

 LUUKKU HOUSE

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Engineering And Construction Brief Report

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Luukku house structural concept

With one of the main architectural goals for the Luukku house to utilise wood and wood based materials in as many applications as possible, part of the engineering concept was to use the inherent technical properties of wood.

Structural solutions of the Luukku house include a unique structural core using Kerto -Q boards as a stiffening building envelope, the elementation of external insulation panels and the division of the building into two space elements for transportation. The Kerto -Q frame also provides the building envelope with a vapour barrier and an airtight layer. The glazing of the Luukku building is a high performance, frameless solution with quadruple glazed units. Interior comfort is enhanced through the use of PCM and highly profiled interior wooden panelling.

Load bearing structures

A special elementation system was developed for the Luukku house in order to meet the targets of easy transportation and installation on site, a high degree of pre-fabrication and maximum energy performance of the building envelope.

The load-bearing structure of the Luukku house consists of an LVL (laminated veneer lumber) panel building envelope and insulated cassette elements. The large, pre-cut LVL panels are connected together to form two volume elements, which can be lifted and transported without exceeding the maximum dimensions for road transportation. Windows and doors remain fixed onto the volumes for the entire construction and transportation process.

The interior of the volume elements is finished and requires no construction work on site. All the building services and wet spaces are located in one of the volume elements and only a small number of electrical conduits need to be reconnected when the two volume elements are brought together on site.

On site the volume elements are connected. The volume elements are covered on all sides by thermally insulated elements containing a sawn timber frame. The LVL panels and wooden frame are mechanically connected to each other, creating together a rigid construction. This can take all the dynamic and static loads the building will meet during its use.

A special feature of the sawn timber frame is the posts and beams that incorporate a thermal break. The posts and beams consist of two sawn timber profiles connected together with metal nail plates. 130mm of thermal insulation was installed in between the sawn timber profiles to cut thermal bridges and make the load-bearing structure lighter.

Load bearing and stability system

Main load bearing and stability is provided by the LVL box. Wall plates are 39mm, roof and floor 51mm thick Kerto-Q plates. At the roof and floor, frames of the insulation elements work as part of the load bearing system.

The dimensioning factor for the structural system is the lifting and transportation; for the roof structure also snow load, for which the standards of the Finnish Building Code were applied. The dimensioning is based on the snow load statistics for Mäntyharju, the final location of the house.

Structural calculations

The structural calculations of the LVL volume elements were carried out using Staad.Pro 2005 Program, which uses FEM (Finite Element Method) for analyzing the structures.



KERTO-Q

The Kerto-Q laminated veneer lumber (LVL) is a load bearing, stiffening and dimensionally precise board. It is produced by Finnish Finforest. The Kerto-Q consists of glued, cross laminated 3mm thick soft wood veneers, with about one fifth of the veneers crosswise. The Kerto-Q product is used as both panels and beams. Due to its crosslaminated structure the material is stronger and more stable than massive wood with the crosswise veneers adding strength and stiffness to the product. LVL is manufactured in Finland using the timber from PEFC-certified local forests.

Innovative detailing

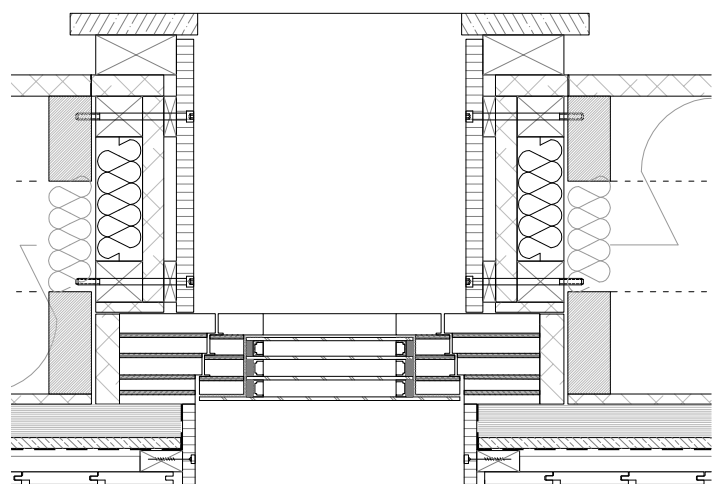
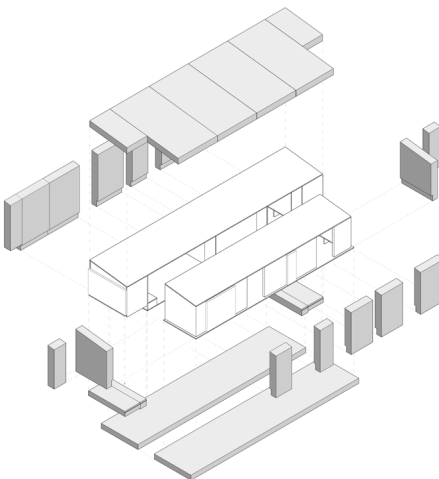
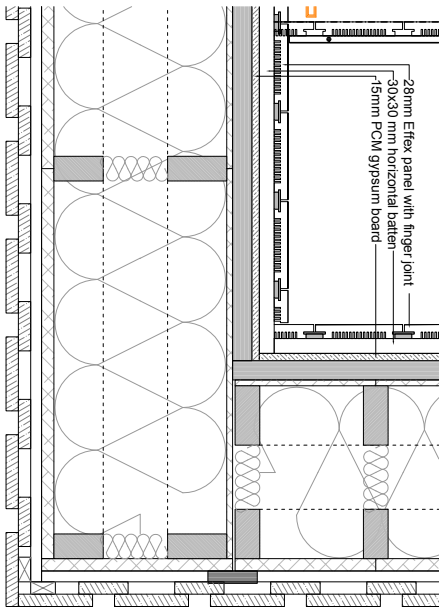
The surface area of the windows and the structural solution was optimized during the design process, as to minimise heat losses without compromising living comfort. Excellent thermal performance at an affordable price is achieved through an innovative, frameless window solution.

For maximal air-tightness and U-values, most of the windows are quadruple-glazed units with stainless steel spacers and Argon-filling. The quadruple glazed windows were produced by the Finnish manufacturer Sely Oy using the glass by Pilkington Oy. According to the product data by Pilkington Oy, the U-value of this quadruple glazed solution is $0.33 \text{ W/m}^2\text{K}$. The value $0.4 \text{ W/m}^2\text{K}$ was used for the simulations.

Since the frames and the edges have the poorest thermal performance in typical windows, the Luukku house has a window solution, where the quadruple glazed unit is fixed directly onto the LVL panel surface. The glass unit is fixed with plywood profiles with neoprene sealer. The thermal insulation overlaps with the edges of the glass unit to eliminate thermal bridging. The g-value of the glazing was optimized in the energy simulations for both Finnish and Spanish climates.

The bathroom has a window which can be opened for ventilation. A new solution was developed also for this purpose; the frame has a thermal break of cork material and 3+1 glazing. The function and the dimensioning of the window solutions is based on the typical Finnish window type, but with the special glazing and the thermal breaks in the wooden components it achieves far better U-value than standard solutions on the market.

No aluminium window or door profiles are used as to minimise CO_2 emissions. The doors have triple glazing and wooden frame of Finnish pine (*pinus sylvestris*). Also for the doorframe, cork is used as the thermal break instead of for example polyurethane foam. The operable window and the doors have safety glass which is glued onto the wooden frame to form a light and rigid construction. Elastic glue by Tremco is used for structural joining of glass and wooden components. On the outside of the doors and the operable window, the outermost glass extends to cover the wooden components, providing better durability and service life for wooden windows. Double doors are used only in the Finnish winter. In the summer use and during the competition in Spain, the inner door leaf is removed.



Functional interiors

Structural solutions of the Luukku house include the use of interior surfaces for moisture and thermal buffering.

The challenge of our project was to create a house that will maintain comfortable temperature levels in both the extremes of Madrid during summertime and Finland during wintertime. In the Luukku house this is supported by the use of PCM gypsum boards, with high thermal capacitance, reducing both mechanical heating and cooling loads. With the use of PCM we have improved the thermal capacitance of the light wooden structure.

Humidity control in the Luukku house is supported by the utilization of the natural characteristics of wood: wood is a hygroscopic material which means that it absorbs and desorbs humidity. This phenomenon has been used to reduce the daily moisture variations in the building. The Luukku house solution is a highly profiled backside of interior panels, produced with a finger joint blade, maximising the surface area. The coating of the panels is chosen accordingly as not to prevent the moisture buffering effect of wooden surfaces.

The final solution is based on the end results of a series of tests, showing that the finger joint profile has a major influence in the moisture buffering compared to parallel grain wood, which is the normal way of using panels. Of aesthetical reasons additional tests were carried out as to determine the functionality of profiled surfaces on the backside of interior panels. The results showed that the profiled surface has a positive influence on the moisture buffering value even if hidden, requiring only a ventilation gap in the structure. Coating tests showed that the chosen Crelim wax has as good moisture buffering value as an uncoated panel.

Interior panels: Stora Enso Effex
Coating: Crelim wax



EFFEX PANELS

Effex panels are produced by Stora Enso Timber Oy. Effex wall and ceiling panels are made of high quality, finger-jointed Nordic pine. The pine derives from sustainably managed woods with a full chain of custody and environmental certification.

