

Towards User-Oriented Suburb Renovation

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Suburb renovation concept

A Finnish national research project, *User- and Business-oriented Suburb Renovation Concept*, was started in 2012. Energy efficiency is emphasised in the project, but it also addresses what improving the energy efficiency of suburban apartment buildings means from the standpoint of architecturally valuable and conservable buildings. Thus, the project will also test the impact that stricter energy efficiency requirements—effective in Finland in 2013—will have on renovation.

The primary goal is to develop a user-oriented, industrial, overall-economical renovation concept for suburban apartment building renovation as well as construction of additional storeys. The concept will make it possible to change from cost-based operation to a new type of service- and user-oriented business where renovation solutions can be site-specifically and all-inclusively tailored within the framework of a novel operating model that integrates suppliers and implement solutions by means of networked business operation.

The project's user-orientation refers to both interactive planning that includes the residents in the planning process and construction that allow the residents to live in their apartments during the renovation. Repairs to the shells of buildings are done with large prefab elements which are fastened to the frame of the building from the outside. In like manner, balconies, new lift shafts and additional storeys made of box like module elements are prefabricated and installed quickly and with as little disturbance as possible. A model book will be created together with partner companies in connection with the first realised pilot projects. The book will help housing companies start renovation projects by providing them with tools for ideating and planning participative, user-oriented renovations.

To make it possible to realise suburban renovations more comprehensively than house by house, the project will also collaborate with the Ministry of the Environment and participating cities in developing a new type of less complex town planning model for suburban renovations and in-fill construction.

Keywords: user-oriented, renovation concept, prefabrication, town planning

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1. Background

Construction in the near future will focus on suburb renovation and in-fill construction, which will face a demanding challenge due to the objective of improving energy efficiency. The concrete-frame apartment buildings constructed in Finland in the 1960s and 1970s are approaching the age when they require renovation. These buildings contain altogether about 570,000 apartments. (Lukkarinen et al. 2011, 42) Approximately 13,500 apartment buildings and 288,000 apartments will be in need of repair in 2016–2025. The cost of renovating these apartment buildings over this 10-year period is estimated to be €7.8 billion. (Lehtinen et al. 2005)

These suburban apartment buildings require exhaustive technical repairs both inside and out. For example, problems related to the quality of the concrete and the reinforcements of the sandwich elements used and the durability of the elements' trusses and fasteners, moisture damage and poor thermal economy are the most common reasons behind façade renovations. These suburban buildings also need roof, window and balcony repairs or renewal. Possible addition of balconies would also increase living comfort and pleasantness.

Research has been made about this kind of renovations. Research project Rebo in Norway dealt with comprehensive upgrading of 1960-70's suburb apartment buildings. The aim of the project was to show how post war residential environments can be improved in general, with focus on energy efficiency, design for all and accessibility and residents' participation in the planning process. Two typical multi-story concrete blocks of flats were renovated. It was demonstrated that economically profitable upgrades according Passive House concept are possible, when the building is in poor condition and a major renovation must be undertaken. Additionally, indoor climate and comfort of the residents were improved. (Buvik et al. 2011)

In Finland these types of renovation projects are excessively laborious and difficult for building managers, housing associations and residents alike. It is hard to find operators who are capable of or willing to take on suburban apartment building renovations, and it is often necessary to search for and hire several contractors for a project. It is very difficult to integrate their work. In practice, renovations are slow, expensive, dirty and disruptive.



Figures 1 and 2: A significant number of suburbs were constructed in Finland in the 1960s and 1970s in which multi-storey apartment buildings constructed of prefabricated concrete elements are the dominant building type.

Early inclusion of all parties involved in the renovation project and the feeling of actually being able to have an influence is the best starting point for getting renovation decisions passed in housing companies' decision-making bodies. Factors of choice and motivation related to buildings and renovation have been studied as they apply to both private and professional owners. (Brohmann et al. 2009, 4) Important in professional operation are management of economic processes and long-term owner policy, i.e. technical and economic rationality. Private individuals are motivated in matters centrally related to their own well-being, such as experienced comfort.

1.1 Social, economic and cultural durability

Reinforcement of social, economic and cultural durability and renovations that support sustainable development are the main cornerstones of suburb development. The principles of sustainable development are naturally connected to environmental challenges, such as slowing down climate change, but also to safeguarding the vitality of each living area. This way, e.g. new and in-fill construction can be used in suburbs to boost area populations, thereby ensuring that services remain and improving the prerequisites for public transport. (Lindgren 2008, 12)

New construction's impact on improving the energy efficiency of the building stock is a slow process. Therefore, it is very important to improve the energy efficiency of existing buildings. Suburbs are currently the least energy-efficient segment of Finland's building stock. The residential apartment buildings built in the 1960s and 1970s are most problematic—they are poorly insulated and they are the most numerous. The most effective measures for improving the energy economy of a residential building are adding insulation to the exterior of the ceiling and outer walls and making them more airtight, renewing the windows, balcony doors and exterior doors to meet the requirements of the near future, renewing heat production systems and constructing an intake and exhaust air ventilation system with heat recovery units in each apartment. (Uotila & Lahdensivu 2012, 85-88)

Most older people live and want to live in their own home. The need for services and an accessible residential environment are decisive factors associated with older people's coping at home. Buildings without lifts are a major problem in Finland's building stock. In 2005 there were 370,000 apartments in three-storey buildings without a lift. Near half a million people lived in these buildings—71,000 of them were at least 65 years old and needed a lift. (Pekka, Pelvas & Peltonen 2008, 74-78)

1.2 Wood material in renovation

The market outlook for renovating suburban apartment buildings changed significantly in Finland in April 2011 when a new fire code became effective. The new regulations allow construction of additional lightweight timber-framed storeys atop residential apartment buildings and renovation and additional insulation of the outer walls of buildings using lightweight timber-framed elements. (E1, RakMK) The reasons for the change are the desire to slow down urban sprawl and the need to preserve suburban populations in order to safeguard their services and thereby their attractiveness.

2. Objectives of the project

The EU's construction directive requires new buildings and renovations of existing buildings to be energy-efficient. Accordingly, in its national climate strategy the Finnish government has set a goal of decreasing the amount of greenhouse emissions produced by buildings. The Ministry of the Environment has prepared new construction regulations according to which also the energy efficiency of buildings must be improved in connection with their basic renovation.

The objective of this project—launched in 2012—is to develop a user-oriented, industrial, overall-economical and efficient renovation concept for suburban apartment building renovation and expansion. All renovation measures must improve not only living comfort, but also the energy efficiency of buildings. The parties to the project are the University of Oulu's Departments of Architecture and Industrial Engineering and Management, Aalto University's Department of Architecture, Tampere University of Technology's Department of Construction Engineering and the Technical Research Centre of Finland. Participating companies in the construction sector include StoraEnso, Isover Saint Gobain and construction companies. Other partners include cities like Joensuu, Kouvola, Porvoo and Turku, real estate representatives, the Ministry of the Environment and the Finnish Real Estate Federation.

Residential apartment buildings are renovated in Finland using the methods of new construction; industrial service concepts for renovation have not been developed yet in this sector. It is not possible to face the growing renovation debt of Finland's suburbs or the near-future requirement to improve the energy efficiency of the existing building stock without enhanced construction methods brought about by industrial construction. However, the individual needs of suburban buildings are so varied in terms of technical solutions and architectural and environmental constraints that it is not possible to develop a universally applicable renovation solution for suburban buildings.

The concept will make it possible to change from cost-based operation to a new type of service- and user-oriented business where renovation solutions can be site-specifically and all-inclusively tailored within the framework of a novel operating model that integrates suppliers and implement solutions by means of networked business operation.

Important from the standpoint of housing companies is the cost structure of the renovation project, as not many housing companies have reserved funds for renovation purposes. For this reason constructing an additional storey(s) may be a decisive opportunity for funding necessary façade and balcony renovation or building a lift, for example.

2.1 All-inclusive

Because no one in the construction field in Finland has the capability to naturally operate all-inclusively—in the same turnkey manner as single-family home deliveries are made—the goal of the project is to build a business-oriented operator network. Since the goal is overall development, attention should be paid to both customer satisfaction and the delivery chains of organisations and their management. With standardised operating methods manageability

will reduce costs, improve quality and decrease dispersion. The operating model will require companies to adopt new kinds of operating processes; the prerequisites for this will be created in the project by modelling value chains and developing networked business models. (Malvalehto et.al 2011)

The project's user-orientation refers to both interactive planning that includes the residents in the planning process and construction that allow the residents to live in their apartments during the renovation. That means speedy, non-disruptive construction work, which is not possible with the renovation methods that are currently employed.

2.2 Users in focus and a model book

For building managers and housing companies, user-orientation in the project means that the project's implementation planning, cost estimation and realisation are reliably available from one source and they are based on a project description compiled and agreed on together in advance. The concept will benefit residents and housing companies by allowing users to participate in renovation ideation and planning from the beginning of the process.



Figure 3 and 4: In Riihimäki the possibility of raising the four-storey buildings to cover the renovation cost and to improve the milieu has been examined. Present situation at the left. (Tomi Tulamo's master thesis, Aalto University 2010)

The objective in this research project is to compile a model book in collaboration with partner companies which will help housing companies start renovation projects by providing them with tools for user-oriented ideating and planning. The purpose of the model book is to present different types of all-inclusive solutions for block in-fill construction and construction of additional storeys atop suburban apartment building using box like module elements; energy-efficient renovation of the outer shell of buildings—particularly exterior walls—and façade renewal using various materials; construction of balcony systems and installation of lifts. The goal of the all-inclusive concept is, if necessary, install also apartment-specific ventilation systems as part of the new façade. To this can be added tools that serve energy and real estate management as well as apartments' indoor environments and methods for verifying performance (instrumentation, monitoring). The current state of buildings and the success of renovations should be verified with *in-situ* measurements.

2.3 Suburb in-fill construction

Suburb in-fill construction is justified from the standpoint of integrating and compacting the urban structure. This has a favourable effect on the environmental impact of communities and promotes preservation of suburbs' dwindling services, which is in the interests of area residents. From the perspective of housing companies, supplementary construction may be one way to finance necessary renovations, although this operating model requires revision of current town planning practices to make supplementary and in-fill construction flexible in practice.



Figure 5: New buildings, in-fill construction within the block structure and additional stories to existing buildings in Kaukovainio suburb, Oulu. (Jaana Keränen's master thesis, University of Oulu 2011)

To make it possible to realise suburban renovations more comprehensively than house by house, the project will collaborate with the Ministry of the Environment and participating cities. An objective of the project is to develop a less complex town planning model for suburb renovation and in-fill construction in collaboration with cities, and simultaneously develop practices for environmental impact assessment tools to support and justify suburb in-fill and supplementary construction. It is also necessary to review parking place requirements from the viewpoint of areal services offered.

3. Content and the results of the study

3.1 Renovation of the facades

Energy efficiency is emphasised in the project, but it also addresses what improving the energy efficiency of suburban apartment buildings means from the standpoint of architecturally valuable and conservable buildings. Thus, the project will also test the impact that Finland's new and stricter energy efficiency requirements will have on renovation.

It is customary to improve the thermal insulation of the facades in connection with apartment building renovations in Finland. Ordinarily this is done by applying a coat of plaster on top of an additional layer of insulation or alternatively by removing the existing facade material, and usually also the most often damaged layer of insulation, and constructing new, better-insulated facades. (Heljo & Vilhola 2012, 33-34; Peuhkuri et al. 2012, 54, 65, 86)

Done in this manner, the work is expensive and slow and it disturbs the residents. For this reason new facade element systems have been designed for renovations in Finland and other European countries. A TES system based on large, lightweight stick-frame elements has been designed for facade renovations. The elements are fastened to the inner shell of a building's concrete exterior wall elements, and due to their lightness they may be several storeys high. (Heikkinen et al. 2009, 101) This type of system has already been used in two apartment building renovations in Finland—the INNOVA project in Riihimäki (Lahti et.al 2011) and Kummatti in Raahe (Hagan 2010).

Large, lightweight stick-frame elements offer a promising renovation solution, so in this study we have concentrated on developing this solution to make it widely usable in renovations. The challenge with exterior wall elements is the airtightness and load-bearing capacity of the exterior wall, especially in cases where the existing building lacks a load-bearing inner shell or the façades consist of horizontal band elements. The frames of elements also require special strength analysis if the façade facing is very heavy, e.g. brick slabs or planks.

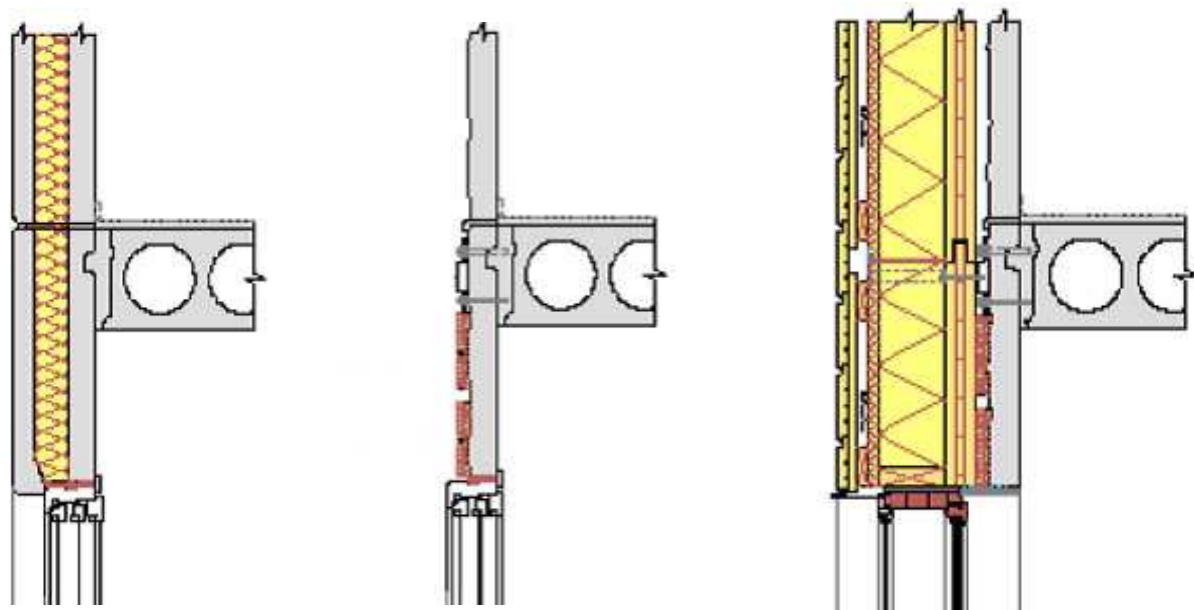


Figure 6: Energy efficient renovation of a typical apartment building made in 1970's. Left the original sandwich façade, external layers removed and on the right the new prefabricated CLT supported timber panels are fitted.

In this study we have designed renovation elements whose inner shell is made of self-supporting cross-laminated timber (CLT) panels. The CLT panels function as a load-bearing, stiffening layer in the element, but they also make the element airtight. And because of the

excellent load-bearing capacity of the CLT panel, the facade facing can be made from practically any material. This is important because the renovation concept for suburb renovations must be such that building renovations completed within its framework can be done using various façade facing materials so that the architecture of the building is preserved in the renovation, but also so that alternatively the architecture and appearance of the building can be changed completely, if so desired.

3.2 Module elements

Constructing additional storeys is an attractive alternative in connection with apartment building renovations, and this is often done in Finland, especially in areas close to city centres. In practice, though, construction has been difficult and costly, and for this reason in this study we are developing ways to utilise industrial prefabrication in construction.

The frames of suburban apartment buildings built in the 1960s to 1980s will easily carry the construction of lightweight additional storeys allowed by the new fire code of Finland. To minimise disturbance inflicted on the residents, it is sensible to construct them from box like module elements. However, designing and constructing module elements is challenging because the top ceiling slab usually cannot be loaded, whereupon loading has to be aligned with load-bearing walls below the slab, which may be few in number. On the other hand, to increase floor area it may be desirable to make the top storey larger than those below it. Special attention also needs to be paid to existing ducts and ventilation pipes that pass through the roof.

In this study we have examined the designs and dimensions of the load-bearing frames of typical suburban apartment buildings constructed in the second half of the 1900s and we have tested how additional storeys made of module elements can be constructed atop the frames. To avoid having the layout of the rooms in the additional storeys dictated by the layout of the rooms in the storeys below, we decided it is practical to make the module elements self-supporting. A modular element system with a load-bearing frame (walls, ceiling and floor) made of CLT panels has been designed in collaboration with StoraEnso.



Figure 7 and 8: Left, fabrication of CLT module elements. Right, a plan for an additional storey made of prefabricated module elements.

Since the module elements are self-supporting, they can be installed so that the load-bearing walls of the elements either coincide with the load-bearing walls below or are perpendicular to them. This solution provides much freedom in designing additional storeys. The self-supporting structure also makes it possible to extend the new, additional storey far beyond the outer walls of the storeys below if so dictated by the room layout or contemporary architecture. Module elements can be quite large, but due to Finland's road transport regulations, it is recommendable to limit element width to 4.5 metres and length to 13 metres.

As the concept calls for speedy construction, also lift shafts need to be installable as large self-supporting elements, for example using Kone Oy's lift technology which doesn't require a separate machine room. The designs have been developed in collaboration with StoraEnso in such a way that the load-bearing frames of lift shafts also utilise CLT elements.

3.3 Pilot projects

The results of the study will be tested in actual suburban apartment building renovations. The first pilot project is a block at Kirkkokatu 18 in Joensuu. The facades of two existing four-storey buildings on the block will be renewed using prefab brick-tile-faced self-supporting elements whose energy efficiency meets the requirements for new construction. At the same time new prefab balconies will be installed. As part of the renovation plan, we devised a way to construct the additional floors of the building being renovated and a new building in the courtyard by utilising module elements.

The project aims to demonstrate differences in the situations before and after renovations in building energy consumption, thermal conditions, ventilation and indoor air quality, performance of building structures as well as to collect feedback of the residents.

3.4 In-fill and additional constructing in suburbs

The building stock of Finnish cities is for the most part located in suburbs, and in international comparison Finnish suburbs are very sparsely and inefficiently built. Indeed, the Ministry of the Environment has set a goal of densifying the structure of Finnish cities, and at the same time make suburban land use more efficient. The target sites for town plan analysis have been chosen together with the cities: two suburbs in Turku, two in Porvoo, two in Kouvola and one in Joensuu. The areas differ greatly in size and nature, so they form an excellent series in which they complement each other. Assessment of the environmental impact of the sites has begun and the re-planning work of each area is on-going.

In these suburbs there is a need to both densify the sparse structure of these areas by erecting new residential buildings to fill in existing blocks and construct additional stories atop existing residential apartment buildings in connection with their renovation. In many cases it is practical to apply both solutions on the same block, as indicated by an assessment of areas near the centre of city of Joensuu.

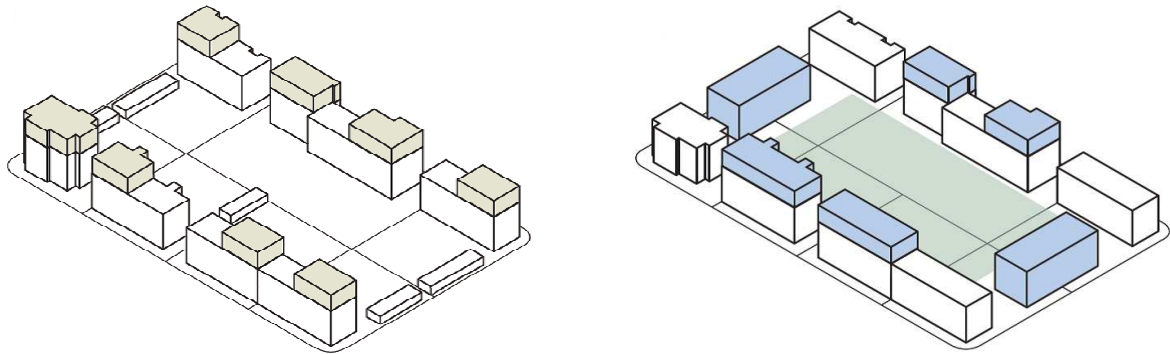


Figure 9 and 10: Additional stories and in-fill construction studied in Joensuu by the architects Anttila and Rusanen.

In this study we will examine whether the town planning procedure currently used in Finland is suitable for steering this type of supplementary and in-fill construction. The town planning procedure is laborious, and on the other hand supplementary and in-fill construction in existing suburbs will take place over quite a long time. So, the project will develop—in collaboration with the participating cities—less complex town planning models for suburb renovation and in-fill construction. At the same time it will develop practices for environmental impact assessment tools. These less complex town planning models could be e.g. an areal exceptional permit process with construction method guidelines or a general area plan with loose specification of permitted building volumes, in which case exact construction methods and building volumes would be specified for each block in the building permit phase. Cities will benefit from the results of the development by getting better methods for compacting the urban structure.

4. Final comments and conclusion

Suburb renovation in Finland is becoming an increasingly large and difficult problem to resolve. Suburbs are deteriorating, new energy efficiency requirements also require energy efficiency from renovated buildings and the largely manual work involved in renovation is slow and costly.

Because suburban apartment buildings require exhaustive technical renovation both inside and out, the motivation and needs of apartment owners are an essential part of the renovation process and the development of a new renovation concept. Residents' choices are limited by their financial capacity, but improvement of their own comfort is most important. Even in energy renovations—which in principle are within the sphere of technical and economic rationality—the primary criterion for making a decision is comfort (e.g. a draught-free apartment is more important than energy or monetary savings). This requires various all-inclusive solutions that are correctly focused also from the end user's (resident's) perspective, where not only are the need for technical repairs resolved and the level of

technology updated, but the residents are offered noticeably better comfort which can be seen and experienced as more pleasant apartments and environment.

The project is developing a user-oriented, industrial renovation concept for energy-efficient renovation and expansion of suburban apartment buildings as well as construction of additional storeys and lift shafts using self-supporting module elements. These solutions will not be developed specifically for certain companies; the development work will be done with government research funding and the solutions are meant to be widely utilised in suburb renovation and development. This will directly benefit residents, housing companies and real estate owners by enabling speedier, neater and cheaper renovations. The concept will also offer housing companies the possibility to upgrade buildings and thereby increase their value and attractiveness.

To manage renovation costs, the development work will concentrate especially on wintertime construction, which would allow house factories to use their underutilised autumn and winter capacity. However, this places challenges on job site conditions, especially moisture control, which needs to be addressed in the study.

The project will promote suburb supplementary and in-fill construction which will help reinforce the areas' population base, thereby ensuring that services are preserved, which is in the interests of the residents and the suburbs. That will also be an effective tool to retard the sprawl of cities.

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