	**0,00**	**0,00**	**0,00**
NC4	Sn4/N11	**-1,09**	-0,02	6,15	0,00	0,00	0,00
NC2	Sn4/N11	**-0,01**	**0,00**	**0,13**	0,00	0,00	0,00
NC5	Sn4/N11	-0,78	**-0,31**	**6,57**	0,00	0,00	0,00
NC1	Sn4/N11	-0,02	0,00	0,17	**0,00**	**0,00**	**0,00**

6.3.1.2. Auflager



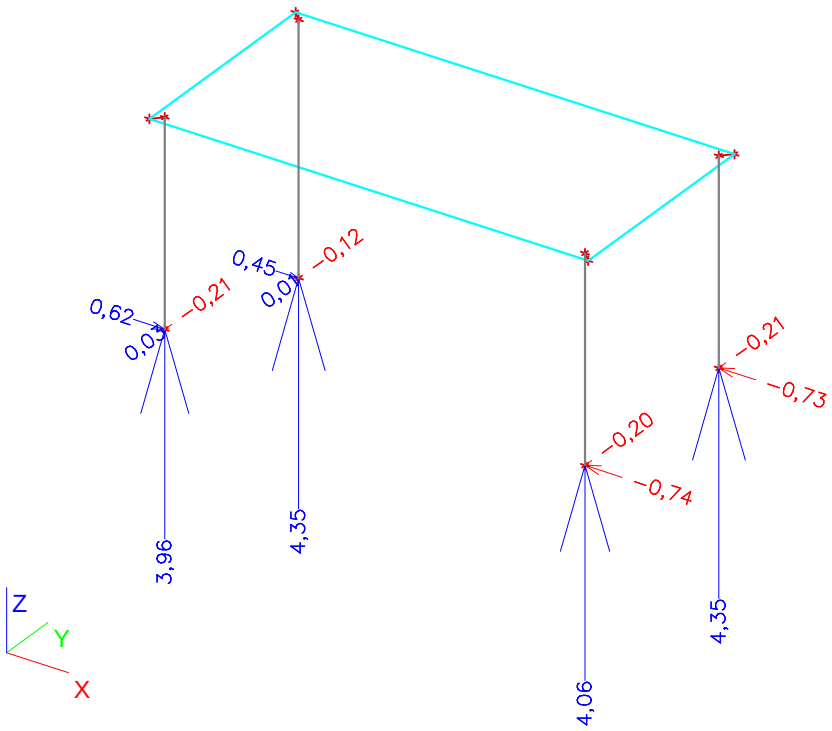
6.3.2. Ergebnisklassen - RC2

Name	Liste
RC2	NC9
	NC10
	NC11

6.3.2.1. Reaktionen

LF	Auflager	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
NC10	Sn1/N5	**0,39**	0,02	3,69	0,00	0,00	0,00
NC11	Sn1/N5	**0,62**	**-0,21**	**3,47**	0,00	0,00	0,00
NC9	Sn1/N5	0,60	**0,03**	**3,96**	**0,00**	**0,00**	**0,00**
NC10	Sn2/N7	**0,32**	0,00	**3,67**	0,00	0,00	0,00
NC9	Sn2/N7	**0,45**	**0,01**	3,87	**0,00**	**0,00**	**0,00**
NC11	Sn2/N7	0,43	**-0,12**	**4,35**	0,00	0,00	0,00
NC10	Sn3/N9	**-0,74**	**0,00**	**4,06**	0,00	0,00	0,00
NC9	Sn3/N9	**-0,54**	-0,01	3,80	**0,00**	**0,00**	**0,00**
NC11	Sn3/N9	-0,54	**-0,20**	**3,33**	0,00	0,00	0,00
NC10	Sn4/N11	**-0,73**	**-0,01**	4,09	0,00	0,00	0,00
NC11	Sn4/N11	**-0,51**	**-0,21**	**4,35**	0,00	0,00	0,00
NC9	Sn4/N11	-0,52	-0,02	**3,89**	**0,00**	**0,00**	**0,00**

6.3.2.2. Auflager



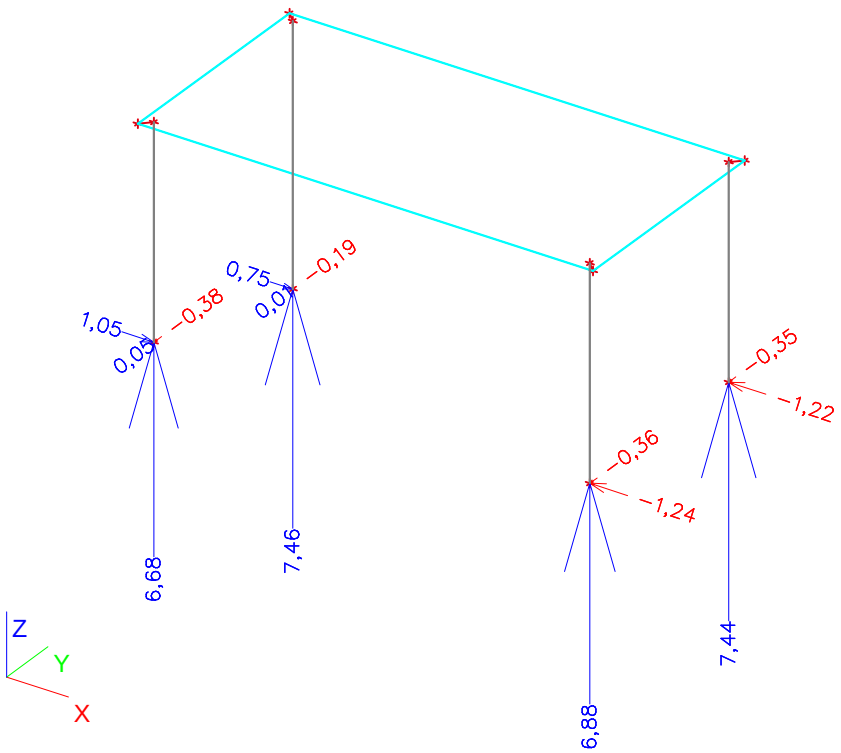
6.3.3. Ergebnisklassen - RC3

Name	Liste
RC3	NC13
	NC14
	NC15

6.3.3.1. Reaktionen

LF	Auflager	Rx [kN]	Ry [kN]	Rz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
NC14	Sn1/N5	**0,65**	0,03	6,12	0,00	0,00	0,00
NC15	Sn1/N5	**1,05**	**-0,38**	**5,70**	0,00	0,00	0,00
NC13	Sn1/N5	1,01	**0,05**	**6,68**	**0,00**	**0,00**	**0,00**
NC14	Sn2/N7	**0,54**	-0,01	**6,08**	0,00	0,00	0,00
NC13	Sn2/N7	**0,75**	**0,01**	6,48	**0,00**	**0,00**	**0,00**
NC15	Sn2/N7	0,71	**-0,19**	**7,46**	0,00	0,00	0,00
NC14	Sn3/N9	**-1,24**	**-0,01**	**6,88**	0,00	0,00	0,00
NC13	Sn3/N9	**-0,89**	-0,02	6,34	**0,00**	**0,00**	**0,00**
NC15	Sn3/N9	-0,90	**-0,36**	**5,42**	0,00	0,00	0,00
NC14	Sn4/N11	**-1,22**	**-0,02**	6,93	0,00	0,00	0,00
NC15	Sn4/N11	**-0,86**	**-0,35**	**7,44**	0,00	0,00	0,00
NC13	Sn4/N11	-0,86	-0,04	**6,51**	**0,00**	**0,00**	**0,00**

6.3.3.2. Auflager



TÜV THÜRINGEN

Modell und technische Beschreibung:

Podest Alu Rapid

- Bühnenpodest –Aluminiumkonstruktion
- Fußtyp: Steckfuß 40 x 40 x 4 mm
- Podestgröße: 200 x 100 cm, 100 x 100 cm
- Rahmenhöhe: 80 mm
- Masse (ohne Füße):
  - Tischlerplatte: ca. 38 kg
  - Siebdruckplatte: ca. 45 kg
- maximale Aufbauhöhe: 1,00 m (horizontale Ersatzlast 1/20)
- Nutzlast: 7,5 kN/m²
- Sicherheitsfaktor Überlastprüfung: 1,65
- Plattenstärke: 22 mm
- verbaute Materialien:
  - Rahmen: EN AW-6063
  - Fußaufnahmen: ZAMAK ZL0410
  - Steckfüße: EN AW-6063 (40 x 40 x 4,0 mm)
  - Podestplatten: Tischlerplatte
Siebdruckplatte
- Besonderheiten: Fixierung der Steckfüße über Andruckwinkel mit Flügelschraube
- Zubehör: Podestverbinder, Stabi-Leiste

Anwendungsbereich: Podeste für Szenenflächen (Bühnen) und Tribünen

TÜV THÜRINGEN

Zeichengenehmigungsausweis Nr.: 3510-6553-17.Z01
Mark Approval Certificate No.

(Nur gültig mit umseitigen Bedingungen und Zeichengehmigungsvertrag / *only valid with terms and conditions overleaf and Mark Approval Contract)*

Genehmigungsinhaber: *Licence holder*	Podestbau Kleu GmbH Rosenthalstraße 18, 42369 Wuppertal
Fertigungsstätte: *Manufacturing location*	Podestbau Kleu GmbH Rosenthalstraße 18, 42369 Wuppertal

Zeichen des Antragstellers *Reference of applicant*	Antragsdatum *Date of application*	Aktenzeichen *File reference*	Prüfbericht *Test report*	Ausstellungsdatum *Date of issue*
	28.09.2017	3510-6553-17	6553/17/01	20.02.2018

Prüfzeichen *(Test mark)*:

TÜV International Certification – TÜV THÜRINGEN – TIC
Sicherheit geprüft
DIN 15921, EK5/AK1 11-01.3
- Belastung
- Steifigkeit
- Gestaltung
- PAK nach AfPS GS 2014:01

ID 3510-6553-17.Z01 www.tuev-thueringen.de

TÜV International Certification – TÜV THÜRINGEN – TIC
Sicherheit geprüft
DIN 15921, EK5/AK1 11-01.3
- Belastung
- Steifigkeit
- Gestaltung
- PAK nach AfPS GS 2014:01

ID 3510-6553-17.Z01 www.tuev-thueringen.de

Erzeugnis: *Product*	**Bühnenpodest-Einzelelement** **Podest Alu Rapid**
Technische Beschreibung: *Technical description*	siehe Anlage 1
Prüfgrundlagen: *Testing fundamentals*	PP 35100010.01 (PfG EK5/AK1 11-01.3:2016, DIN 15921:2015-09), AfPS GS 2014:01 PAK

Das/die oben aufgeführte/n Erzeugnis/se erfüllt/erfüllen die in den oben genannten Prüfgrundlagen gestellten Anforderungen. Die Genehmigung, das oben abgebildete Prüfzeichen gemäß den umseitig abgedruckten Vertragsbedingungen zu verwenden, wird hiermit erteilt. Die Übertragung der Zeichengenehmigung durch den Genehmigungsinhaber auf Dritte ist unzulässig.

The product/s specified above fulfils/fulfil the requirements of the testing fundamentals mentioned above. Approval for using the test mark illustrated above in accordance with the contractual conditions printed overleaf is hereby given. The licence holder is not authorized to transfer the mark approval to a third party.

Dieser Ausweis gilt bis zum 19.02.2023. ***This certificate is valid 19.02.2023.***

Eine Veröffentlichung dieses Zertifikates ist ohne schriftliche Genehmigung der Prüfstelle nicht gestattet.
The publishing of this certificate needs the written approval of the testing centre.

Dieser Ausweis besteht aus / *This certificate consists of:*
1 Blatt / *1 sheet*, 1 Anlage Seite 1 – 1 / *1 annex sheet 1 – 1*

Dipl.-Ing. Beate Grüning
stellv. Leiterin der Zertifizierungsstelle / *Deputy head of certification body*

TÜV Thüringen Anlagentechnik GmbH & Co. KG, Prüfstelle für Gerätesicherheit, Ichtershäuser Str. 32, 99310 Arnstadt

Ingenieurkammer-Bau
Nordrhein-Westfalen
Mitglied 310657

Architektur

Statik

Ausführung

Controlling

VAHL

Statische Berechnung

Typenberechnung

Herstellung & Vertrieb:

Podest - Bau Kleu GmbH
Ludwig-Richter-Straße 7
D-42329 Wuppertal
Telefon: 02 02 / 27 90 90

Ausführung:

Geländer PK1
mit Geländerhalter

Bauort:

Fliegende Bauten

Aufgestellt:

Planungsbüro • Dipl.-Ing. Manfred Vahl
Wuppertaler Straße 46, 45549 Sprockhövel

Inhalt: Statik Seite 1 - 13

Anlagen: Werkszeichnungen Podest - Bau Kleu GmbH Seiten 14 + 15

Sprockhövel, den 20.11.2004

Aufgestellt: .....

INGENIEURKAMMER-BAU NORDRHEIN-WESTFALEN MITGLIED 310657

Planungsbüro • Dipl.-Ing. Manfred Vahl • Wuppertaler Str. 46 • 45549 Sprockhövel • Tel. 02324/702417 • Fax: 02324/702418

Inhaltsverzeichnis:

			Seite/Blatt
	Deckblatt		1
	Inhalt, Vorschriften,		2
	Allgemeine Vorbemerkungen		3
	Geländer	Positionsplan	4
	Detail „ C “	Positionsplan	5
	Materialangaben		6
Pos. 1	Handlauf	Bemessung	7
Pos. 2	Geländerpfosten	Bemessung	8 + 9
Pos. 3	Schweißverbindung oben Handlauf / Pfosten	Bemessung	10
Pos. 4	Schweißverbindung unten Pfosten / Geländerhalter	Bemessung	11
Pos. 5	Schraubverbindung Geländerhalter / Podestrahmen	Bemessung	12
Pos. 6	Scherkräfte am Podestrahmen durch Nutensteine	Bemessung	13
	Anlagen: Podestbau – Kleu GmbH		
1.	Geländer 1,00 x 1,10 m	Zg.-Nr.:PK 00100	14
2.	Nutenhalter	Zg.-Nr.:PK 00101	15
3.	Verbindungsstücke	Zg.-Nr.:PK 00102	16

Vorschriften:

DIN 1055/3	Lastannahmen, Verkehrslasten (06.71)
DIN 4112	Fliegende Bauten (02/83)
DIN 4113/1	Aluminiumkonstruktionen
DIN 15920/11	Bühnengeländer (08/78)
DIN 18800/1	Stahlbauten, Bemessung und Konstruktion (11/90)
DIN 18800/2	Stahlbauten, Knicken von Stäben und Stabwerken (11/90)
DIN 18808	Tragwerke aus Hohlprofilen
DIN 7990	Schrauben
FiBauR	Richtlinie über den Bau und Betrieb Fliegender Bauten (12.1997)
BGV C1	Berufsgenossenschaftliche Vorschriften -- Veranstaltungs- und Produktionsstätten für szenische Darstellung (04.1998)
VStättVO	Versammlungsstättenverordnung (12.2002)
Berechnung	u.a. nach Schneider - Bautabellen 12. Auflage (07.1996)

Allgemeine Vorbemerkungen

Die vorliegende Konstruktion für eine Bühne kann an verschiedenen Orten wiederholt aufgestellt werden.

Die Geländer werden aus Stahl in Längen von 1,00 m und 2,00 m hergestellt. Sie sind beliebig reihbar. Die einzelnen Geländer sind mit den Podestrahmen fest zu verbinden. Es sind mindestens 4 Befestigungen je 1,00 m - Geländer am Podestrahmen erforderlich.

Die Geländerhöhe beträgt 1,10 m über Podestboden für Fliegende Bauten. Der Stababstand der geschweißten Ausfachung ist in einer Richtung kleiner als 10 cm gewählt.

Die Geländer können mit einer Horizontallast von 1,00 kN/m in einer Höhe von 1,10 m belastet werden.

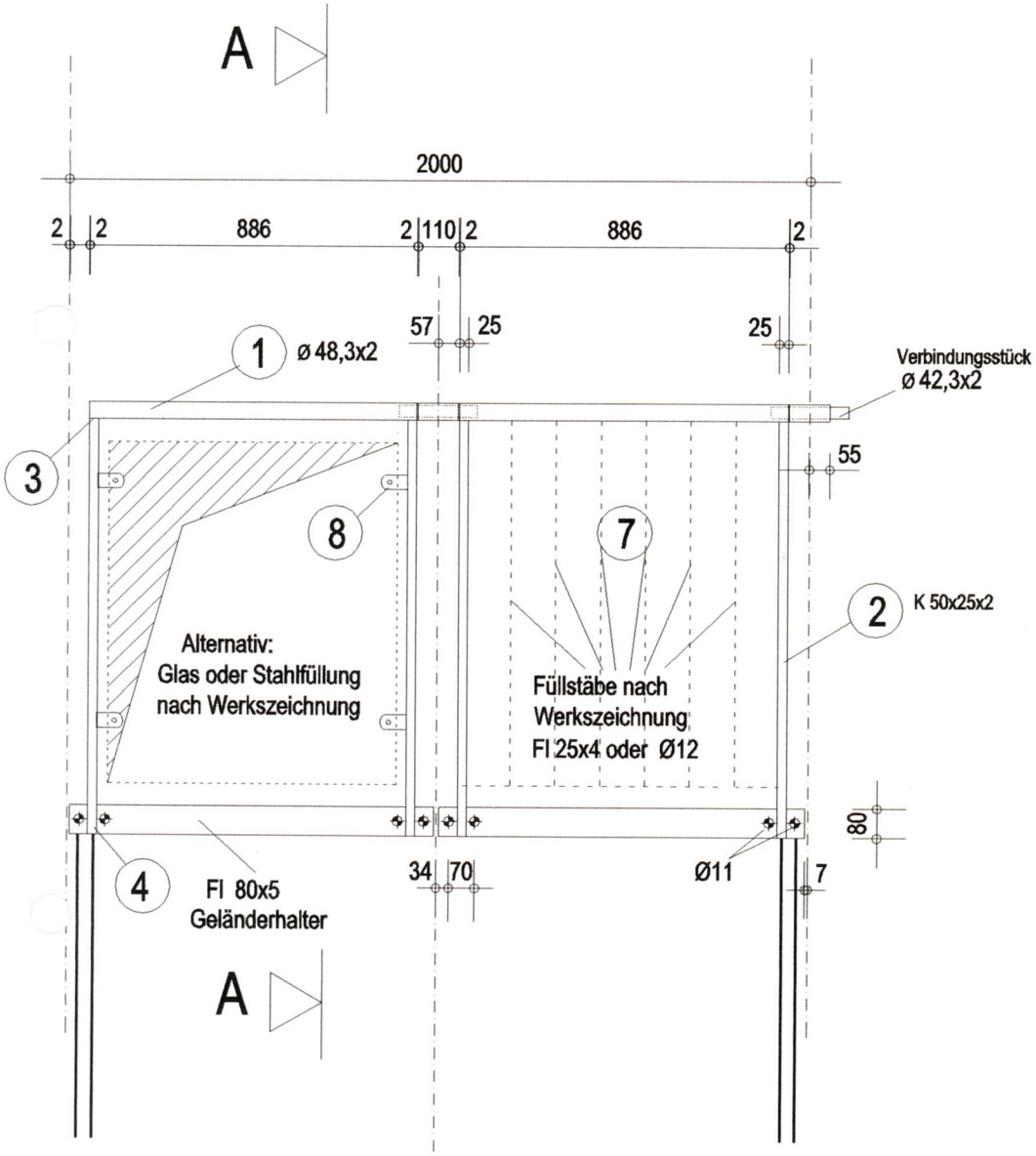
Bei der Montage der Geländer ist zu beachten:.

1. Sie sind mit den vom Hersteller vorgegebenen Verbindungsmitteln zu befestigen.
2. Nach längeren Standzeiten (>3 Monate) oder großen rhythmischen Belastungen mit Volllast sind die Verbindung zu überprüfen.
3. Die Schrauben sind mit einem Drehmomentenschlüssel kontrolliert anzuziehen.

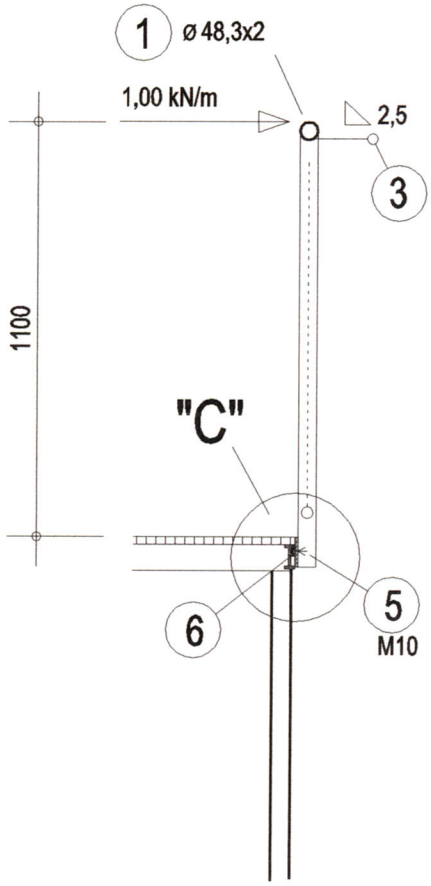
   M = 8 mit Md = 24 Nm; **M = 10** mit Md = 49 Nm; **M = 12** mit Md = 84 Nm

STATIK	VAHL Planungsbüro	Dipl. - Ing. Manfred Vahl Wuppertaler Str. 46 45549 Sprockhövel	Tel. 02324/702417 Fax. 02324/702418	Blatt Nr. 4
Maßstab 1:20	Herstellung & Vertrieb: Podest-Bau Kleu GmbH	Geländer PK1 Positionsplan - Geländer		2004-03-21

Geländeransicht



Schnitt A



Schweißnähte:
2,5 mm Kehlnaht

1 Handlauf, Geländerrohr Ø 48,3x2 (1 1/2")

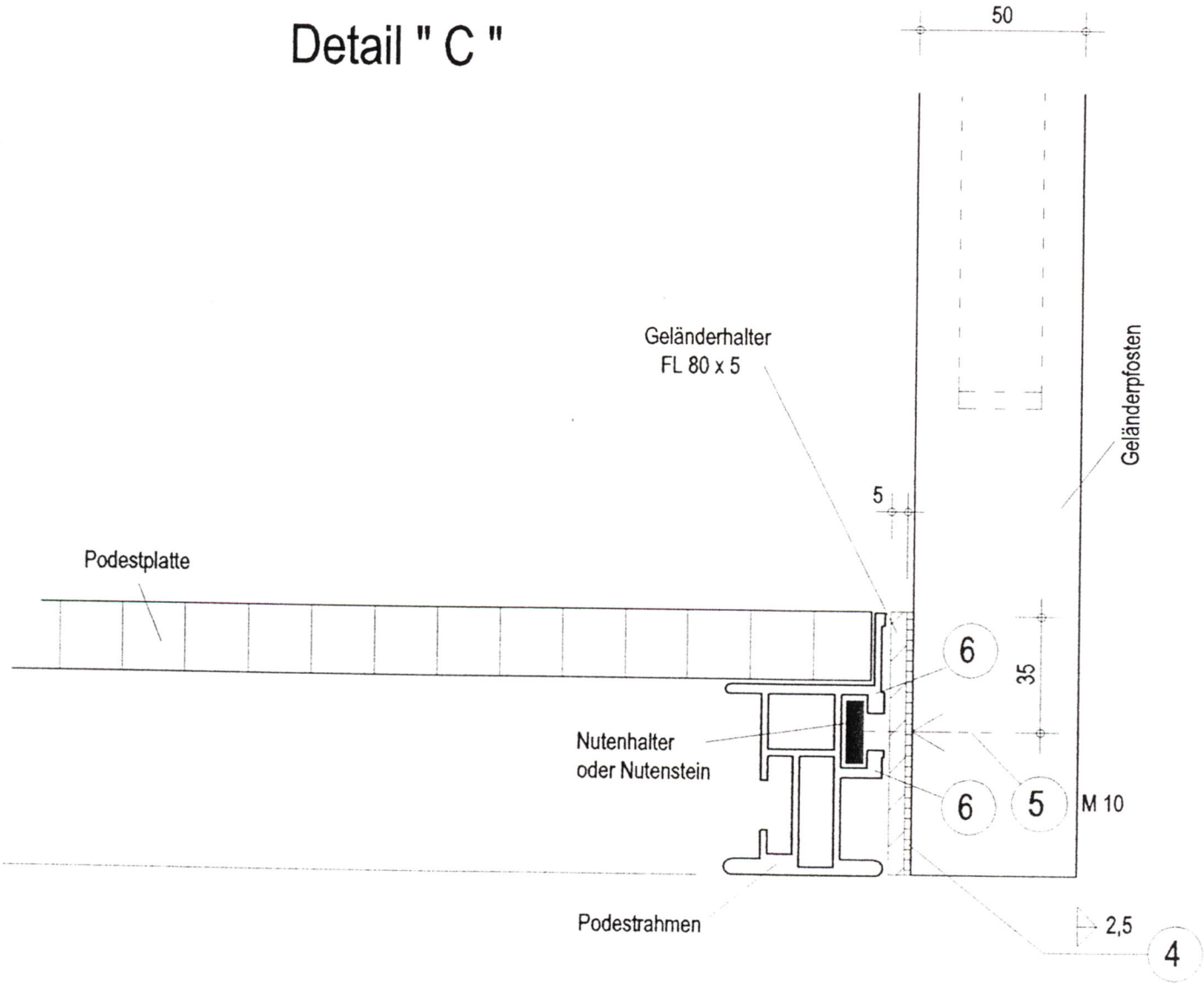
2 Pfosten, Kastenrohr 50 x 25 x 2

7 Füllstäbe, Ø 12 oder Fl 25 x 4

8 Glashalter

STATIK	VAHL Planungsbüro	Dipl.-Ing. Manfred Vahl Wuppertaler Str. 46 45549 Sprockhövel	Tel. 02324/702417 Fax. 02324/702418	Blatt Nr. 5
Maßstab 1:2	Herstellung & Vertrieb: Podest-Bau Kleu GmbH	Geländer PK 1	Detail " A "	2004-03-20

Detail " C "

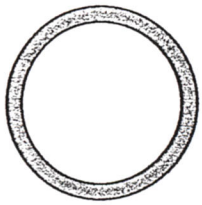


Materialangaben

Pos. 1 Handlauf

Geländerrohr ∅ 48,25x2 (1 1/2")

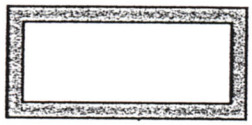
Werkstoff: R St 37-2



Pos. 2 Geländerpfosten

Rechteckrohr K 50 x 25 x 2

Werkstoff: R St 37-2



Geländerhalter

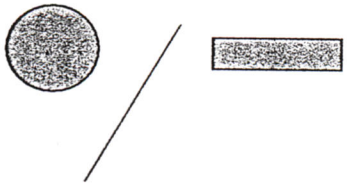
Flachprofil: Fl 80x5

Werkstoff: R St 37-2

Füllstäbe ohne Nachweis

Rundstäbe ∅ 12 / oder Fl 25x4

Werkstoff: BSt 220 S / oder R St 37-2

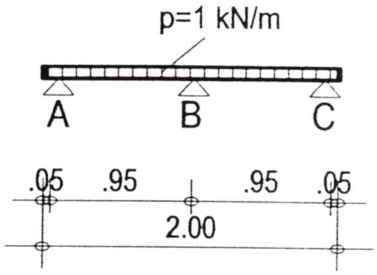


Statische Werte:

Profil mm	A mm²	$J_y = J_{T/2}$ mm4	J_z mm4	$W_y = W_{T/2}$ mm³	W_z mm³	i_y cm	G kg/m
∅ 48,25x2	291	77.846	77.846	3.227	3.227	1,64	2,284
K 50 x 25 x 2	283	29.500	89.500	2.360	3.580	2,05	2,222
Fl 80x5	400			333	5.333		3,140
∅ 12	113,1			170	170		0,888
Fl 25x4	100			67	417		0,785

Bemessung

Pos. 1 Handlauf



A = C = 1,0 * 2,00 / 4 = 0,5 kN

B = 1,0 kN geteilt auf 2 Pfosten mit je = 0,5 kN

M =1,0 * 0,95 * 0,95 / 8 = 0,11 kNm

gewählt: Handlauf, Rohr Ø 48,3 x 2
St 37 – 2 oder Edelstahl V 4A

W_z = 3,227 cm³

σ_{vorh} = 110.000 / 3.227 = 34,09 N/mm²
σ_{zul} = 240 / 1,5 = 160 N/mm²

$\sigma_{vorh} / \sigma_{zul}$ = 34,09 / 160 = 0,21 < 1

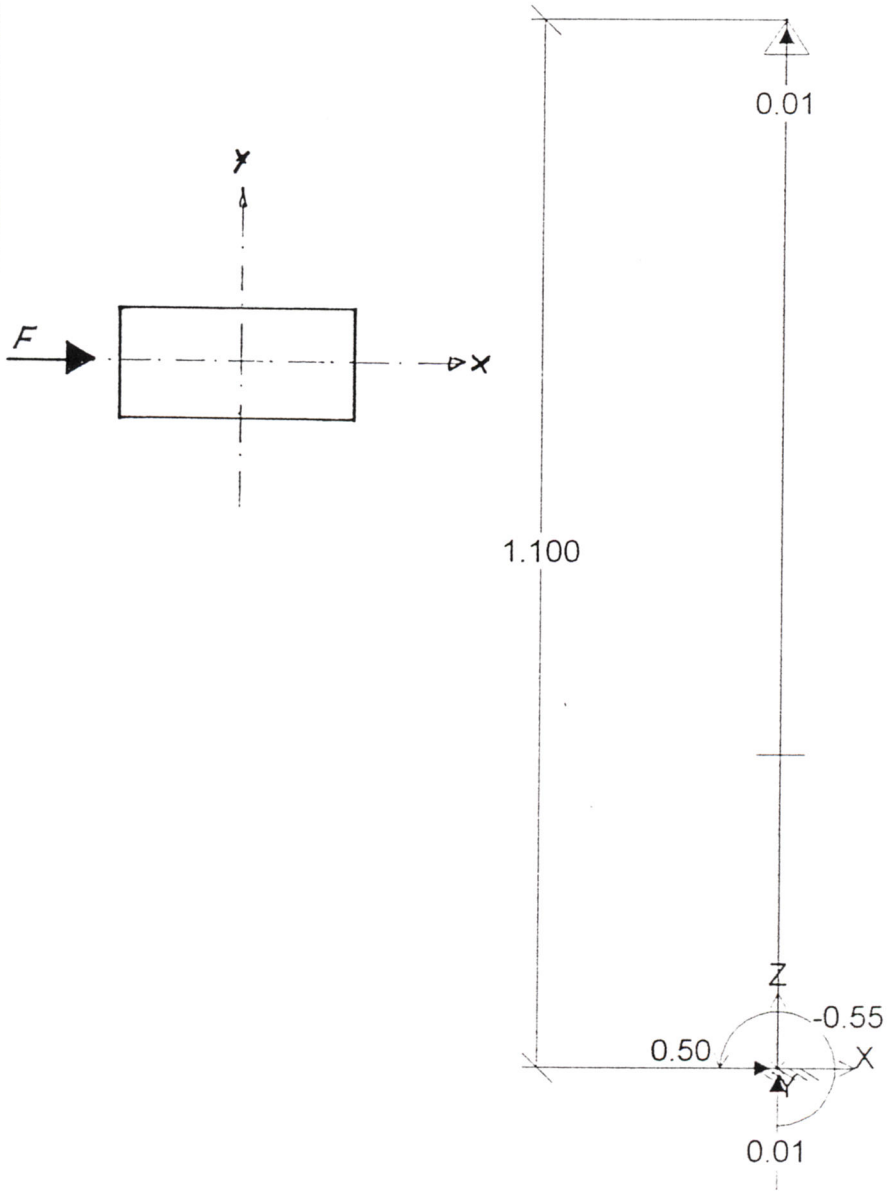
Alternativ: Rohr Ø 33,5 x 2 A = 1,98 cm² G = 1,554 kg/m

W_z = 1,469 cm³ σ_{vorh} = 110.000 / 1.469 = 74,88 N/mm²

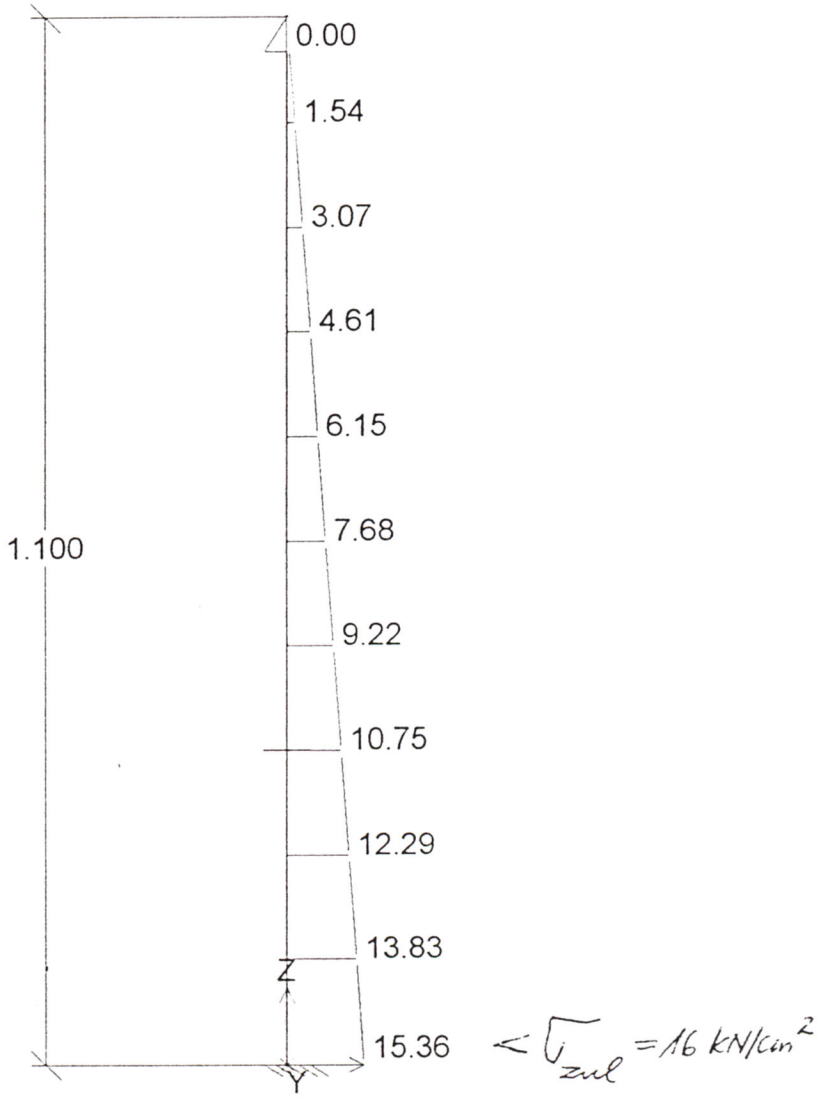
$\sigma_{vorh} / \sigma_{zul}$ = 74,88 / 160 = 0,47 < 1

Pos. 2 Geländerpfosten

gewählt: Kastenrohr 50x25x2
St 37 - 2



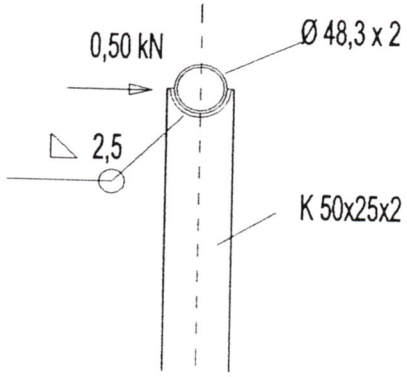
Planungsbüro Dipl.-Ing. Vahl D.I.E. Software - XEST Version: 5.31	Tel. 02324/702417 Fax: 02324/702418
Eigengewicht in Lf 1 Theorie 2. Ordnung Nichtlinear berechnet Auftrag:Geländer PK1 Position: 2 # K50x25x2 Benutzer:Pfosten	Abs. Min/Max aller LFK Auflagerkräfte [kN]/[kNm] aus max Vx Min/Max: -0.6,0.5 1:8 Seite: 08



Planungsbüro Dipl.-Ing. Vahl	Tel. 02324/702417 Fax: 02324/702418
D.I.E. Software - XEST Version: 5.31	
Eigengewicht in Lf 1 Theorie 2. Ordnung Nichtlinear berechnet Auftrag:Geländer PK1 Position: 2 # K50x25x2 Benutzer:Pfosten	Abs. Min/Max aller LFK Stahlspannung [kN/cm²] Summe Sigma Min/Max: 0.0,15.4 1:8 Seite: 09

Pos. 3 Schweißnaht zwischen Handlauf und Pfosten

gewählt: **2,5 mm Kehlnaht einseitig**
St 37 – 2 oder Edelstahl V 4A



aus Pos. 1 F = 0,50 kN

Beanspruchung aus Zug durch das Geländer

A = (3,14*48,3) * (2,5 - 0,5) = 303,32 mm²

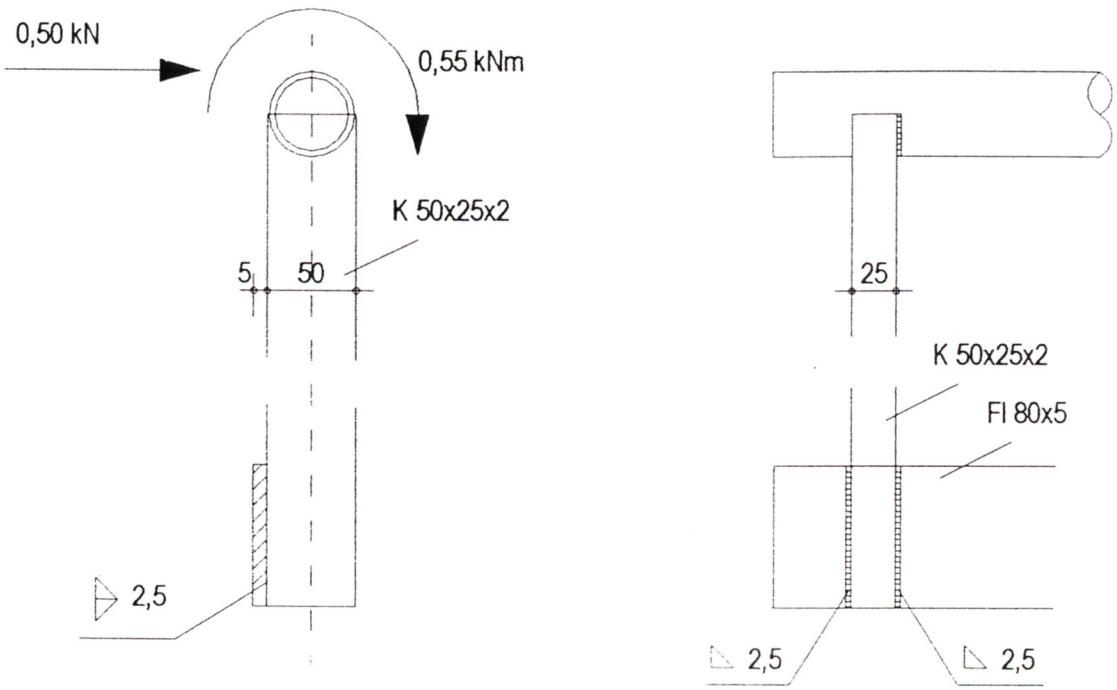
τ vorh = 500 / 303,32 = 1,65 N/mm²

τ zul = 0,95*240 / 1,5 = 152 N/mm²

τvorh / τzul = 1,65 / 152,00 = 0,011 < 1

Auf Grund der geringen Belastung sind Abminderungen aus Längen- und Dickenbegrenzung nicht nachgewiesen.

Pos. 4 Schweißnaht zwischen Pfosten und Geländerhalter



Geometrie der Kehlnaht

im Ansatz 2 Kehlnähte a 2,5 mm – 0,5 mm Toleranz, hier relevant kleinste Materialdicke 2 mm

A	=	80 * (2,5-0,5) * 2	=	320	mm²
W_x	=	(2,0 * 80 * 80 / 6) * 2	=	4266,7	mm³
F	=	0,50 kN	M =	0,55	kNm

Bemessung

τ vorh	=	500 / 320	=	1,56 N/mm²
τ zul	=	0,95*240 / 1,5	=	152 N/mm²
τvorh / τzul	=	1,56 / 152,00	=	0,01 < 1
σ vorh	=	550.000 / 4266,7	=	128,9 N/mm²
σ zul	=	0,95*240 / (1,1 *1,1)	=	188,43 N/mm²
σ vorh / σ zul	=	128,9 / 188,43	=	0,684 < 1

Auf Grund der geringen Belastung sind Abminderungen aus Längen- und Dickenbegrenzung nicht nachgewiesen.

gewählt: 2,5 mm Kehlnaht beidseitig, durchlaufend
St 37 – 2

Pos. 5 Schraubverbindung – Geländerhalter an den Podestrahmen

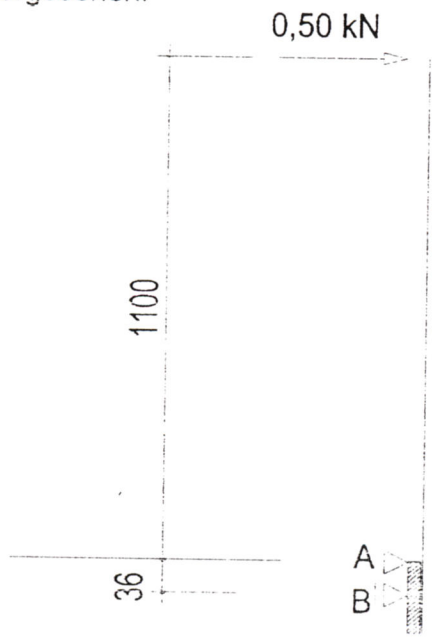
gewählt: **2 Stück Gewindestangen M 10 l = 32 mm**
Festigkeit wie SFK 4.6 nach DIN 7990

2 Stück Mutter M 10
SFK 4.6 nach DIN EN 24 034

1 Stück Flacheisen 100x20x7
St 37 – 2

2 Stück Unterlegscheibe Ø 21, t = 3 mm
DIN 6916

Die Gewindestange wird an das Flacheisen (Nutenhalter) geschweißt. Zg.-Nr.: PK 00101
Je Geländerpfosten sind 2 Schrauben vorgesehen.



Nachweis der Schraube (Gewindestange) nach DIN V ENV 1993-1-1

M_z = 0,50 * 1,136 = 0,568 kNm

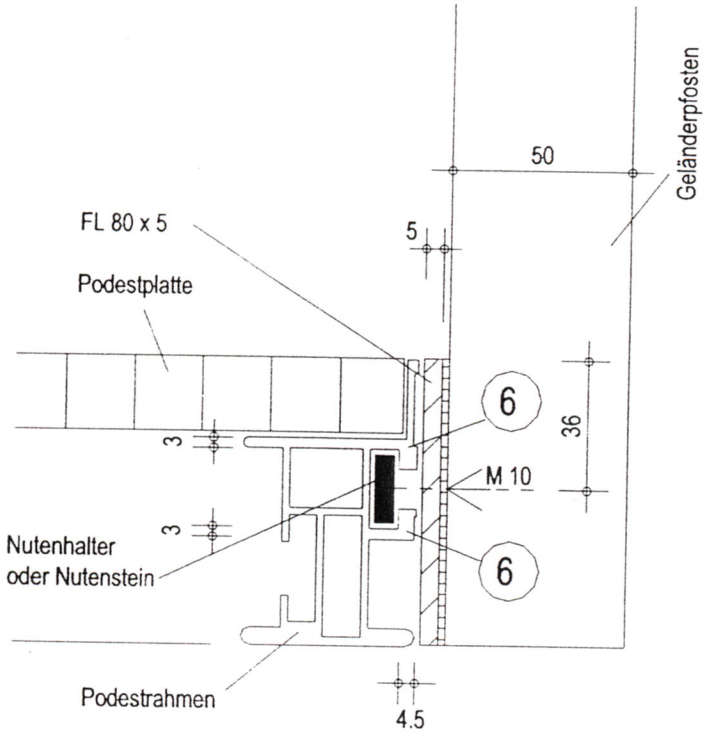
$F_{t,Sd}$ = 0,568 / 0,036 = 15,8 kN

Grenzzugkraft M10 (A_s = 0,58 cm²)
$F_{t,Rd}$ = 0,9*40,0*0,58/1,25 = 16,7 kN (Schneider S. 8.152)

Die Mutterhöhe M 10 m = 8 mm
Dicke des Nutenhalters d = 7 mm
daraus folgt: $F_{t,Rd}$ = 16,7 * 7/8 = 14,6 kN
Für 2 Muttern:

$F_{t,Sd}$ / $F_{t,Rd}$ = 15,8 / (14,6*2) = 0,54 < 1

Pos. 6 Scherkräfte am Podestrahmen durch Nutensteine



Nutenhalter L = 100 mm Alternativ: 2 Stück Nutensteine L = 2 x 40 mm

Im Ansatz:
Alu – Profil des Podestrahmens Werkstoff: Al Mg Si 0,5 – F 25,
Nutensteine aus Zinkdruckguß oder St 37, τ_{zul} = 92 N/mm² DIN 15 018

Abscheren

A	=	(40 * 2) * 4,5 * 2	=	720	mm²
F	=	15,8 kN	aus Seite12		

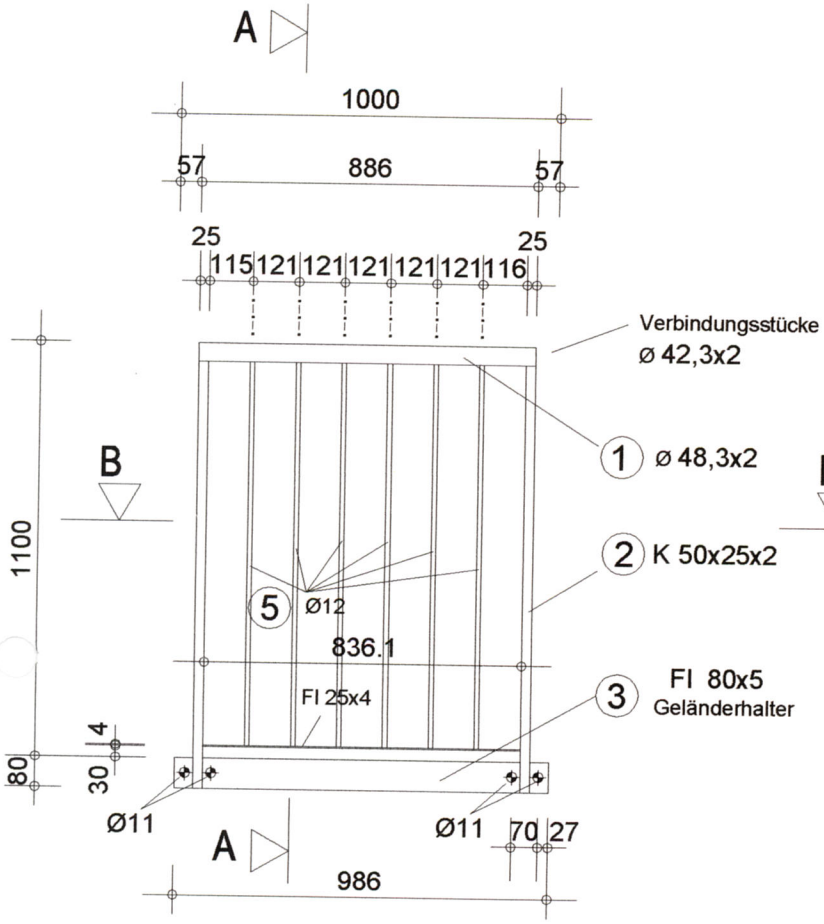
τ_{vorh}	=	15.800 / 720	=	21,94 N/mm²
τ_{zul}	=	62 N/mm²		DIN 4113
τ_{vorh} / τ_{zul}	=	21,94 / 62,00	=	0,35 < 1

Zug

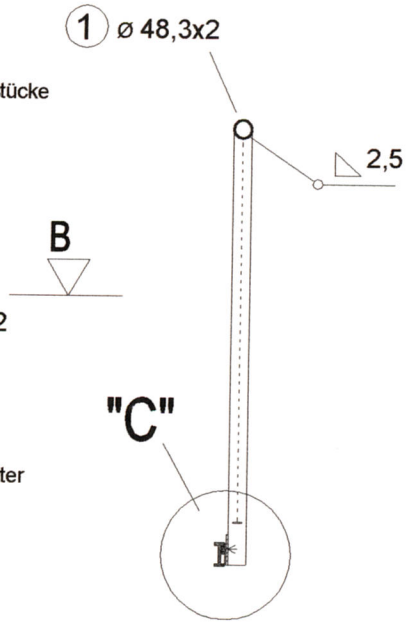
A	=	(40 * 2) * 3,0 * 2	=	480	mm²

σ_{vorh}	=	15.800 / 480	=	32,92 N/mm²
σ_{zul}	=	106 N/mm²		DIN 4113
$\sigma_{vorh} / \sigma_{zul}$	=	32,92 / 106	=	0,31 < 1

Geländeransicht 1 : 20

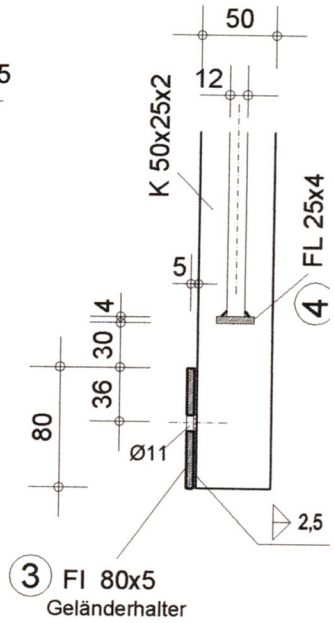


Schnitt A

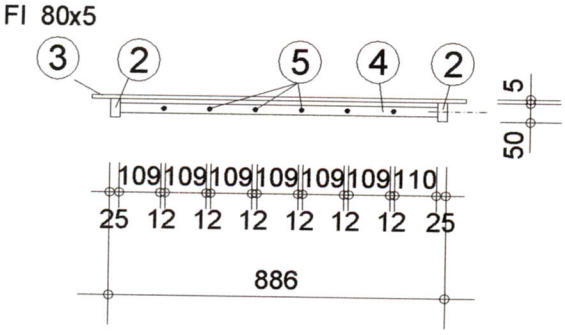


Detail "C"

1 : 5



Schnitt B



Pos.	Stück	Profil	Länge	G (kg/m)	Gesamt (kg)
1	1	Ø 48,25x2	886	2,284	2,024
2	2	K 50x25x2	1160	2,222	5,155
3	1	Fl 80x5	986	3,140	3,096
4	1	Fl 25x4	836	0,785	0,656
5	6	Ø 12	1018	0,888	5,328
				Summe	16,259 kg

Schweißnähte:
2,5 mm Kehlnaht

2005-02-07	Bemaßung	a
Datum	Änderung	Index

Betrifft

Geländer 1,00 x 1,10 m
mit Geländerhalter

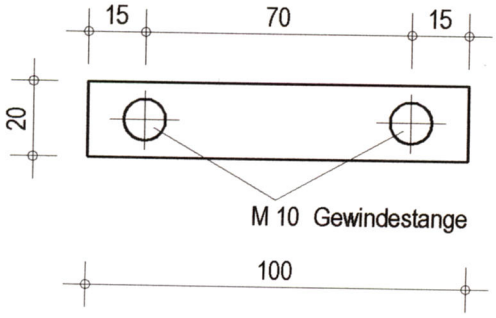
Bearbeitet

Geprüft

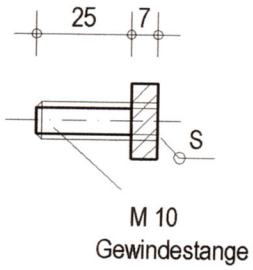
KLEU Bühnenbau Sportbau Messebau
Tel. 0202/ 27 90 90
Fax: 0202/ 73 54 56
Podest-Bau Kleu GmbH
Ludwig-Richter-Straße 7• D-42329 Wuppertal

Datum 2004-11-20	Zeichnungsnummer PK 00100		Blatt 1
Maßstab 1 : 20, 1 : 5	Werkstoff St 37 - 2	Gewicht 16,3 kg/Stück	

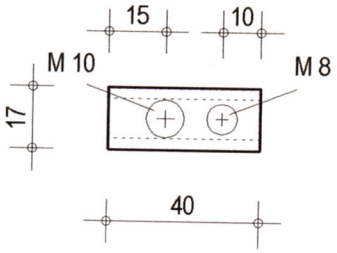
1 Nutenhalter Fl 20 x 7, l = 100 mm



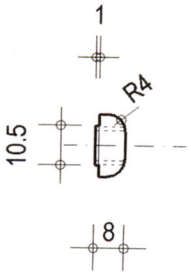
Schnitt



2 Nutenstein



Schnitt



Datum	Änderung	Index

Betrifft

Nutenhalter

Bearbeitet

Geprüft

KLEU Bühnenbau Sportbau Messebau

Tel. 0202/ 27 90 90
Fax: 0202/ 73 54 56

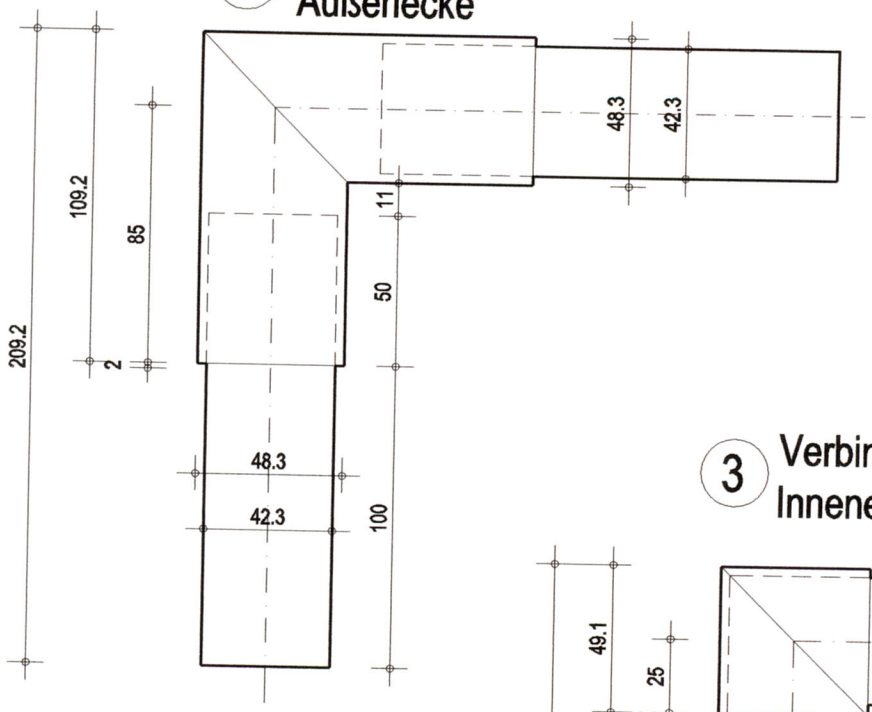
Podest-Bau Kleu GmbH

Ludwig-Richter-Straße 7 •D-42329 Wuppertal

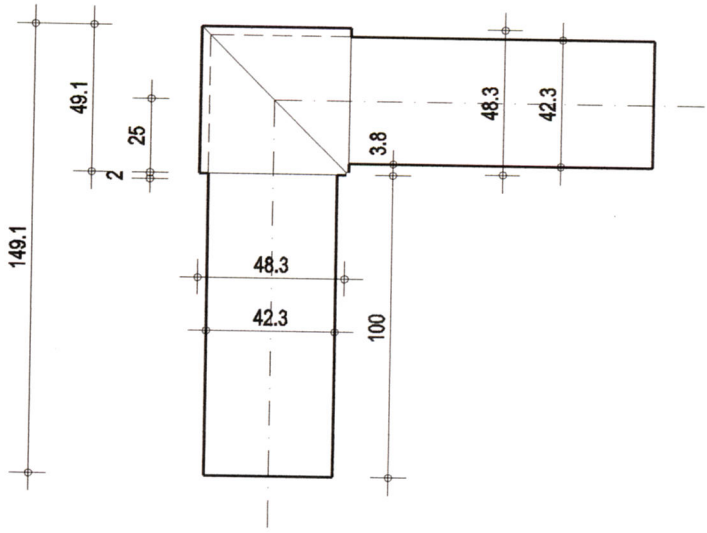
Datum	Zeichnungsnummer	Blatt
2004-11-21	PK 00101	1

Maßstab	Werkstoff	Gewicht
1 : 2	St 37 - 2	

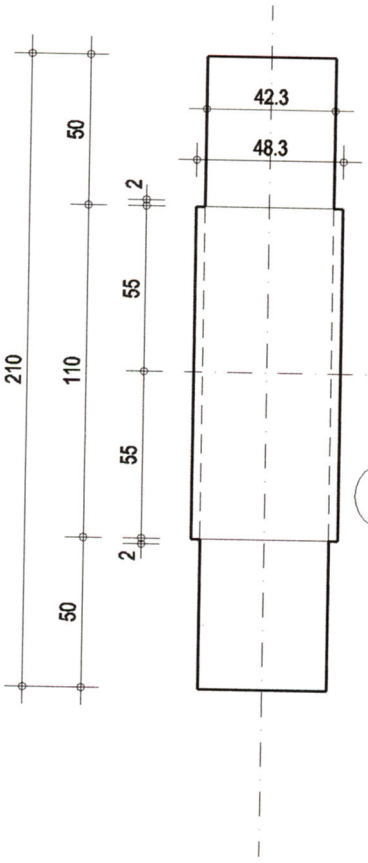
2 Verbindungsstück Außenecke



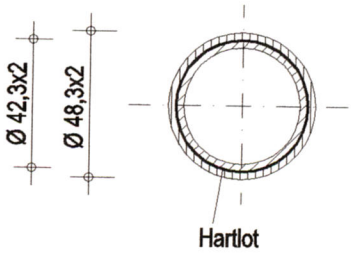
3 Verbindungsstück Innenecke



1 Geradverbinder



Schnitt



Datum	Änderung	Index

Betrifft

Verbindungsstücke

Bearbeitet	KLEU Bühnenbau Sportbau Messebau	Tel. 0202/ 27 90 90
Geprüft	Podest-Bau Kleu GmbH	Fax: 0202/ 73 54 56
	Ludwig-Richter-Straße 7 D-42329 Wuppertal	
Datum 2005-01-28	Zeichnungsnummer PK 00102	Blatt 1
Maßstab 1 : 2,5	Werkstoff Rohr St 37 - 2	Gewicht