Biomass façade insulation for existing buildings

Marc Großklos, Institut Wohnen und Umwelt GmbH
Rheinstraße 65, D-64295 Darmstadt, Germany, m.grossklos@iwu.de

Introduction

The ABG Frankfurt Holding is Frankfurts largest building company. Between 2008 and 2011 they retrofitted seven apartment dwellings built in 1956. The 61 apartments have a total reference area of approximately 3800 square metres. After the retrofit the dwellings are reaching the passive house standard. Apart from marketable certified products two different façade insulations were developed, mainly made out of renewable raw materials. They meet the requirements of passive house standard, are designed for retrofit and for apartment dwellings with their increased requirements for fire control.

The seven houses in Frankfurt, Main, Germany, are assembled in three blocks of houses with three to six storeys each. Every block of houses composes one construction stage. The apartments in the existing dwelling have 2 or 3 rooms with 50 - 65 square metres living space, the newly attached topmost storeys have 3 or 4 rooms with about 100 square metres living space.

The planning bureau “faktor10”, Darmstadt, was responsible for design and construction management of the whole project. Structural engineering and fire protection was made by consulting engineers “bauart Konstruktions” in Lauterbach. Both developed the façade insulations to be presented in this paper in line with a research project for the Hessian Ministry for Environment, Energy, Agriculture and Consumer protection. The scientific monitoring and the energetic assessment of the façade insulations were accomplished by Institut Wohnen und Umwelt (IWU).

Measures at the buildings

The buildings got an all-embracing insulation during the retrofit. It was possible to execute the cellar insulation with a thicknes of 26 cm under the ground floor by using cellulose insulation blown-in in the hollow space of a suspension. The cellar insulation was done without vertical insulation panels at the top of the cellar walls. The certified passive house windows were mounted in front of the existing walls and were sealed on the exterior plaster. From there the airtight envelope is lead over the window reveal to the inner plaster. The exterior wall insulation was conducted in two different types with cellulose and a wooden construction which is described in the following chapters. The original roofs were dismantled and replaced by a new attic floors made out of wooden light weight construction.

Controlled ventilation with heat recovery in each apartment is used. The ducts for air distribution were placed in the bath room and in a hollow space in the corridor.

Beside the optimization of the thermal envelope a range of additional energy saving measures in heat generation, heat distribution and hot water preparation were implemented. A detailed documentation of the planning period and execution of construction can be found in [IWU 2010] and [Großklos 2011].

Façade insulation 1

The façade construction of the first construction stage (three buildings with three storeys each) is made out of prefabricated boxes out of wooden oriented strand boards (OSB) with the height of one storey. The edges are reinforced by square timber. For thermal isolation these boxes were mounted 5 cm in front of the wall by metal brackets (image 1).

Image 1: **Boxes of the façade insulation one storey in height (left), fastening of the profiles 5 cm in front of the existing wall by metal brackets for thermal isolation (right)**

A boarding of wooden planks with a thickness of 2,5 cm was mounted on this substructure followed by a 3,5 cm thick wood wool panel to close the construction on the outside and as a plaster underground (image 2). Afterwards the total hollow space of 31 cm depth between the existing wall and the wood wool panel was blown-in with cellulose. At each floor horizontal square timber with additional OSB-panels were mounted for load bearing. The thickness of the whole construction reaches 36 cm.

Image 2: Wooden planks on the substructure on a sample wall (left) as underground for wood wool panels with drilled holes to blow-in the cellulose in the hollow space (right)

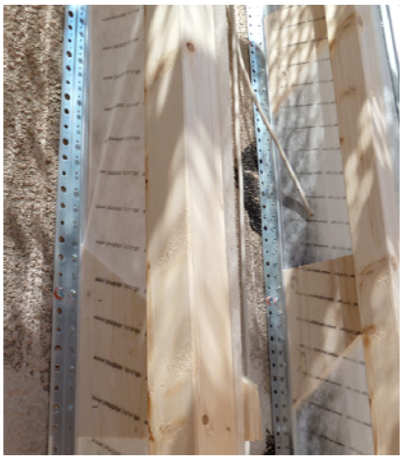
The windows were surrounded by OSB-panels and additional gypsum fibre panels to reinforce fire protection. An additional mineral fibre plate increases the insulation of the window frame (image 3).

Image 3: Border strip of the windows with OSB-panels and gypsum fibre plates (left), insulation of the window frame with a mineral fibre plate (right)

The calculation of the U-values of this construction was complex because every side of the façade has a different value according to the window division that forces a deviation from the basic grid of 62,5 cm and the resulting different wood fraction of the construction. Several parts of the construction were evaluated by three-dimensional thermal bridge calculations to develop a simplified calculation approach. The results were used in combination with the assessment of the wood fraction of the different façade sides to calculate the total-U-value of the exterior wall insulation. The mean value of all four façades is 0,13 W/(m²K).

Façade insulation 2

The following construction phases got a modified façade design at the exterior walls, based on the system ”lambdaplus“. Here, wallboard consoles at folded metal rails were mounted (image 4 left) and anchored on the existing wall. The consoles were sloped onto the outside to reduce thermal bridge effect. A square timber at the outer side of the console forms the underground of the following boarding of wooden planks and the wood wool panels just like in façade insulation 1. Additional fleece material was put along the metal rails to form well-defined vertical hollows to blow-in the cellulose in separated sections.



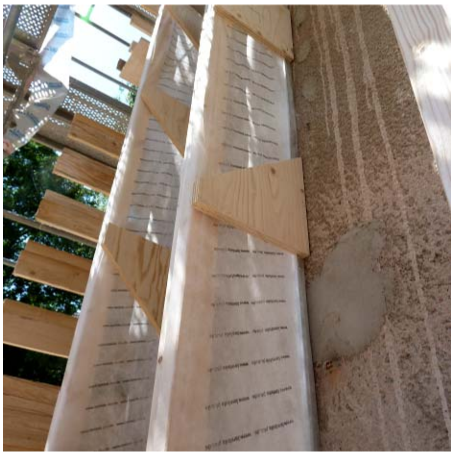


Image 4: Detailed view of the console and the metal rail (left), mounting of the substructure at the existing wall (centre + right)

Image 5: Detailed view of the separation between the floors with a fire protection panel, still without the mineral insulation plate (left), brackets for mounting the shading on the insulation structure, which is possible easily (right)

The separation between the floors is made with thin horizontal fire protection panels and additional 5 cm thick mineral fibre insulation (image 5 left). Since this construction has a lower thermal bridge effect than in the other façade and the timber fraction of the consoles is lower than the one in the first façade the construction 2 is energetically favourable. As a result of this the insulation thickness could be reduced by 2 cm to reach the same U-value of 0,13 W/(m²K). The construction of façade insulation 2 has a total thickness of 34 cm. The design of the window reveals is similar to construction 1.

Review of the façade insulations

Because of their construction both façades have some advantages to insulation compound systems. The insulation material is cellulose from recycled paper. The construction consists mainly of the renewable material timber and the parts of the construction can be separated to a large extend for recycling at the end of life cycle of the house. Due to the construction concept there are no fixed temperature boundaries during the mounting of the wall insulation (e. g. freezing) and the attachment of objects is possible quite easy (e. g. light, shading) (image 5 right).

In contrast one has to account for a higher time requirement for mounting the substructure of the construction. Complex façade geometries lead to many hollows so the blow-in of the cellulose has to be done accurately to avoid individual regions without insulation. Here the quality demands are increasing. Finally the planning efforts for the construction are higher compared to an insulation compound system so the planning should be executed by qualified staff.

Image 6: The first construction phase

The U-values of both constructions reach 0,13 W/(m²K) hence they are suitable for passive houses. The two façade insulations show that alternative insulation methods with renewable materials could even be deployed to bigger apartment dwellings (image 6).

Results of the retrofit

The 7 dwellings were nearly totally insulated with recycled cellulose and reach the passive house standard after the retrofit. Measurements of the air tightness of the buildings result in a mean n_{50}-value of 0,29 1/h with low scattering between the buildings, even though some of them have an elevator inside. This shows that the air tightness concept could be implemented quite well.

Each block of houses has its own thermal solar system for hot water, which together with a rapeseed oil co-generation in a small local heating system supplies the dwellings with more than 80 % renewable energy. Together with the credits from electricity production of the rapeseed oil co-generation the green house gas emissions of the buildings could be reduced to zero.

Acknowledgment

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