Thermography of the extensive green roof of multifunctional building Brno

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Abstract. The article describes the state of the extensive green roof in winter. It deals with heat transmission on a vegetated roof with a vegetation layer thickness of up to 10 cm. The case study describes the condition of the green roof, which was implemented a year ago on a multi-functional building on Bratislavská Street in Brno. A pre-grown vegetation carpet on a coir mat was installed on the roof. A control segment of the vegetation roof is installed in the roof structure, the influence of which was also monitored as part of the preparation of the article. The article follows the control measurement of humidity in a green roof and the investigation of the influence of the vegetation composition on the thermal-technical properties of the roof.

1 Introduction

The aim of this article was to follow the thermophysical processes on the extensive green roof of a multifunctional building in Brno, which was functional in 2022. The roof underwent a partial reconstruction with the addition of layers of compositions, the restoration of greenery and the modernization of edge structures with the addition of edge aggregates. The entire revitalization was monitored and analyzed using a time-lapse video, and an implementation schedule was created with possible optimization alternatives.

The structure was measured in the early hours of the morning, when the air temperature was below freezing (-2° C). The images were partly distorted by the action of sunlight, but the detailed shots of the individual structures tell everything about the thermophysical processes on the building's green roof.

The detection of thermophysical phenomena on the extensive green roof follows on from the recent installation of a control segment of the green roof, from which data on the saturation of the roof composition is regularly collected. It is determined here what humidity conditions occur in the composition depending on the amount of precipitation and the time of year. The entire measurement should serve as the output of the scientific works of the authors of this article.

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2 Extensive green roof

The essence of an extensive green roof is vegetation with a maximum degree of self-regulation, capable of maintaining adequate quality without regular watering and with only minimal human care (usually 1 to 2 times a year inspection, removal of unwanted vegetation, fertilization according to the type of substrate and development stage of the growth). The selection of plant species used must be adapted to the habitat conditions as much as possible.

The vegetation of extensive green roofs consists of plants with a high regenerative capacity and able to adapt to the extreme conditions of the habitat. The plants must be sufficiently competitive in the given conditions to suppress the development of unwanted plants. The vegetation of the extensive roof consists of vegetation with a predictable successional development, which may also include spontaneous settlement by other species not used during the implementation.

The thickness of the vegetation layer of extensive green roofs is usually in the range of 60-150 mm. For appropriately selected types of succulents, a layer thickness of only 40 mm (or less) may be sufficient, on the other hand, for steppe herbaceous vegetation types, a layer thickness of up to 200 mm can be used. Extensive green roofs are usually non-walkable, i.e. access to areas with vegetation is only allowed to trained persons for inspection and technical maintenance [1].

Fig. 1. Researched extensive green roof. [author]

2.1 Heat island of the city

In cities, often used surfaces are concrete, asphalt, metal materials and glass. The ambient temperature is influenced not only by the type of material, but also by its darkness and structure. The dark colour of the material has a greater ability to absorb heat energy and subsequently radiate heat. Metal materials, which have an increased ability to accumulate heat, which subsequently radiate, behave similarly.

Human activity also contributes to the warming of cities. Buildings radiate heat from air conditioning and heating facilities. Transport and industry also produce thermal energy. Cars not only emit heat, but also emit large amounts of exhaust gases.

All plants have the ability to transpire, thanks to which they bring moisture from the soil into the air. Even water that sticks to the surface of leaves from rainfall or water in dew drops is later evaporated into the atmosphere.

Vegetation also has a significant effect on vertical air flow. During the day, plants create cooler air in their surroundings, which sinks to the ground and pushes the warm air to the sides. At night, this phenomenon is reversed. This flow ensures air exchange. [2]

Heat islands are urbanized areas that experience higher temperatures than outlying areas. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures relative to outlying areas. Daytime temperatures in urban areas are about 1–7° F higher than temperatures in outlying areas and night-time temperatures are about 2-5° F higher. [3]

Fig. 2. Researched extensive green roof. [author]

2.2 Used pre-grown vegetation mat

During the reconstruction of the green roof, a new substrate was introduced and a new pre-grown vegetation mat was placed on top of it. The mat was transported using a truck crane on pallets. The mat was grown on coconut fibers.

The pre-grown vegetation mat on an extruding coir carrier interwoven with polypropylene (PP) mesh is intended primarily for flat vegetation roofs. The mats contain a layer of substrate in which a mixture of several species of the Sedum genus are rooted. [4]

The pre-grown mat contains 5-8 species of plants from: Sedum Album, Sedum Album Coral Carpet, Sedum Sexangulare, Sedum Hispanicum Minus, Sedum Lydium, Sedum Lydium Glauca, Sedum Acre, Sedum Refl exum, Sedum Refl exum Angelina, Sedum Spurium Fuldagut, Sedum Hybridum Immergrunchen. [4]

3 Measurement

3.1 Measurement Details

The measurement took place from 7:00 a.m. to 7:30 a.m. The outside temperature stabilized at -1° C at the time of measurement. This time was chosen due to minimal ambient thermal noise and to achieve the highest difference between interior and exterior temperatures. At this time, the building's air conditioning system was also in operation. Changes were therefore visible on the vent of the air conditioning system and other shafts.

3.2 Measurement Progress

3.2.1 Temperature analysis

Fig. 3. Thermovision of eaves sidewalk. [author]

In the picture above Fig. 3, it is possible to see the temperature differences between the vegetation layer and the layer of river aggregates that make up the eaves pavement. The temperature differences here were in the order of °C units. It can be said that a material such as aggregate accumulates temperature longer and it takes longer for a master material with a higher volumetric weight to heat up than it does for vegetation.

In the picture we can also see the big temperature difference between the aluminium profiles that separate the aggregate and the vegetation. These profiles have a significantly lower temperature in the morning and much higher again at the end of the day. Unlike other materials, however, aluminium profiles cannot maintain their temperature for a long time, which is why the temperature fluctuations of metal materials are so different.

Of course, large temperature differences must be evident in the shafts and ventilations Fig. 4, which are in operation during the winter and can be clearly seen on thermal imaging images.

Fig. 4. Thermovision of air-condition shafts. [author]

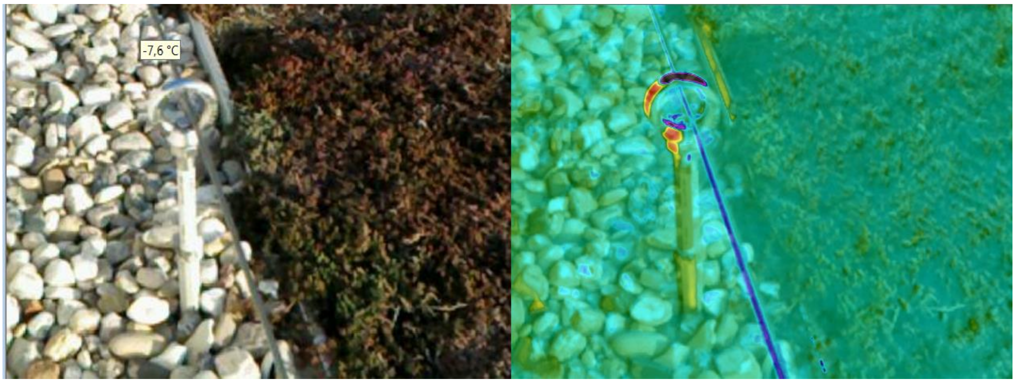

Fig. 5. Thermovision of the safety anchor system. [author]

Fig. 6. Thermovision of the roof drain. [author]

As part of the thermophysical phenomena on the layers of the green roof, the influence of the implementation of the control segment in the green roof, which was additionally implemented in the structure, was also investigated. The segment used to measure moisture in the structure, even if it is made of thermally conductive material, after being inserted into the layers of the roof, is not as clearly visible on thermal images as other metal materials. During the implementation, due to the fear of the investor, there was uncertainty as to whether the segment would have a negative effect on the thermal technical properties of the roof. However, we can rule this out based on the values found.

Fig. 7. Thermovision of the control segment. [author]

The only significant surface temperature changes were noticeable on the construction of the steel segment mounts Fig. 7, which are raised from the structure for easier segment mounting.

3.2.2 Measuring equipment

A Fluke Ti450 thermal camera was used to measure the structure.

Fig. 8. Thermal camera [5].

4 Conclusion

The conclusion of the investigation of the thermophysical phenomena of an extensive green roof on a multifunctional building in Brno-Bratislavska is the finding that the vegetated surface of the roof in winter better thermally insulates the roof structure than it would be the case with constructions made of PVC or other artificial coverings. Apart from the construction of shafts or ventilation ducts, the construction of the roof was without major thermal and technical fluctuations. The control segment of the green roof did not have a negative effect on the thermal-technical properties of the roof, even though the material of the structure is steel. In the case of investigating thermophysical processes in the summer months, we could also consider a greater influence of vegetation, which is more diverse in vegetation in these periods.

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