Chapter

Wooden Facade Renovation and Additional Floor Construction for Suburban Development in Finland

Markku Karjalainen, Hüseyin Emre Ilgın, Lauri Metsäranta and Markku Norvasuo

Abstract

Finnish urban settlements are in the age of restoration, and the suburbs need improvements in Finland. In this sense, wooden facade renovation and additional floor construction are viable and sustainable solutions for this development in the Finnish context. This chapter focuses on these important applications from the Finnish residents' perspective as ecologically sound engineering solutions through a survey. In doing so, the challenges of facade renovation, as well as the benefits of additional floor construction, were presented. The main purpose of the survey was to get the opinions of the residents, find out which variables are important, make inferences for the planning and improvement of such areas, and determine what will be emphasized in the sustainable suburban development of the future. Therefore, the results were based on this empirical approach—survey—but further research such as energy analysis, wood-based facade renovation, and additional floor solutions will be done as part of other studies. It is believed that this study will contribute to the use of sustainable materials and decarbonization of buildings as well as zero energy building (nZEB) to overcome the challenges posed by climate change by the diffusion of wood in the renovation of buildings.

Keywords: timber/wood, facade renovation, additional floor construction, suburban development, zero energy building (nZEB), sustainability, Finland

1. Introduction

Over 220 million building units built before 2001 accounted for 85% of the EU's building stock, of which about 90% will continue to be in service in 2050 [1–3]. However, most are not energy-efficient and use fossil fuels and older technologies and about 40% of the EU's total energy consumption, and more than 35% of energy-related greenhouse gas emissions originate from buildings [4]. In this sense, to achieve a 55% emission reduction in the 2030 Climate Goal Plan, European countries must make a significant 60% reduction in the greenhouse gas emissions of buildings [5].

The abovementioned scenario was highlighted in the Renovation Wave, which needed changes in current construction and renovation practices in the industry and supported a combination of strong efficiency measures alongside the phasing out of fossil fuels and the transition to renewable energy [6]. Due to the aging of the European building stock, building owners and the entire building sector are faced with extensive renovation works. The renovation and refurbishment of the building facades and external walls are among the most critical tasks to be undertaken [7].

Therefore, it becomes urgent to focus on refurbishing existing building stock within the principles of ecologically responsive engineering to make it more energy-efficient and less carbon-intensive. In addition to reducing energy bills and emissions, renovation can provide many possibilities with social, environmental, and economic benefits such as making buildings more durable, healthier, greener, more accessible, and smarter. However, the current deep renovation rate of 0.2% needs to grow by at least 10 to 2% and approach 3% as quickly as possible [8].

Here, it is worth mentioning that “Net Zero Energy Buildings” (nZEBs) will be the next major frontier for innovation and competition in the world real estate market and can scale rapidly in Europe [9]. In this sense, European energy policies set the nZEB target [10] to promote the energy transition of the construction sector. EU programs, notably “Horizon 2020,” introduce the nZEB design as well as its evolution to the Positive Energy Generation (PEB) model [11].

Moreover, Scandinavian countries are working toward regional carbon neutrality before the goals of the European Union. Finland aims for carbon neutrality by 2035 and is developing several policies, including low-carbon construction legislation [12]. The new approach includes normative carbon limits for different building types before 2025.

Similar to the aforementioned EU building stock situation, which is poor in terms of energy efficiency, most of the building stock in Finland was built between the 1970s and 90s and needs serious renovation, with residential buildings accounting for 63% of the total gross floor area [13, 14]. Nearly a third of the housing stock that makes up a significant portion of the Finnish building stock was poorly insulated

Figure 1.
A typical suburban apartment in Finland.

suburban apartments from the 1960s and 1970s and in need of refurbishment [15, 16] (see **Figure 1**).

It is worth noting here of the total annual construction expenditures in Finland, approximately 47% is spent on infrastructure projects, 21% on new buildings, and 32% on renovations [17], in which low energy efficiency, lack of balcony, lack of elevator, and unpleasant appearance are among the critical issues identified for Finnish suburban apartments [18]. On the other hand, in practice, apartment renovation is a slow and expensive process that requires a lot of capital and government subsidies [19].

At this point, wooden additional floor construction (**Figure 2**) stands out as an ecological engineering solution with many advantages such as being environmentally friendly, providing a significant increase in the gross floor area and energy efficiency of the existing building, and improving esthetic appearance [20].

Furthermore, additional floors essentially increase the building's energy efficiency directly, but also indirectly, for example, by using the revenues from the building for energy regeneration. These energy-related measures help increase the cost-effectiveness of the entire renovation process and maintenance of buildings [21–23]. Additional floors do not significantly increase the overall energy consumption of the upgraded building, and as passive energy-efficient structures, they can significantly increase the energy efficiency of refurbished buildings, especially if the upper floors have not been renovated for a long time [24].

Similarly, one of the most effective energy-saving measures for buildings is facade renovation and roof/attic insulation with wood-based solutions in the building envelope [25–30]. The amount of this saving varies according to the system and material used such as 50 mm thermal-bridge-breaking on-site mounted additional isolation (total U-value 0.26 W/m^2K), a modular prefabricated facade renovation system (total U-value 0.18 W/m^2K) [31]. Moreover, some prefabricated and integrated facade

Figure 2.
Representative image of wooden additional floor construction.

module solutions offer the possibility to improve the current energy performance up to zero energy, while ensuring minimum disturbance for the occupants, during and after the renovation [32, 33].

As in many other projects, material selection has critical importance in renovation projects such as facade renovation (**Figure 3**) and therefore additional floor construction. Wood as a renewable material is ecological and environmentally friendly: One cubic meter of growing wood can hold about one ton of CO_2 from the atmosphere, the mass of wood is about 500 kg/m^3, and half of this mass is carbon = 250 kg/m^3. One of our best allies in solving the climate crisis due to its potential eco-friendly properties, wood is at the forefront of tackling European climate policy [34–37]. Furthermore, due to its significantly lower carbon footprint and potential cost-effectiveness compared with conventional materials such as reinforced concrete and steel, and numerous positive effects on the environment combined with technological advances [38–41]. Besides this, as it is well known, from an architectural point of view, wooden buildings are thought to have the potential to generate a more pleasant, warm, and natural environment.

Thus, renovating and expanding existing buildings with wood can contribute significantly to sustainable urban redevelopment. Renovation of building envelopes (e.g., roof, facade) with highly insulated wooden components can significantly reduce the conduction heat losses of existing buildings and the associated heating energy demand [42]. In addition, the characteristics (e.g., load-bearing capacity, flat roof) of Finnish suburban apartment blocks from the 1960s and 1970s and the current Finnish fire code allow light additional floor construction.

In literature, there is a limited number of research on residents' or consumers' attitudes toward the use of timber in building construction [43]. Important research over the past 10 years has reported perceived benefits and barriers to consumers' use of wood as a building material. Among these studies, Lähtinen et al. scrutinized the ecological, physiological-technological, esthetic, and welfare properties of wood as a building material from the Finnish perspective [44]. Environmental features and

Figure 3.
Representative image of wooden facade renovation.

esthetics concerns were assessed as the most important advantage of wood in several studies [45–47], while coziness and longevity were highlighted as other benefits [41, 44]. On the other hand, some studies [46–48] showed that users are skeptical of the use of wood as a structural system material on certain issues. Such as durability, maintenance, structural performance, and fire safety. In addition, there are few studies on the construction of wooden additional floors, among which, Karjalainen et al. [20] focused on the various stages and benefits of wooden additional floor construction for the Finnish housing and real estate companies, and Soikkeli [49] highlighted the financial and practical advantages of developing an industrial scale model for wooden additional floor construction.

No study has been found on the perceptions of the residents regarding the renovation of wooden facades and the construction of additional floors in literature. At this point, it is worth noting that the acceptability of a new construction method by users or residents is important to ensure its sustainability and diffusion as a contributor to the Finnish forest-based bioeconomy. It is believed that the study will make an important contribution to this issue. This chapter focuses on wooden facade renovation and additional floor construction through a resident survey as ecologically sound engineering solutions to contribute to the decarbonization of buildings and a zero-energy building approach. In doing so, the challenges of facade renovation and the benefits of additional floor construction are presented.

In this study, timber or wood refers to engineered wood products such as cross-laminated timber [(CLT) a prefabricated multi-layer EWP, manufactured from at least three layers of boards by gluing their surfaces together with an adhesive under pressure], laminated veneer lumber [(LVL) made by bonding together thin vertical softwood veneers with their grain parallel to the longitudinal axis of the section, under heat and pressure)], and glue-laminated timber (glulam) [(GL) made by gluing together several graded timber laminations with their grain parallel to the longitudinal axis of the section)].

2. Wooden facade renovation and additional floor construction

Facade renovation has many advantages (e.g., esthetic improvement, energy-saving, increased thermal comfort, reducing CO_2 emissions, and improving the quality of the built environment) as demonstrated in many EU projects [50–54]. The most common facade renovation technologies and applications consist of installing external and internal insulation, enhancing airtightness, installation of photovoltaic panels, heat recovery, and installation of efficient heating, ventilation, and air conditioning (HVAC) systems [55].

It is worth mentioning here the main barriers and challenges encountered particularly in deep renovation projects as follows (**Table 1**) [56, 57].

On the other hand, the advantages of additional floor construction that contribute to overcoming the abovementioned obstacle can be summarized as follows [20]: (i) promote beneficial development of the building stock and increase property owners' incomes; (ii) provide short-term income to housing companies by selling additional floors and proceeds to be used to finance the renovation of existing property, such as the renovation of an elevator to improve the building's accessibility and commercial conditions; (iii) although it significantly increases the total floor area, it does not significantly increase the overall energy consumption of the upgraded building. (iv) significantly improve the energy efficiency of older buildings as passive energy-efficient

Barrier typology	Barrier
Embedded market inefficiencies	split incentives and conflicts of interest between the building owner and tenants
Informative-social	lack of information dissemination and convincing end users of the benefits of deep renovations
	time-consuming and complex decision-making processes
	lack of consensus and support from residents, which generally hinders effective approval of interventions
	inconvenience during site, studies and relocation of users
	lack of communication between different interested parties
	low awareness of energy efficiency and non-energy benefits of refurbishment
Financial	limited financing options offered and limited third-party financier involvement
	lack of satisfactory financial support, especially for low-income homeowners
	limited impact of Energy Performance Certificate i on property value
	lack of trust in investors
	long payback periods
	limited financing/ insufficient budgets - high up-front costs and owners' reluctance to borrow for energy replacement purposes
Organization and structure of the renovation market	Difficulties in coordinating communications with other relevant stakeholders
	Insufficient resources on part of small and medium-sized enterprises for larger tenders
Regulatory, Knowledge informative based technical	lack of continuity in regulations
	limited government subsidies and programs in specific regions
	lack of skills and lack of training
Technical	performance gaps and uncertainty
	lack of reliable and standardized or integrated solutions to meet the various building standards requirements related to energy savings
	inadequacies in technical solutions
	safety risk associated with deep renovation processes
	users' lack of technical knowledge and confidence in the effectiveness of savings in energy regeneration

Table 1.
Main barriers and challenges of the (deep) renovation process.

structures, especially if the upper floors have not been renovated for a long time; (v) improve the image and appearance of the building; and (vi) advantageous in terms of carbon footprint over demolition and new construction.

3. Research methods

This study was carried out mainly as a literature review including international peer-reviewed journals and similar research projects, supported by materials collected during "Effects of wooden buildings on neighborhood-level" at the Tampere University—a project that is part of the Ministry of the Environment's Growth and

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Development from Wood support program involves cross-sectional data from the Pukinmäki-Savela (postcode 00720) area in the City of Helsinki, Finland [58]. The focus of the project was to study the attitudes of residents and users of a neighborhood toward wooden buildings and to use this information in the planning and infill construction of urban areas. One potential method is the construction of additional floors to suburban apartment houses, as an ecologically sensitive engineering solution to support the decarbonization of buildings and a zero-energy building approach.

It is worth mentioning here that Pukinmäki is a district in the northeastern part of Helsinki. The area was added to Helsinki in 1946, and the first few apartment blocks were built in the 1960s. Most of the apartments are from the 1970s and 1980s. On the other hand, Savela (**Figure 4**) is a residential area in the Pukinmäki district. In the 1960s and early 1970s, Savela was under threat of partial rezoning and segregation of single-family homes in the city as green space. However, over time, the area turned from a detached area to an apartment area, with mostly low-rise apartments built in the 1980s and 1990s.

The sample, 800 Finnish-speaking people aged 18–69 in the area, was chosen randomly. A total of 243 responses were received for the entire survey, corresponding to a response rate of 30%. The survey data generally represented the population of the selected area, but there were also minor differences in representation among background variables such as gender and age. For example, in terms of gender, 54 and 57% were female, 46 and 43% were male in the whole population and sample, respectively. On the other hand, in terms of age groups, the older population was slightly overrepresented, while younger respondents were slightly underrepresented; in the whole population and sample, 20 and 30% were aged 60–69, and 25 and 15% were aged 18–29, respectively. As regards education level, high school and university graduates constituted 73% of the entire population; this rate was 90% in the sample group.

Focusing on facade renovation and additional floor construction, the survey was divided into five main parts. The first part was about background information, and in the second part, the participants were asked about their opinions of timber in buildings. The third part was about the dwelling preferences (number of floors, facade material, etc.), and in the fourth part, the opinions on the wooden Eskolantie apartment houses were asked. In the last part, six different renovation alternatives were

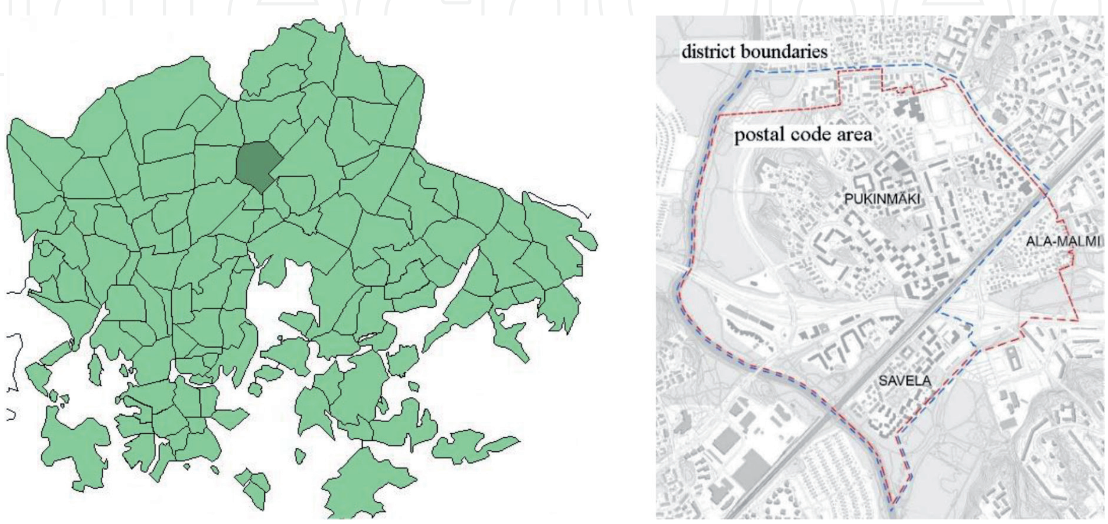

Figure 4.
Pukinmäki—Savela area in the city of Helsinki (Finland).

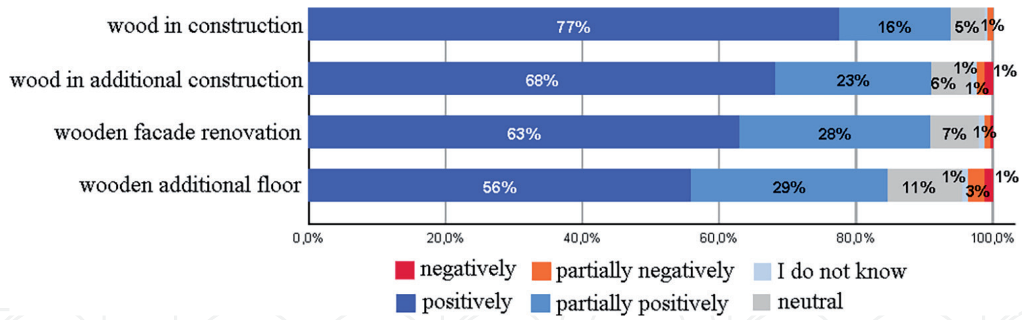

Figure 5.
Residents' perception of wood in (additional) construction, wooden facade renovation, and wooden additional floor.

presented, and the residents' opinions on wooden additional floor construction and facade renovation were asked.

4. Main findings from suburban residents' survey

The survey results mainly highlighted the following (**Figure 5**):

- respondents supported suburban development through wood refurbishment and additional construction.
- attitudes toward wood in construction were positive, and wood was perceived as an ecological alternative in construction.
- residents of suburban settlements preferred low-rise and low-dense suburban fabric, and wood was considered the most pleasant facade material.
- wooden structures were also generally perceived as more beautiful, more ecological, and healthier than buildings made of other materials.
- concerns about wood material were mainly related to its technical properties, such as fire safety, long-term durability, and maintenance needs of facades.
- it was reported that wooden facade renovation and additional floor construction can increase the attractiveness of residential areas.
- apartment owners would welcome their housing company's decision to implement wooden facade renovation and additional floor construction.

5. Conclusion

This chapter focuses on wooden facade renovation and additional floor construction as ecologically sensitive engineering solutions from the Finnish residents' point of view. In doing so, the challenges of facade renovation and the benefits of additional floor construction are presented.

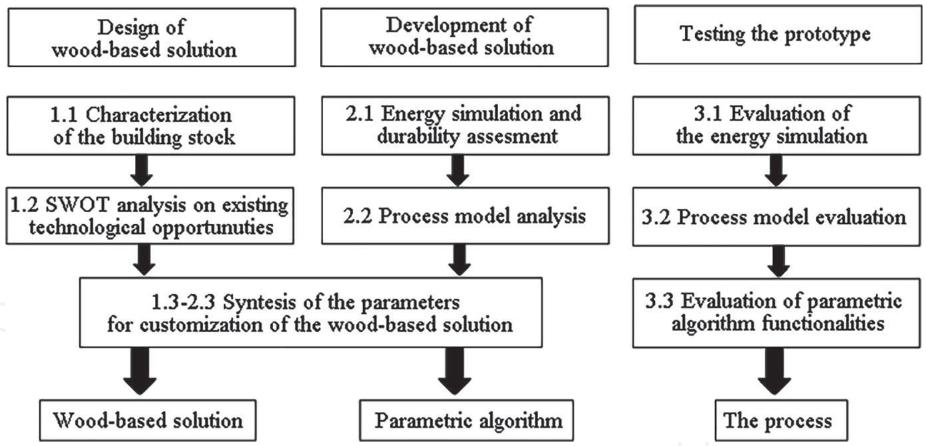

Figure 6.
Suggested methodology for future studies.

In the context of the transition to service-oriented business solutions in Europe, future and emerging technologies in facade renovation and additional floor construction can make a difference with the risks of overheating from climate change and the reduction in energy demand for cooling in existing buildings, considering the human-centered design approach and emerging intelligent building operating systems such as digital platforms and control strategies. It will help Europe become an early leader in these promising technologies and will focus on building energy efficiency and the productivity and well-being of building occupants to renew the foundation for future competitiveness and growth in the coming decades.

Significant market acquisitions must be initiated to transform facade renovation technologies into mainstream technologies. This includes innovations in low-impact and climate-sensitive refurbished buildings through unexplored collaborations between advanced multidisciplinary design teams and innovative facade engineering. The European Energy Performance Building Directory (EPBD) highlights the importance of comfort, smart readiness, and high energy efficiency of buildings to be renovated [59]. With climate change and the increasing risk of overheating, the potential for the building renovation industry to renew the basis of its future competitiveness and growth and increase the use of facade refurbishment technologies and additional floor construction in the future is high. At this point, residents' attitudes toward new construction methods such as timber facade renovation and additional floor construction play a critical role in the spread of these practices and contribute to the transition to a forest-based bio-economy, the decarbonization of buildings, and a zero-energy building approach in Finland.

This study revealed the characteristics that residents value and guided those concerned about the direction in which residential areas should be developed. According to the results, residents were ready for large-scale use of wood in suburban development and renovation. The decision is ultimately made by the homeowners' positive attitude toward wood facade renovation, and the additional floor construction is an encouraging display of the enormous potential of the construction method. The additional floor construction contributes to overcoming the obstacles encountered in the difficult facade renovation process. Wood as a renewable material and carbon sink as a working material should be used for suburban regeneration as an ecologically responsive engineering solution to contribute to the decarbonization of buildings and a zero-energy building approach.

The results of this chapter were based on the empirical approach—residents' survey—but further research such as energy analysis, wood-based facade renovation, and additional floor solutions, developed prototypes testing will be done as part of other studies by following the methodology suggested in **Figure 6.**

Appendix: sample questions used in the questionnaire

- Answer the following questions related to Eskolantie wooden apartment buildings:

  a. How do you think Eskolantie's wooden apartment buildings are suitable for a residential area?

  * Very well * Well * Neutral * Poorly * Very poorly * I do not know.

  b. What do you think about the architectural features of the wooden apartment buildings in Eskolantie?

  * Very satisfied * Satisfied * Neutral * Dissatisfied * Very dissatisfied * I do not know.

  c. Do you accept new wooden additional construction in your residential area like Eskolantie wooden apartment buildings?

  * Agree * Partially agree * Neutral * Partially disagree * Disagree * I do not know.

  d. The wooden apartment buildings in Eskolantie have changed your opinion about wooden construction:

  * Positive * Partially positive * Neutral * Partially negative * Negative * I cannot say.

- The impact of Eskolantie wooden apartment buildings on the quality of the living environment in Pukinmäki (compared to the quality of the living environment before their construction) has been:

  * Positive * Partially positive * Neutral * Partially negative * Negative * I cannot say.

- If you wish, indicate that you think it is particularly successful in the wooden apartments in Eskolantie.

- If you wish, indicate that you think it is particularly unsuccessful in the wooden apartments in Eskolantie.

Author details

Markku Karjalainen, Hüseyin Emre Ilgın*, Lauri Metsäranta and Markku Norvasuo
Tampere University, Tampere, Finland

*Address all correspondence to: emre.ilgin@tuni.fi

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