

Membrane keeps buildings dry



Timber-framed building on the outdoor area at IBP.

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"Initially we did not understand much about polymer membrane," points out Dr Hartwig Künzel. "As specialists in building physics we are primarily interested in the transfer of moisture and heat in buildings." And yet the departmental head at the Fraunhofer Institute for Building Physics in Holzkirchen kept returning to the subject of lining material when just over 10 years ago he started to become involved in the renovation of old buildings: "At the time we were conducting work on a research contract for the restoration of timber-framed buildings. Materials were being tested in outdoor conditions on the Institute's premises and the first computations of moisture behavior were being made." The façades of historical timber-framed buildings are normally subject to preservation orders, which means that the buildings can only be insulated from the inside.

In such cases thermal insulation has far-reaching consequences: rainwater penetrates into the beams and the infilling through the timber framework, some of it even gets into the insulating layers. If the interior paneling is hermetically sealed e.g. by membrane material made of impermeable polystyrene or plastic sheet, the dampness from the wall cannot evaporate into the room – it is trapped and at some stage the beams will start to rot. Inside the building, condensation will form on the cold walls and mould will spread.

The Fraunhofer Institute for Building Physics IBP has achieved a major success with a nylon membrane, a product from the packaging industry. This material is now used throughout the world for the thermal insulation of buildings.



The moisture barrier is quickly and easily applied.

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Künzel first sought a solution to this problem by theoretical means. While working on his thesis at university he developed the WUFI (from the German abbreviation for 'unsteady transfer of heat and moisture') computer program to calculate the transfer of heat and moisture. He explains: "The ad-

vantage of such computations is that things can be simulated which do not yet exist." The computer-run models showed that for retrofitting timber-framed buildings a moisture diffusion layer is required which in summer permits the moisture from the walls to penetrate inwards. In winter, however, when the rooms are warm and humid, the layer must do exactly the opposite. Moisture should not migrate from the inside outwards, as condensation would form on the cold walls.

In order to find such a moisture diffusion layer, Künzel with his team firstly examined dozens of commercially available types of membrane. They were delighted to find that one of them exhibited precisely the calculated characteristics. The material based on nylon had up until then been used to make sausage skins or baking film. No one had realized that it could be used for insulating walls, let alone roofs.

An intelligent, adaptive membrane

Using the WUFI program Künzel, computed that nylon membranes are suitable for moisture regulation in thermally insulated roofs. The membrane adapts its permeability



The research scientists tested the function of the moisture barrier on a building with a sheet metal roof.

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ty to the ambient air humidity: in winter it protects against condensation, in summer it facilitates the drying out of roof and wall structures. The 'intelligence' of nylon resides in its structure: in dry condition the material's plastic molecules form a tight im-

Computing with WUFI

The WUFI computer program, developed at the Fraunhofer Institute for Building Physics, is now used throughout the world to calculate the transfer of heat and moisture in building components. The program is suitable for determining the drying time and the risk of condensation, it can simulate various climatic zones and calculate the effects of modernization and renovation work. "With WUFI the relatively time-consuming outdoor measurements can be restricted because data is now only needed for checking the calculations," explains Dr Hartwig Künzel, who had the original idea behind the program.

WUFI is now deployed in various versions: 3.0 contains a material database and the climate data records from the Fraunhofer Institute in Holzkirchen. The WUFI-2D program is suitable for representing entire building constructions and for computing two-dimensional hygrothermal phenomena. Both versions can be installed on PC.

At the Fraunhofer Institute in Holzkirchen WUFI is currently being used to simulate the environment inside aircraft envelope. The aim is to develop a moisture barrier which shields the envelope from cabin humidity and avoids the formation of large quantities of condensation by drying the envelope between flights.

permeable network. As soon as the membrane comes into contact with moisture it swells up, the polar water molecules penetrate between the polymer molecules and the material becomes soft. As a result the plastic acquires pores through which further water molecules can penetrate. In summer when the air is humid, the moisture penetrates through the pores into the building interior. Walls and roof dry out. If the relative ambient air humidity decreases the pores close up again, and the membrane then acts as a barrier to moisture. In winter this barrier protects the walls and roof behind the membrane from condensation.

Künzel immediately registered his idea of using a humidity controlled membrane as a

moisture protection layer with the Patent Office – the Fraunhofer Institute for Building Physics now has the patent rights in almost 40 countries. An industrial partner then had to be found to market the membrane. That was in 1995. The research scientists entered into a commercial agreement with Saint-Gobain Isover G+H AG, a market leader in Germany for insulating materials.

The membrane now had to pass practical tests: The Fraunhofer engineers studied its moisture permeability in a building on the institute's outdoor testing area: the roof structure under the impermeable sheet metal roof was first insulated with mineral fiber and then lined with nylon membrane. For a whole year, temperature and humidity sensors in the roof provided data. "The results were excellent. The target values we had set for moisture transfer were exceeded," recalls Künzel.

Sales success in numerous countries

The engineers at Saint-Gobain-ISOVER tested the material's fire protection and mechanical properties, as well as its aging behavior. Their conclusion: "The membrane selected for use as a humidity controlled barrier passed both required fire protection tests without any fire-retardant chemicals having to be added to the material." The mechanical properties, too, proved highly satisfactory: the membrane displays high impact strength, and therefore does not tear so readily if someone inadvertently snags it with a roof batten. A four-week weathering test showed that heat and cold have no effect on the polyamide. Another positive characteristic of the membrane was only recognized later: it also protects against wood preservatives used to treat the roof structure or the timber framework, because non-polar organic compounds cannot penetrate the pores – unlike the polar water molecules. As a final trial the membrane was used on a pilot construction site, then in 1997 it was introduced to the market under the brand name 'ISOVER-Vario'.

Saint-Gobain Isover G+H AG already supplies to several countries in Europe and sells around 8 million square meters of Vario membrane per year. "We are now in the pleasant situation where we are receiving license income," Künzel comments happily.

Monika Weiner