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Abstract

Development of standard solutions for thermal insulation and airtightness of existing buildings using blown-in insulation and sealing adhesive

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A major challenge in the energetic refurbishment of existing buildings is to ensure airtightness and moisture protection at the same time. The inadequate consideration of connection details can lead to increased heat losses, which ultimately leads to the formation of condensation or mould. In addition, convective moisture can be introduced due to inadequate air tightness, which as a result causes damage to the construction due to condensation.

The danger of condensation or mould formation on the inner surfaces in connection areas of the construction can usually be prevented by local insulation without major structural interventions. To prevent the penetration of convective moisture, the air tightness must be improved. As an alternative to the use of foils, which is often associated with high deconstruction costs, liquid sealing adhesives can also be used.

Therefore, the aim of the research project was to test different blown-in insulating materials and sprayable airtightness layers as well as the associated application techniques with regard to their effectiveness and applicability in the energetic refurbishment of buildings.

In addition to the application of various loose insulating materials with the installation densities recommended by the manufacturer, the targeted injection of additional insulating material into structures already provided with blown-in insulating material was also investigated in order to determine the improvement of the air tightness. The injection was carried out through punctiform openings in the thermal shell of the building by means of a blowing insulating, without any major structural interventions on the construction. In this way, additional insulating material can be introduced into critical areas or over the entire building component. The tests were carried out on standard test benches and real wall and roof models in the laboratory. These were carried out with different blown-in insulating materials and application techniques and an evaluation of the effectiveness and workability was carried out.

Glass wool and cellulose insulating materials were investigated within the scope of the project. The results for glass wool insulating materials can be transferred to insulating materials based on glass wool, which are comparable in terms of material properties, raw density and fibre structure. The investigated cellulose insulating materials consist of small particles and without the admixture of high-gloss paper as filler and can only be transferred to such materials. Injection hoses, rotary nozzles and insulating needles were used to introduce the bulk insulating materials. In addition, different liquid sealants and their application techniques, airless sprayers and brushes were tested for their applicability and effectiveness.

On the basis of recommendations for use, the necessity of additional structural measures or unsuitability can be deduced. In addition, recommendations for these structural measures are developed and evaluated, to what extent the investigated application techniques are suitable.

In the process, the components in the refurbished condition were examined with regard to condensation formation in the insulation level and water content in the external wooden construction or facing shell. Typical designs of flat and pitched roofs, upper floor slabs, exterior walls with clinker facing and exterior walls in timber construction with and without weather protection are considered. All constructions were tested and evaluated with the tested insulating materials. The results show that the formation of condensation water within the insulation level is less problematic. The permissible limit values are rarely exceeded. If the construction fails, it is because the permissible water content in the existing wooden construction is exceeded.

Steep roofs are usually unproblematic. Steep roof constructions open to diffusion are functional even after renovation. However, it should be ensured that the rear ventilation under the tiled roofing remains effective. If insulation material reaches this area, e.g. due to a defective underlay membrane, a vapour barrier should be installed. On steep roofs with solid wood formwork or wood-based panels on the outside, however, the permissible water content may be exceeded. Therefore, a high air tightness and a reduction of the diffusion flow must be ensured.

In the case of flat and green roofs, it can be seen that these are only functional if there is an air-tightness level on the room side and there is no shadowing of the roof or parts of the roof. In addition, the infiltration of moist, warm room air must be reduced to a minimum, which can be achieved by increasing the installation density of the insulation. However, it is still a moisture-critical component. To ensure moisture protection, these roofs must be provided with additional insulation of 80 to 120 mm thickness, depending on the application.

The upper floor slabs are unproblematic and independent of the used insulation material. There is neither condensation nor water accumulation in the wooden formwork. In the case of upper floor slabs, it is possible to fill up the insulating materials or to inflate them openly. The resulting density of minor importance together with the open inflation, since a possible settlement of the insulating material can be seen as unproblematic.

Solid wall constructions with clinker facing are also fully functional. There is no condensation and the water content in the facing layer is low, so there is no risk of frost. For the injection of the loose insulating material into the cavity of the double-shell wall, special injection and rotary nozzles with small openings are available. These can be pierced into the joints of the facing shell. In this way a non-destructive strengthening is possible.

Directly weathered exterior walls in timber-frame constructions are only functional together with a room-sided vapour barrier membrane. This can be sprayed on or produced in the conventional way with foils and adhesive tape. If a wood-based panel is applied on the outside as a plaster base board, the glass wool insulation is the only material out of the investigated insulation materials, which can be used in order not to exceed the maximum water content within the wood-based panel. On the other hand, exterior wooden walls with weather protection are unproblematic in terms of moisture protection as long as further ventilation is guaranteed after renovation. All examined insulating materials are suitable for the renovation of weather-protected wooden outer walls, whereby slightly lower water contents result for the examined glass wool insulating material.

In order to increase the air tightness of critical connection details in terms of moisture protection, increasing the density with an insulating needle is particularly suitable. Due to the small cross-section and the shape of the needle tip, the insulating needle can be pierced into the existing insulation material and the density of the insulation material can be increased in the relevant and targeted areas. The injection hose and the rotary nozzle are less suitable for subsequent execution of density increasement because the hose cannot be pushed into existing insulation and the rotary nozzle cannot be positioned into the construction.

For easily accessible joints, a brush can be used to close leaks in the area of critical connection details in terms of moisture protection by means of sprayable airtight layers. An airless spraying device can be used for application of the sprayable airtightness layers for larger flat application and also for the sealing of gaps that are difficult to access.

With regard to the application techniques, there are no restrictions for the use of the injection hose and the injection needle. Only for the rotary nozzle there are prerequisites with regard to the air tightness of the construction. In order to achieve the required density of the insulating material, the pressure in the component must be kept constant. In the tests carried out, it was therefore nearly not possible to achieve the density recommended by the manufacturer by application with the rotary nozzle. Here, possible problems might occur due to partial settlement and flaw formation evolved over time. A settlement due to wind inflow or irrigation of the component within the framework of outdoor weathering of the roof model could not be determined.

If the improvement of the air tightness level shall be achieved by increasing the installation density of the insulating material, the application with the injection hose is best suitable. In the tests carried out, the highest densities could be achieved with the hose. However, subsequent compaction is not possible with the hose. If the construction has to be recompacted in the area of critical connection details in terms of moisture protection, the insulating needle is suitable for this purpose. As with the rotary nozzle, when the injection needle was used for high desired densities, the hose was blocked at the tapered cross-section.

With regard to the choice of insulating materials, the volume flow measurement on the standard test bench as well as on the real wall and roof model showed that using cellulose insulating material requires approx. 10 - 15 kg/m³ more material in order to achieve the same airtightness. This has also been confirmed by the determination of the length-related flow resistance. For the glass wool insulating material more than double flow resistances resulted compared to the cellulose insulating material. In order to achieve the same length-related flow resistance, a 20 kg/m³ higher installation density is required for cellulose insulation. The installation of blown-in insulating materials in existing constructions usually leads to an increased flow resistance and thus to an increased air tightness of the construction. This reduces ventilation heat losses and improves comfort (due to reduced draughts). In the volume flow measurements on the wall model it could be determined that a high reduction of the air permeability can already be achieved by application of the blown-in insulating materials. However, it cannot be generally assumed that air tightness levels like in new buildings can be reached. For this purpose, sealing measures (e.g. sealing with sprayable airtightness layer, adhesive tapes or masses) must usually be carried out before the blown-in insulating material is applied. It was also shown in the experiments on the wall model that together with additional application of a sprayable airtightness layer, a further increase of the airtightness can be achieved, whereby the effect is significantly smaller compared to the injection of bulk insulating materials.

During the examination it was noticed that the density distribution of the insulation material fluctuates over the construction for the standard cross-section as well as for the roof and wall model. Therefor in practice, a quality control after execution of the insulation is necessary. This can be done, for example, by endoscopy, thermography or an airtightness measurement. During endoscopy, leakages can be detected and areas with no or less insulating material can be identified. However, it is not possible to assess the density of the insulation material, since the thermal conductivity of the insulation material investigated is almost independent of the density.

A further option for quality control is the combination of thermography and an airtightness measurement. This can be used to create so-called „temperature difference images", where changes in surface temperatures as a result of forced flows through the component are displayed. In this way it is possible to mark the area with a leakage at the component even for almost inaccessible points.

When processing the sprayable airtightness layer, it was shown that different application techniques are suitable for different applications. The brush has a higher material application and is suitable for smaller surfaces due to the low cleaning effort. The sprayer has a high area performance and the material application is thinner and more even. Due to the relatively high cleaning effort this application technique is more suitable for larger areas of application.

For quality control in case of "blind spraying" an endoscopy is highly recommended and necessary in order to check whether all areas have been reached with the spraying device and whether the material application is uniform.

With regard to the sealing of leaks, the examined sprayable airtightness layers showed similar properties. Several spraying processes were necessary to achieve a reduction of the leakage volume flow. However, the leaks were still visible. More than four layers of material have been required to achieve sufficient sealing of the leaks. Leaks smaller than 3 mm could be sealed relatively well by the sprayable airtightness layers when more than four layers were applied. Leaks greater than 3 mm could not be sealed by sprayable airtightness layers as sole action.