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A New Suburb Renovation Concept

A. Soikkeli, L. Sorri

***Abstract*—**Finnish national research project, User- and Business-oriented Suburb Renovation Concept (KLIKK), was started in January 2012 and will end in June 2014. The perspective of energy efficiency is emphasised in the project, but also it addresses what improving the energy efficiency of suburban apartment buildings means from the standpoint of architecturally valuable buildings representing different periods. The project will also test the impacts of stricter energy efficiency requirements on renovation projects.

The primary goal of the project is to develop a user-oriented, industrial, economic renovation concept for suburban apartment building renovation, extension and construction of additional storeys. The concept will make it possible to change from performance- and cost-based operation to novel service- and user-oriented, site-specifically tailored renovation methods utilizing integrated order and delivery chains.

The present project is collaborating with Ministry of the Environment and participating cities in developing a new type of lighter town planning model for suburban renovations and in-fill construction. To support this, the project will simultaneously develop practices for environmental impact assessment tools in renovation and suburban supplementary and in-fill construction.

***Keywords*—**Energy efficiency, Prefabrication, Renovation concept, Suburbs, Sustainability, User-Orientated.

I. Introduction

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. Ministry of the Environment has prepared new construction regulations according to which also the energy efficiency of buildings must be improved from September 2013 in connection with such renovations that require planning permission for minor or larger construction [1].

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 1960's and 1970's are approaching the age when they require renovation. These buildings contain significant share of the whole housing stock, making this a renovation job that affects a large share of Finns [2]. The total number of dwellings in Finland was 2.8 million in the end of year 2010 and the 44 % of the dwellings were located in apartment buildings. [3] The number of dwellings located in apartment buildings built in the 1960's and 1970's is approximately 570,000 [4].It is estimated that 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 [5].

These suburban apartment buildings require exhaustive technical repairs both inside and outside. For example, problems related to the quality of the concrete and the reinforcements of the sandwich elements used and the durability of the trusses and fasteners of the elements, moisture damage and poor thermal economy are the most common reasons behind facade renovations. Not only the outer walls but also the roofs, windows and balconies need repair or renewal. Adding balconies to smaller apartments that often are lacking a balcony or enlarging the existing balconies with insufficient size would also increase living comfort and pleasantness [6],[7].

Research has been made about this kind of renovations. Research project Rebo in Norway dealt with comprehensive upgrading of 1960's and 1970's suburban 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-storey concrete apartment buildings 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 [8].

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.

The reputation of suburbs is poorer than the possibilities they offer [9]. The Finnish suburbs are usually sparsely built and the parks and recreation areas are numerous. Many of the suburbs are rather well-located. Therefore, renovations that promote good practices are very significant as improvers of the profile of suburbs.

However, traditional developing and contracting have been dominated by functional decentralisation where various contractors and operators are chosen on the basis of the lowest bid, without regard for life cycle costs or other indirect expenses. For this reason projects that employ traditional bidding methods are very costly for the orderers and do not induce suppliers and interest groups to act in accordance with the orderers' objectives. Deficient management of the

A. Soikkeli and L. Sorri are with the Faculty of Architecture, University of Oulu, PB 4100, 90014 Oulu, Finland (e-mail: anu.soikkeli@oulu.fi,laura.sorri@oulu.fi).

numerous parties involved in renovation projects has often led to contradictions and at least partial failures of the projects.

By developing new operating methods that affect the entire delivery chain it is possible to convert suburbs from underrated living areas into attractive environments. Although real estate companies are generally aware of the need for renovation, the problem has become getting renovation decisions passed by the companies' decision-making bodies. Postponement of renovation decisions has partly led to a situation where the condition of ownership-based housing company apartment buildings is poorer than that of rental apartment buildings in the same suburb, as the latter undergo regular maintenance.

Fig. 1 A significant number of suburbs were constructed in Finland in the 1960's and 1970's

Fig. 2 The concrete-frame multi-storey apartment buildings 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 [10]. 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 [11].

A. Social, Economic and Cultural Sustainability

Reinforcement of social, economic and cultural sustainability 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 [9], [12].

New construction's impact on improving the energy efficiency of the building stock is a slow process. Only 1 % of the housings stock is renewed annually.[12] 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 1960's and 1970's are most problematic—they are poorly insulated and they are the most numerous. The 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 than before, 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 [14].

The market outlook for using wood in 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 [15].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.

Majority of the older people live and want to live in their own homes. The need for services and an accessible residential environment are decisive factors associated with older people's coping at home [16]. In the future there will be a growing need for apartments suitable for lone dwellers and well-equipped life-cycle apartments where services that replace institutional care can be arranged. The lack of a lift is a major problem in Finland's apartment building stock. In the end of 2006 there were 48,700 staircases in at least three storeys high buildings without a lift. More than a half a million people lived in these buildings—100,000 of them were at least 65 years old, which means every third of the 65+ dwellers living in apartment buildings [13].

II. Objectives of the Project

The objective of this User- and Business-oriented Suburb Renovation Concept (KLIKK) project (1.1.2012-30.6.2014) is to develop a user-oriented, industrial, overall-economical and efficient renovation concept for renovation and extension of suburban apartment buildings. All renovation measures must improve not only living comfort, but also the energy efficiency of buildings.

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 will 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 facade and balcony renovation or building a lift, for example.

A. All-Inclusive

Because no one in the construction field in Finland has the capability to operate naturally 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 standardized 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 [17].

Since the goal is overall development, attention should be paid to both customer satisfaction and the delivery chains of other organisations and their management. Standardized operating methods, methodicalness and manageability will reduce costs, improve quality and decrease dispersion. Thus, the main objective of the project is to create a user-oriented, industrial, overall-economical and efficient renovation concept for suburban apartment building renovation and extension. From the standpoint of the housing company and residents, user-orientedness means speedy, non-disruptive construction work, which is not possible with the renovation methods that are currently employed. 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. The goal of the project is to collaborate with the various operators in formulating novel operating models and processes for working together which are transferable to practical business operations.

Early inclusion of all parties involved in the renovation project and the possibility to 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. 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 [11].

Because suburban apartment buildings require exhaustive technical renovation both inside and outside, 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 good comfort which can be seen and experienced as more pleasant apartments and environment than before [11].

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 facade and balcony renovation or building a lift, for example [4].From the standpoint of housing companies or other real estate owners, alongside of selling permitted building volume it is necessary develop new types of financing instruments in collaboration with the Housing Finance and Development Centre of Finland (ARA) and employee pension companies. These could be, for example, partial ownership of the real estate through supplementary construction and financing of supplementary or in-fill construction through leasing or so-called life-cycle model funding. The goal of the project is to come up with user-oriented ways to finance suburb renovation and in-fill construction and find new business models at the interface between the financing and real estate and construction sectors.

B. User 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.

The objective in this research project is to compile a publicly available 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 facade 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 facade. 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.

In terms of environmental impact assessment, user-orientedness in suburb renovation calls for a participative process and consideration of sustainable development values already in the project planning phase. The objective is to achieve resident-oriented solutions to local needs that are in the interests of the owners. The guideline is a comprehensive vision that includes resident-oriented planning objectives regarding e.g. the housing company's energy consumption, the residents' safety, comprehensive waste handling and indoor environment control (indoor air quality, lighting, heating and temperature conditions).

Guidelines for post-renovation monitoring of use will be compiled during the research project. The monitoring phase consists of observing key performance indicators (KPI) for environmental impact assessment, such as land use, energy and water consumption, indoor environmental quality (e.g. moisture, air quality) and the impact that visualising energy consumption has on residents' behaviour and social interaction. The outcome will consist of guidelines for assessing and possibly certifying the realisation of objectives accordant with sustainable development. The objective is to support value creation for residents by means of marketing, communication, price trends, better sales value and monitoring of energy savings. The project will gather the best practices of assessing the environmental impact of suburb renovation in Finland's conditions.

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.[4]

(a)

(b)

Fig. 3 (a), (b) The possibility of building a new storey to cover the renovation cost and to improve the milieu has been examined. Present situation above, 3 (a) [24]

C. Suburb In-Fill Construction

To make it possible to realize suburban renovations more comprehensively than house by house, the project will collaborate with Ministry of the Environment and participating cities. An objective of the project is to develop a simple zoning model for suburb renovation and in-fill construction in collaboration with participating cities, and simultaneously develop practices for environmental impact assessment tools to support and justify suburb in-fill and supplementary construction. The project will analyse and test new types of flexible zoning practices in pilot areas indicated by participating cities in collaboration with urban zoning and building authorities and the areas' residents and real estate. These less complex zoning 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. It is also necessary to review parking place requirements from the viewpoint of areal services offered.

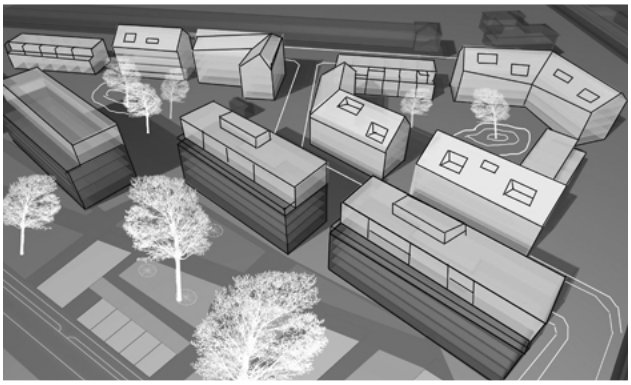


Fig. 4 New buildings, in-fill construction within the block structure and additional storeys to existing buildings in Kasarminmäki suburb, Kouvola [25]

III. Parties of the Project

The parties to the project consist of a wide range of Finnish universities, research institutions and companies in the construction sector. The participants are the University of Oulu's Department of Architecture and Department of 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 Stora Enso, Isover Saint Gobain and construction companies. Other partners include several cities like Joensuu, Kouvola, Porvoo and Turku, real estate representatives, Ministry of the Environment and the Finnish Real Estate Federation.

IV. Content and the Results of the Study

A. Renovation of the Facade

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 [18], [19].

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 (a timber based element system) is based on large, lightweight stick-frame elements which have been designed for facade renovations. The elements are fastened to the inner shell of the sandwich elements of the exterior wall, and due to their lightness they may be several storeys high [20]. This type of system has already been used in two apartment building renovations in Finland—the INNOVA project in Riihimäki [21] and Kummatti in Raahe[22].

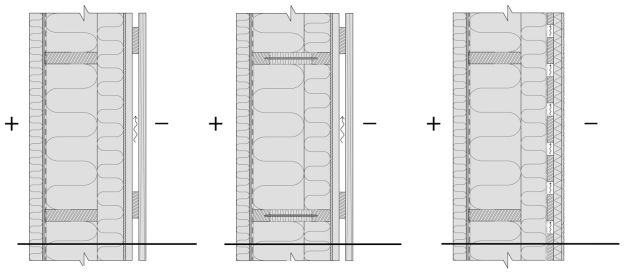


Fig. 5 Examples of TES system based stick-frame elements to be fastened to the inner shell of a building's concrete exterior wall elements. The facade can be made of plaster or ventilated cladding, for example [26]

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 facades consist of horizontal band elements. The frames of elements also require special strength analysis if the facade facing is very heavy, e.g. brick slabs or planks.

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 facade 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 [8], [20].

Insufficient or unsatisfactorily functioning ventilation is one reason for moisture problems. Apartment-specific ventilation solutions (wall ventilation and heat recovery) have been tried in new sites and have performed well. Installation has been relatively free of problems. Apartment-specific ventilation may also be partially realized by using existing ductwork or new lightweight ducts. Ventilation solutions and testing of their functionality as part of exterior wall renovation is an

important part of the concept.

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

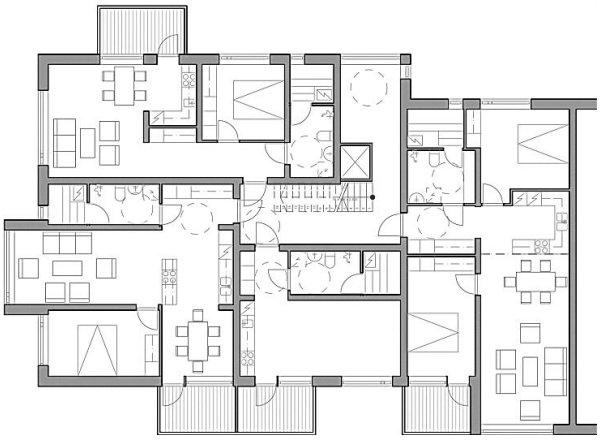
B. Module Elements

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 utilize industrial prefabrication in construction.

Fig. 6 Fabrication of CLT module elements

The frames of suburban apartment buildings built in the 1960's to 1980's will easily carry the construction of lightweight additional storeys allowed by the new fire code of Finland. To minimize 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 [23].

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 20th century 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 Stora Enso.



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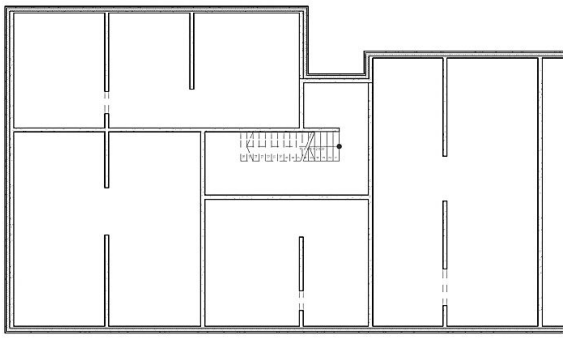


(b)

Fig. 7 (a) A plan for an additional storey made of prefabricated module elements 7 (b) Existing floor plan

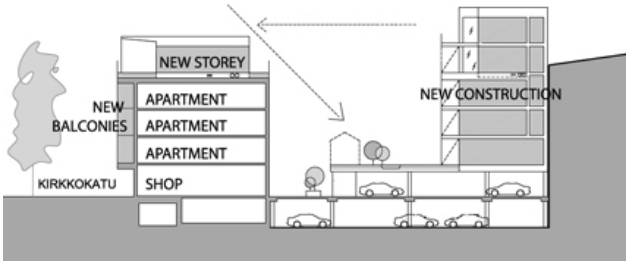
Since the module elements are self-supporting, they can be installed so that the load-bearing walls of the elements either coincide with the load-bearing walls below or are perpendicular to them. Preliminary studies have revealed that another good solution is to install steel beams on top of the existing structure. This solution provides much freedom in designing additional storeys and in installing heating, plumbing and ventilation. Installation of the module elements is easier atop of the beams than atop of existing roofing deck, which can very uneven. The beam structure makes also building the roof top terraces easier. The self-supporting structure of the module elements also makes it possible to extend the new, additional storey approximately 2 metres beyond the outer walls of the storeys below. Module elements can be quite large, but due to production, transport and lifting expenses, it is recommendable to limit element inside width to 4.2 metres, length to 12.0 metres and height to 2.95 metres. Due to acoustic and fire safety regulations rooms of two separate apartments can't be located in same module element. Sanitary rooms with wet sealing can't be divided in two adjacent module elements.

As the concept calls for speedy construction, also lift shafts need to be installable as large self-supporting elements, for example using KONE´s lift technology which doesn´t require

a separate machine room. The designs have been developed in collaboration with Stora Enso in such a way that the load-bearing frames of lift shafts also utilize CLT elements.

C. Piloting Renovation of the Facades and Module Elements

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.



(a)

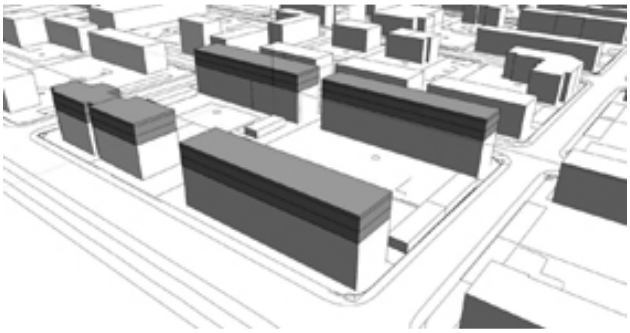
(b)

Fig.8 (a), (b) Additional story on top of an existing building and a new in-fill construction in the courtyard [27]

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.

D. 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, Ministry of the Environment has set a goal to densify 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.



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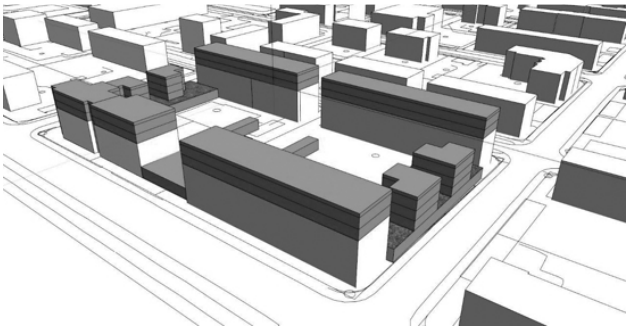

(b)

Fig. 9 (a), (b) Additional stories and in-fill construction KLIKK-case study in Joensuu. New building volume is indicated by dark grey color [28]

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. New residential buildings not only raise the plot ratio but also make the existing sparse block structure more defined and improve the micro climate.

For the cities' pilot suburbs, the research and guidelines will support buildings' project-specific planning and compilation of lists of tasks. In the planning phase it is necessary to assess the quality of the city image and the immediate surroundings, evaluate the need to improve drainage water treatment, map the landscape of plots and examine the need for landscape and traffic planning. The planning process also includes energy simulation or calculation and a tentative life cycle analysis of materials. Environmental impact assessment requires

documentation and verification calculation of quantities for material life cycle analysis (LCC and LCA). The environmental impact of the renovation process should also be monitored during the realisation phase. Attributes that should be documented include use of time, construction site energy consumption and transports. Waste formation should be monitored with the goal of planning material savings; the quantity and quality of waste produced by the building products used during the production process and at the construction site.

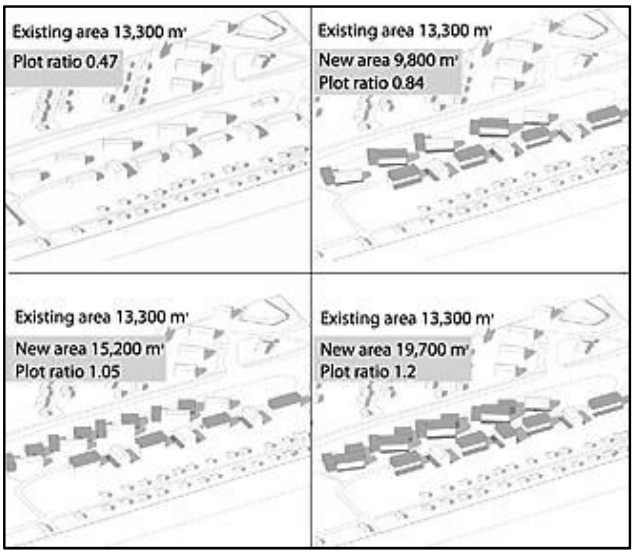

Fig. 10 Examination of different plot ratios in Kaunisnurmi suburb, Kouvola [29]

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.

V. Final Comments and Conclusions

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 outside, 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 than so far which can be seen and experienced as more pleasant apartments and environment.

The project will develop a user-oriented, industrial, overall-economical and energy-efficient renovation concept for suburban apartment building renovation and expansion 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 utilized in suburb renovation and development. This will directly benefit residents, housing companies and real estate owners by enabling speedier, neater and cheaper renovations than used so far. 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 underutilized 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.

The results of KLIKK (User- and Business-oriented Suburb Renovation Concept) project benefit housing corporations in improving energy efficiency by offering new methods of renovation and retrofitting. Same time in-fill construction offers a possibility to finance the renovation and also a possibility to build new common facilities. The residents benefit from less intrusive renovation method than normally which minimizes the disturbances and can be realized without emptying the flats. Construction companies have possibility to create new know-how, a business model and marketable industrial solutions. New retrofitting methods can be applied globally as the industrially produced concrete-frame apartment buildings are common in many countries. Finally, the enhanced housing quality and declined energy consumption benefits the residents and housing corporations allover in cold

climate.

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