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Modular retrofitting approach for residential buildings

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Abstract. Residential buildings are one of the crucial energy consumers. The vast majority of the existing buildings require urgent retrofitting due to the very poor thermal insulation properties of their external building envelope. There are many building retrofitting technologies available on the market. However, thermal insulation technologies, such as rendered and double facades, require large amount of on-site human working hours. One of the most promising technologies is a modular retrofitting.

1. Current situation

According to the Latvian Ministry of Economy, 741 buildings in Latvia were renovated between 2009 and 2015, achieving energy savings of 45% on average. While in almost all cases ventilation systems were not renovated, the natural ventilation systems were left as they were initially designed. Since 2016, 508 projects have been submitted, most of which have not yet been completely built. According to the State Building Control Office, the average specific consumption for heating in multi-apartment dwellings in 2020 was 124.21 kWh/m^2 per year, similar to 125.59 kWh/m^2 per year in 2019. These figures also show that renovation is taking place on a small scale and at a slow pace and the overall efficiency of implemented measures is not sufficient to reach general EU targets.

One of the most perspective solutions is modular retrofitting. There are many benefits of this approach [1]. However, one of the main challenges is the higher construction cost in comparison to conventional retrofitting and lack of clear guidance on panel mounting specifics.

2. Lessons learnt from the existing case study

In scope of H2020 MORE-CONNECT project, small multi apartment building was renovated using prefabricated wooden frame panels (Figure 1). It represents a typical brick multi apartment building built in 1960ies. The pilot building is a silicate brick residential house with a lateral bearing system. All wooden frame windows were replaced by PVC windows more than ten years ago.

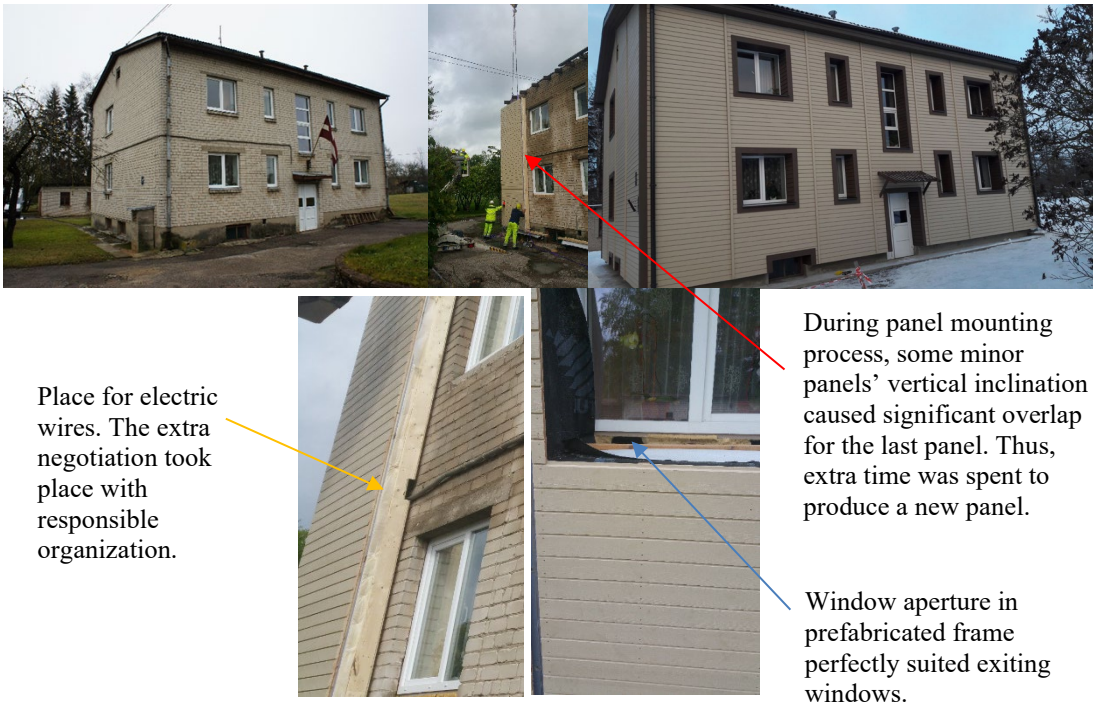

Figure 1 Demonstration case in Latvia

During the project development the delay occurred also due to the owner of electric wires. The initial requirement was to disconnect the wire and to place it on top of the new facade. After some negotiation and calculations, it was allowed to leave it on the exit façade and to embed it into panels.

The main problem for old buildings is a facade vertical deviation. The research made earlier [2] has shown that vertical displacement of external wall could be up to 48mm from foundation level. Thus, unification of prefabricated panels for all buildings requires extra calculation fasteners. The selection of thickness of steel corner brace and steel screws as well as calculation of their number per square meter could require an extra effort during adaptation of prefabricated panel for specific building. Figure 2 (left) represents results of façade 3D scanning. While Figure (right) – solution how wooden frame carcass can be fixed. For demo building point fasteners were used.

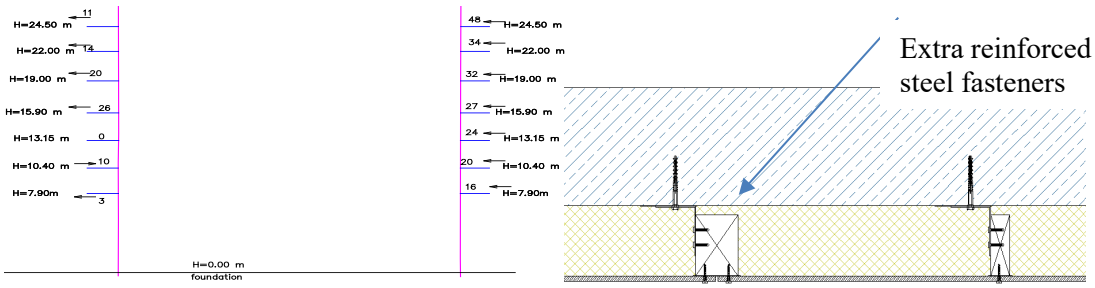

Figure 2 Façade vertical deviations and wooded frame mounting to the wall

Using angles with a thickness of 2 mm, a width of 50 mm and the anchor bolt arrangement shown in Figure 2, these angles need to be placed in 250 mm increments, provided that the vertical beams are in 1200 mm increments. This calculation of angles applies to both the wind loads for the Liepaja region and for Riga. The angles can be increased in increments by increasing their width and thickness. Similar to study [3] , even with all necessary data on building technical condition, anchor mounting requires extra effort and time.

The overall project implementation required slightly less than two months. The most time consuming was the development of architectural project including all permissions from the local authorities.

Figure 3 Time frame of renovation project.

The main disadvantage of the proposed modular retrofitting solution is relatively high proportion of linear thermal bridges which has 4.6% higher heat losses in comparison to rendered facades. The critical point are external corners.

Table 1 Review of thermal bridges

Type of thermal bridge	External Ψ_e W/(m·K)	Internal Ψ_i W/(m·K)	Classic rendered facade Internal Ψ_i W/(m·K)
Basement/stem wall	0.37	0.4	0.3
External corner	-0.09	0.1	0.05
Wall/attic slab	0.14	0.30	0.24
Panel joint	0.02	0.05	0.00

In addition, initial moisture content [4] of the existing wall has an impact on overall wall assembly hydrothermal performance. However, these data are unique for each building and depend on its location, effect of wind driven rain and technical condition of the building (gutters, roof overhang, etc.) This issue is especially topical for prefabricated panels since they have an OSB on the internal side to ensure straightness during transportation and panel mounting.

3. Conclusion

Retrofitting of multi apartment buildings has many advantages such as construction quality and short on-site construction time.

Existing wall vertical deviation can require extra effort to adapt typical layout of prefabricated panels. It is recommended to pay extra attention to vertical deviation during creation of 3D building model bases on 3D scanning data.

The more extensive study on existing wall moisture content should be performed in Latvia to prepare all necessary data for the fast deployment of prefabricated retrofitting.

Even though prefabricated panel has a bigger share of thermal bridges, its overall impact can be neglected since the major impact refers to heat recovery from exhaust air and overall improvement of energy performance of external building envelope.

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