STRATEGIES FOR THE PLANNING AND IMPLEMENTATION OF AIRTIGHTNESS ON EXISTING SLOPED ROOFS

Wilfried Walther

Energie- und Umweltzentrum am Deister (e.u.[z.])
Zum Energie- u. Umweltzentrum 1
D-31832 Springe, Germany

ABSTRACT

A project at the Energie- und Umweltzentrum (e.u.[z].) Springe looked into strategies how insulation and sealing components can be installed in existing constructions to improve the best airtightness.

KEYWORDS

Air tightness issues, building physics, vapor retarder, Quality assurance

1 INTRODUCTION

Figure 1: Melting snow in some regions shows a bad airtightness

Sloped roofs on existing buildings have a number of penetrations, connecting walls and beams with poor airtightness.

The attics are completely developed, with a layer of plaster applied to baseboards on the inner side of the rafters. Unfortunately, connecting light-construction interior walls and the visible beam construction so frequently penetrate the air tight layer that an n_{50}-value of app. 3.5 1/h was the best that could be done despite comprehensive improvements.

Figure 2: View Eastern side – main e.u.[z.] building, constructed in 1925

Now, roof renovation from the outside should considerably improve that value.

2 FOCUS AND AIRTIGHTNESS CONCEPT

When adding insulation from the outside (externally) of a roof U-values below 0.20 W/(m²K) are relatively easy to attain with a combination of completely insulated rafters and rooftop insulation. Though, it is not self-evident that the airtightness is improving. In many cases we don’t know, whether there are problems or not. A measurement of the building's airtightness before renovation is a big help for the planning process. By looking for leaks based in the old airtightness layers, we can determine:

- Which connection and which layers are sufficient?
- Which ones need to be changed and improved?

Figure 3: Fog in a room and pressurizing shows the air passage from the inside to the outside

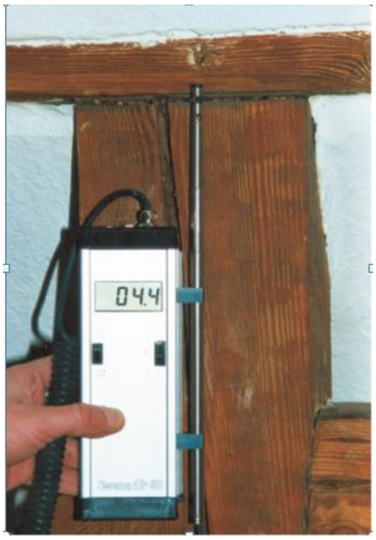
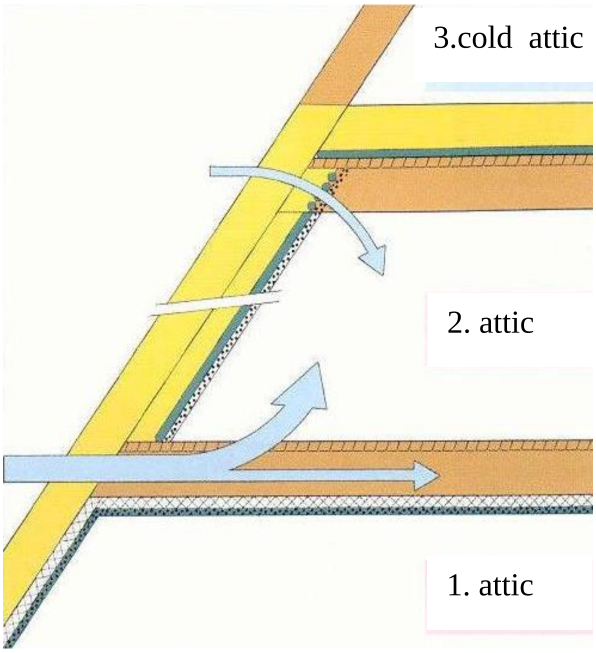


Figure 4: Depressurizing shows airflow on gaps of timber construction



In our object we find following materials air tight:
- Plaster of walls in the ground floor
- Plaster of walls on eaves storage space
- Concrete ceiling of the ground floor

Not air tight:
- sealing to roof windows
- sealing to light-construction and
- Gaps from timber that penetrates the wood-wool slab
- Gaps from electric cables and pipesac
- Grove and tongue boards in the attic floor

It is quite obvious, that the airtightness must be achieved in the surface area from the exterior and not through sealing from indoor.

Figure 5: Airpath from the outside through the leaky construction

Figure 6: After removing the roof tiles you can see the big cavity where the floor structure between the 1. attic und 2. attic is located.

To characterize the air permeability of the building it is not so important to calculate the n_{50}-Value but rather air permeability with reference to the envelope's surface (q_{50}). Values above 3.0 m³/(hm²) show us a surface that should be upgraded.

In our object, we measured a permeability of q_{50} = 4,1 m³/(h m²).

3 PLANNING AND INSTALLATION TIPS FOR ROOF SURFACE

The planning concept shows an additional airtightness layer over the whole roof. This layer must be bond to the ground floor ceiling, gable wall, roof windows, penetrations e.g.. The thermal insulation is situated between and over the rafters. Above the new timber there is a sheathing membrane, or wooden fiber sheeting plate with vapor permeable quality planned. A number of manufacturers of vapor barriers and airtight materials offer three variants to improve airtightness.

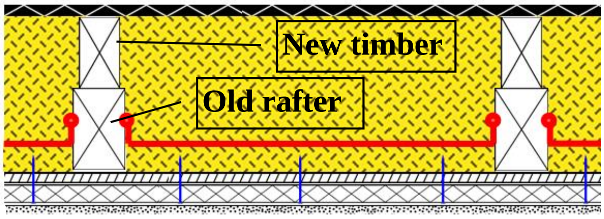


Figure 7: Var. I – airtight and vapor barrier (red) fixed with adhesive bonding compound from rafter to rafter.

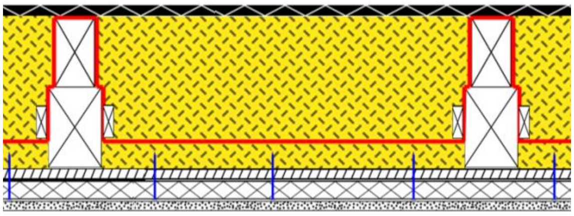


Figure 8: Var. II – airtight and variable vapor barrier (red) "sub and top" system. The layer can as well situate between the rafter and timber.

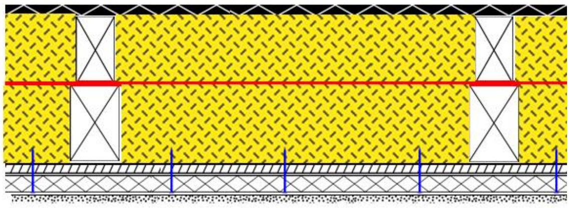


Figure 9: Var. III – airtight layer and water vapor permeable on the old timber, covered with insulation.

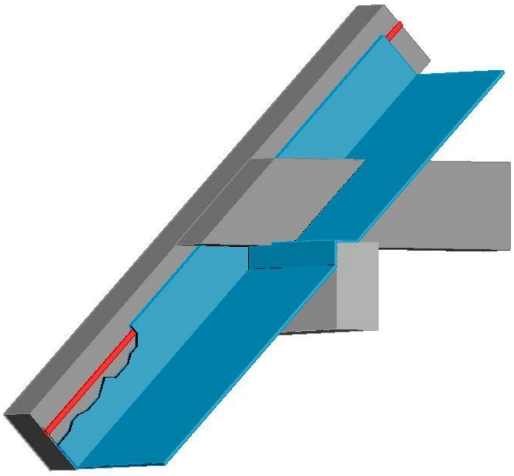


Figure 10: Var. I – Airtightness from rafter to rafter with collar beams (Source: WTA, Airtightness of buildings)

Var. I needs a lot of bonding-material for sealing gaps and jags from rafter to rafter (most expensive). It will only succeed across small surfaces without collar beams, roof windows or dormers.
For this reason this is not a useful solution.

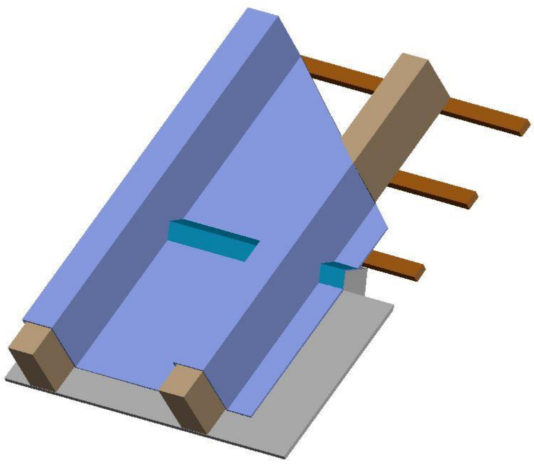


Figure 11: Var. II – Airtightness with sub-top implementation (Source: WTA, Airtightness of buildings)

Var. II solves this problem of sealing gaps and jags. The air barrier, installed on the bottom, runs by the rafter to the cold site covering the whole rafter und runs to the warm site to the bottom. In terms of building physics the layer must be a variable vapor retarder. This material becomes more permeable if there is a hight relative humidity around it. This characteristic is needed on the outside (cold side) of a construction. The same material reacts on the warm site (dry condition) like a vapor retarder.

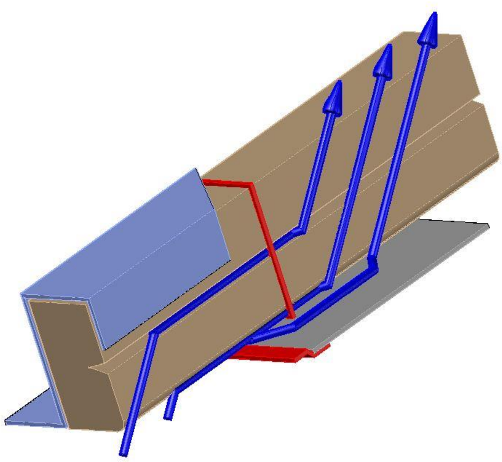


Figure 12: Gaps by alteration the airtightness with sub-top to a system of indoor airtightness. There are a lot of air paths (Source: WTA, Airtightness of buildings)

The “sub and top” system has three disadvantages:

- The bonding to roof-Windows is difficult
- The bonding and sealing to the eaves is difficult, because the rafters do penetrate the airtight layer
- The bonding and sealing by alteration to the inside airtightness (fig. 12)

Figure 13: Var. III Airtightlayer above the timber

A retaining ledge on the bottom of the rafter makes sure that the layer is fixed to the rafter and there are no gaps where warm air moves fast to the cold site of the timber.
Experience on the construction site has shown that there are considerable tricky situations in applying adhesives for this variant and that the success of sealing systems should not be taken for granted.
Var. II is possible with a modest roof area with few roof windows and dormers,

Figure 14: Var. III (left) and Var.II (right) on site. In Var.III the rafter space is already filled with insulation (cellulose-fiber)

Var. III uses this opportunity: In terms of building physics it is possible to separate airtightness-layer and vapor barrier. The old construction with plaster and wood-wool slab has the character of the vapor retarder und the new layer above rafter has the character of the airtightness layer.

Rafter heads have to be cut off in variants II and III, and the eaves and roof overhang have to be constructed new.

Figure 15: Var. III airtightlayer above the original rafters

Var. III is advantageous in all respects. Connections and folds are minimized.

Figure 16: Var.III the rafter space is quiet filled with insulation (cellulose-fibre) and now the timber cavity will be filled with cellulose fibre.

The airtight layer must be covered with an insulation material, so there will be no condensation if warm air circulation from the inside moves to this layer.

4 PLANNING AND INSTALLATION TIPS FOR DORMER

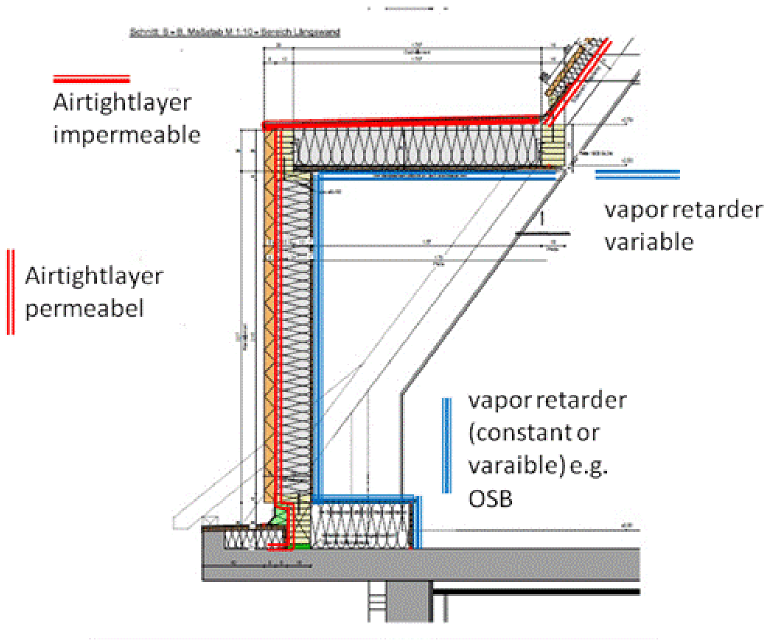


Figure 17: Horizontal section of a dormer, different kinds of vapor barriers are necessary

The new dormer elements (front, sides) also now have an airtight layer outside in accordance with the airtightness concept. It is covered with 8 cm wood fiber insulating board. Inside, the wall elements have a variable vapor retarder in the flat roof and an OSB panel, like those generally used in timber frame construction as a moderate vapor retarder in the wall.
The flat dormer roof has a impermeable airtight layer outside. In terms of building physics this construction is free of failure, if there is a variable vapor retarder inside and the roof gets solar heat in the summertime. The surface must be grey or of dark colour, a green roof can not be applied.

Figure 18: Connection of the dormer-base to the concrete Ceiling, different kinds of vapor barriers are necessary

The airtight layer must be sealed to the threshold and then to the concrete of the ceiling. To realize that, it is necessary to sweep and vacuum-clean the ground. A primer is needed when the surface is still draggled. If the surface is to rough it is necessary to smooth the surface with plaster.

5 QUALITY ASSURANCE

The success of adhesives and sealants largely depends on whether the people to use them are informed. In advance of plans to review the targets for the maximum air permeability value q_{50} must be provided to support quality assurance. After renovation, measurements can be taken to determine success.

WTA Workgroup 6.14 (Wissenschaftlich-Technische Arbeitsgemeinschaft für Denkmal-pflege und Bauwerkserhaltung e.V.) “Luftdichtheit im Bestand” (Airtightness of buildings) aims to work up measurement procedures, target values for air permeability and planning tips. These issues were studied in this project.

The existing envelope permeability is measured with a value q_{50} = 4,2 m³/hm².

The new airtightness specifications of the layer should go below the value q_{50} = 1,5 m³/hm².

Under the assumption that the air permeability with reference to the envelope's surface (q_{50}) of the existing structure is equally spread over the surface of the building envelope, we can generate a new value q_{50} by relating the reverence q_{50} (1,5 m³/hm²) to the new/renovated surface area to the surface area that has not been changed.

The new default values q_{50} for the whole building are calculated according to the following equation (1):

$$q50\ (requir.) = \frac{\text{q50 (existence)} \times \text{Area(existance)} + \text{q50 (new)} * \text{Area (new)}}{\text{Area (existance)} + \text{Area (new)}} \quad (1)$$

Figure 19: After renovation, 2011

After the completion of the reconstruction we measure a n_{50} of 1,5 1/h just reaching the target-setting. The high demands of Passivhouse-Standard with a q_{50} of 0.6 till 0.8 m³/hm² could not be achieved.

Here we see the limits of what can be done in current practice and on the other hand the need of quality control.

6 CONCLUSIONS

In the project the discussion with planners and craftsman has show us, that the success of adhesives and sealants largely depends on whether people are well informed. The knowledge

about which material is the airtight layer and which sealants are not tight helps construction workers a lot.
To inspire planners and craftsman it is of advantage that targets for the maximum air permeability value q50 are provided. After the renovation work has finished, measurements should be taken to determine successful airtightness.

7 ACKNOWLEDGEMENTS

This project has been realized in different workshops with the help of voluntary craftsmen and planners during 2006 until 2011 where we developed good practice solutions. Many thanks to all of you.

8 REFERENCES

WTA Guideline E-6-9 (2014). Airtightness of buildings, Part 1: General principles of planning; WTA Publications, email: wta@wta.de; (available in English 2015)
WTA Guideline E-6-10 (2014). Airtightness of buildings, Part 2: Planning details; WTA Publications, email: wta@wta.de; (available in English 2015)
WTA Guideline E-6-11 (2014). Airtightness of buildings, Part 3: Measuring procedure; WTA Publications, email: wta@wta.de; (available in English 2015)