Moisture and its condensation in external construction of wooden house

D Bladová¹, A Struhárová¹, M Kostelecká²

¹ Slovak University of Technology in Bratislava, Department of Material Engineering, Slovak Republic
² Czech Technical University in Prague, Klokner Institute, Czech Republic

E-mail: diana.bladova@stuba.sk

Abstract. This work is focused on the assessment of moisture condensation in different external constructions of wooden house. The studied wooden construction is constructed from 3 different external wall compositions. There were sensors measuring relative humidity within the external constructions. Meanwhile, external and internal conditions were measured. These conditions and composition of external constructions were used in Teplo 2017 software to assess the moisture condensation. In this work, the influence of the imperfect realization of the vapor barrier on the moisture in external constructions is also theoretically evaluated.

1. Introduction

Wood as construction material was very popular in the past. In the building industry, it fulfilled many functions from load-bearing (e.g. cottages) to decorative. Wood was gradually replaced by reinforced concrete after the beginning of the industrial revolution. Today, wood is getting back to its place in people's minds and is used in construction of modern wooden houses. The return to traditions or mature is not the only reason why people opt for the wooden houses. Main reasons for that are the fulfilment of much stricter energy requirements for reasonable price and larger floor area due to smaller thickness of external walls. Some also like the fact the wooden houses are mostly build from environment friendly materials that cause lesser ballast to the nature or have less complicated production and transport.

There are two possible external wall compositions. First is diffuse open and it is more preferable from the health aspect, because the house “breaths” through it. Materials allow water vapour transmission and at the same time make the construction airtight. Diffusion resistance of individual layers decreases towards the exterior so that vapour can be released from the structure. Permeable ecological insulation is the most used in this composition. Second is diffuse closed composition. This composition differs from the open one by a vapour barrier. This barrier inhibits water vapour transmission. Barrier tightness is secured by a proper execution without any gaps. It is a material with high diffuse resistance and installation fore-wall is in front of it to prevent it from damage [1].

Possible water vapor condensation within the construction has to be taken into consideration during design and execution. It is an unwanted phenomenon that appears when the partial pressure of water vapor is higher than the partial pressure of saturated water vapor at certain point within the construction [2]. Condensation can influence the functionality, durability and degradation of
construction materials. Their thermo-insulating and mechanical characteristics are getting worse. It also leads to mould formation and loss of integrity of the structure due to canker [3].

2. Methods

2.1 Object description
Measured object is a prefabricated wooden house showed on figure 1. It is placed in Dubňany on the east of Czechia. The gross floor area is 148 m² and gross building volume is 645 m³. The house meets the requirements for energy passive construction. It uses the technologies such as recuperation, wall cooling and solar panels.

The object consists of underground floor, floor and residential attic. The technical building equipment is situated in the underground floor. There are 2 types of external constructions. Diffuse open construction is located on the east and south side and diffuse closed construction is located on the north and west side.

![Figure 1. Object ground plan with sensor placement.](image)

2.2 Specifically used compositions of external constructions
From inside out, each composition of external constructions consists of: silicone plaster, adhesive reinforced with glass mesh, fibreboard insulation, column construction from STEICO wall I profiles filled with fibreboard insulation, oriented strand boards OSB 3, adhesive tape/vapor barrier/permeable barrier, installation fore-wall with wooden grate construction and plasterboard. Composition of external walls is always same except from one layer placed on the OSB. It is the adhesive tape, vapor barrier or permeable barrier. Changing this layer makes individual compositions diffuse open or diffuse closed.

2.2.1 External construction Nr.1.
This is a diffuse open construction. The OSB joints are taped over with AIRSTOP FLEX 50mm wide. It is situated in the east side of the object. Measuring sensor Nr. 1 is placed here. Its complete composition can be seen in the figure 2.
2.2.2 External construction Nr.2
This is a diffuse open construction. Instead of adhesive tape the ISOCELL permeable fibre-reinforced barrier with diffuse resistance 9090 is applied. It is situated on the south side of the object. Measuring sensor Nr. 2 is placed here.

2.2.3 External construction Nr.3.
This is a diffuse closed construction due to vapor barrier, specifically Guttafol WB foil with diffuse resistance 210 154. It is situated on the north and west side of the object. Measuring sensors Nr. 3 and 4 are placed here. Sensor Nr. 3 is on the west side and sensor Nr. 4 is on the north side.

2.3 Measuring
During the measurement, the parameters such as temperature and relative air humidity of the external and internal environment were measured. The measurements took place every 27 minutes and they were done by the resistive measuring sensors WS-16 by Elbez which were installed in the external walls.

The company Úsporné bydlení Ltd. provided us with the measurements from July 2017 – March 2018. To evaluate the occurrence of condensation we have chosen the measurements from March 2018. After the measurement analysis, it was obvious that the lowest exterior temperature was reached in this month. Therefore we chose those.

Measurements were evaluated in the Teplo 2017 program. Teplo 2017 is program that serves to assess the compositions of building structures in terms of heat and water vapor distribution. The compositions of external constructions and conditions mentioned in table 1 were imported to the program. We also used the supplied data and diffuse resistance factor of vapor/permeable barrier to determine the amount of relative humidity in the structure when the barrier was improperly executed.

3. Results and analysis
In table 1, the measured humidity and temperature values of the exterior and interior are shown, as well as the relative humidity values measured by the sensors placed in the external walls of the house in the time of lowest exterior temperatures in March 2018.
Table 1. Measured humidity and temperature values in March 2018.

| March 2018 | Temperature external | Temperature internal | Humidity external | Humidity internal | Humidity – sensor [%] |
|------------|----------------------|----------------------|------------------|------------------|----------------------|
| -10.9 °C   | 23.0 °C              | 29.7 %               | 30.0 %           | 3.1              | 4.0                  | 6.9                  | 7.8                  |

3.1 Evaluation of condensation occurrence inside external walls
Condensation inside external walls occurs when the partial pressure of water vapor (pink line) is higher than the partial pressure of saturated water vapor (red line) at certain point within the construction.

3.1.1 External construction Nr.1.
Measuring sensor Nr. 1 is placed here. According to results from Teplo 2017 program (figure 3), water vapour condensation does not occur in the external construction Nr.1 with adhesive tape on the OSB (diffuse open construction).

![Figure 3. Condensation evaluation of external sheet Nr. 1.](image)

3.1.2 External construction Nr.2.
Measuring sensor Nr. 2 is placed here. According to results from Teplo 2017 program (figure 4), water vapour condensation does not occur in the external construction Nr. 2 with the ISOCELL permeable fibre-reinforced barrier (diffuse open external construction).

![Figure 4. Condensation evaluation of external sheet Nr. 2.](image)
3.1.3 External construction Nr. 3.
Measuring sensor Nr. 3 and 4 are placed here. For the evaluation we used humidity measured by the sensor Nr. 4 as it recorded higher humidity on the north side. According to results from Teplo 2017 program (figure 5), water vapor condensation does not occur in the external construction Nr. 3 with Guttafol WB foil (diffuse closed external construction).

![Figure 5. Condensation evaluation of external sheet Nr. 3.](image)

3.2 Evaluation of the influence of an improper execution of vapour barrier
In the figure 6, the influence of improper execution of vapor/permeable barrier on the relative humidity in the external construction is shown. The ISOCEL permeable fibre-reinforced barrier that is in the external construction Nr. 2 was used for this analysis. This particular barrier has a diffuse resistance of 6902 and the proper execution causes the relative humidity of 7.3% at the measured point in the external sheath. If the barrier is damaged or is executed improperly, the relative humidity rises up to 10.06%. Not using the barrier at all, the relative humidity in the construction is 12.84% which is the value calculated in the external sheath Nr. 1.

![Figure 6. Evaluation of improper execution of vapour barrier.](image)
4. Conclusion

The aim of this work is to evaluate various types of external constructions concerning the water vapor condensation within it. Evaluation was processed by Teplo 2017 program. All external wall compositions have proved up to the standards. Which means there is no water vapor condensation inside construction. That is why we consider the result positive.

For the future we would recommend installing 2 more sensors than are installed now. Specifically, one in the air layer resp. installation fore-wall, and one closer to the exterior. More sensors would significantly help in better analysis of water vapor transmission through construction.

In conclusion, we can state the wooden houses are very convenient alternative of traditional-build houses concerning the environmental impact, construction time, space options, costs and all-year-round construction possibilities.

Acknowledgments

This article was created with the support of the Ministry of Education, Science, Research and Sport of the Slovak Republic within the Research and Development Operational Programme for the project "University Science Park of STU Bratislava", ITMS 26240220084, co-funded by the European Regional Development Fund.

References

[1] Anderson L 2002 Wood Frame House Construction (The Minerva Group)
[2] Halahyja M, Chmúrny I and Sternová Z 1998 Building thermal technology (Bratislava: JAGA GROUP)
[3] Katunský D 2017 Building physics Lecture (Košice: TUKE)
[4] Kandráč P 2015 Thermodynamics of the atmosphere. Air humidity Lecture (Košice: TUKE)
[5] Kantor P 2012 Chemical composition of wood Lecture (Brno: MENDLU)
[6] Makoviny I 1995 Measurement of wood moisture (Zvolen: TUZVO)
[7] Reinprecht L 2008 Wood protection (Zvolen: TUZVO)
[8] Nagy E 2009 Low energy and passive house (Bratislava: JAGA GROUP)
[9] Roberts N 1981 How to build your own wood-frame house from scratch (Tab Books)