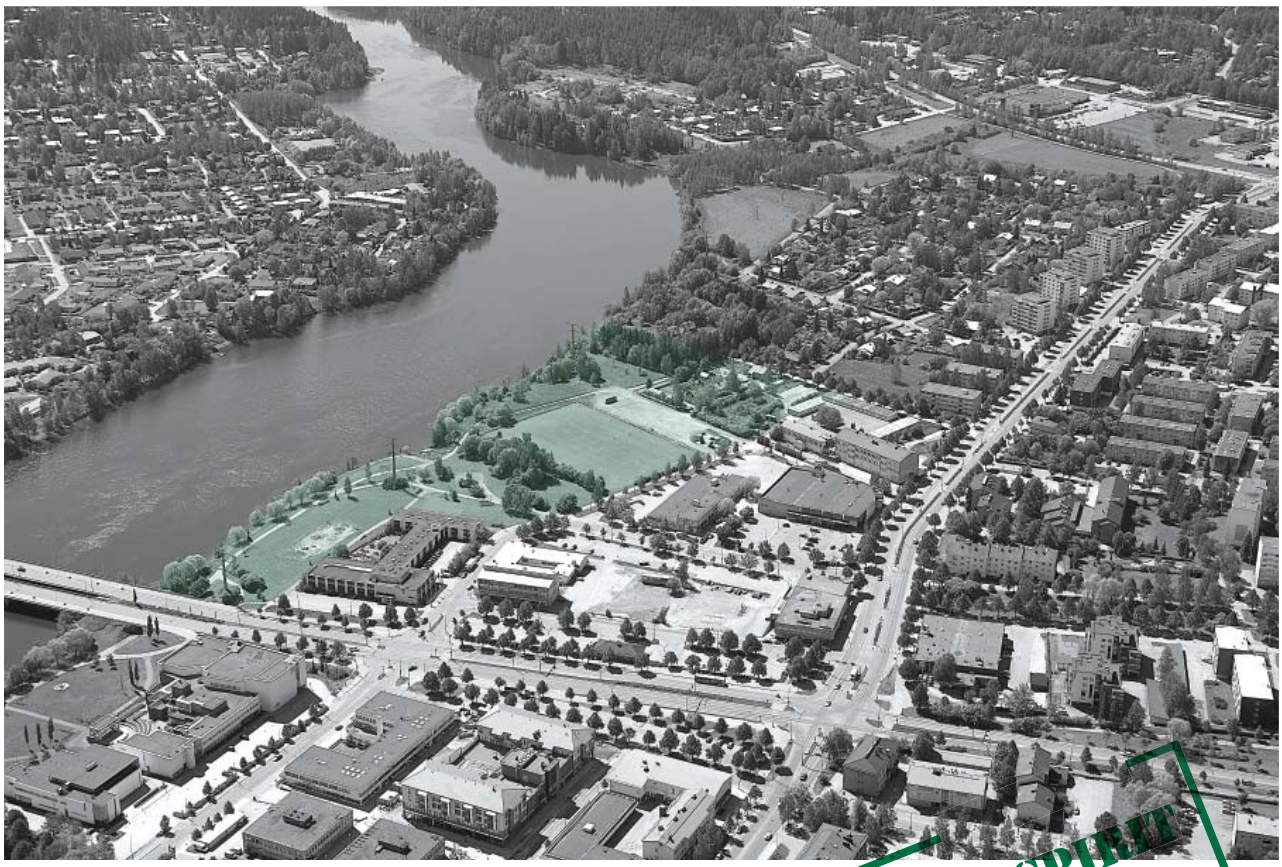
E2

ECOLOGY + ECONOMY
TIMBER DEVELOPMENT COMPETITION

JURY REPORT



GREEN SPIRIT

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Cover images from proposals “Puu-Bo” and “E^{2}volution”

KOUVOLA
CITY BY THE KYMI RIVER

www.kouvola.fi/E2

Leverage from the EU 2007–2013

KYMENLAAKSON LIITTO
REGIONAL COUNCIL OF KYMENLAAKSO

KSS ENERGIA

Finnish Forest Industries

SITRA

FINNISH FOREST FOUNDATION

Tekes

Introduction

Increased environmental consciousness and economic challenges reflect the current global concerns. Tackling the climate change, improving energy and cost efficiencies, and using the renewable resources raise questions about the environmental impacts of the construction cluster. The efficiency requirements of industrialized construction business parallel to the inevitable need to cut greenhouse gas emissions call for new approaches. The E2 Competition was about searching ways to increase the production of wooden multi-storey residential buildings that enable the alternative culture of residential development.

The construction cluster consumes approximately half of the – primarily non-renewable – raw materials and produces 40% of the waste. The building occupancy takes 40% of the total energy consumption and only a little less of the CO2 emissions. The energy required for building materials industry and its GHG emissions have caught very little attention until now.

Sustainable design solutions preventing climate change have a significant effect on the carbon footprint of the buildings. The European Union has set an objective for all new buildings to fulfill the zero energy building requirements after 2019. Additionally, the EU calls for reducing the CO2 emissions 80% by 2050 in comparison to the level of 1990. All aspirations mean a tremendous challenge to the construction cluster.

The changing consumer behavior introduces a new situation to the construction cluster, and in particular, to the housing development. Sustainability and low utility costs are already success factors today in housing sales, but tomorrow they will be crucial. Residential construction industrialized in the 50s enabling cost-effective suburban housing for a greater number of people. Environmental concerns arose not until two decades later. At that point building techniques had already matured and become business as usual. Today, the quality of housing, user friendliness, and delightful design steer the consumers' choices more than before.

Timber developments involve a substantial national interest. Wood is the most significant natural resource serving also as a carbon sink. The forest cluster provides employment either directly or indirectly to the largest group of labor force. Adding the value of the forest cluster continues to serve the Finnish well-being in the future.

Timber is the leading material in constructing summerhouses and single family houses. Multi-storey residential buildings, however, have the most substantial role in residential construction which enables a denser city structure enhancing sustainability. New solutions are needed for prefabricated housing in order to better utilize the carbon sink of timber developments. The effective use of wood benefits the national economy and prevents the climate change.

The competition demonstrated that launching a new industrial tradition is possible today. The change takes place only through the cooperation of multiple stakeholders. Developers and investors have a key position but they need support and solutions from other parties, such as designers and component manufacturers. Cost efficient, sustainable, and high quality design, production, and installation solutions serve common interests.

Arrangements of the Competition

Organizer and the purpose of the competition

The City of Kouvola organized an international Design and Build competition for a pilot site in collaboration with the local energy company KSS Energia, the Finnish Forest Industries Federation, Finnish Forest Foundation, the Finnish Innovation Fund, the Finnish Funding Agency for Technology and Innovation, and the Regional Council of Kymenlaakso. The Finnish Association of Civil Engineers and the Finnish Association of Architects partnered with the City of Kouvola in organizing the competition.

The competition aimed at developing a concept of a multi-storey residential building with wooden structural frame. The concept was expected to introduce relevant construction elements and demonstrate those in a residential development on the pilot site of Kouvola. The competition was organized as a design competition according to the Public Procurement Act of Finland. After the Request for Qualifications (RFQ) period, four multi-professional teams were invited to submit a proposal to the competition.

Eligibility and schedule

The international RFQ was open to all qualified teams. The RFQ period took place during three first weeks of September in 2010. The four selected teams began their work at the beginning of October in a workshop that was held in Kouvola. The teams submitted their proposals on the 17th of January 2011. The Jury convened in Kouvola during 8-9 of February. Final decisions were announced on the 15th of March 2011.

Jury

The Jury has prepared an evaluation for each proposal. The Jury has had the right to appoint and hear experts.

Members of the Jury:

Mr. Ilmari Absetz, D.Sc., Chief Technology Advisor, the Finnish Funding Agency for Technology and Innovation

Mr. Aimo Ahti (chair), City Manager on Economic Affairs, the City of Kouvola

Mr. Hans Andrén, Project Leader, Växjö kommunföretag AB

Mr. Pekka Heikkinen, Architect, Professor, Aalto University

Mr. Kyösti Jääskeläinen, Executive Director, KSS Energia Oy

Mr. Ari Kevarinmäki, Senior Research Scientist, Dr.Sc. (Tech.), the Finnish Association of Civil Engineers

Mr. Olav Kristoffersen, Architect, the Finnish Association of Architects

Mr. Jouni Koiso-Kanttila, Architect, Professor, University of Oulu

Mr. Jarek Kurnitski, D.Sc., Senior Lead - Built Environment, Sitra the Finnish Innovation Fund

Mr. Hannu Luotonen, Head of City Planning, the City of Kouvola

Ms. Liisa Mäkijärvi, Executive Director, Finnish Forest Foundation

Mr. Erik Serrano, Professor, Linnaeus University

Mr. Tapio Välinoro, Regional Mayor, the Regional Council of Kymenlaakso

Competition rules and approval of the competition program

The rules of the competition were published at the official website of the competition. The Jury, representing the organizer and its collaborators, approved the program of the competition.

Queries

The Jury received 8 queries. The questions and answers were published on the official website of the competition.

Overview of the submittals

The competition set high demands for the teams that were expected to deliver a building system for wooden multi-storey developments, demonstrate its qualities on a pilot site, and envision business opportunities related to wooden developments. The organizer of the competition received four submittals fulfilling the requirements set in the Competition Brief. The competition was a secret one and the Jury evaluated the submittals under the following pseudonyms: Fox, E^{2}volution, PuuBo©, and 5.353.691.

The Quality of the Industrial Concept

The teams had adopted either an engineering or architectural approach to the problem-solving. None of the proposals studied in-depth the process of wood-based innovations and the related business opportunities that the proposed building systems and products could impose. However, some very promising hints for efficient, flexible, and environmental friendly systems exist. The results provide an excellent base for studying and developing the concepts further jointly with different stakeholders, and potentially also in other locations.

Architecture

The teams had stressed the architectural solutions to varying degrees. Some of the proposals represented very generic solutions without a sensitive touch to the local settings. Given the nature of the competition this approach could be justified, but on the other hand, the essence was to demonstrate the system and its capability to local interpretations. It is not merely enough to demonstrate that the wooden building system is capable of producing similar surroundings as prefabricated concrete system. Such an approach lacks the critique towards conventional concrete based mass-production with a risk of loosing the characteristic advantages of wood in making the architectural forms.

The difficulty for the Jury was to see what was not there, that is, the possible potential related of a building system which demonstrates mediocre architectural solutions. The Jury could only credit the submittals on the basis of presented solutions. However, suggestions of the Jury revising the proposal could produce very desirable solutions not only for architecture but also for engineering.

Energy and Material Efficiency

The submittals were very equal in energy efficiency. All entries reached high level energy-efficiency, although, some entries claimed very ambitious values for air-tightness of the building shell (below 0.6/h in E^{2}volution, or even 0.4 /h in Puu-Bo). These values would require high precision in the construction process.

The ecological performance followed the rule, the higher the investment, the higher the gain. In short, the solution would have to be optimized both in terms of energy and material efficiency. The optimization acknowledges the consumed resources in return for the gained usable space. Obviously, qualitative aspects such as architectural quality or urbanism would be extremely difficult to evaluate and such qualitative aspects should be evaluated separately. Unfortunately, none of the submittals explored studies related to optimization. For example, large carbon sinks have a specific price which correlates to the price of wood. However, residential developments with a less advantageous carbon sink may gain a better financial efficiency and thus get a better market share which in turn could result in an increased use of wood.

The proposed developments have versatile approaches to material efficiency, or Global Warming Potential (GWP), comprising the carbon storage and emissions. Three out of four proposals work as carbon sinks. The fourth one, 5.353.692, represents an incremental strategy for increasing the use of wood in multi-storey residential developments. It compromises material efficiency and aims at high volumes and a wider acceptance of the markets. The acceptance of a poorer material efficiency is a strategy for a technological transition aiming at increasing the use of wood, rather than a strategy representing a technology leap. Despite of the poorer material efficiency in comparison to the other submittals, the proposal 5.353.692 performs twice as efficient compared to conventional concrete-based residential developments. The question is whether an incremental strategy (accept more concrete) or a more revolutionary strategy (use as much wood as possible) is desirable. It may be demanding from the perspective of construction industry to invest in transitional technology and again and again learn new ways of making.

Feasibility and Cost-Effectiveness

All entries provided similar conclusions for the cost evaluation. A gross square meter of wooden multi-storey building costs approximately 1500 euros. Puu-Bo made the only exception and claimed a lower price, slightly exceeding 1300 euros/m2. Considering the contingencies, the complex shape of the building, and the complexity of technical details and fittings, the Jury has a concern that the estimated lower price may in reality be higher than the authors aspire despite of, for example, ground level outdoor parking reducing the overall costs. In terms of the estimated costs, all the submittals meet the criteria of not exceeding the cost level of conventional residential construction.

All entries need improvements in technical issues. Considering also the nature of the competition, the Jury expected a more consistent and rigorous level of engineering in all proposals. However, it is likely that all issues related to fire safety, weathering, sound insulation and moisture protection can be solved, but this could also affect the architecture of the proposals.

The Jury considered phased development of each proposal possible. In addition to further development of the designs, the phasing should also be considered in more detail.

Assessment of Submittals

E²volution

The clarity of construction and simplicity in structural behavior are the most appealing features of the proposal. The submittal has three basic elements: load bearing exterior wall, external shear wall, and wooden slab with a box structure. The story line of the proposal demonstrates logically the use of the basic elements.

The authors claimed these elements to achieve a free span of up to 10 meters. The Jury viewed that the span could be extended, for example, up to 12 meters to better optimize diverse residential solutions by increasing the height of slab elements. A free span without columns and internal shear walls could in fact impose new opportunities for wooden housing design. Despite of the good level of residential design, the proposal fails to demonstrate the full options related to the structural system. The box-like examples, in fact, restrict the creative thinking for alternative architectural solutions that might be desirable in flagship developments demonstrating the qualities of wooden buildings. The Jury anticipated that, for example, a tapered roof slab element could easily be constructed with the given structural system. The form is not merely a question of architectural taste and expression but creation of versatile living environments in diverse scales with an efficiently and industrially produced system. Further, in some developments the site and its functional characteristics may call for other solutions than rectangular basic forms.

The proposed structural system could have several industrial benefits. Firstly, the scale of the elements may allow fast assembly and cost-effective transportation. Moreover, issues related to weather protection during construction could be easier to treat. Secondly, the use of LVL offers potentials in optimizing the use of material resulting in lighter weights and theoretically cheaper prices of materials. Thirdly, the hollow cores may offer opportunities for prefabricated installations of HVAC systems. Finally, the system has considerable capacity to decrease the use of concrete.

The proposed industrial concept could be developed further. The external shear walls have problems related to both weathering and fire protection. The Jury viewed that those shear walls could technically be part of the internal load bearing wall structure acting as components of gable walls and separating walls between apartments. The external elements could be used as studs

for supporting balconies in case this is a desirable architectural solution. In that case the pillars should be covered with non-combustible fire protective materials such as fiber cement boards.

The joint between the floor slabs and the exterior walls raised many concerns due to the lacking technical data. For example, the continuous multi-storey exterior wall elements connected to the slabs may cause contingencies in transmission of sound. The authors present an additional facing formwork mounted to the ceiling and external walls for the sound installation, but no information is given for its execution. Another unclear issue related to the connections of the basic elements is their structural detailing, in particular for the bracing forces of the structure.

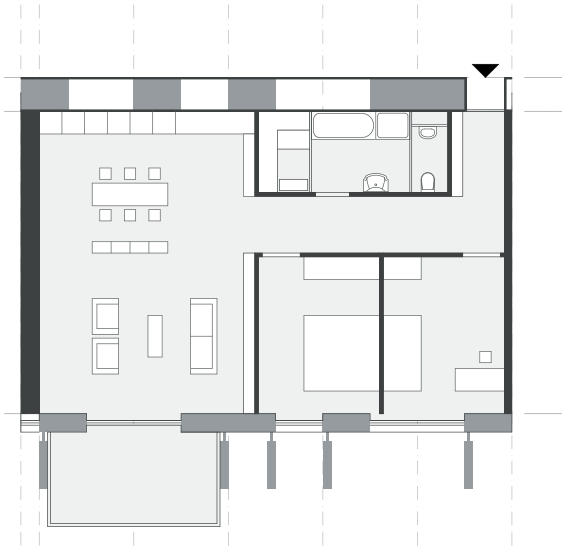
The flat roof structures, like in all other submittals, may prove to be difficult to construct in a reliable manner. Constant freezing and melting during winter causes structural movement in water proofing membranes causing them to crack easily.

The structural system was partially seen restrictive as such to the exterior architecture. In particular, the vertical elements would be likely to be dominant. On the other hand, the Jury saw that changes in the structural system could solve this issue. Even if exterior bracing walls would be used, the number of continuous load bearing lines could be reduced for each façade giving more freedom for architectural expression.

The Jury considered the use of the site to be problematic. The proposed buildings in front of Hotel Sommelo are questionable due to poor ground conditions. The same applies to building on the shore of Kymi River. Further, extending the buildings to the river cuts the public green area causing a confusing situation between public, semi-public, and private spaces. Removing the proposed office building from the northern edge of the site and pushing the residential building north would help to solve the situation. At the same time the parking places would need to be re-designed in the northern side of the site.

The orientation of the buildings towards each other instead of towards the river looses some of the essence of the site. The urban pattern of the buildings offers north-south views and maintains the connection between the center of Kuusankoski and the river. The view from the flats is rather restricted, in particular, if the proposed external shear walls are to be used. On the other hand, the buildings form nice but rather conventional courtyards facing south. The distance between the façades may also be slightly too urban in the context of the City of Kouvola.

In conclusion, E^{2}volution offers many extremely interesting starting points for the industrialized production of multi-storey timber developments. The proposal underpins the future work of WoodInno in the Region of Kouvola.



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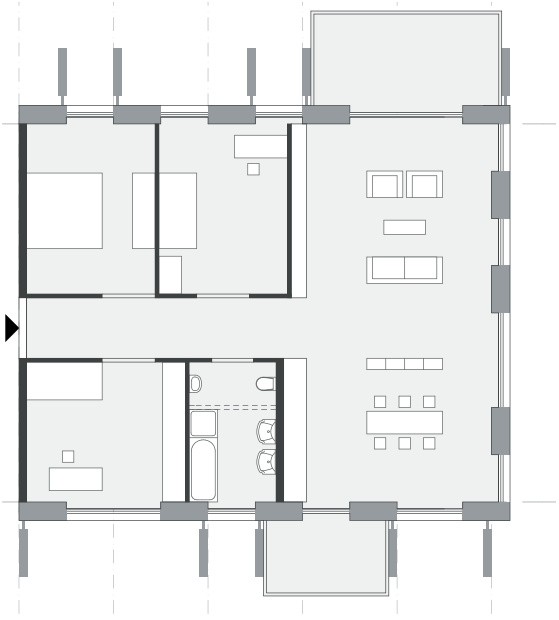

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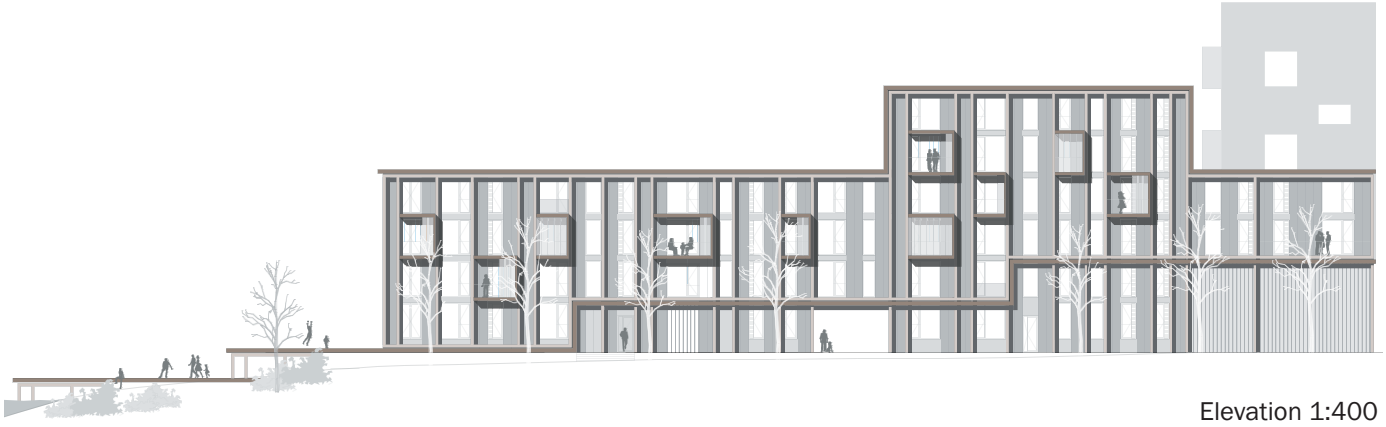

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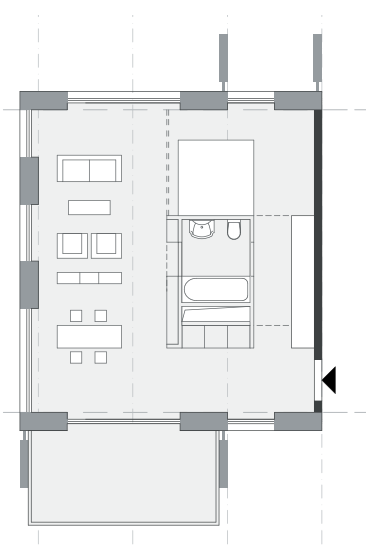

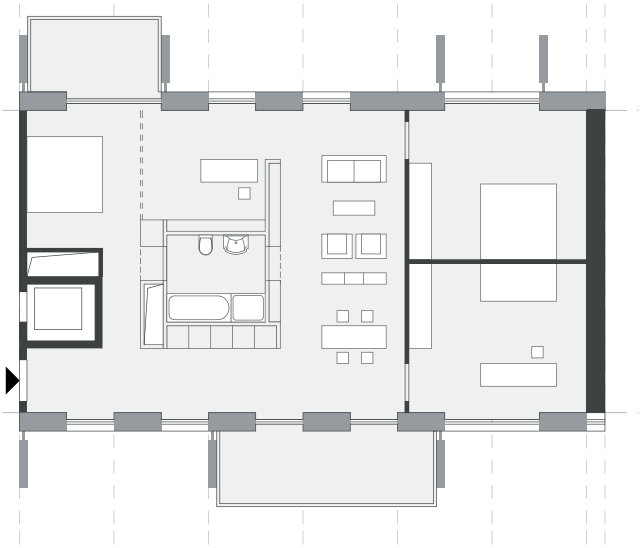

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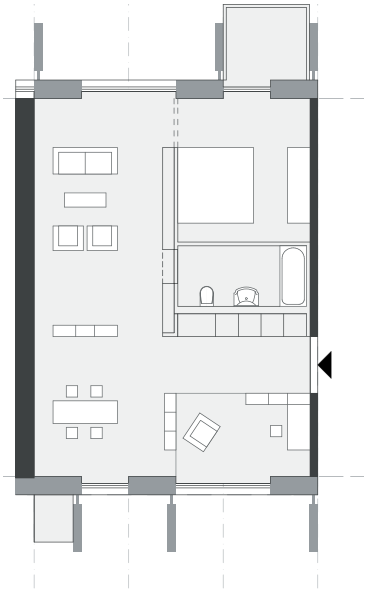

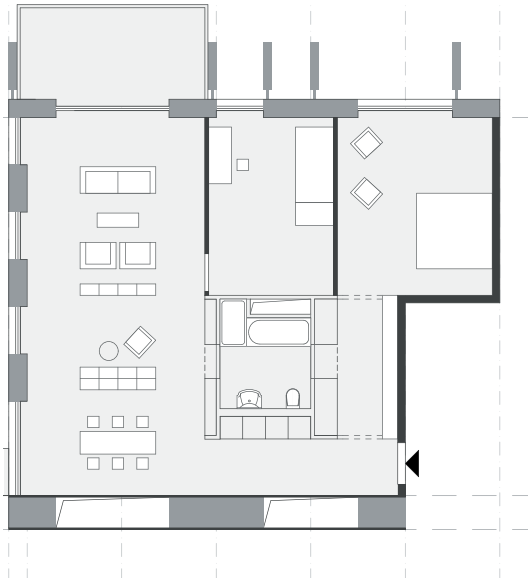

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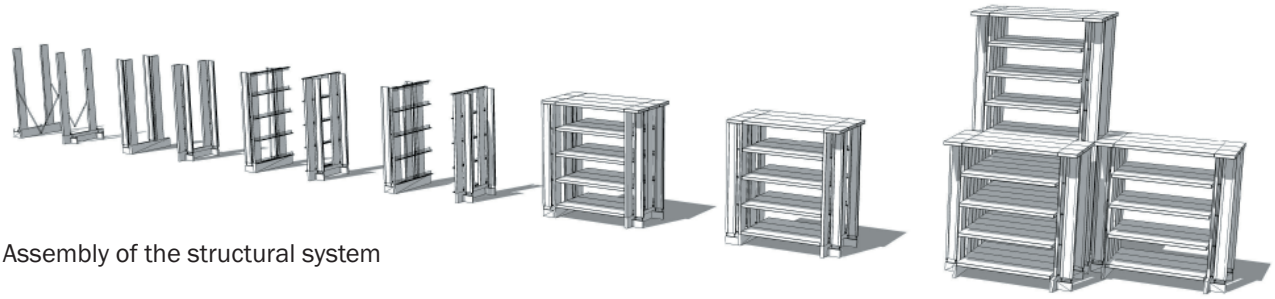
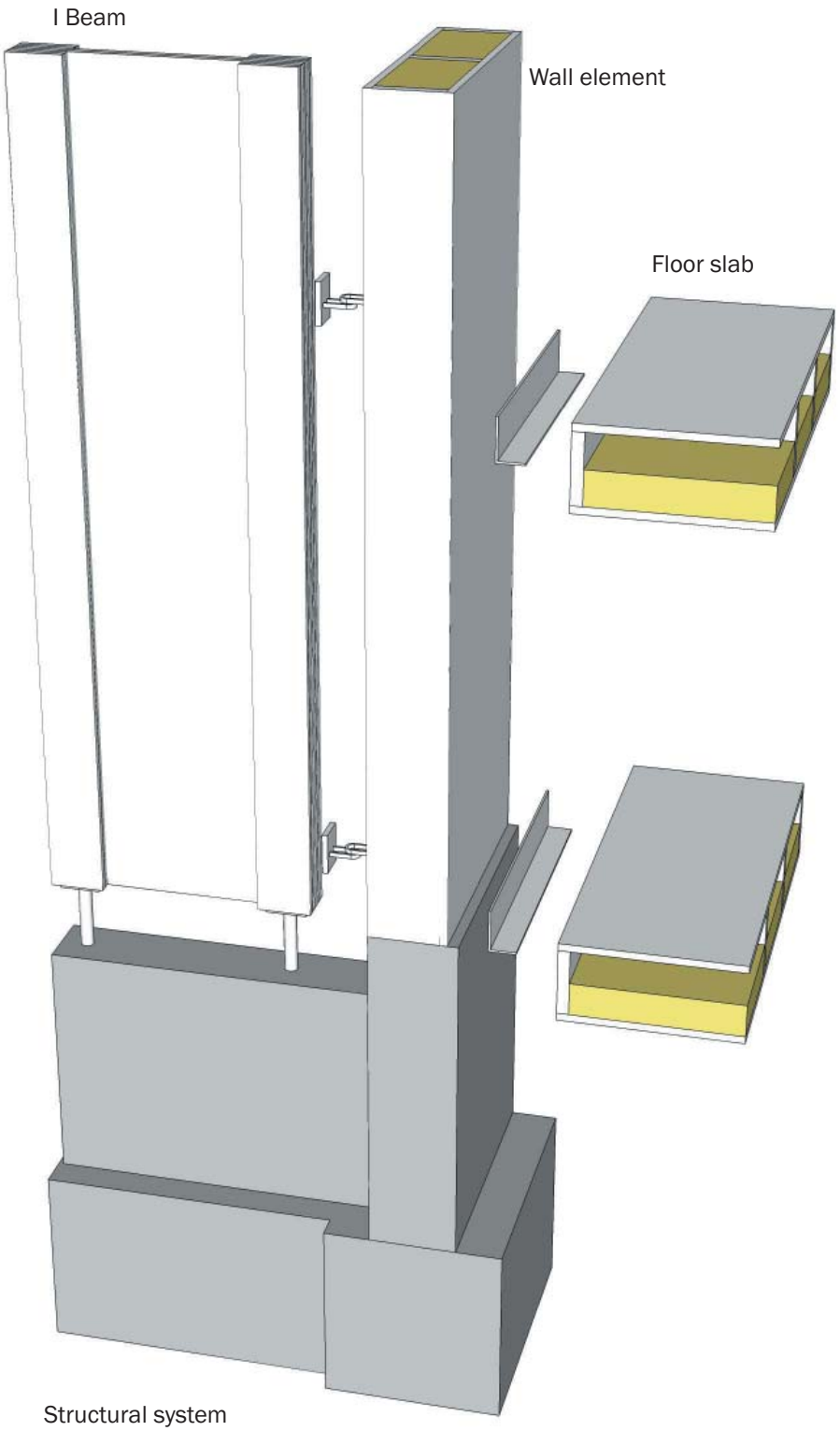


Assembly of the structural system



Structural system

Puu-Bo

The entry has the most expressive and eye-catching character of all proposals. Its gentle renderings and subtle use of color give an appealing sense of the urban environment. The scale of the proposal introduces a label of uniqueness which is a typical feature of architecture in urban megastructures. In this particular case the proposal does very well in using the site. It responds to the environment with shapes of its own without a contextual connection to the surrounding forms.

Puu-Bo was the only proposal truly acknowledging the aspiration of the Competition Brief: to look at the surroundings of the buildings and the spaces in between as potential opportunities for green development. For example, the winding shape and varying heights of the building provides many opportunities. Firstly, it creates a clear park area south from the residential building with interesting qualities for living. All the dwellings have a strong relationship to and views towards the park area and river. Secondly, the north side of the building offers a pedestrian and light traffic zone with appealing street views that seduce to take the bicycle instead of a car. Even if one has a car or uses one, there is cost-effective street parking available along the curvy streets and smaller parks on the north side of the building. All these landscape components help to fit the building to its surroundings.

The downside of the long continuous building is a clear cut in a south-north axis and the resulting disconnection to the Kymi River from Kuusankoski centre. The design development should explore openings in the building volume. Cutting the single building into three or four sections could be another option. Additionally, the phasing of the development would be easier without having a risk or transitional periods related to unfinished developments.

The building volume contains an excellent opportunity to demonstrate versatile apartments such as townhouses with gardens and storages rooms, duplexes, flats of varying sizes, and studios. Based on conventional wisdom on flat roofs, the water proofing membranes above the thermal insulation cause a risk of roof leakage. The issues related to flat roofs apply to all competition proposals.

The architectural concept is based on wedge-shaped modules. These modules, however, have a very weak connection to the structural system. In other words, the modularity does not offer any significant manufacturing advantages in wooden

construction, nor in CAD/CAM based manufacturing in general. In contradiction, the modularity in this case restricts the architectural layouts, for example, the floor plans of the flats. The only advantage of modularity might be the ease of planning, assembly and logistics in case the majority of components are the same and the assembly order doesn't matter.

The comparison of Le Corbusier's Domino system to Puu-Bo fails to distinct the main idea of the load bearing system in Puu-Bo, which is unclear. The proposal combines load bearing exterior walls, columns and even internal load bearing shear walls creating structural confusion and an unnecessarily complicated system. In the proposed post and beam system inside the exterior walls an uneconomical column spacing of 3,8 m has been used. The exterior walls might be executed as normal continuous load bearing timber framed wall elements. The massive structural system is the main target for improvements and simplification.
The façades and balconies should also be studied further. The durability of the façades raises some concerns. The position of the windows in the façade causes difficult fittings with thermal insulation and siding thick enough. It is most likely a challenge – including technical, functional, and cost issues – to have the glazing on the same level as the exterior siding as shown in the renderings of the project.

The fire safety of the project should be studied in more in depth, in particular regarding the facades and the floor and roof slabs. The presented visible solid timber ceilings should be protected against fire by non-combustible materials. The use of a suspended ceiling would also solve the problem of installations of HVAC and sprinkler systems and would improve the acoustic performance of the floor so that the floating concrete slab may be omitted.

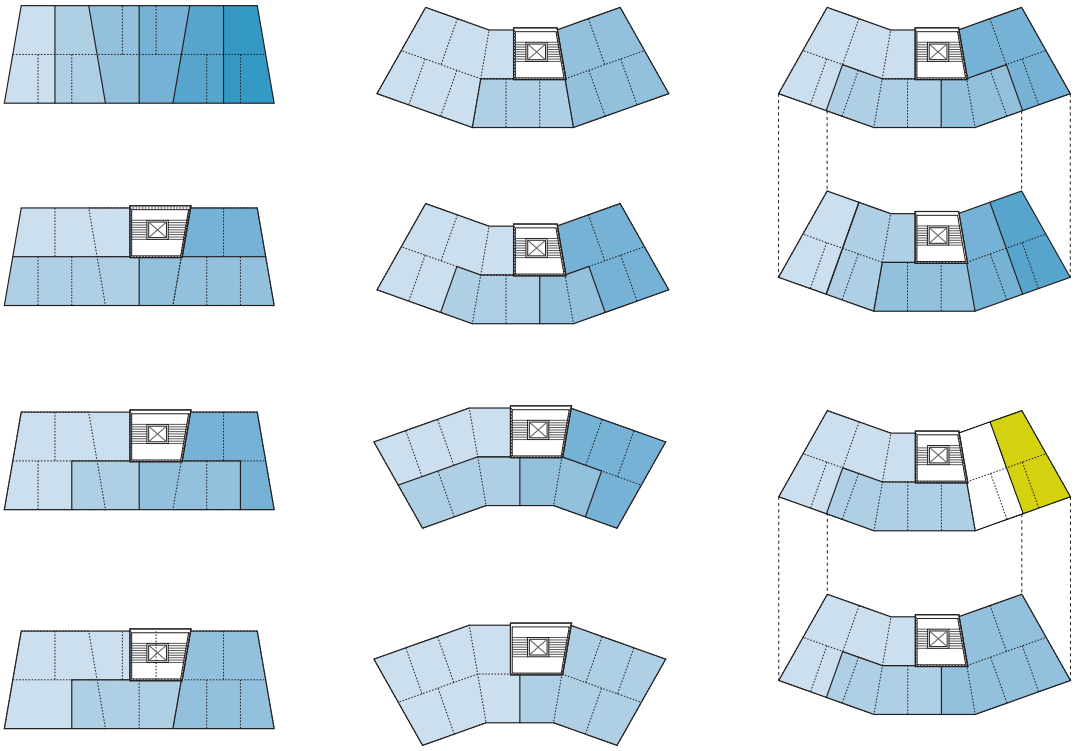
The proposal uses a large amount of concrete – up to 200 mm in floor slabs and 120 mm in roof slabs. The self weight of the presented floor slab (about 560 kg/m2) is clearly higher than the weight of common hollow-core concrete slab floors. Due to the massive weight of the floor, the

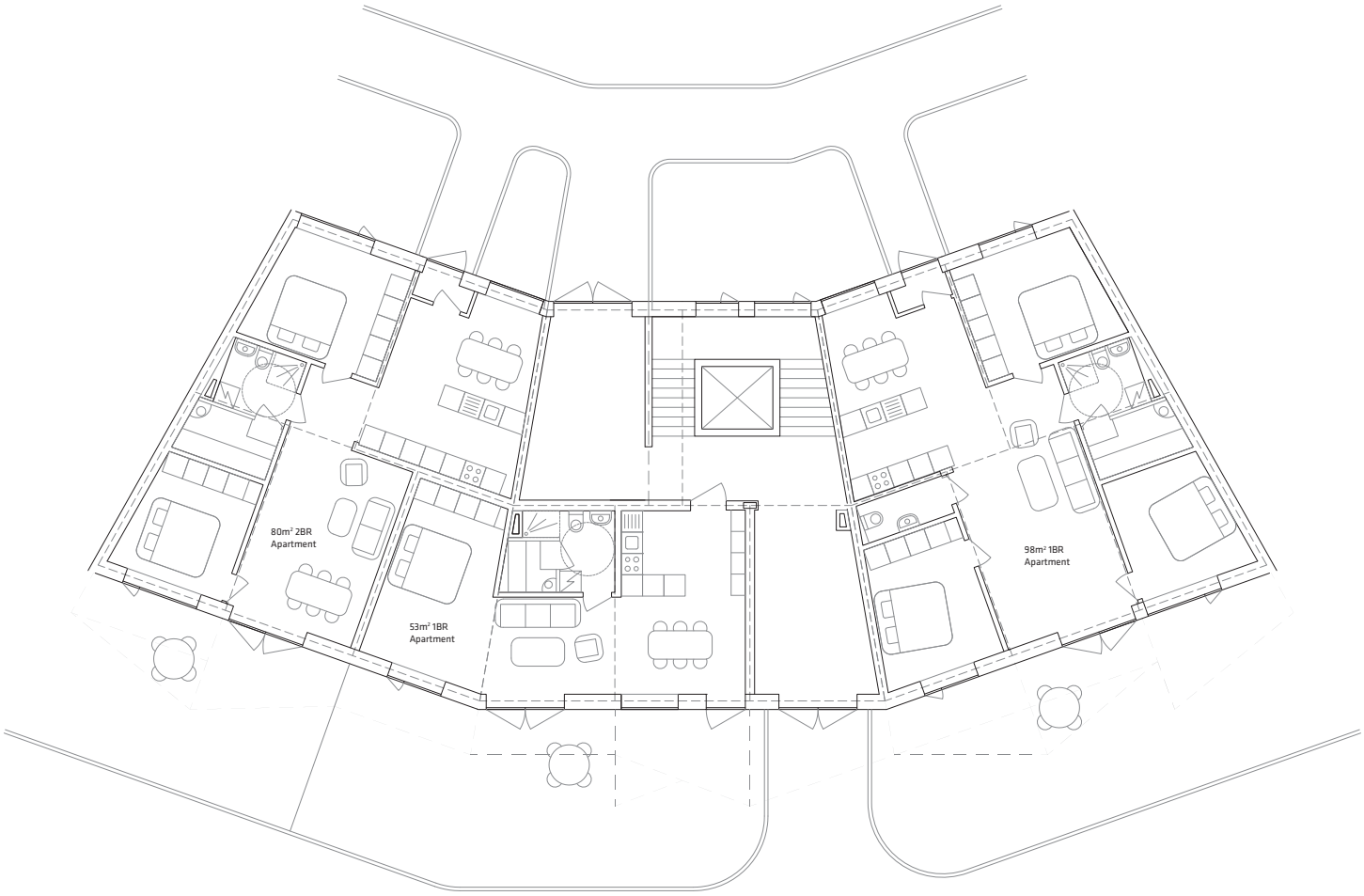
fundamental frequency of the structure would be low, which means that the vibrations of the floor may cause unacceptable discomfort to the users.

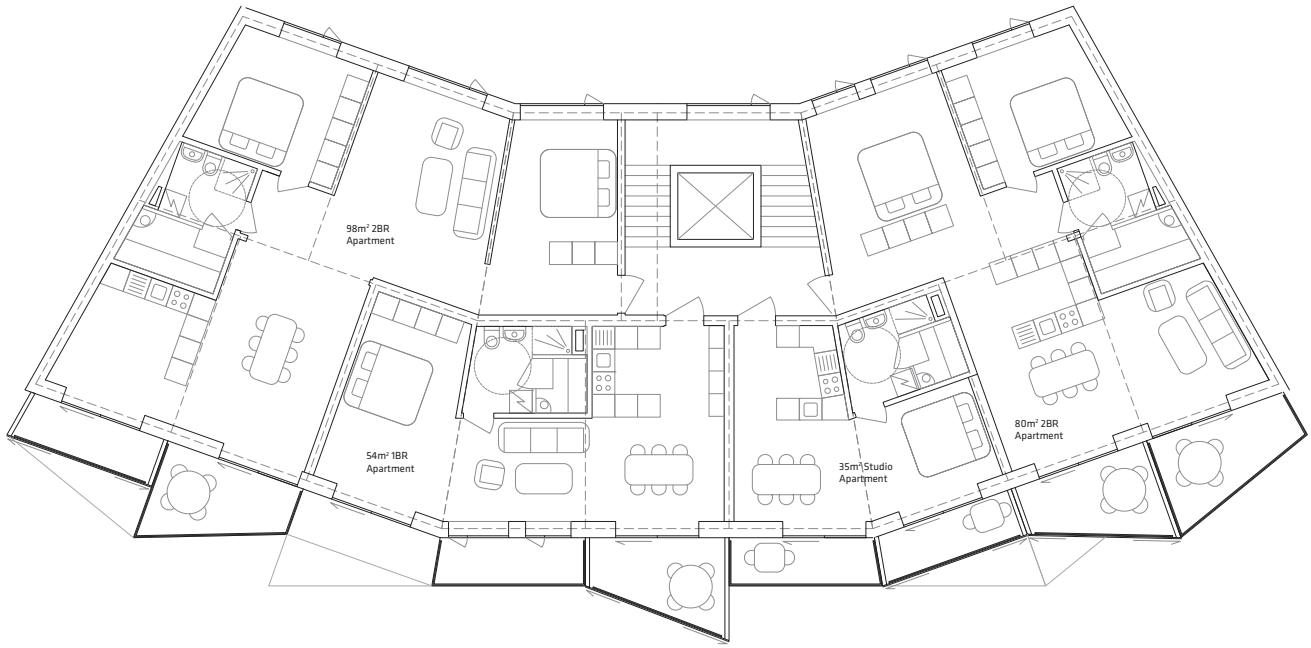
The massive use of concrete proposed increases considerably the weight and affects negatively the possibility to have a simple structural system. The proposed use of recycled concrete is also seen as problematic since it probably isn't readily available in the region. The supply chain of recycled concrete may prove to be not so ecological considering, for example, transportation effects. In particular cases, when a large amount of demolished concrete structures are available nearby, the system may be efficient and ecological, but as a standard solution for a multi-storey wooden development it is not plausible.

In short, Puu-Bo offers appealing settings for living. Its versatility provides a very fruitful living lab for a numerous technical applications related wooden multi-storey developments. The structural system needs to be simplified with a clear idea of the load bearing components.

Multiple unit configurations







Layouts 1:200

5.353.692

The most interesting character of the proposal is its alternative and bold strategy of hybrid structures. The entry suggests combining wood, steel, and concrete structures up to 8 floors without a sprinkler system. The extensive use of concrete, however, raises some concerns at the same time, in particular if the use of concrete doesn't solve the fire protection issues according to the current Finnish legislation (the proposal responds to the expected new legislation). The Jury viewed that the issues related to fire safety have already been solved in a satisfactory manner with current sprinkler systems on the market. Further, the sprinklers should be seen as a safety advantage instead of a hinder.

The proactive façades of the proposal using the gap solar® or lucido® systems fit very well to the energy efficient wooden development. The dark colors of the façade further support this idea. However, the color may otherwise be rather dark in the northern conditions and create a gloomy urban environment.

Another technical feature is the vapour-open principle of the façades. They may provide efficient opportunities for manufacturing and in particular for assembly on the site. However, the Jury viewed that the presented vapour-open wall and roof constructions have a moisture condensation risk considering Finnish climate conditions. These issues should be studied further, for example, in the works of WoodInno.

The submittal proposes a particular post and beam structure with simple connectors in each end of a post. The structure involves also load bearing shear walls. The result is a quite complex system but it does have its advantages, for example, in the eventual renewal of the facades. Another issue is the precision of the assembly work in mounting the posts with the proposed LEGO-type of system and leveling them to hold loads equally along the beam throughout the construction of 8 stories.

The acoustic performance of the building would be at a very high level thanks to the proposed massive use of concrete in the floors, in separating walls, and in the staircase shafts. The proposed composite concrete-CLT walls with the fire protections of CLT are however unreasonable expensive solutions since the presented concrete

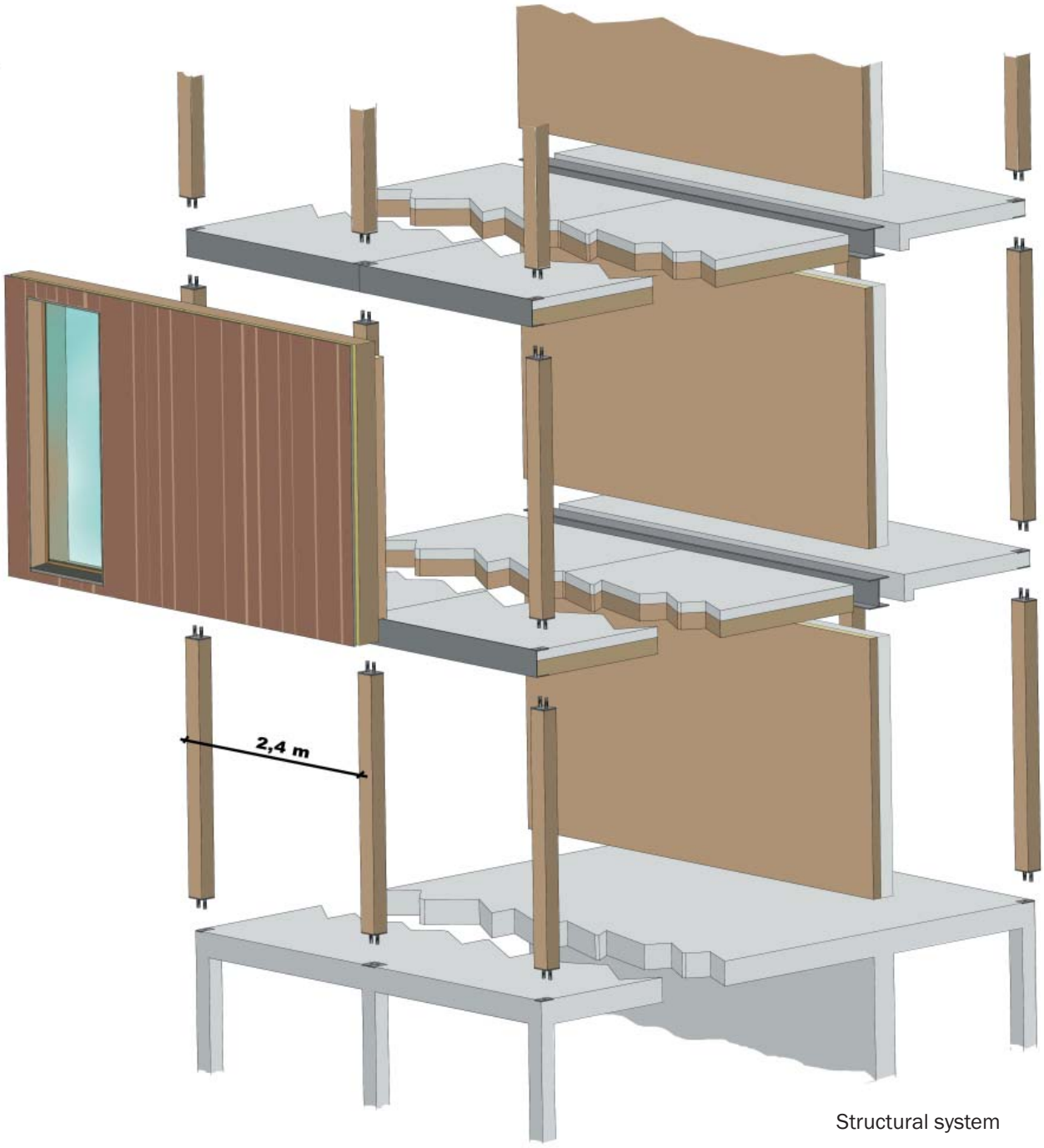
coverings of thickness of 160 or 180 mm would fulfill the requirements by themselves. The proposed composite concrete-wood floor slab has been designed for a maximum span of 7,2 m with allowed deflection limit ufin < L/300, but for this magnitude of the span, the floor seems too heavy compared to its bending stiffness and it is highly questionable whether the Finnish requirements of limiting the vibration of the floor would be satisfied.

The prefabricated concrete-wood floor slabs are proposed to function as a weather protection during the construction work. Assembly of large slabs can take place within hours, but the protection from the rain remains inadequate. Rain water will travel underneath the slabs and driving rain will affect the slabs directly.

The architecture of the proposal introduces a clear form that could be adapted very well to diverse locations. In fact, the architecture resembles the conventional practice of housing production with modularity and visible seams between the elements. These features link the entry to the tradition of industrialized housing production of the 60s and 70s. The balconies, however, give fresh variety for the façades. The floor plans are efficient and economical.

The Maisonettes at front of Hotel Sommelo introduce an appealing housing typology with interesting layouts and sections. The proposed location for the Maisonettes isn't feasible due to poor stability of the soil, but in another location the scheme could be developed further.

The approach to urban design is clearly undeveloped and fails to demonstrate the potential qualities of the housing as living environments. The housing is situated in the middle of the park more like a pavilion or a public building without any division into private, semi-public, and public space. Sustainable housing needs well-designed yards for local recreation. Large parking areas typical of the suburban developments of the 60s and 70s are unlikely to produce neither good parking solutions nor visually appealing environments. Further, underground parking would be very costly to build in the given location. The urban scheme could be developed, for example, by using diverse scales and building heights in a closer relation to each other to give a spatial structure that is more suitable for living.



Structural system

Fox

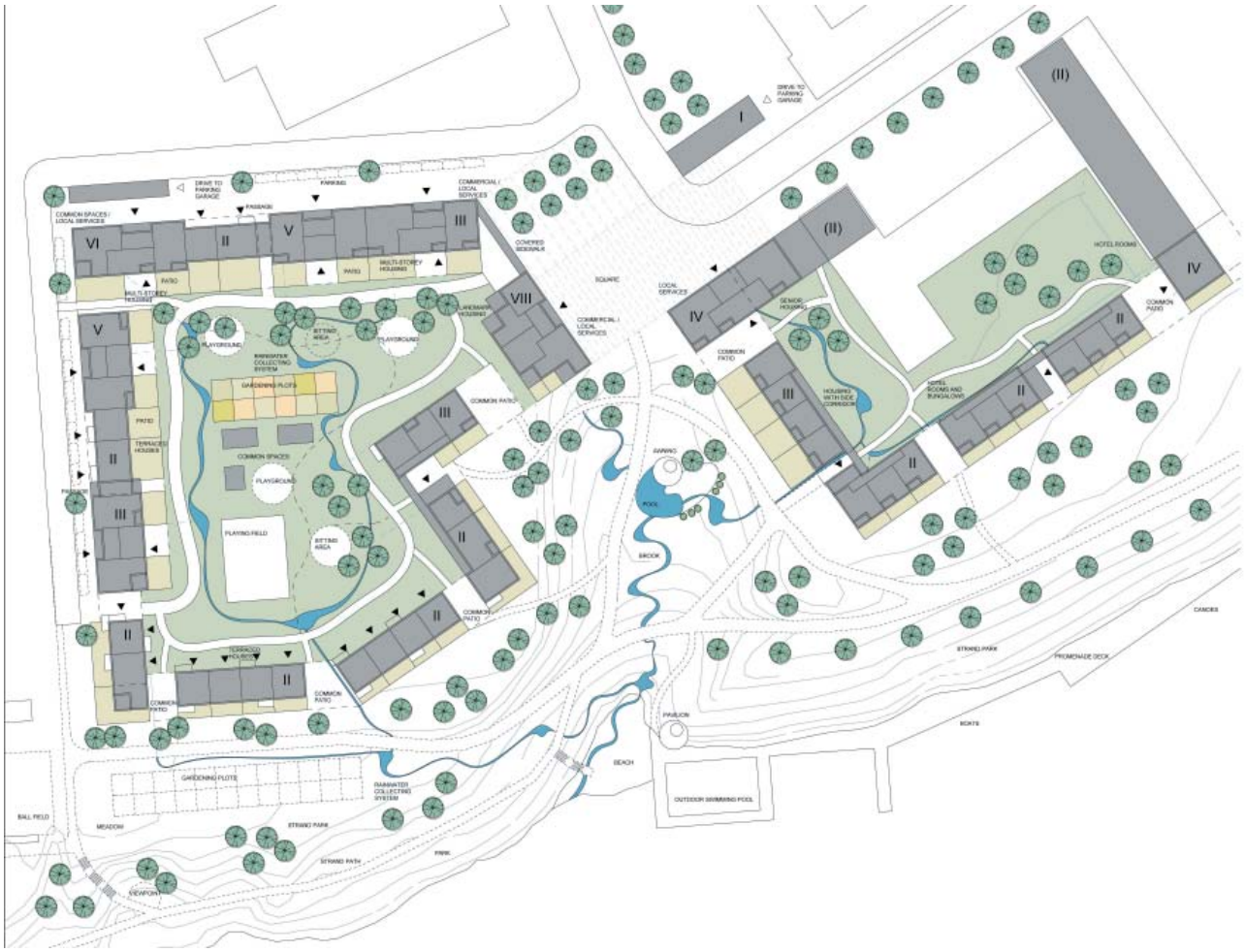
The entry is based on a post and beam system. The proposed span width is only 3.8 meters causing some contingencies in interior architecture, for example, posts in the middle of a living room. This may, on the other hand, be a desired quality emphasizing the architectural character of a wooden residential development. But, from the perspective of a building system, the solution is very restrictive for diverse architectural solutions. The building system contains also many components making the assembly laborious on the site and requiring precision in mounting them. The proposed box sanitary elements are innovative components that should be studied further, for example, in the work of WoodInno.

The proposed steel elements for beam and column connections are expensive, just as the proposed solution of a steel tube column inside a hollow glulam cross-section. The authors present that the load-bearing glulam beams and columns may be protected against fire only by a flame retardant treatment of fire class B. This doesn't satisfy the essential principle of the Finnish fire requirement, where all combustible load bearing parts of the structure in multi-storey houses shall be protected by inflammable cladding materials of class A. The proposal pays attention to the acoustic performance and the limiting of vibrations in new technical ways that must be credited.

The urban design of the entry connects to the city structure of Kuusankoski. The result is a local interpretation that uses different scales and continues the pattern of the city. The treatment of Hotel Sommelo provides an interesting example how concrete element buildings from the 60s and 70s could be renovated and expanded with wooden building components.

The layout leaves a generous park area close to the river. The extensive rain water collecting system connected to landscape architecture may prove to be difficult and expensive to maintain in a good shape.

Parking is mainly solved with expensive underground parking solutions instead of using more ground level parking. The entry demonstrates well the opportunity to locate the underground parking easily underneath the light-weighted building volume. This is a clear advantage if, for some reason, it is desirable to locate parking underground.



The architecture and layouts of the proposal are conventional and in that sense safe, considering the acceptance of the local markets. On the other hand, the problem in the Finnish housing markets has been the lack of variety and alternatives for consumers

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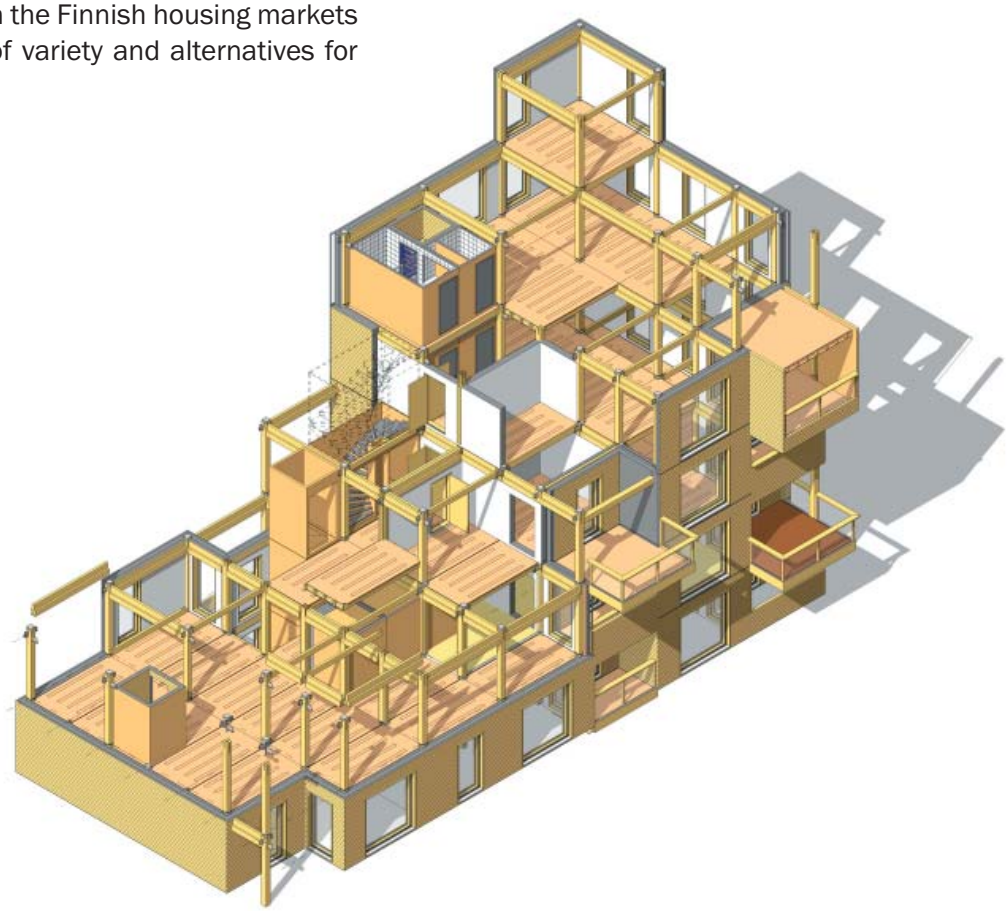

Structural system

Result of the Competition

All invited teams received an honorarium of 55 000 euros (+VAT). The Jury selected two winners for the E2 Timber Development Competition: E^{2}volution and Puu-Bo.

The merits of these proposals were diverse yet equally important for further development of wooden multi-storey buildings. The best features of each proposal – as described above in the assessment of the entries – should be respected and acknowledged in the continued development of the pilot site and in the work of WoodInno.

Signatures of the Jury Members

Ilmari Absetz

Aimo Ahti (chair)

Hans Andrén

Pekka Heikkinen

Kyösti Jääskeläinen

Ari Kevarinmäki

Jouni Koiso-Kanttila

Olav Kristoffersen

Jarek Kurnitski

Hannu Luotonen

Liisa Mäkijärvi

Erik Serrano

Tapio Välinoro

Authors of the Competition Submittals

The Jury opened the envelopes containing the names of the authors after reaching the final decision.

The submittals contained the following information:

E^{2}volution

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SeYoung Jin, HHS Planer
Annamaria Mandaric Mraz, HHS Planer

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Marcus Fischer, Finnforest Merk
Johannes Ranzmeyer, Finnforest Merk
Jaakko Länsiluoto, Finnforest

Jari Viherkoski, arkhmv (local architectural consultant)

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Fox
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E2

Timber Development Competition

The competition focused on industrial concepts for wooden multi-storey residential developments. New climate friendly solutions aim at increasing the added value of wood and sustainable development. Solutions and services creating a new kind of industrial culture and business lie at the core of the competition. The results of the competition produced inspiring architectural solutions and new ideas for developing the industrial production of wooden buildings.