Climate adaptation of wooden roofs

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Summary

This paper summarises the main findings of a recent PhD Thesis aiming to increase the knowledge about moisture safety and air flow through the air cavity of pitched wooden roof structures. Experimental research, field measurements and numerical simulations have been used to assess and characterise the driving forces and resistances for roof ventilation. The work shows that pitched wooden roofs adapted to the Nordic climate of tomorrow need:

- Increased climate adaptation and moisture safety by improved air cavity design.
- Convection barrier when insulation thickness exceeds 200 mm.
- More knowledge and relevant documentation if BIPV roofing

Key words: Building physics, wood structure, pitched roof, ventilated air cavity,

1. Introduction

Wooden frame structures are especially common in wooden houses in the Nordic countries. The roof structure is often constructed with a load-bearing system, referred to as wooden roof. Ventilated pitched wooden roofs with exterior vertical drainpipes and wood-based load bearing systems have to be ventilated. The purpose of the ventilation is 1) to remove heat transferred through the insulated roof structure possible causing snow melt and subsequent icing at the eaves and gutters, and 2) to ensure that excessive moisture is removed from the roof structure.

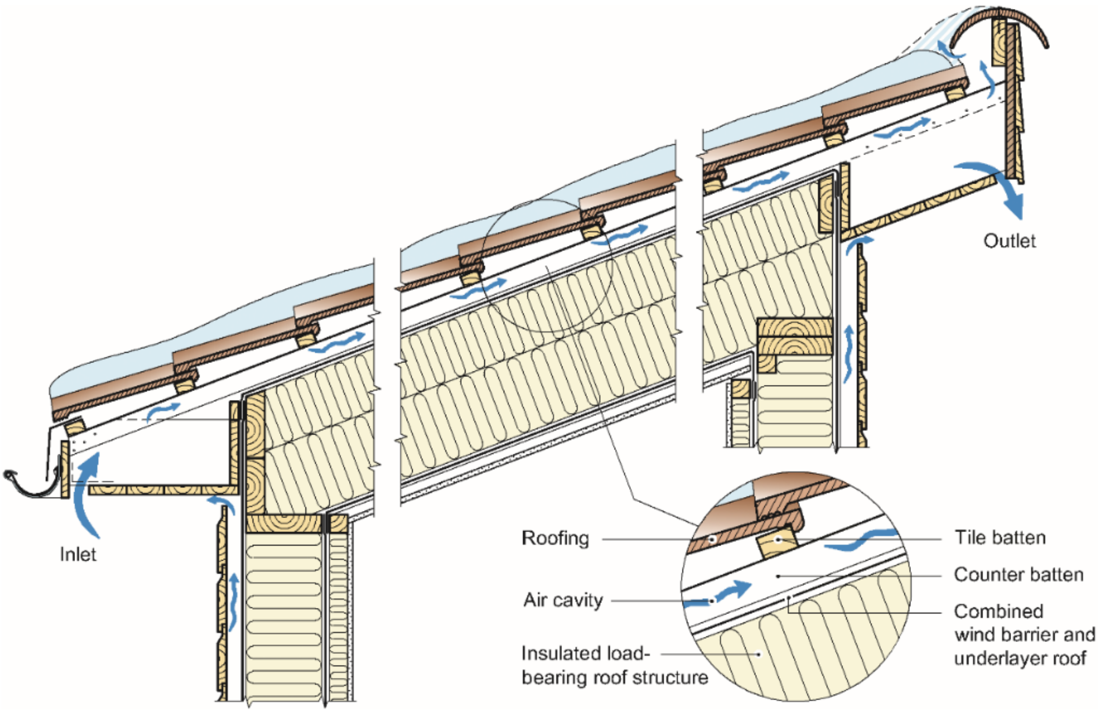

Figure 1. A ventilated lean-to roof structure with snow on the roof. The snow may reduce the air flow through the opening in the upper air cavity opening.

The objective of this study has been to increase the knowledge about moisture safety and air flow through the air cavity of pitched wooden roofs. One of the main goals has been to form a basis for development of design guidelines for large low-pitched wooden roofs (> 15m x 15m) applicable in the Nordic climate. Today, such roofs must be planned for each individual building project, which is not very efficient.

2. Methods

The main research methods applied has been assignment report review of the SINTEF Building Defect Archive, full-scale laboratory measurements, field measurements and numerical analysis. The Defect Archive includes assignment reports by SINTEF (former Norwegian Building Research Institute) mapping Norwegian building damages from the last 60 years. The study covers documents from the archive for the 10-year period from 1993 to 2002, which contains 2003 reports describing 2423 incidents or cases of defects.

The laboratory measurements includes measurements performed in a rotatable guarded Hot-Box and a large-scale test model of the air gap of a pitched roof. Field investigations includes measurements of the roof structure of a full-scale laboratory building, ZEB Test Cell Laboratory, as well as measurements of wind pressure coefficients at the facade of a test house located on a flat area in Tyholt in Trondheim, Norway.

3. Results and discussion

According to the Defect Archive, moisture from both precipitation and indoor air is the dominant source of roof damage. This is especially critical when we bear in mind a 10-20% increase in precipitation in the years to come in Norway and a slightly warmer climate. Hence, increased focus on risk reduction and moisture safety for building structures is needed.

Stricter building regulations and an increased focus on zero energy and zero emission-buildings make energy production on the building facades more relevant. Use of BIPV, especially on southern facing roofs can be a reasonable way to utilise roofs for energy production. However, the missing link between the PV and construction industry is a reason for the limited use of these systems. The main building physical challenges concerns rain-tightness of the BIPV-systems as well as snow covering and snow downfall hazards.

Natural convection inside highly insulated structures were found to significantly increase the heat transmission of roof structures. Natural convection may cause redistribution of moisture inside the insulation cavity. The effect causes higher moisture levels in the cold part of the structure. In order to reduce this risk, introduction of a vapour open convection barrier is recommended when the insulation thickness exceeds 200 mm, also for pitched roof structures

A measure to increase the ventilation of the air gap beneath the roofing is the design and dimensions of the counter- and tile battens. Increased counter batten height as well as use of round-edged tile battens was found to considerably lower the pressure loss. The study of local loss coefficients inside the air cavity of a roof and the study of wind pressure coefficients was performed in order to increase knowledge about the driving forces and resistances of ventilated roof structures.

4. Conclusions

The presented work is a step towards more climate adapted wooden roofs. Some possible approaches are proposed. However, further investigations are necessary. The main theme for further investigation is related to the design criteria for the air cavity.

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