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Thermal insulation from the inside

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1 Mounting of composite panels from plaster with 8 cm thick insulating boards of Neopor

Thermal insulation from the inside

Not all heated buildings can be energetically retrofitted from the outside. Frontages worth preserving or even under monument protection but also lacking intervening space are factors against exterior insulation. A professionally installed interior insulation is a simple alternative in order to preserve frontages and to still reduce heating costs and CO2-emissions.

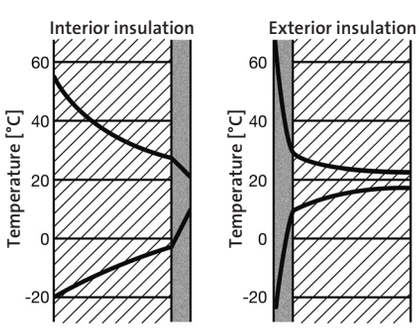
An essential difference between the two insulation methods is the fact that rooms insulated from the inside produce a different temperature profile in the building component. With the interior insulation the outside wall remains colder in the winter, and in the summer, especially under insolation, it heats up more (picture 2, temperature profile). That is why building components insulated from the inside have to bear bigger temperature fluctuations than constructions insulated from the outside. This effect has to be considered during the planning and execution.

Construction physical fringe conditions

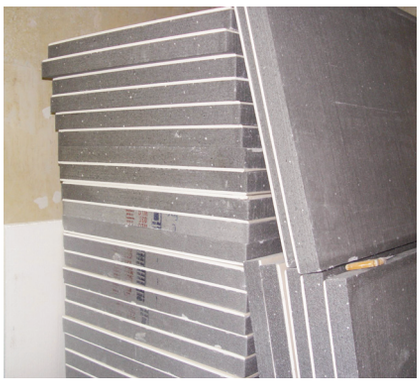
The thinner the insulating courses in the interior are supposed to be, the more important it is to use insulating products with low thermal conductivity for the thermal protection. Furthermore it is important to avoid thermal bridges in walls, ceilings and reveals during planning and execution. Protection against moisture from the inside can be achieved for example with uninterrupted vapor retarders. With the help of a computer-operated simulation on moisture transport and thermal behavior (e.g. Wufi or Delphi) it can be decided if a vapor retarder has to be used in the respective present case. Additional protection can be reached with controlled ventilation. The building receives moisture protection from the outside by hydrophobizing that prevents capillary water transport from the outside in the construction. Insulating boards with a favorable spring system reduce the transfer of airborne and impact sound and thus provide noise protection. It is important to look at the interior emissions: Neither insulating materials nor other building materials must pollute the interior air.

Energetic modernization while maintaining the historic frontage

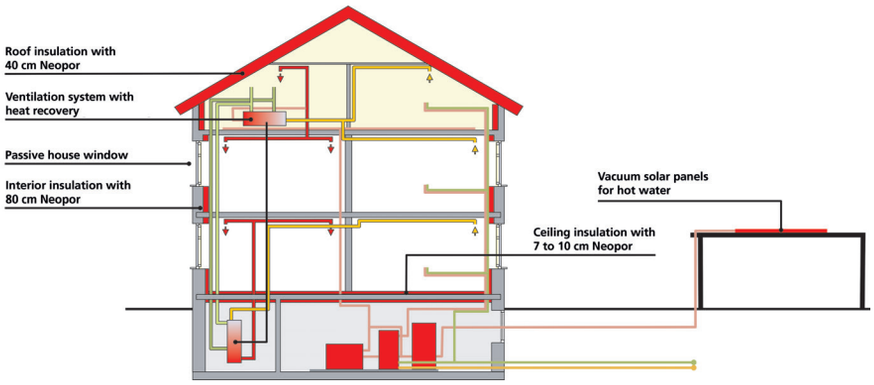
Within the framework of the nationwide model plan “Turning existing houses into low energy houses” [Niedrigenergiehaus im Bestand] of the German energy agency [Deutsche Energie-Agentur], BASF Wohnung und Bauen GmbH modernized a building older than 100 years in the historic workmen’s dwellings “Alte Kolonie” in Ludwigshafen (picture 9, house in the initial state). The comprehensive modernization of Sodastrasse 40 – a residential building built in 1892 with a frontage with exposed brickwork – was carried out in 2005 (picture 10, house in final state). The aim was an energetic retrofitting (KfW [energy standard] 60 in existing



2 The temperature profile shows that the exterior wall remains colder in the winter through interior insulation



3 **Composite panels from plaster board (white) and insulating boards of Neopor (silver-grey)**



4 **Walls, roof and cellar ceiling were insulated with insulating materials of Neopor, a silver-grey, graphite-bearing EPS.**

houses), to use passive house components as far as possible and to maintain at the same time the historic clinker frontage.

Hence the exterior walls (picture 4: house graphics) have been insulated from the inside with 8 cm thin insulating boards of "Neopor" by BASF together with plasterboards (picture 3: composite panels). Neopor is a silver-grey EPS (expanded polystyrene), worked in the graphite. These boards were selected, because with their help a low thermal conductivity of 0.032 W/mk and thus a good insulating effect with a low insulation thickness can be reached. The especially elastified insulating boards do not only provide thermal protection, but in combination with the mounted plasterboards they also reduce the conduction of airborne and impact sound. Further, important components of the energy concept were triple-glazed windows, a ventilation system with heat revovery and solar panels to support the hot water generation.

The passive house institute Darmstadt carried out concomitant technical measurement studies on thermal and hygric behavior on the building over a period of 1.5 years after its modernization. The energetic studies showed that the heating energy demand of about 250 kWh/(m2a) could be reduced to 54 kWh/(m2a), so by almost 80 percent (picture 5; reference magnitude: energy reference area, calculation according to PHPP [passive house project package]). The invoices of the energy supplier from the years 2014 and 2015 confirm the reduced heating energy demand after the renovation.

Protection against moisture, thermal bridges and simple wallpapering

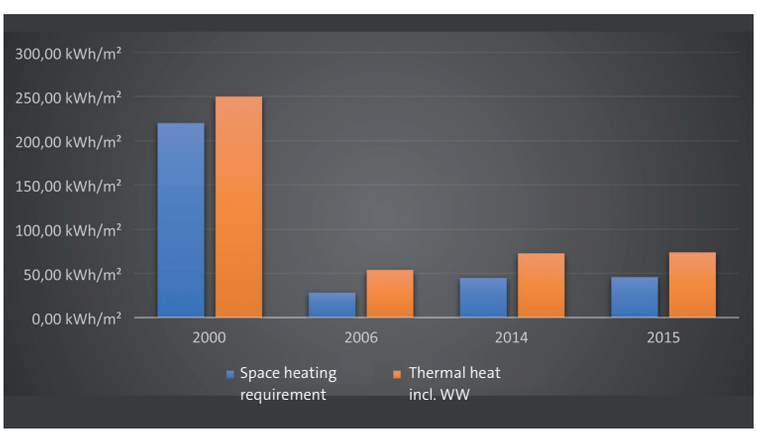
Protection against moisture from the outside: Due to capillary action in the wall, moisture coming from the outside can penetrate as far as the interface of the old internal plaster and the interior insulation and thus create damages. That is why it is important to sufficiently protect the frontage against driving rain irrespective of the used insulation material through hydrophobization in case of an interior insulation. During the modernization of Sodastraße 40 a hydrophobizing frontage protection was applied after the cleaning of the clinker frontage. The measurements of the passive house institute showed that only the repeated application of a hydrophobization provided sufficient protection against driving rain.

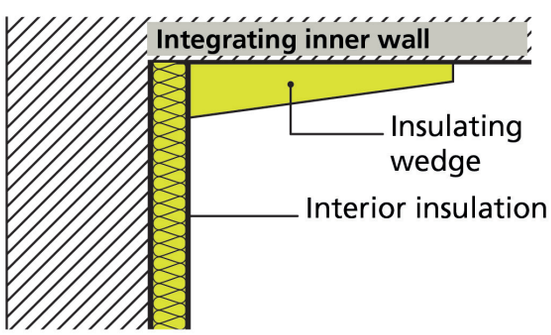
In the interior the expert mounting of composite panels and their connection with the construction is essential (picture 1). Thermal bridges develop in reveals and in spots where interior walls, ceilings and other building components integrate into exterior walls. Insulating wedges in these building components significantly reduce the negative impact of thermal bridges (picture 6). Protection against moisture from the inside was reached by the uninterrupted integration of steam breaks: They avoid that inside air humidity from the interior diffuses into the construction (picture 7).

In the practice composite panels, such as of EPS and plasterboard, have proved themselves as interior insulation. The finished surface to be painted, wallpapered or tiled is made in one working operation together with the insulation (picture 8). This kind of interior insulation has been standard procedure in France for several years now: Neopor prevailed by the combination of low thermal conductivity and elasticizability.

Indoor emissions

Against the background of the increasing





5 **Left: Heat requirement of the building in Sodastraße 40 before and after the energetic retrofit (2005)**

6 **Above: Insulating wedges reduce thermal bridges**

7 **Vapor retarders have to be mounted uninterruptedly over the insulating wedges in integrated inner walls and ceilings, as well as in reveals.**

8 **Mounting of a second plaster board as ground for painting, wallpapering or tiling.**

importance of the quality of indoor air, especially after structural alterations, the Association of European Producers of Synthetic Materials "Plastics Europe" (Working Group EPS HSE) commissioned the accredited institute Eurofins to examine the VOC-emissions (volatile organic compounds) of EPS indoors. The measurements took place in twelve test elements of different insulating board manufacturers and are part of EPDs (environmental product declarations), drawn up and published by the European governing body of EPS insulating material manufacturers EUMEPS Construction: The emissions of the entire VOC are far below the strictest limit values, determined in the norms and guidelines of the various EU-member states. EPS thus is especially suitable for the interior insulation in comparison with other insulating materials.

Conclusion

Indoor insulation with graphite-bearing EPS and plasterboard is an efficient option of energetic retrofitting of buildings. If heating and cooling energy is to be saved permanently, a detailed structural-physical planning, calculation and excellent technical execution are indispensible. It is especially important to avoid thermal bridges and to have steam brakes that are uninterrupted. Controlled ventilation additionally facilitates the dehumidifaction. The frontage should also be effectively protected against driving rain by hydrophobization. Sound insulation can be optimized by the elastification of the EPS insulating material in one working operation. The emission values of such an EPS and plasterboard insulation are evidently far below the limit values of the EU and the energy saving potentials are considerable.

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9 **Building with clinker frontage worth preserving: The "Master house", Sodastraße 40 in Ludwigshafen, year of construction 1892**

10 **Sodastraße 40 after the energetic and architectural modernization.** *Graphics/Photos: BASF*