CONTRIBUTING TO A FLAGSHIP PROJECT OF THE STRATEGY

Baltic Sea Region
Programme 2007-2013

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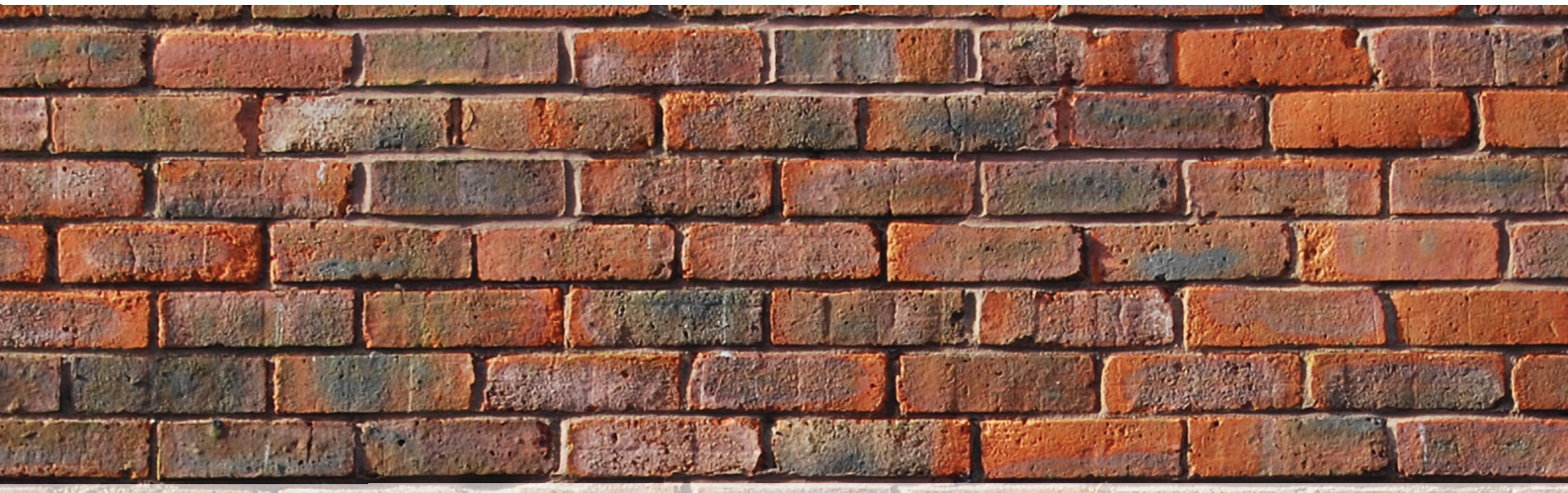
Partnership Instrument)

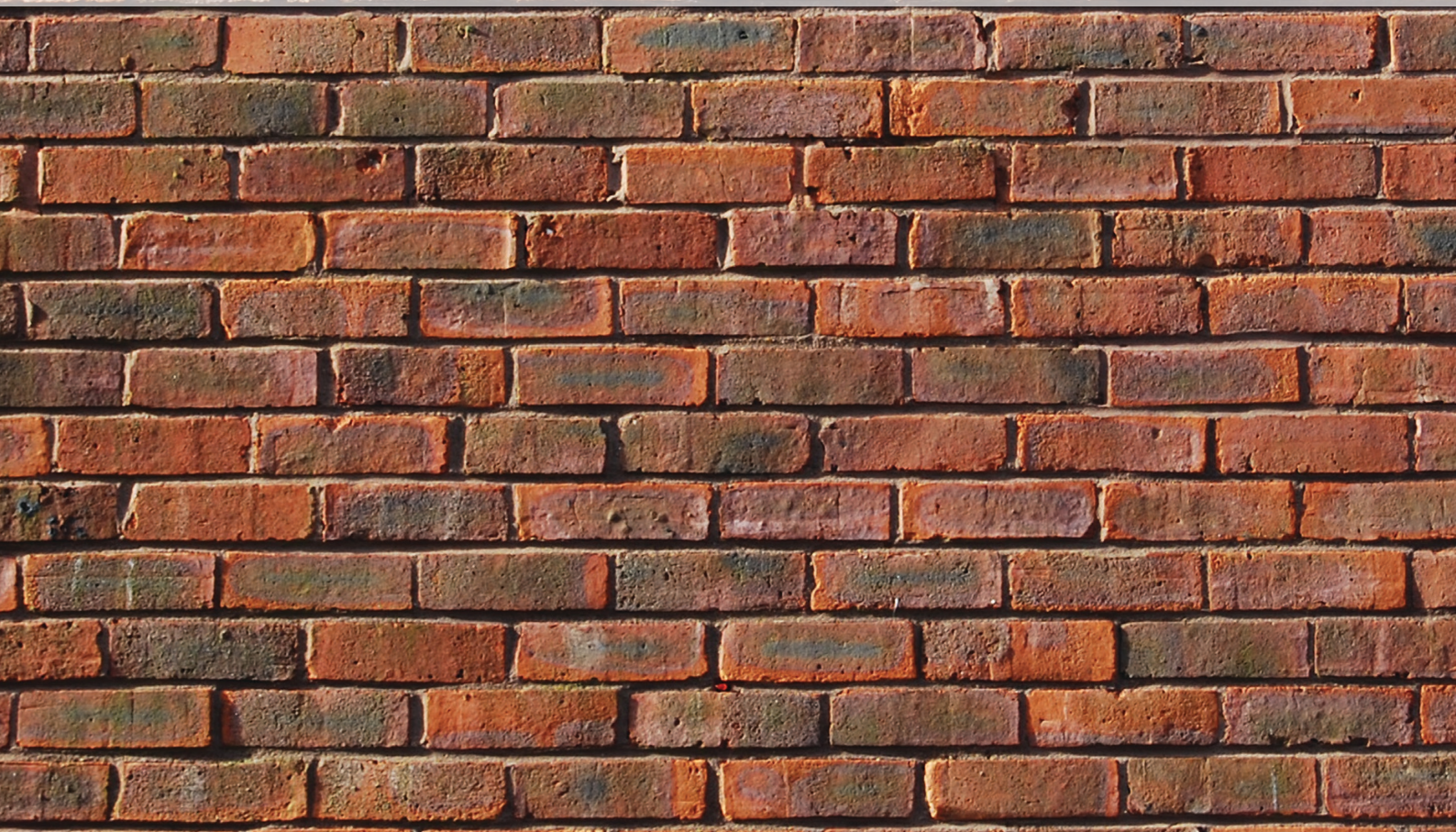
CO2olBricks



WP5 Education and Economic Promotion

Post-insulation of sloped ceilings

Educational product: New lecture material for training modules dealing with knowledge and skills how to apply suitable methods of energy efficient refurbishment of historic constructions and how innovation can be combined with cultural heritage



Post-insulation of sloped ceilings

Target group: architecture, construction, energy audit students

Educational objectives: To give the systematic knowledge of types and constructions of sloped ceilings, possibilities to add insulation layer

This measure can help to save up to 15% total energy used in building

Lecture course: 2 academic hours, additional on-site visit recommended

References:

Rasmussen, Torben Valdbjørn. "Post-insulation of existing buildings constructed between 1850 and 1920." *Department of Construction and Health, Danish Building Research Institute, Aalborg University, Hørsholm* (2010).

Byrne, Aimee, et al. "Transient and quasi-steady thermal behaviour of a building envelope due to retrofitted cavity wall and ceiling insulation." *Energy and Buildings* (2013).

Møller, Eva B., Ernst Jan de Place Hansen, and Erik Brandt. "Performance and durability of external post-insulation and added roof constructions." (2011): 915-922.

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Introduction

Buildings are a crucial sector for controlling energy demand because currently buildings account for around 30% of the total energy use in the world. The buildings as energy consummators are important also because they will consume future energy.

Around 50% of the existing buildings in the Baltic Sea Region were built before 1970 and have lower energy efficiency and higher GHG emissions than modern buildings. Existing older buildings have a very low thermal standard compared with today's requirements. Therefore, there is an increased interest in improving the insulation standard of many existing and older buildings.

Thus, failing to retrofit old buildings to improve their energy and environmental performances may endanger GHG mitigation. Figure 1 shows the part of energy consumed in buildings with low energy efficiency.

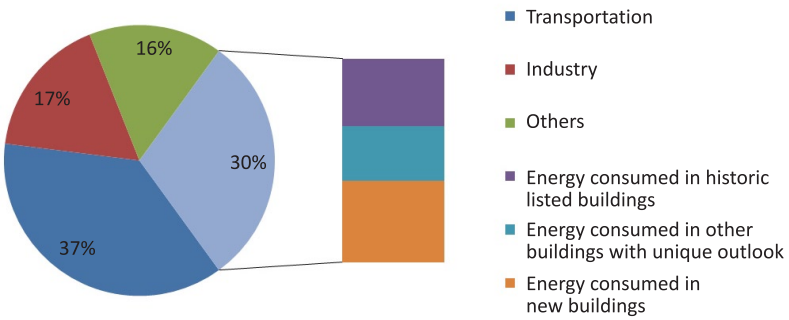

Fig. 1 Energy use and part of energy consumed in historic listed buildings and buildings with unique outlook in Europe

In Baltic Sea Region (BSR) most of historic buildings were built from bricks. The standard BSR historic building is 2-7 storey high, with a cellar, it usually has 45-90 cm thick solid brick wall, with outer walls and inside construction bearing wall also used for ventilation and smokestack. BSR is colder climate

zone and the windows in historic buildings were traditionally small. Usually the biggest energy losses happen in the roof and walls. Figure 2 shows average energy losses in typical historic brick building in BSR. Ceiling and roof construction is usually wooden; roof is covered with traditional tiling and has to have at least 35°.

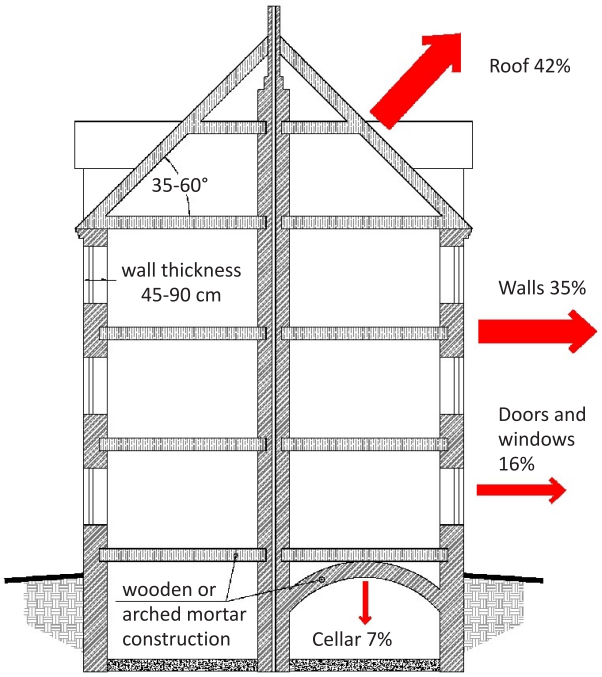

Fig. 2 Typical historic brick building of Baltic sea region and average heat energy losses

Roof insulation

When roof insulation is considered, the necessity of complete roof insulation should be taken into account. Otherwise, there is a high probability of the formation of thermal bridges and moisture condensation that will cause envelope and roof damage.

Roofs are divided into two groups - pitched and flat. Installation of thermal insulation material on the pitched roof can be done in two main ways, which are then divided into four methods:

1. Insulation at rafter level (warm roofs);
2. Attic ceiling insulation (cold roofs).

The flat roofs, in turn, have three traditional insulation methods:

1. Warm roof coating;
2. Cold roof coating;
3. Inverted warm roof coating.

Pitched roofs

Many methods to post-insulate the roof are used; main four are illustrated in figure 3. According to the placement of insulation material the space beneath the roof can be made warm or left cold.

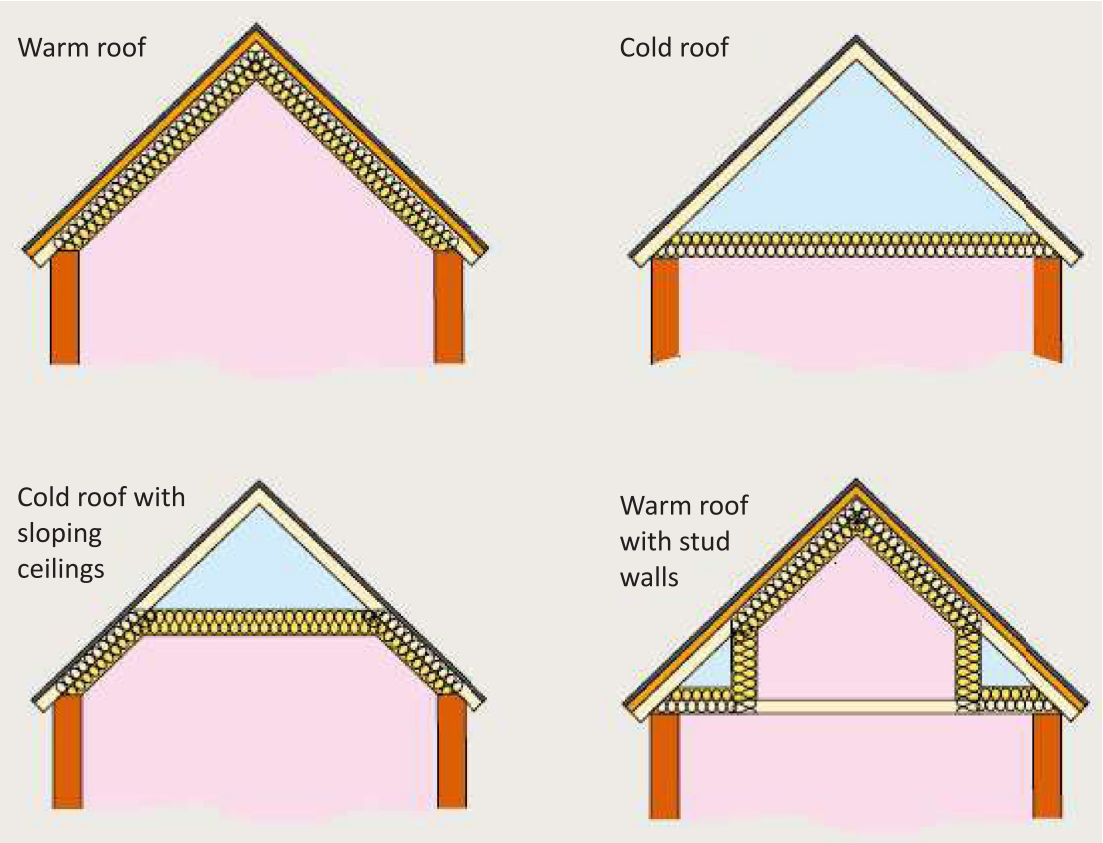

Fig. 3 Four pitched roof insulation methods

The term “cold roof” means that the insulation material is laid horizontally on the building attic ceilings, leaving uninsulated roof space - attic. In contrast in the case of “warm roof” thermal insulation material is embedded between, under and / or over the roof rafters providing insulated attic space, which can be heated and used as a living space.

Warm roofs

Advantages and disadvantages of the warm roof insulation methods are showed in Table 1.

Insulation method	Advantages	Disadvantages
Thermal insulation above the rafters	• Continuous thermal insulation layer which provides 100% avoidance of thermal bridges. • Reduces the risk of condensation on a wooden frame. • Prevents attic from overheating caused by solar radiation. • Ceiling structure is not being damaged.	• Additional costs to provide scaffolding and temporary roofing. • Roof level rise, which leads to changes in the eaves and on the outskirts. • The roof is not always exactly in the same plane and without bumps, so the insulation installation requires a lot of attention to make a qualitative insulation plate connection. • Adding extra weight to the rafters, additional roof reinforcement is possible.
Thermal insulation between the rafters	• No visible roof level increase. • Lower cost. • Ceiling structure is damaged, if the insulation is installed from the top.	• Broad rafters are needed to impose a sufficiently thick insulating layer (the most common insulation layer is 75-150mm). • Cracks between the rafters and insulation may be formed, through which there will be an air infiltration, so in this case it is more appropriate to use soft insulating material instead of plates. • Water vapor impermeable insulation can cause moisture absorption in rafters and start wood rotting.
Thermal insulation under the rafters	• No visible roof level increase. • Continuous thermal insulation layer with well-sealed connections.	• Substantial improvements cannot be made without the reduction of interior space area. • It is hard to insulate joints around the openings and obtain a smooth layer of insulation. • It is not possible to insulate attic ceilings with elements recognized as cultural and historical heritage.
Insulation over and between rafters or between and under rafters	• The most effective type of insulation at rafter level. • Ensures combined advantages and excludes majority of the disadvantages from both.	• Increased costs.

Cold roofs

In case of the Insulation of attic covering the most efficient way is to put insulation in two layers. The first layer is laid between the ceiling joists but the second layer is laid over the beams - it helps to reduce thermal bridges from the ceiling joists.

In many historical buildings joists can be uneven, with differing heights or not tick enough to ensure qualitative installation of the thermal insulation. In these conditions minor height differences and unevenness can be filled with cotton wool, but bigger ones - with bulk cellulose insulation.

Cold roof ventilation is provided with cavities in the roof, where there are open eaves or openings in gable walls, gable or through the roof coatings. Reduction of ventilation may cause moisture condensation problems, especially if the roof covering is waterproof.

One possible solution is to install a fan at the roof eave, which would help to maintain the ventilation paths (see Figure 4).

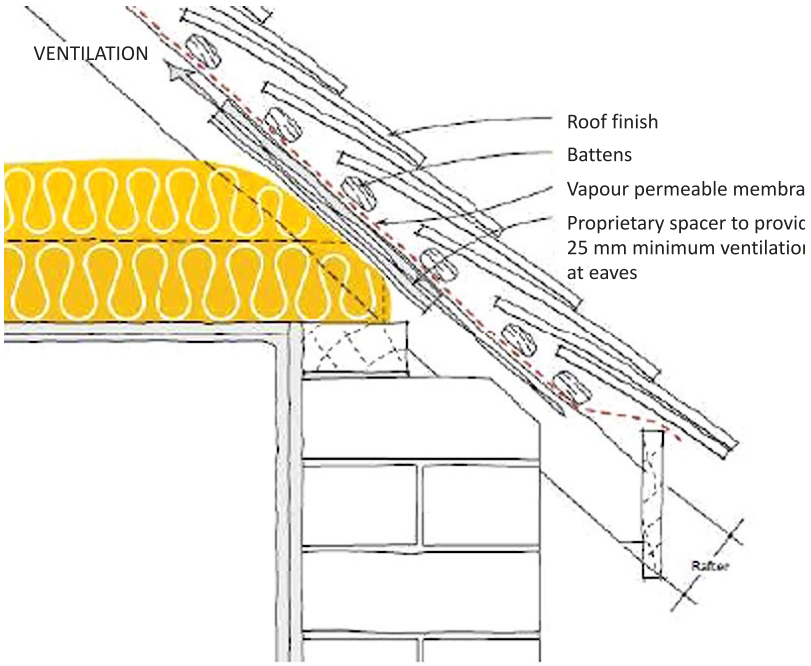

Fig. 4 Eaves ventilation

Flat roofs

The main risk for the insulation of the roofs like this is the increased risk of condensation in roof structures. This can lead to corrosion of some types of metal roofing and metal support structures or decay of wood constructions.

There are two main methods of dealing with the potential risk of condensation:

1. Installing a vapor barrier under the insulation;

2. Ensure effective roof ventilation in the cold area above the insulation

Which method is best depends on the individual circumstances of each roof and insulation type and thickness.

There are two ways in which thermal insulation can be incorporated into flat roof construction:

1. Below the roof and above the ceiling material (cold roof coating);

2. Above roof covering and below the waterproof layer (warm roof coating).

Isolation with cold covering system is the most commonly used method for historical buildings, but not always the most appropriate. In order to obtain the highest possible efficiency, both systems are combined in compliance with thorough assessment of the condensation risk.

Cold roof covering

Figure 5 shows cold covering thermal insulation method.

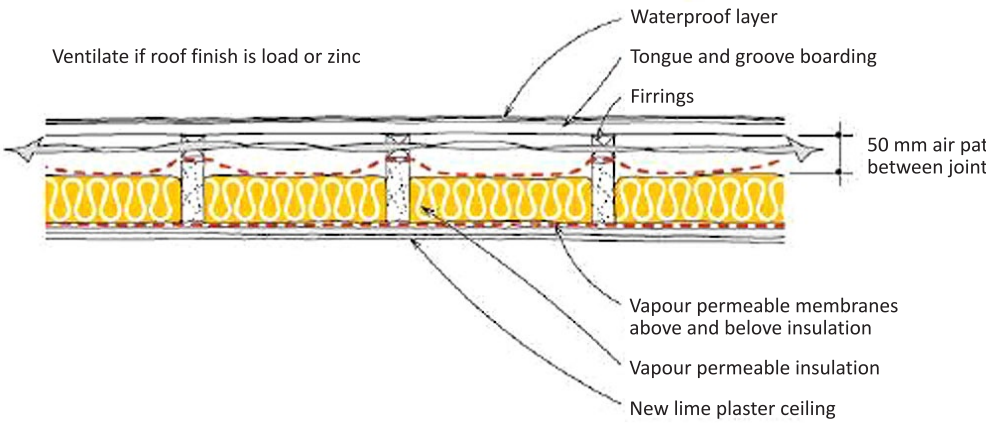

Fig. 5 Cold roof covering

Ceiling trim is removed to insert the insulation. Insulation material is embedded in it, in order to remain at least 50mm slot between the roofs for ventilation.

Warm roof covering

Where it is possible to lift the roof covering level without endangering buildings value, thermal insulation layer can be mounted above the surface. Plates that can withstand compressive loads must be used for the insulation.

If solid insulation boards are using, the new roof covering can be made of stainless steel or copper. The existing roof covering can serve as a vapor barrier, if its condition is satisfactory.

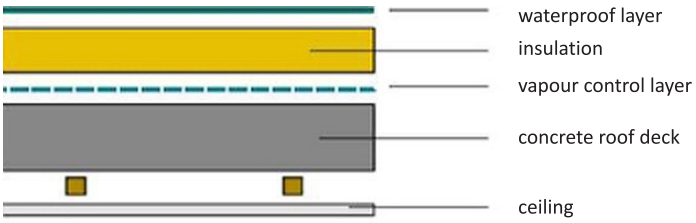

Fig. 6 Warm roof covering

An alternative is to install wooden frame on the top of the existing coverage, but, if it is necessary to install thick thermal insulation layer old covering can be demounted and the insulation material embedded in the existing roof carcass in case where such method is used it is necessary to perform calculations checking the risk of condensation.