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Physico-technical measurement of green roof in climate chamber module

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Abstract

Not for nothing it is said that "a good roof is priceless." Although it may lead to discussions, which roof is good, because there are a lot of requirements and criteria for the functional characterization. It must be understood that the roof structure defines the durability of the building as a unit, therefore it defines lifetime of other parts of the building and also the function of space that is covered by the roof. Therefore it is very important to pay particular attention to the design, as well as the realization of the roof structure. The aim of this publication is to judge the physical and technical parameters in the design of the roof coating module in a climatic chamber.

Key words: glass systems, buildings materials, roof in situ measurements, laboratory measurements, building envelope.

1 Implementation panel in Test chambers

Presented article is treated in two parts. First part of measurements consisted of roof structure measurement in climate chamber, where the only one difference in roof structure was in adding of vapor barrier on the part of roof structure S2. These results were evaluated and after their investigation we conclude estimation, that roof structure must be modernized due to the fact, that in summer time the temperatures on waterproofing layer were high. Modernisation of roof structure was mounting by module of green roof layer on roof structure S2 (Figure 1). By this module of roof structure we want to achieved elimination of increased surface temperature on waterproofing layer in summer time, which is listed in second part of this article. Test chambers measure 4200 x 2440 x 2830 (mm) and include exposed interfaces for installing material samples and structural elements. The other walls, floor and ceiling are insulated with polyurethane insulation with a thickness of 150 (mm). The thermal resistance of these structures measures U = 0,3 W/(m^2.K). Samples subjected to monitoring of selected physical properties are embedded in the open interface of the climate chambers. The experimental chambers are differentiated by the cardinal orientation of the openings which

allow the performance of the building envelope to be monitored from a north and south orientation respectively.
chamber No.1 and 2 are identical in construction but differ in the orientation of the monitored panels - specifically for comparing physical properties when exposed to the north, and south chamber No.3 and roof module No.1 are orientated due south. Fenestration systems (windows) are installed in elements of the envelope construction [1].

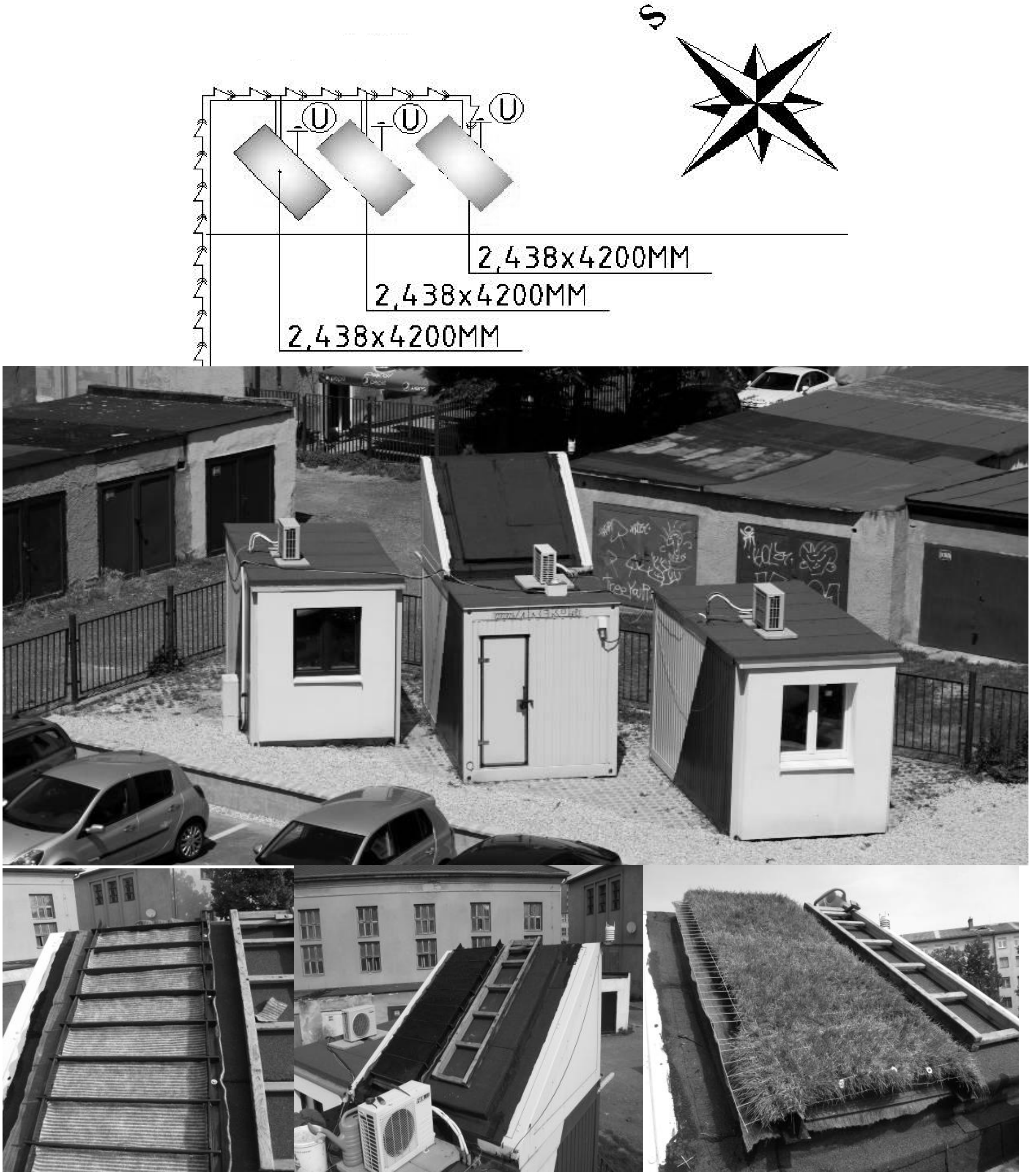
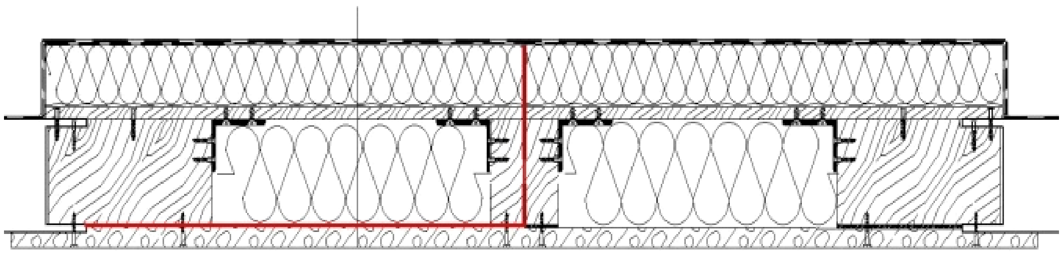


Figure 1: Situation of test chambers measure

2 Preparation and production of measuring samples of roof cladding

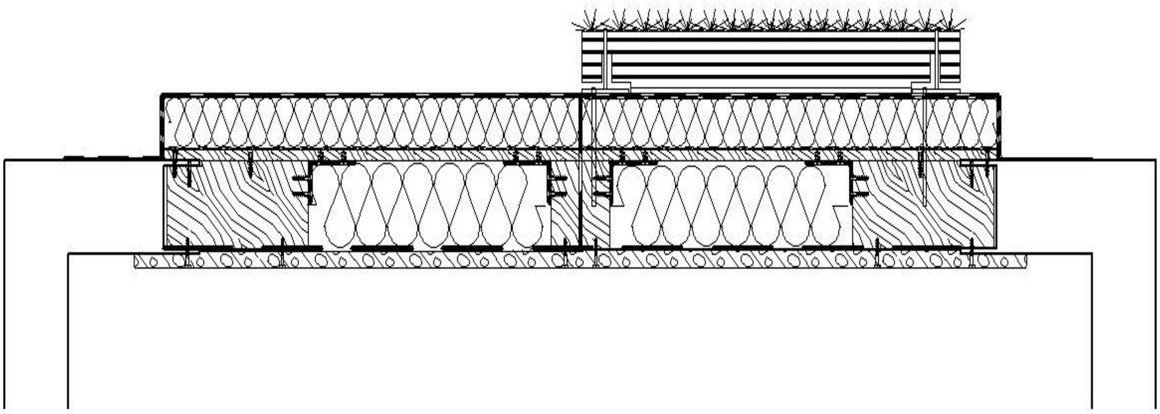
The configuration of the roof skin was the result of a detailed analysis featured in. Because the roof model, measuring 1700 (mm) x 2200 (mm) lacked a Centre support, 2 pieces of identical roof panels had to overlap the module so as to create two distinct parts. The structure of the two roof elements differs. The left side of the module is equipped with thermal insulation manufactured by NOBASIL with a vapour barrier from JUTAFOL N; the drywall ceiling is anchored to the support above using a "U" profile. The left side is equipped with NOBASIL 125 (mm) thermal insulation, but excludes a vapour barrier while the drywall ceiling is similarly anchored as the one on the right side. Surface ceiling is left without finishing treatment. The roof module with dimensions of 1700 (mm) x 2200 (mm) was supported and separated by a 125 (mm) x 125 (mm) wooden beam with known thermo-technical properties.
While the left half of the module up to centre beam axis contained JUTAFOL N the right half deliberately had the vapour barrier omitted. Sample roof deck above the rafters will be the same the two halves of the roof module was made and then fitted into the roof module and will consist of the following compositions: OSB with increased load thickness of 15 (mm) is attached to the top of the rafter. As second layer Prominent layer is anchoring / with micro-ventilation for polyurethane insulation /. As the end of the bottom and the top is used metal edging / made on the site of galvanized sheet hr.2 (mm) / Attached to the OSB and then affixed anchoring layer Prominent. The following panel is modified by a gas burner Snapping insulation Thermobase / polyurethane thermal insulation the top layer of cardboard / thickness 80 (mm). So manufactured roof panels were fitted into the roof module. As last layer is applied bitumen from the company board index mineral thickness of 4.5 (mm) brown colour overlay to the overall roof structure [1]. After the evaluation of testing measurements in winter and summer season described and evaluated in the dissertation thesis, it has to be taken in account, if it is possible to modernize the roof deck, alternatively improve its thermal properties. After analysis, we have reached the decision that addition of vapor barrier to the roof structure S2 is necessary and for improving thermal features, it would be possible to add on the roof deck green roof layers/ Fig. 3 /.



bitumen belts with upper spread	4,5 (mm)
thermobase thermal insulation with overpoled belt	80 (mm)
prominent anchoring system with microventilation	4 (mm)

OSB board, laquered	15 (mm)
wood beam	125 (mm)
thermal insulation Nobasil	125 (mm)
vapour barrier Jutafol	1 (mm)
plasterboard lowe ceiling	12,5 (mm)

Fig. 2: Previous roof layers composition



soil, thermal insulation along the edges	80 (mm)
drainage layer	
bitumen belts with upper spread	4,5 (mm)
thermobase thermal insulation with overpoled belt	80 (mm)
prominent anchoring system with microventilation	4 (mm)
OSB board, laquered	15 (mm)
wood beam	125 (mm)
thermal insulation Nobasil	125 (mm)
vapour barrier Jutafol	1 (mm)
plasterboard lowe ceiling	12,5 (mm)

Fig. 3: Current roof layers composition

3 Distribution and type of sensor in the test sample roof cover.

The construction in the roof research module was divided into construction S1 and construction S2. S1 contains a vapour barrier JUTAFOL N in contrast to S2 which is illustrated in Fig.1 Sensors in the roof construction sample were positioned in individual layers of the roof element, mirroring each other at 300 (mm) from the centre line defined by a load bearing beam. The first temperature sensor was mounted closest to the exterior underneath the bitumen layer of S1 A37 as with S2 sensor A3.8. the second layer of the roof cover consists of thermal insulation (polyurethane) with a sensor A3.9 and A3.10 placed in the centre line of the insulation i.e. 40 (mm). The third layer of the roof cover consists of a connection layer which placed on OSB particle board. They house sensors A3.11 and

A3.12.Sensors A3.7, A3.8, A3.9, A3.10, A3.11 and A3.12 are temperature sensors based on the resistance without a tip with capabilities from -50 to +125 (°C). Internal insulation consists of mineral wool 125(mm) thick where a sensor I1/6 was placed at its centre which mirrors v I1/2. These sensors measure air temperature, relative humidity, dew point and absolute humidity. Finally sensors are D1/13 and D1/14. They were positioned on the internal drywall on the interior surface. This sensor measures the surface temperature at two points.The structure S2 / green roof construction / was mounted sensor surface temperature directly below the vegetation mat D1 / 41 [2].

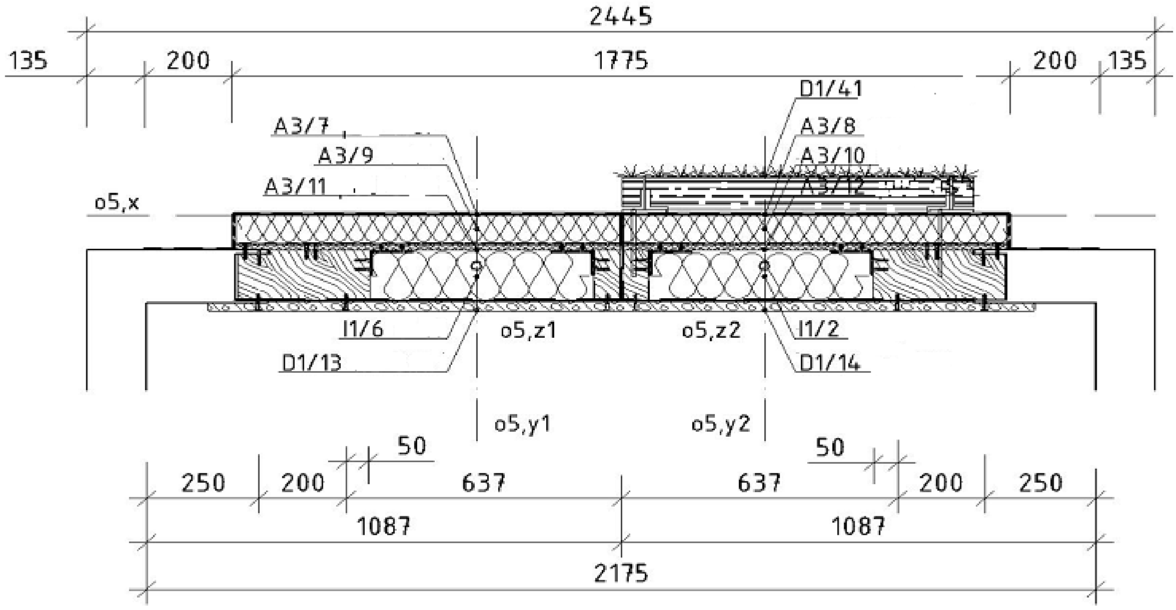


Fig. 4: Deployment of sensors

Measured parameters are outside and inside air temperature and relative humidity, temperature and relative humidity inside the structure, surface temperature and heat flux. For those purposes is used temperature sensors based on resistance without nib, type NTC and NiCr. Weather station measures wind direction, average and maximum wind speed, atmospheric pressure, air temperature and relative humidity, rainfall and we also monitor global radiation by Pyranometer [3,4].

4 Measurement results of the climatic chamber module

All measured data of a test roof module except for data obtained by the meteorological station were recorded in one minute intervals over duration of four winter months at the Civil Engineering Faculty of The Technical University of Kosice. The Meteorological station fixed to the given module of the climatic chamber supplied real time data regarding the outside air temperature, wind speed and the duration and intensity of global solar radiation. Values of outside air temperature used in this work were obtained from meteorological station sensors. Licensed software was used to process data. In order to improve visibility and reduce overlapping of individual curves in charts a maximum of three sensor readings were used in graph.

- *Measurement of heat transfer coefficient "U" of roof structure*

Winter pre-test measurements of heat insulation properties and structures factors were the subject of the tests. The first measurements involved the heat transfer coefficient structure (U-value). These measurements were made with a measuring device Testo 635 with the probe to determine the U-value (heat transfer coefficient) and then compared with the calculation. A total of 6 measurements were made with 4 measurements made every 15 minutes, and two measurements at 60 minute intervals, all conducted under different ambient temperatures, (the difference of internal and external temperatures was a min. 20°C). Table 1 lists the measured values compared to calculated values.

Table 1: Comparison of calculated and measured values of heat transfer coefficient roof S2

Measurement		Calculated value
1	0,178 W/(m^{2}K)	0,17 W/(m^{2}K)
2	0,179 W/(m^{2}K)	
3	0,180 W/(m^{2}K)	
4	0,182 W/(m^{2}K)	
5	0,180 W/(m^{2}K)	
6	0,182 W/(m^{2}K)	
($\bar{x}$)	0,180 W/(m^{2}K)	0,17 W/(m^{2}K)

Table 2: Comparison of calculated and measured values of heat transfer coefficient roof S1

Measurement		Calculated value
1	0,158 W/(m^{2}K)	0,14 W/(m^{2}K)
2	0,147 W/(m^{2}K)	
3	0,155 W/(m^{2}K)	
4	0,160 W/(m^{2}K)	
5	0,165 W/(m^{2}K)	

6	0,167 W/(m^{2}K)	
($\bar{x}$)	0,158 W/(m^{2}K)	0,14 W/(m^{2}K)

5 Conclusion

Measured sample roof coating structures S1 and S2 in the climatic chamber module is no sign of improper design, non-working practices in the construction and the measurement itself has taken place in compliance with all procedures specified by the manufacturer and this it can be concluded that the difference in measured and calculated values of heat transfer coefficient is 0,0105 W/(m^{2}K) S2 and 0,018 W/(m^{2}K) S1. This difference may arise:

- measuring device Testo 365 is measured with an accuracy of ± 0,005 W/(m^{2}K),
- measuring probe for measuring the heat transfer coefficient with an accuracy of ± 0,003 W/(m^{2}K),
- in the actual values averaged values were calculated to three digits after the point (0,000).

Roof construction S1 and S2 shows almost identical data in the calculated value of heat transfer coefficient and the actual measured value of heat transfer coefficient structure.

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