Energy-efficiency Up-grade with Pre-fabricated Façade Elements – the Innova Project Renovation in Saturnuksenkatu 2, Riihimäki

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Summary

In the Innova project, a typical multi-storey house of the 1970s is renovated to meet the Finnish Passive House requirement, i.e. the heating energy demand after the renovation is max. 25 kWh/m²a. The four-storey-high building, originally constructed in 1975, is located in the Peltosaari area in Riihimäki. The building has 33 rental apartments and a day-care center.
The renovation includes new doors and windows, balconies, additional thermal insulation and the new ventilation system with effective heat recovery. The ventilation unit is equipped with filters that prevent the problems of minor infiltration of the exhaust air and the incoming air in the rotating heat exchanger.
The exterior of the building was measured by laser scanning and modelled for the dimensioning of the elements. The outer concrete pane and the thermal insulation of the old exterior walls are dismantled and replaced by vertical facade elements with wooden frame structure. The ventilation ducts, windows and the balcony doors are installed in the elements, as the first layer of the plaster rendering of the facades.
The new renovation method reduces the duration of the on-site construction work. The entire construction phase is planned to be ready in 5 months, which is half the time compared to the respective renovations of similar multi-storey houses in the Peltosaari area. Retrofitting is also an opportunity for up-grading the architecture of the building.

Keywords: energy efficiency, Passive House, retrofit, pre-fabrication

1. Introduction

1.1 Innova Project

The Innova project aims at motivating housing cooperatives to carry out energy efficiency improvements. The project organized a competition, in which one multi-storey house was selected to be renovated as a Passive House, supported by the expertise of the project consortium.
The Innova project is supported by ARA (the Housing Finance and Development Centre of Finland), Sitra (the Finnish Innovation Fund) and TEKES (the Finnish Funding Agency for Technology and Innovation), as well as several industrial partners including Enervent, Ensto, Lammin Ikkuna and Paroc. The expert consulting and monitoring after the renovation is carried out by VTT, Technical Research Centre of Finland. [1]
The Innova project searches for innovative methods and solutions for energy-efficiency up-grades of the existing building stock. The project was commenced in the beginning of 2010. In August, a multi-storey rental apartment building in Riihimäki was selected to be the target building for the Innova renovation. The planning started in the end of 2010. The construction work started in the August 2011.

1.2 TES Method

The renovation system utilizing pre-fabricated façade elements has been used in retrofit projects in several European countries. In Finland the method was introduced through the research project *TES – Energy Façade* by Aalto University, NTNU (Norway) and TU Münich (Germany, coordinator) in 2008–2009 [2]. The research and development work of the TES method continues in the international *SmartTES* project.

1.3 Multi-storey house Kotikulma 10

Kotikulma Oy is a rental apartment company owned by the city of Riihimäki. The four-storey-high building in Saturnuksenkatu 2, originally constructed in 1975, is located in the Peltosaari area in Riihimäki.

Even though Peltosaari is located very close to the Riihimäki centre, the neighbourhood suffers from socio-economic problems, similar to many other suburban areas in Finland. The challenges of the urban and social development as well as the technical condition of the residential building stock in the Peltosaari area were analysed in the research project EcoDrive by VTT, Helsinki University and Aalto University in 2008–2011. [3,4]

The most multi-storey houses in the Peltosaari area are typical 1970s buildings. The facades are usually built of pre-fabricated sandwich elements. The outer concrete pane of the sandwich element needs to be supported or replaced, since the strength of the metal connectors between the panes is reduced by the corrosion. The 70s buildings are currently being renovated also in Peltosaari. Typically the outermost layers of the old facades are dismantled, new thermal insulation with plaster rendering added and new windows, doors and balconies installed. Since the flat roofs have had leakages, they are often replaced with a new roof with eaves and an external rainwater system.

The four-storey high multi-storey apartment building in Saturnuksenkatu 2 has 33 rental apartments and a day-care centre. Before the renovation, the building used electricity for both the heating of spaces and for the heating of domestic hot water. In the energy metering, the energy consumption for heating, domestic hot water, lighting, building services or tenant electricity could not be separated.

The on-site work was started in the August 2011 and the work is planned to be completely ready in the January 2012.

Fig. 1 The multi-storey house in Saturnuksenkatu 2, Riihimäki is retrofitted to meet the Finnish passive house requirement, i.e. the heating energy demand after the renovation is max. 25 kWh/m²a. Photo: Jari Kiuru.

2. Solutions

2.1 Facade elements

The new façade consists of 69 elements with various widths. The element widths were selected so that plaster rendering of all the window and door recesses can be done in the element factory. The dimensioning of the elements was based on the laser scanning of the exterior and the 3D-modelling of the building.
The new façade elements are 12 meter high vertical elements wooden frame structure. The primary frame profile is 39x300 mm LVL (laminated veneer lumber). Since the frame profile is glued and consists of parallel veneers, the moisture movements will be relatively small compared to the sawn timber frame.
The elements have to be transported, lifted and turned before the installation on site. To eliminate the movements in lifting, the wood frame has panel layers on both sides of the frame. On the inside, the 9 mm spruce plywood is fixed onto the frame by gluing and by screws.
On the outside, mineral wool with plaster rendering was glued onto the cement fiber board. The façade material behind the balconies is wooden cladding with ventilation cavity behind it. The façade material of the day-care center in the ground floor is painted cement fiber board.
A model element was tested by lifting and turning before the manufacturing started. Neither the windows nor the first layer of the plaster rendering got damages in the lifting. The dimensional tolerance of the façade element is 4 mm.
All the work on site is carried out without scaffoldings.

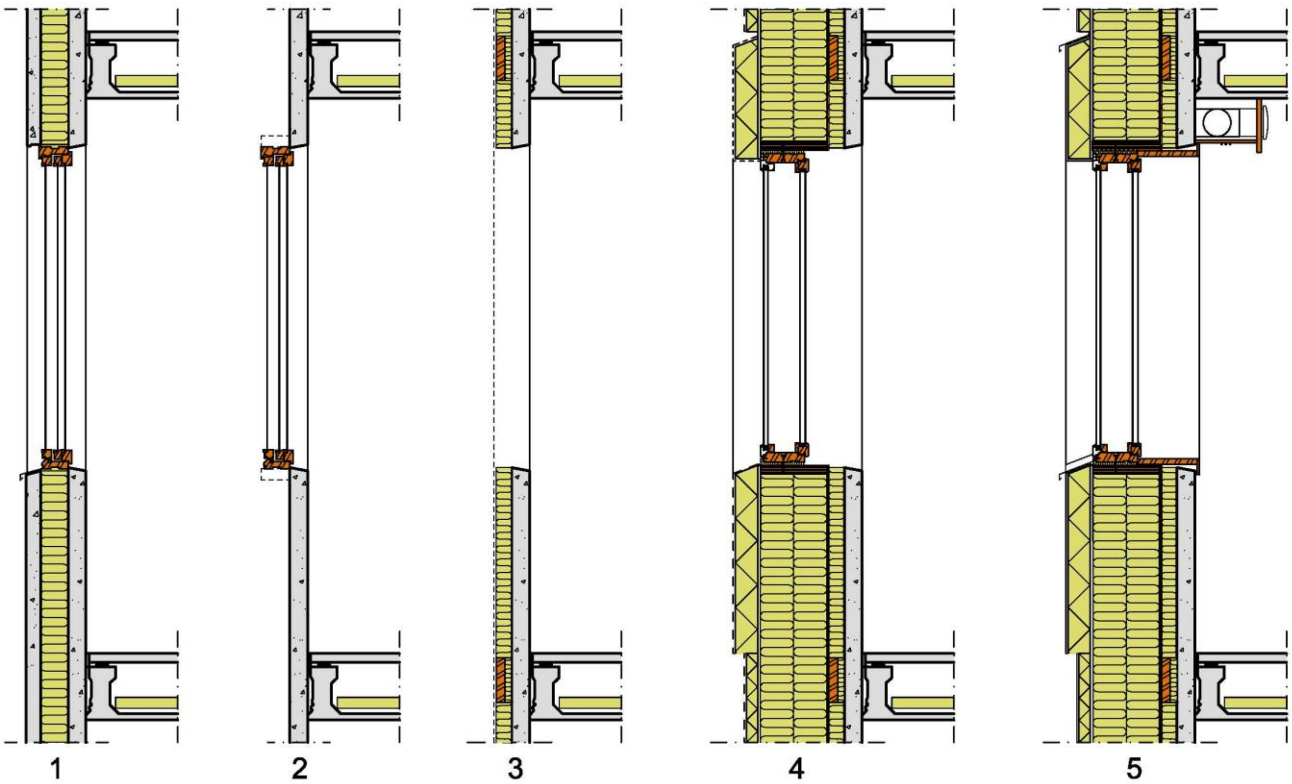

Fig. 2 The outermost concrete layer of the sandwich element is dismantled (2) and the existing thermal insulation removed. 70 mm of thermal insulation is mounted on the concrete surface (3) to make the surface even enough for the elements. The facade element (4) has 350 / 400 mm of thermal insulation. The windows, the balcony doors and the vertical ductwork for the supply air are installed in the elements. The finishing work is done on site (5). Image: Kimmo Lylykangas Architects.

Fig. 3 The elements are transported in horizontal position and will be turned by the crane. The model element was tested at the element factory before the manufacturing was started. The round holes are the ventilation ductwork connections. Photo: Kimmo Lylykangas.

2.2 Windows and balcony doors

The new windows are operable and have two double-glazed sealed units with Argon fill and selective films. The U-value is 0.66 W/m²a. The new balcony doors have triple glazing with Argon fill and selective films.

2.3 Balconies

The old concrete and steel balconies are demolished. The new balconies are pre-fabricated steel-framed balconies.

2.4 Roof

The new roof has an attic with ventilation ductwork and a new technical space for ventilation units.

2.5 Ventilation

The vertical ductwork for supply air is built in the elements. Two rectangular dimensions, 100x120 mm and 100x150 mm are used for the rooms in the apartments. Two larger dimensions, 100x200 mm and 100x250 mm, are used for the vertical ventilation ducts of the day-care center. The exhaust air is led out through the existing ductwork.
The centralized ventilation system was preferred for easier maintenance. The filters need to be changed 2 – 3 times a year. With the centralized system, there is neither need to have an access to the apartments nor to make the tenants responsible of filter changing.
The ventilation unit has a rotating heat exchanger. This would not meet the requirements of the Finnish Building Code without filters on both sides of the unit, preventing the harmful effects of the possible minor mixing of the exhaust and in-take air. The rotating heat exchanger enables high efficiency of the heat recovery.

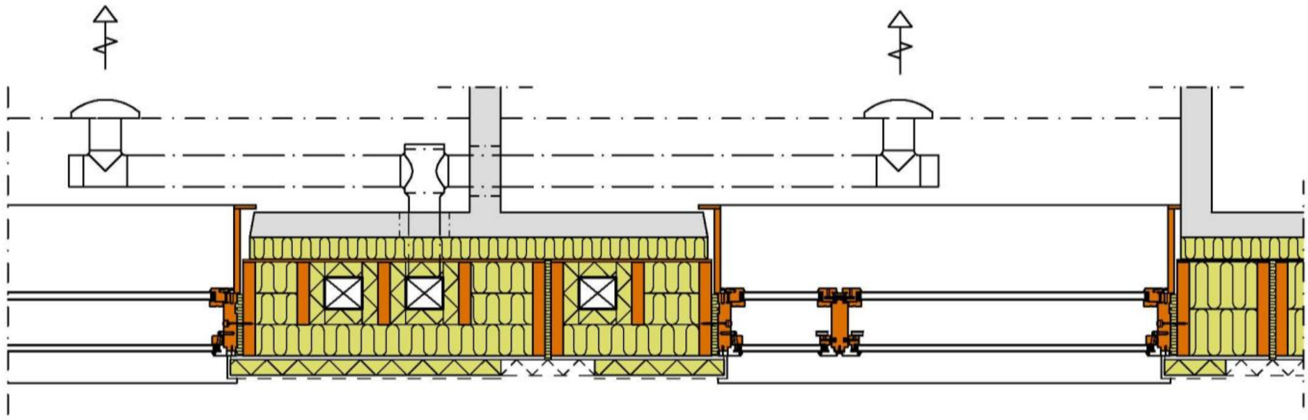

Fig. 4 The vertical ventilation ducts for the supply air are installed in the elements.

2.6 Heating and domestic hot water

Before the renovation, the Saturnuksenkatu 2 multi-storey house used electricity for both heating of spaces and for domestic hot water. In the renovation, the domestic hot water will be connected to the district heating. For economic reasons, the electricity will be used for the heating also after the renovation. The new heat distribution system would have caused more work inside the apartments, even though the element system would also enable the integration of the heat distribution system.

3. Improvements in Energy-efficiency

The target was to meet the requirement of the Finnish Passive House definition as suggested by the VTT researchers, i.e. the heating energy demand of the building should be max. 25 kWh/m²a after the renovation. The value is calculated for the gross floor area of the building.
The requirement for the air-tightness is $n_{50} \leq 0.6$ 1/h.
The energy simulation of the building was carried out with the dynamic simulation software IDA Indoor Climate and Energy 4.0 by the VTT researchers. The simulation results show, that the target is met even without any additional thermal insulation in the floor structure. The heating energy demand is reduced by 75 %.
The energy consumption of the building and the performance of the new wall structures will be monitored by the VTT researchers after the renovation is completed.

		BEFORE	AFTER
FLOOR	W/(m²K)	0,46	0,46
EXTERIOR WALL, LOAD BEARING	W/(m²K)	0,27	0,1
EXTERIOR WALL	W/(m²K)	0,25	0,1
DOOR	W/(m²K)	1,8	0,8
ROOF	W/(m²K)	0,22	0,08
WINDOW	W/(m²K)	2,9	0,66
HEAT RECOVERY IN VENTILATION	%	no heat recovery	75

Table 1 The improvements of the U-values and the heat recovery in the ventilation. Energy simulation was carried out by VTT.

Fig. 5 The new façade materials are plaster rendering, cement fibre board (day-care centre) and wood cladding (balconies). The 3-dimensional surface of the plaster rendered facade and the variation of colour show the division of apartments behind the façade. The target of the architectural design was to upgrade the facades, but still maintain a connection to the original character of the building. Image: Kimmo Lylykangas Architects.

4. Discussion

Pre-fabrication in renovation requires measuring with high precision and detailed information about the building envelope. Laser scanning seems to be a good method for measuring the exterior of the building. However, the measurements do not provide any information about the concrete surfaces inside the structure.

The energy-efficiency of the 1970s multi-storey houses can be improved significantly by retrofitting. Since the typical 1970s buildings are relatively compact in shape, and the window surface area is reasonable, the heating energy demand can be drastically reduced with additional thermal insulation, with the new ventilation system with effective heat recovery and by improving the air-tightness of the building envelope.

The retrofit utilizing pre-fabricated facade elements has clearly some advantages compared to the current renovation practise of the 1970s buildings. The duration of the on-site work can be reduced. Since part of the work is done in the element factory, it is more comfortable for the tenants to stay in their apartments during the renovation work. When part of the ventilation ductwork is installed in the wall elements, the need for new suspension ceilings becomes significantly smaller, and the room height is not reduced by the installations as much as it would be if whole ductwork would be built inside the building. Furthermore, this reduces the amount of construction work inside the apartments.

5. References

[1] HAIKONEN P, NIEMINEN J, ”Passive House refurbishment of apartment buildings of the 1970s”. In Conference proceedings. SB10 Finland, Sustainable Community – building SMART™. Helsinki 2010. pp. 146–147.

[2] ”TES Energy Façade. Energiatehokkuuden parantaminen puurunkoisilla ja esivalmisteisilla julkisivuelementeillä. Tutkimushankkeen loppuraportti.” Helsinki University of Technology, Espoo 2009. available at http://www.tesenergyfacade.com

[3] VAATTOVAARA M, KORTTEINEN M, RATVIO R (ed.), “Miten kehittää lähiöitä? – tapaustutkimus Riihimäen Peltosaaresta, metropolin laidalta”. Suomen Ympäristö 46. Helsinki 2009, pp. 26–31.

[4] LAHTI P, NIEMINEN J, NIKKANEN A, NUMMELIN J, LYLYKANGAS K, VAATTOVAARA M, KORTTEINEN M, RATVIO R, YOUSFI SAARA, ”Riihimäen Peltosaari. Lähiön ekotehokas uudistaminen”. VTT tiedotteita 2526. Espo 2010.