Quality Assessment of Detail in Wooden House

Critical connection of the wall and the ceiling construction

Lucie Kucerova, Sarka Korbelova
VSB- Technical University of Ostrava
Faculty of Civil Engineering
Ostrava Poruba, Czech Republic
lucie.kucerova@vsb.cz, sarka.korbelova@vsb.cz

Abstract— **The development of thermal insulation materials that can be used in modern wooden houses noticed a large shift. But there are also some negative aspects which affect long-term quality of the thermal insulation properties. Influences as poor implementation or improper design are a problem that can be eliminated. But if there is a deterioration of the thermal properties due to these aspects, the problem arises that brings a financial burden of the buildings which is undesirable. The article points out the problems of critical places in the construction of the wooden house.**

Keywords— Wooden building; wooden house; condensation of water vapor; indoor surface temperature; ceiling construction.

I. Introduction

The construction details such as the bottom corner at the connection of the foundation and the external wall or corners at the level of spatial bracing are very risky in terms of the condensation of water vapor [4].They are also crucial for ensuring the mechanical resistance and stability of the entire building. The degradation of load bearing timber elements in these details which were caused by condensation of water vapor can cause serious structural defects [5].

II. Subscribtion of the Reference Wooden House

The selected wooden building is a family house located in the area of Bohemian Paradise. It is a two-storey building without basement with gabled roof. It is the passive house standard. The house was designed as a wooden building frame structure with walls which is designed as a diffusion-open. The entire structural system of the timber skeleton was made on site from dried lumber SM / JD humidity 12 ÷ 14% without impregnation.

Wooden wall frame consists of upper and lower corner which is connected to the vertical uprights. Such a frame is also used for the ceiling structure. External walls with a thickness of 450 mm are assembled from two separate coats with stacked panels of mineral wool boards. The inner shell is designed from the laminated gypsum board Fermacell 12.5 mm mounted on the grid with space for installation wiring. Vapor control layer of foil Jutafol N is set before the thermal insulating layer of mineral insulation Rockwool Airrock HD and thereby the penetration of excessive water vapor into the wall structure is prevented.

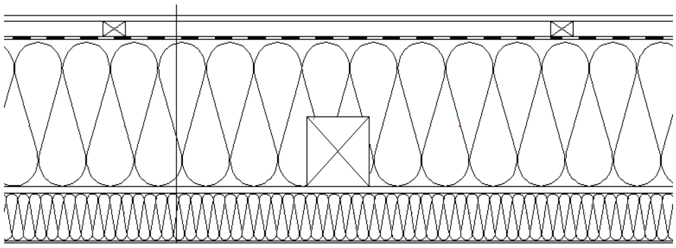

Fig. 1. The diffusion-open wall of the timber construction

Materials used in the wall of the wooden house:

- 12,5 mm Fermacell board
- 30 mm closed air gap
- 0,25 mm vapor control layer Jutafoln N 140
- 300 mm thermal insulation Rockwool airrock HD (wooden column 140/140 mm)
- 15 mm OSB board
- 95 mm thermal insulation Rockwool fasrock
- 5 mm silicate plaster

A second layer which is directed to the exterior and is exposed to weather conditions is dealt variously with thin-layer plaster and facade insulation Fasrock. Fig. 1 shows the wall of the wooden house which was the subject of research.

In detail at the level of the ceiling structure is necessary to ensure the quality of the insulation. At this point, there is a large load and the related potential problems settling upper jamb wood frame wall construction. Incorrect or improper implementation of structural details might make all efforts to achieve energy savings would be ineffective [3].

Warm air heating, ventilation, and cooling in the building provides two-zone system of heat recovery units Duplex RB connected to the natural circulation heat exchanger, and the distribution of warm air above the fireplace in the whole building.

This paper was supported by Student grant competition „SP2014/164-Thermal technical and humidity issue of wooden buildings with crawl space..

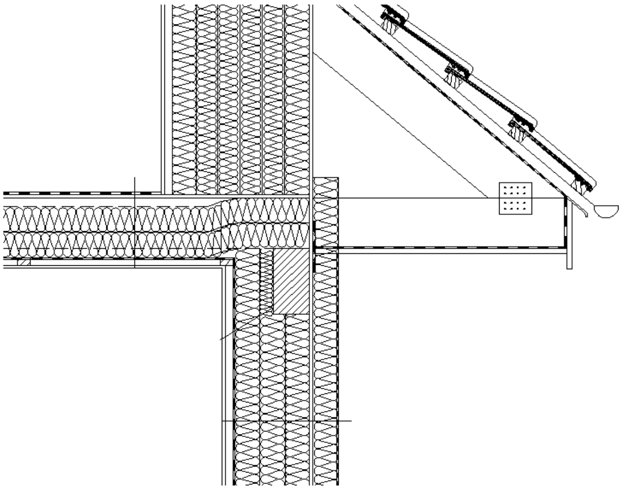

Fig. 2. The detail of the connection of the wall and the ceiling construction

Materials used in the wall of the wooden house:

- 12,5 mm Fermacell board
- 30 mm closed air gap
- 0,25 mm vapor control layer Jutafoln N 140
- 300 mm thermal insulation Rockwool airrock HD (wooden column 140/140 mm)
- 15 mm OSB board
- 95 mm thermal insulation Rockwool fasrock
- 5 mm silicate plaster

Materials used in the ceiling of the wooden house:

- 12,5 mm Fermacell board
- 30 mm closed air gap
- 0,25 mm vapor control layer Jutafoln N 140
- 200 mm thermal insulation Rockwool airrock HD
- 15 mm OSB board
- 0,25 mm vapor control layer Jutafoln N 140

III. Detail of the Timber House

A. *Connection of the wall and the ceiling construction.*

The condensation of water vapor and the temperature were determined by using the computer simulation (Fig. 2).

This construction is very well insulated and special attention was paid at the time of construction of construction details. A frame of the wooden house is made of laminated spruce and fir lumber. The strength of wood has a very close bond with moisture. It also depends on density, type of wood and the quality of used wood.

Moisture is the effect that acts on the strength properties and on the thermal insulation properties of materials as well. Internal condensation occurs when water vapor diffusion in a structure exceed the dew point temperature in that place [2].

For general terms, the requirement for the lowest indoor surface temperature determined by means of the temperature factor of the inner surface $f_{Rs\,i} \geq f_{Rsi,N}$ [1]

$$f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_{ai} - \theta_e}$$

Θ_{si} the lowest internal surface temperature in °C
Θ_{ai} design indoor air temperature in °C
Θ_e design outdoor air temperature in °C

Wooden buildings are inhomogeneous structures that conceal elements causing thermal bridges. These places are characterized by significantly higher heat flow which causes a lower surface temperature in that place.

The evaluation of temperature factor is very important because of the quality of internal environments of the building. In case, it would not meet the requirement of the temperature factor already during the design of the construction so the problem of mold at some critical locations could arise. Critical locations are corners of rooms at the floor or ceiling structure.

B. *Assessment of the actual condition*

Suitable thermal measurement period is in the event that the exterior temperature is several days under freezing, respectively, a difference of the exterior and interior temperatures of at least 15 K. It is suitable to perform the measurement in the morning and night- time because there was excluded the exposure to sunlight which has accumulated in the peripheral structures of the building.

During the measurement, the building was heated and the interior temperature was below freezing. Table I. shows the temperatures during measurement. On the thermal camera was set emissivity for wall construction, so when measuring wall with windows must consider the possible deviation of discoloration on the glass window.

TABLE I. THE TEMPERATURES DURING THE MEASUREMENT

	Value	**Unit**
Indoor air temperature	21,34	°C
The internal temperature of the wall	19	°C
Outdoor air temperature	-8	°C
Emissivity of the wall	0,96	-

C. *Assessment of the actual condition*

Suitable thermal measurement period is in the event that the exterior temperature is several days under freezing, respectively, a difference of the exterior and interior temperatures of at least 15 K. It is suitable to perform the measurement in the morning and night- time because there was excluded the exposure to sunlight which has accumulated in the peripheral structures of the building.

During the measurement the building was heated and the interior temperature was below freezing. Table I. shows the temperatures during measurement. On the thermal camera was set emissivity for wall construction, so when measuring wall with windows must consider the possible deviation of discoloration on the glass window.

Fig. 3 and 4 show that the model evaluation is very positive both in terms of temperature and humidity in the structure.

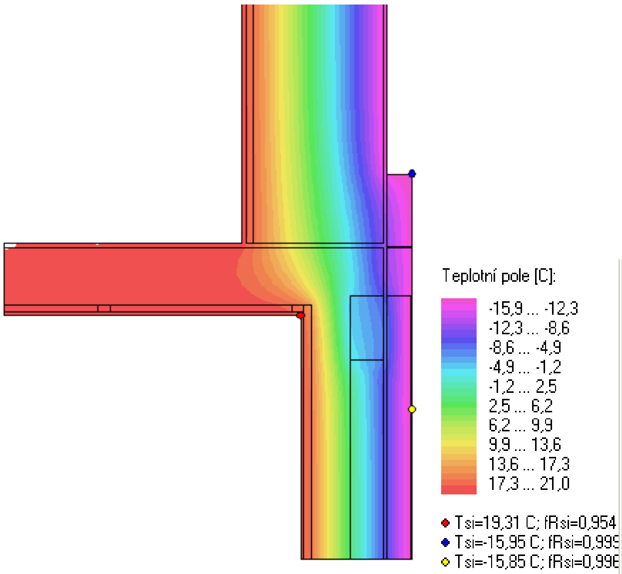

Fig. 3. The simulation of temperature in detail

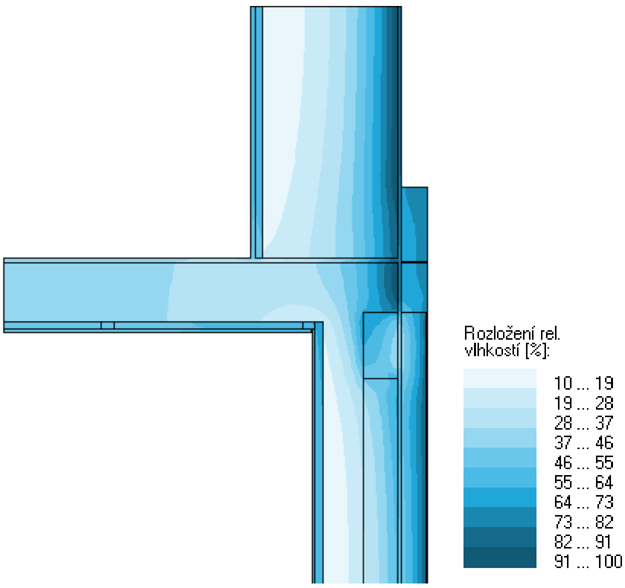

Fig. 4. The simulation of moisture process in detail

Within the evaluation of the structural condition, the thermography images were taken after five years of use of the building. Investigated detail was also checked if over the years has not changed its structural dimensions in terms of swelling and shrinking of the wood.

The changing of the temperatures in places of the ceiling structure is not detected in Fig. 5 (which shows the gable wall of the building). The wall has at its surface a low surface temperature. This indicates very good build quality of the structural detail at the level of the ceiling structure.

This Fig. 5 and 6 also show that the supporting structure, which is formed from glued beams KVH does not visibly change its shape after five years of using the building.

Thermal measurement shows minimum, maximum and average surface temperature in the demarcated boundaries in the picture.

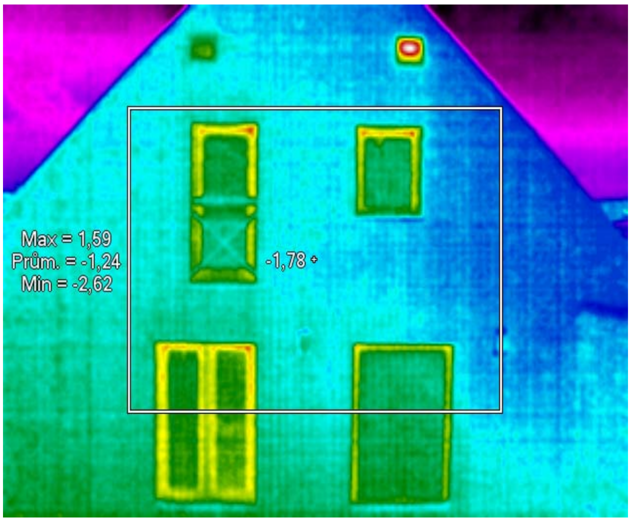

Fig. 5. Thermal measurement of the wooden house

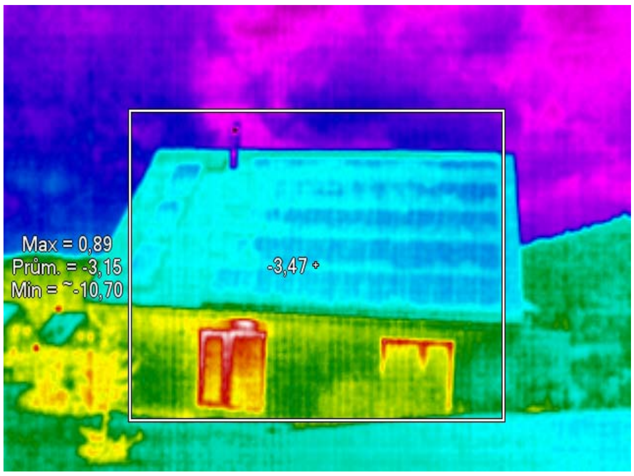

Fig. 6. Thermal measurement of the wooden house

IV. SUMMARY

In the case of construction of the wooden buildings designed as framed, there is great advantage of low consumption of timber. There were used glued beams KVH on the supporting frame. The KVH beams have very good mechanical properties and even over the years do not change the characteristics of the object (as demonstrated by thermography images). This finding also contributes the fact that the investigated place is provided with the sufficient thickness of insulation which is able to prevent any leaks. Overall, we can say that properly designed and subsequently constructed critical details lead to the energy savings.

REFERENCES

[1] CSN 13788 Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods. Praha: Cesky normalizacni institut, 2002.

[2] CSN 730540-2 Thermal protection of buildings - Part 2: Requirements. Praha: Cesky normalizacni institut, 2011.

[3] J. Chybik, Natural building materials, Grada, Praha, 2009.

[4] T. Jiri et al. “Airtightness and acoustic properties of family house from straw”, Adv. Mater. Res. vol. 860-863, pp. 1215-1218, 2013.

[5] J. Vaverka, Wooden houses for living. 1. ed., Grada, Praha, 2008.