

Damages in Wooden Roofs over Heated Rooms

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1. GENERAL REMARKS

An ordinary pre-war construction is presented in Fig. 1. The thermal insulation was heavy, f.i. dry, pulverized clay, sand, slag etc. The joists were high even over spans less than 4 metres and a spacing of 60 cms.

Sometimes a vapour barrier of an asphalt roofing felt was laid under the insulation when the owner was afraid of fungi attack because of wet clay or slag insulation. Usually, however, an ordinary impregnated building paper was laid down on the 1 in. boards, turned up along the joists, and the insulation was then filled flush with the upper joist surface.

There was no ventilation space above the insulation, and the gutters were mounted along the eaves because most people did not trust the interior downspouts.

When ice from melting snow had destroyed gutters and leaders and attacks of dry rot had frightened the owners, a rebuilding was the only solution: the gable roof with the cold attic was once more in favour. Since leakages had frequently occurred in the prewar flat roof constructions, the asphalt felt roofing and the poor slope got a bad reputation.

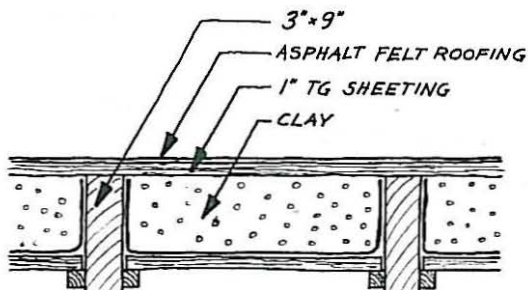


Figure 1. Flat wooden roof before 1938.

During the first years after the war the steep gable roof was used even on large buildings within city areas, in spite of obvious disadvantages as snow-slips, icicles, downspouts destroyed by ice, etc.

When better knowledge of vapour- and heat transmission was presented to the architects, the flat or gently sloping wooden roof had its come back after 1960.

Unfortunately, experience is not always good, it seems that the fitness of the construction depends both on outdoor and indoor climatic conditions, and - to a large extent - on the architects and the carpenters.

2. THE NEW CONSTRUCTION

Fig. 2 shows a section of a flat roof construction frequently used after 1960. To avoid failures three main principles are followed:

- a) The thermal insulation should be sufficient,
- b) the ventilation (above the thermal insulation) rate so great, and
- c) the vapour barrier below the insulation so tight, also air-tight, that snow-melting on the roof is avoided even in areas sheltered from wind.

This is however, impossible in certain cases, and the conclusion is that when a flat, wooden roof is to be built in a sheltered area, the water should be led down by leaders (soil) within the house.

In windy areas the snow is blown off the roof, and the gutters could be mounted along the eaves. But even here an inside drainage should be preferred.

The thermal insulation now frequently consists of 10 cm bats of mineral wool. Since the height of the joists is usually 8 in. (20 cms), the insulation thickness should be at least 15 cms which is a more economic thickness. The air space between insulation and sheeting is used for ventilation. If the openings along the

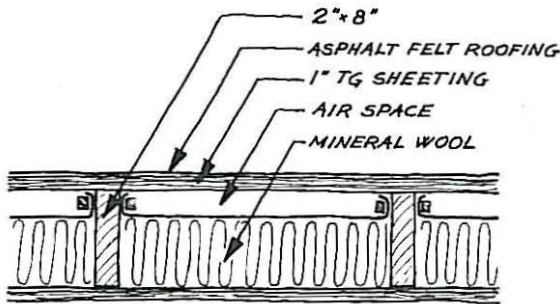


Figure 2. Flat wooden roof after 1960.

opposite edges are made as big as the section of this space, the O/A ratio¹⁾ for a 10 m wide house is 1/100 for a distance = 55 cms between the joists. (15 cm of insulation). This rather great ventilation rate is not sufficient to prevent snow melting on roofs in sheltered areas, even not in cold periods, and certainly not when there are air leakages in the vapour barrier and in the wind barrier.

3. AIR LEAKAGES IN THE VAPOUR BARRIER

Due to temperature difference a super pressure of air is usually formed across the roof. If the outdoor temperature is -20°C , the indoor temperature $+20^{\circ}\text{C}$ and the room height 2.5 m, the super-pressure will be about 0.25 mm of water column provided that the neutral line is in mid-height.

We have never measured air leakages in roofs in practice. Wooden roofs without attics, however, are built according to the same principles as the frame wall, the sheeting and the water tight roofing should be looked upon as a rain coat, i. e. it has the same function as the outside panel on the wall. In the roofs, as in the walls, the thermal insulation is supplied with a vapour barrier on the warm side and a wind barrier on the cold side. The barriers are frequently of the same materials in both constructions. It could be assumed that the air leakages would be the same in both constructions, about $0.04 \text{ m}^3/\text{m}^2\text{h mmWC}$, when there are no holes in the barriers and when the overlaps in the barriers are pressed together.

It is difficult to obtain a good sealing between walls and roof, even when the vapour barriers overlap each other along the cornice-line, and it is still more difficult to seal the gap between roof joists and chimney or fire walls of bricks. Electric boxes and conducts built in the roof construction frequently perforate the vapour barrier, the barrier is not seldom broken by load bearing walls, or main beams. Holes for ventilation stacks, pipes etc., are usually made too big and the gaps are rarely sealed.

Thus, the air leakages might be much greater than calculated according to the results from air measurements of air penetration in wooden walls.

The results of air leakages are worse than of condensation alone, "roof dripping" occurs both in dry and moist apartments. The moisture usually condenses on the underside of the sheeting carrying the roofing. In cold periods without snow the condensate freezes, the ice can be rather thick before the thaw is coming or the snow layer is sufficiently thick to rise the sheeting temperature above $\pm 0^{\circ}\text{C}$. Then the water runs down along walls, drips out of the ceiling around electric boxes, etc.

¹⁾ O = Total area of openings from air space to free air. O = max 2 times the section of air space (one opening at each end of space).

A = roof area to be served by the openings.

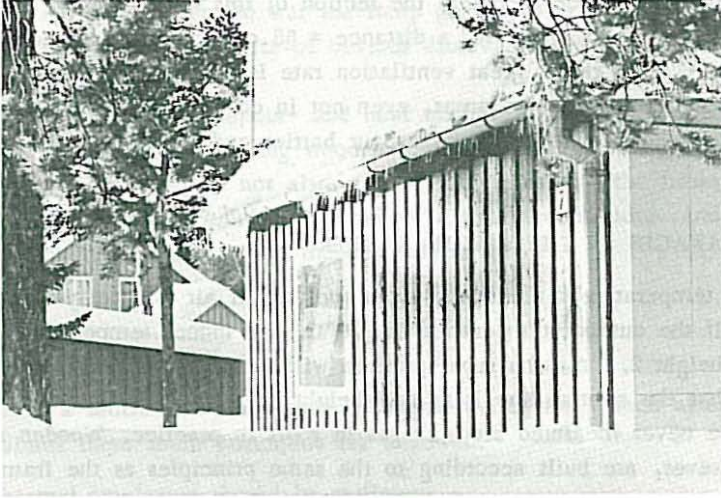


Figure 3. Ice melting on a gently sloping roof destroys gutter and leader.

Fig. 3 presents a gently sloping roof on a villa in Trondheim. The thickness of the ice under the snow is approximately 20 cms. The thermal insulation is 10 cms of rockwool, the vapour barrier is a plastic foil pressed against the underside of the joists by the ceiling panel. The wind barrier is a building paper fastened to the joist sides by nailed battens.

The indoor climate is normal, no excess humidity could be measured in the living room. In spite of this, condensation occurs in the roof and ice is formed in cold weather. The amount of water running down along the inner surface of the lower wall (on Fig. 3) can rise to 5-6 litres per winter along the 4 m cornice, according to the owner.

Similar cases are rather few in Trøndelag, this house is, however, situated in an area sheltered against wind. In return, the snow layer can be rather thick, and the ice destroys gutter and leader. - During the winter 1963-64 hundreds of complaints came to the NBRI in Oslo from the south east part of Norway where calm, cold winter weather is usual. In most cases air leakages were found, and some methods of repair proposed.

Later on the Norwegian Building Research Institute made a data sheet especially dealing with flat, wooden roofs. (NBRI 26.002). A translation of the data sheet will be made if CIB/Rilem members are interested in it.

The owner of the house presented in Fig. 3 does not want to destroy the ceiling to seal the vapour barrier, and considers a rebuilding from above. He wants to tear off the roofing, take up the wind barrier and the insulation and inspect the vapour barrier between every pair of joists. Then all gaps will be sealed with suitable materials, insulation laid down again, and another 10 cm bat laid upon it, thus

filling the joist space with insulation. On top of the joists a new wind barrier will be laid, and 2 in. x 3 in. wooden battens then will be fastened across the joists. Then the old sheeting will be used again and a new roofing laid upon it. The ventilation space, 3 in. high, will be shortened from about 9 meter to 7 meter, and the new O/A ratio will be less than 1/50. In this way the owner hopes to avoid future damages on outside gutter and leader.

A cheaper solution is to use a small medium pressure fan to blow in cold air above the insulation in the existing roof, creating a super pressure in the air space to prevent air leakages from beneath. In this case the lower ventilation openings of the roof would have to be closed.

The third possibility is to maintain a diminished air pressure in the rooms by means of fans blowing out the indoor air. Since few people like mechanical noise and the results from the use of fans are more or less uncertain, the last ideas are less actual than the rebuilding. It should be emphasized that a better ventilation above the insulation does not help when air from the rooms is penetrating the construction. The only possible solution along that line is to build a very well ventilated attic above the old, flat roof, i. e. the pre-war solution once again.

A rather peculiar case of air leakages and water vapour diffusion is presented in Figs. 4 and 5. The joists are laid parallel to the eaves that have been cut flush with the exterior wall according to fashion. Thus a proper ventilation above the insulation is prevented. The architect, however, had considered vapour pene-

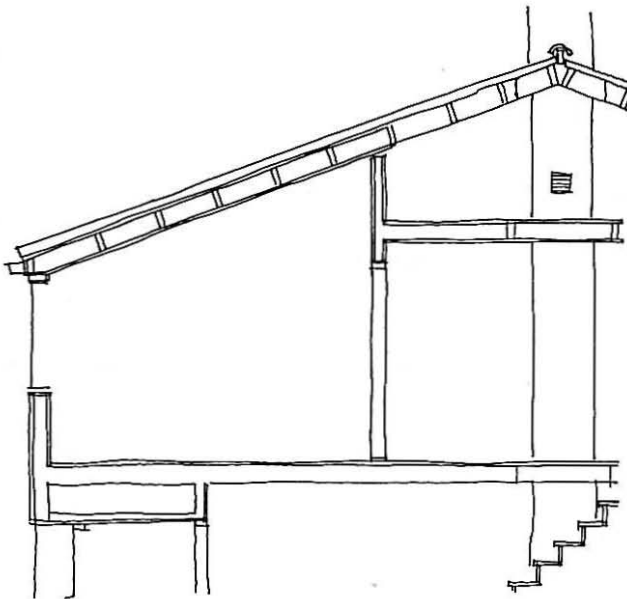


Figure 4. Section of an unventilated roof. Air leakages from bedrooms to insufficiently ventilated attic.

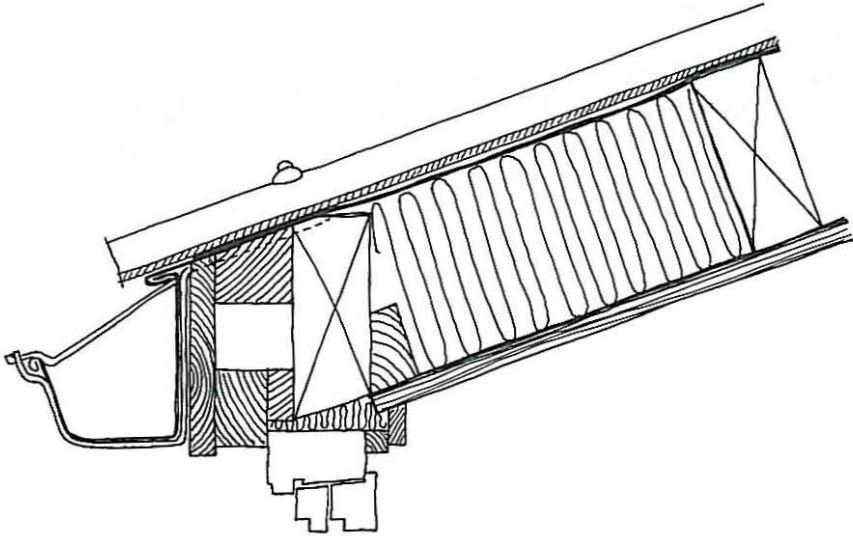


Figure 5. Detail of roof in Fig. 4 near the eaves.

tration, and did not use a board sheeting and a roofing felt on top of the joists, he simply fastened the building paper, the wind barrier on the joists and chose corrugated asbestos cement plates for roofing. Over the little attic, only the wind barrier and the corrugated roofing was used above the joists, insulation and ceiling was omitted.

The local building authorities did not permit the construction and demanded that the roofs still under construction should be supplied with a normal roof sheeting and an asphalt felt under the asbestos cement roofing, also above the attic. They had discovered fungi on the joists near the walls surrounding the attics and feared that water leakages from above were the reason.

Now, the partition walls surrounding the attic against the bedrooms are not load bearing, they stand on the wooden tile of beams between ground floor and first floor. Shrinkages both in beams and within the partition walls lead to great air leakages between roof and partition walls.

Since the attics are badly ventilated, some fungi occurs in the joists. The most severe attacks were found in the new houses where the authorities demand was followed. There was no fungi at all in one of the elder houses (without sheeting and asphalt felt) where one of the ridge tiles was broken!

The insulated non-ventilated part of the roof supplied with a wood sheeting and an asphalt felt has not yet been opened, but fungi attacks can be expected.

Obviously the architects own solution was not bad when the insulated part of the roof is considered. He should, however, have foreseen coming air leakages over the partition walls and also made a better ventilation of the attic. It is also clear

that the local building authorities do not understand that their demands are doing bad worse.

Since the insulated part of the roof can not be ventilated, the cheapest repair is to return to the original solution, take away sheeting and asphalt felt roofing and replace a diffusion open building paper. - The gaps between partition walls and roof have to be sealed completely, and stacks should be placed near the ridge to dry out the attic.

4. CI - GULLY ON FLAT, WOODEN ROOFS

Shrinkage of joists, sheeting and sills sometimes creates a situation as in Fig. 6, the gully is no longer effective and water leakages occur around it. When the plumber instals the CI leader in the house, he forgets that wooden materials are still wet, and make no clearance between the gully and the upper socket of the CI leader.

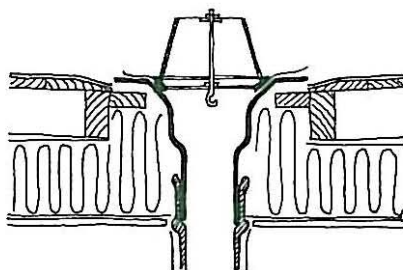


Figure 6. CI-gully stands proud of the roof due to drying out of wood constructions.

5. CONCLUSIONS

Roofs without attics have got a bad reputation in Norway because of poor knowledge of the problems attached to it. We have built very well ventilated attic-roofs in hundreds of years and are not accustomed to tackle questions as necessary ventilation rates, sufficient thermal insulation to prevent snow melting, air leakages through the roof, etc. Practice is not expected to be bettered in a short time, still we might hope that the cheap and simple roof construction will survive.

Bygghøgskolen i Trondheim

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Page	Line from above beneath	Printed	Should be read
1	4	Norway	Norway
3	6	rise	raise
3	1	A = roof are	A = roof area
4	6	will be made it	will be made if
5	Figure 4	unsufficiently	insufficiently