LVL Rib Panels – A competitive alternative for medium spans and flexible floorplans

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1. The project Wood City in Jätkäsaari, Helsinki (Fi)

Wood Ccity is an urban development project in ~~a re-development~~ former port area in the heart of Helsinki. When finalized, this ~~The~~ project ~~is meant to~~will become a landmark demonstrating the major benefits that industrialized construction with wood can bring to our urban environments. ~~It~~Wood City has been developed by Stora Enso and SRV to showcase and foster the use of wood as a renewable material for large urban scale construction projects. The main advantages that this project intends to demonstrate are: high construction speed, reduction of material consumption and waste, reduction of impact to the urban surroundings and the higher quality obtained with an industrialized process. ~~The project is meant to become a landmark demonstrating the major benefits that industrialized construction with wood can bring to our urban environments.~~

Figure 1: Rendered aerial view from the 4 Wood City buildings in its urban context in Helsinki.

As a long term strategy, Stora Enso has been developing a range of building components for the construction industry based on existing wood based materials such as construction beams, glulam, CLT and LVL.
An architectural competition was organized based on the above principles in 2012, won by Antinnen Oiva Architects Oy, to propose the urban design and the planning of the future buildings. The project is a mix between residential, office and hotel use, with a total surface of approximately 28 200 m² in four parts. Two residential buildings were developed for the Helsinki Housing Production ATT with a total of 8 200 m² to be completed in 2018. An open floor office building was plant to be built in 2018 to 2019 with 13 000 m², and a hotel is foreseen with approximately 7 000 m² aiming at a completion in 2020.
The project design was influenced in an early stage by the possibilities and limitations of wooden based components and industrialization, in a collaborative design environment.

2. Residential Buildings

Two dwelling towers are planned, of 8 floors each, with a total of 98 apartment units plus common spaces, with a mix of homes for different family sizes ranging from 35 to almost 100 m².

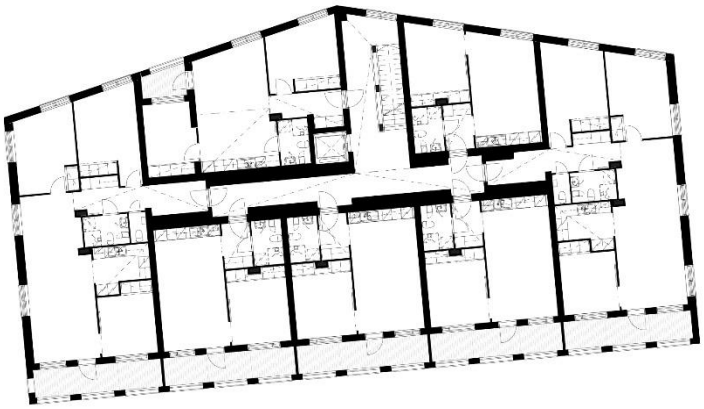

Figure 2: Floor plan of one of the residential buildings. SOURCE: Antinnen Oiva Architects

Figure 3: Front view of the main façade. Project rendering.

2.1. Main parts of the building

The building has been planned according to the following principles:

Massive timber components for the internal core and compartments walls: the load-bearing structure was designed to match the compartment walls between flats and corridor (but not the external envelope). Therefore, there is a full correspondence between structural components and the fire and acoustic compartmentation, conditions under which massive timber components are particularly effective.
Non-load-bearing external walls: The main facades are planned in timber fame, which enhances the prefabrication possibilities and architectural design. The architectural freedom seen on these facades is only possible with a non-load-bearing envelope, allowing for a free opening arrangement which is no longer determined by the structural function. It can also be prefabricated and delivered by the existing timber frame industry independently from the main frame.
LVL Rib Panels for floor elements span between compartment walls (therefore parallel to the façade) without any intermediate load bearing structure, with 7.2 meters in average. The span increase in a residential building allows for open floorplans, following a current trend in the industry. It also provides a higher flexibility in the architectural layouts and in any future layouts.
All internal partition elements can be built with the most economic methods such as dry walling, and not respond to any structural design considerations. Prefabricated bathroom units can also be placed freely on the free floorplan, as another non-load-bearing element, speeding up the prefabrication process.

Figure 4: Picture during construction of an apartment prior to the dry-walls.
SOURCE: Antinnen Oiva Architects

Figure 5: Picture during assembly of the structural elements: LVL massive compartment walls and LVL Rib Panels for floors.

2.2. LVL Rib Panel and build up

The most cost effective building component for this 7.2 meter floor was the LVL Rib Panel with a total depth of 436 mm, open in the bottom, in a single field arrangement.

The fire performance of REI 60 was achieved with a double layer of gypsum fire boards on the underside. The acoustic requirements of 55 dB R´w and 53 dB L´n,w were met by the aforementioned ceiling connected elastically, a 100 mm Mineral wool, and a dry screed with impact sound insulation.

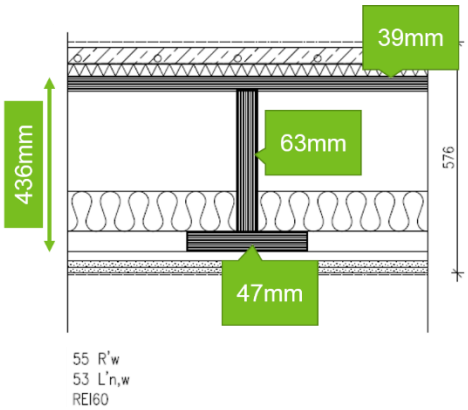

Figure 6: Section of floor build up for the 7.2 meter span
SOURCE: Based on planning details from SWECO

Figure 7: LVL Rib panel for Wood City in the prefabrication at Timberpoint Oy.
SOURCE: Stora Enso; Timberpoint Oy

2.3. Main advantages ~~by the use of~~using LVL Rib Panels

The use of LVL Rib Panels demonstrated several advantages compared to other alternatives: reduced weight, less material required and a fully dry construction process, resulting in cost savings, enabling for free open floorplans.

A standard CLT floor would have been approximately 220 mm thick, significantly lower in depth, but with approximately 2.35 times more timber as the chosen LVL Rib Panel (108 against 46 kg/m² respectively). This weight also impacts directly on the load bearing walls, which are more demanded due to the previous decision of using only compartment walls.

The weight transferred to the foundations is reduced accordingly to less than half compared to the CLT solution and by a factor of approximately 1/10 compared to a standard on site concrete slab. LVL Rib Panel allows for a fully dry build-up, which is an important advantage compared to any sort of concrete or timber-concrete composites.

The weight saving has also an advantage by the reduction of the number of lorries arriving to site, minimizing a significant impact on the city center.

By using a cost competitive timber component for medium spans, the residential solution has earned in flexibility of design for current and future use. Tenants benefit from an open interior design which is not limited by structural components. The owner –and future occupants- profit from the possibilities for different internal fit-outs and layouts for new possible uses or requirements in the future, making it a more sustainable and future-proof investment.

3. Office Building

The second phase of the Wwood Ceity quarter consists of 13.000 m² of office space.,~~,~~ W~~and w~~hen ready, it will be the highest and second largest timber based office building in Finland. The project ~~has~~ attracted the attention of the gaming company Supercell for their Headquarters in Helsinki. Construction on site ~~have~~ started in 2018 with the groundworks, and the erection of the timber Post & Beam frame ~~has~~ started in November 2018.

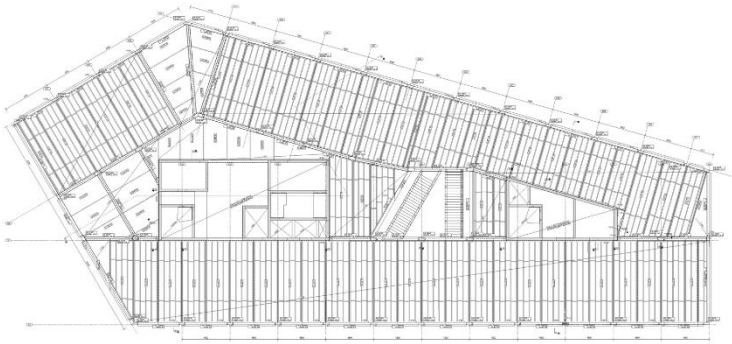

Figure 8: Typical structural floorplan, showing the main load-bearing components.
SOURCE: SWECO project planning

Figure 9: Front view of the main façade. Project rendering.
SOURCE: Antinnen Oiva Architects

It is ~~a~~ the client´s wish, as often in office buildings, that the working space should be as open and flexible as possible. Therefore, the spaces should be as free of ~~colums~~columns as structurally sensible and economically feasible. The same applies for ceilings, which are required free of structural elements to facilitate service distribution. As the standard has been historically set by the concrete industry, common spans are in Finland around 9 to 12 meters, and designers and clients will tend to expect similar configurations for this or any new building.

This building shape has not been designed to necessarily fit a timber structural optimum, but rather following urban-architectural features and commercial criteria. The open office space is planned between service closed cores in the middle, and an envelope with a relatively free form on the outside, resulting in spans of 8.5 meters in average.

3.1. Main structural parts of the building

The central core has been planned as a concrete structure because of its high stiffness and its acceptance by the fire authorities. The structure is therefore conceived as a classical post and beam frame around a closed-stiff stabilizing core. The main post and beam frames are placed between the closed cores and in the external facades. The LVL Rib Panels are supported in between, spanning perpendicular to the thermal envelope.

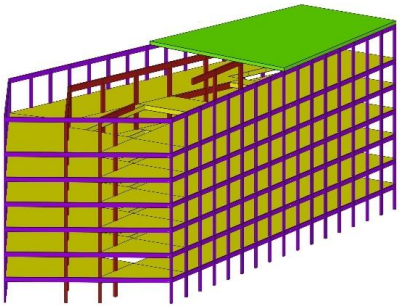

Figure 10: 3D model of the main structural elements.
SOURCE: Stora Enso, OTS department for offers and technical services

Figure 11: Prototype of re-glued LVL
SOURCE: Stora Enso | R&D Building Solutions

The internal main beams are designed to long spans, up to 7 meters, to reduce the necessary ~~amount~~number of columns. The structural grid of the external layer is designed with the opposite criteria, by reducing it to a span which is narrow enough to allow the main beam to have the same depth as the LVL-Rib Panels, allowing floor to ceiling high glazed openings without visible lintels.

The main post and beam frame was planned with re-glued LVL sections from 225 x 600 mm up to 300 x 900 mm. The higher strength of LVL compared to glulam allows for slenderer components. Another significant advantage is the incorporation of cross layers of fibers, increasing resistance perpendicular to the main structural axis and the efficacy of steel connectors. By the re-gluing of LVL-S and LVL-X layers in different combinations, the structural properties can be engineered to its required optimal. The columns will be covered by a spruce 3-layer board for visual quality and fire protection.

3.2. Building service integration and distribution

A main challenge in modern office buildings is the integration of building services. Ventilation ducts set the highest level of complexity due to their big diameter. Main ducts are planned under the ceilings next to the internal cores and distributed the office spaces by secondary lines between the Ribs. The difference in height is used as an architectural feature to differentiate circulation and working space.

Some floors of the building foresee a high amount of electric installations and require a high flexibility to cope with maintenance and changes. For ~~this areas~~these areas, a raised floor solution has been found with a 100 mm standard system in the market. An additional layer of gypsum board is added on top ~~in order to~~to increase weight and improve the acoustic and vibration performance.

The secondary ventilation and lighting distribution lines are integrated between the ribs of the floor panels. The acoustic challenge caused by the interruption of the suspended ceiling is solved by the installation of the double gypsum layer around the cavity, also assuring the continuity of the fire protection barrier.

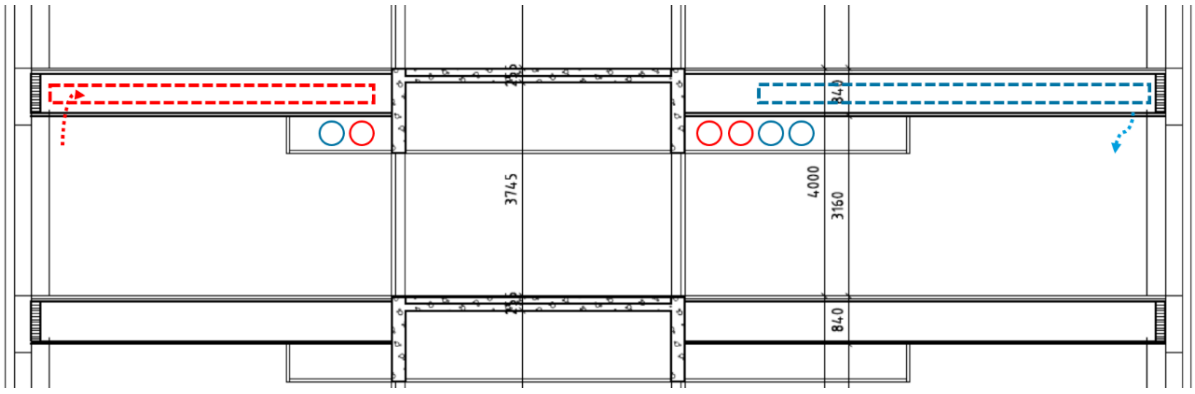

Figure 12: Representative cross section of the building, showing the ventilation distribution concept.
SOURCE: Stora Enso based on detail planning from SWECO.

3.3. LVL Rib Panel and Build-up

The optimal Rib Panel for this project was found without a bottom flange, in a total structural depth of 661 mm. A fire resistance of REI 60 was achieved by the double layer fire rated gypsum ceiling.

The required R´w of and L´n,w of 52 and 63 dB respectively were achieved by an elastic fixing of the ceiling, 300 mm of mineral wool between the Ribs and a dry screed on impact sound insulation on the top. A visible wooden ceiling was not allowed by building authorities due to fire restrictions.

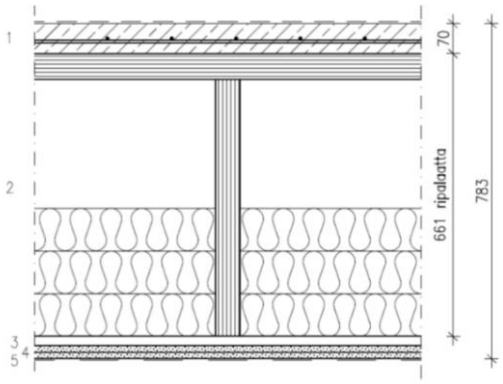

Figure 13: Section of a typical floor build up
SOURCE: Detail Planning by SWECO

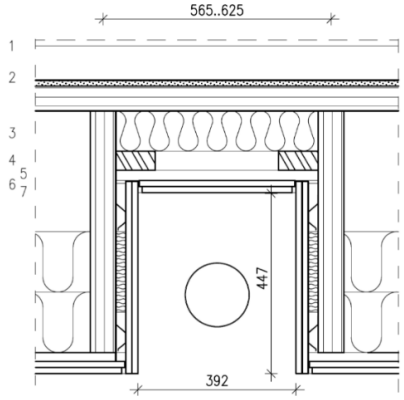

Figure 14: Section of the detail for integration of service distribution.

The use of an LVL based post and beam frame and an LVL Rib Panel results in a cost ~~effective~~ efficient solution: reduced weight and increased usable living area, allowing for an open space floorplan. The space between ribs allows for air and lightning distribution in the working space achieving a flat ceiling with hidden service distribution ducts, which helps compensating for the higher depth as compared to other standard floors.

4. Middle Spans with wooden timber based components

Open floorplans ~~is~~ are a growing need in modern buildings, not only as an architectural tendency, but also because of the flexibility they allow in an increasingly changing environment. In the whole life cycle of a building, the possibility of alternative floorplans and layouts has a strong impact in a both economical and an environmental assessment, giving the building a chance to adapt to new tenants and needs without having to be demolished and rebuilt. Residential buildings demand for open living spaces, and the possibility of conversion of the building in a not-so-far future. A reduction of internal intermediate structural elements enhances the future possibilities. Office buildings are in essence flexible and open, as the tenants will redo the entire fit out and layout to fit their needs, therefore, a post and beam system with larger spans and grids increases the utilization possibilities.

Wooden construction has had difficulties in the past delivering solutions for medium span floors. Although they have been demonstrated technically sound since a long time, it has been difficult to prove their cost competitiveness against standard solutions. A direct comparison between timber based and concrete or composite floor panels rapidly indicates against it. However, a deeper comparison from different design perspectives and further costs implications seem to point in a different direction.

LVL Rib slabs allow for a fully dry construction method, reduce our building´s material consumption along with weight and transportation costs. From a design perspective, when integrating other functionalities as the building service distribution, they can offer innovative and cost saving solutions.

As experience in the development of the Wood City projects suggest, LVL Rib panels could be the right answer.