Condition of the extensive green roof of the Brno-Komín Kindergarten in winter 2 years after implementation

Jan Jilek[1*], *Ondrej* Porwisz[1], and *Martin* Mohapl[1]

[1]BUT, Faculty of civil engineering, Veveri 95, 602 00 Brno, Czech Republic

Abstract. The article describes the state of the vegetation layer of the extensive green roof on the kindergarten building in Brno-Komín. Due to the low temperatures, some plants are in a vegetative rest. On the contrary, some resistant plants are in good vegetative state even during adverse climatic conditions. The green roof was implemented in 2021 and as vegetation a pre-grown vegetation carpet was used, which was grown and transported on a coconut mat.

1 Introduction

The article discusses the state of the extensive green roof during the period of vegetation dormancy. The roof was implemented in 2021 and since then the vegetation has already gone through the vegetation cycle and after 2 years we can see the visual result of the implementation company's work on the structure. In the pictures we can see the differences in the amount of vegetation that was green in its entire area after laying the carpet and in the vegetation boom phase (Fig.1).

Fig. 1. Extensive green roof.

* Corresponding author: jan.jilek93@seznam.cz

1.1 Extensive green roof

The essence of an extensive green roof is vegetation with a maximum degree of self-regulation, capable of maintaining an adequate quality without regular watering and with only minimal human care (usually 1 to 2 times a year inspection, removal of unwanted vegetation, fertilization depending on the type of substrate and development phase 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 chosen 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].

1.2 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].

2 Reconstruction of the green roof of the Brno-Komín kindergarten

The reconstruction of the green roof at the kindergarten in Brno took place in May 2021. It was an addition to the original roof structure, which was covered with PVC foil. A nop film with a laminated geotextile was placed on the structure, then a hydroaccumulation layer, aggregates and finally a substratum, on which a pre-grown vegetation carpet was placed in the last phase. Photos from the implementation are inserted into the texts on how the implementation went on the timeline (Fig.2, Fig.3, Fig.4, Fig. 5).

Fig. 2. Waterproofing control.

Before actually laying the roof structure, it was necessary to check the existing waterproofing (Fig.2). A number of control measurements were performed. One of the tests was a spark test, which locates capillary leaks in the waterproofing. A few minor bugs were found and fixed. To prevent rainwater from entering the structure.

Fig. 3. Placement of geotextile and nop film.

When laying the geotextile, there was a problem with strong wind, and therefore it was necessary to gradually load the geotextile with rolls of nop film and bales with hydroaccumulation plates (Fig.3).

Fig. 4. Hydroaccumulation and gravel placement.

As part of depositing the substrate and gravel, aluminum perimeter profiles were also placed, which separated the substrate from the aggregate around the perimeter of the roof and also in the areas where the ventilation shafts and ventilation ducts penetrate.

Fig. 5. Substrate and green vegetation carpet placement.

During the implementation, a mobile truck crane was used to transport materials to the roof of the building. A loose mixture pump was used to deposit the substrate, because manual spreading would be time-consuming on a roof area that exceeded 700m^2.

The implementation itself did not take more than a week. Workers worked systematically in work squads.

The completion of the roof was prevented only by an insufficiently blooming vegetation carpet, which was supposed to be supplied by a Czech company, but in the end was imported from southern Europe where the climate in May was warmer than in the Czech Republic.

The resulting appearance of the roof can be seen in Fig. 1 at the beginning of the article. The vegetation layer looks intact and the roof makes a beautiful impression.

2.1 Used pre-grown vegetation carpet type TR K 20

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 [3].

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 [3].

3 Condition of the roof and vegetation after 2 years

Since its implementation, a number of work activities have been taking place on the green roof of the kindergarten. First, the roof ridge was repaired, the wiring was repaired and the control segment of the green roof was installed 1 year after reconstruction.

Fig. 6. Control segment installation.

During continuous inspections during the year, differences in the density of vegetation can be seen on the roof. The conditions for the vegetation on the green roof are different throughout the year, because the roof is not artificially irrigated, but only uses rainwater.

So we can see in Figure 7 that in the dry season in July 2022 the roof was less green and the density was lower than when the first image was taken.

Fig. 7. Green roof in 07/2022.

The next imaging took place 3 months later in October 2022 (Fig.8). In the photos we can again see the reduction of the green area of the roof and small areas without vegetation. It can therefore be said that the appearance of the extensive green roof exactly copies the seasons and the dependence of the state of the vegetation.

Fig. 8. Green roof in 10/2022.

4 Thermal imaging and dormant season

One of the last imaging took place at the beginning of 2023. It was imaged with a thermal imaging device. The condition of the vegetation is recorded in detailed photos and we can see in them that the vegetation is dampened by the frost and especially very resistant plants and weeds are doing well.

Fig. 9. Green roof in 02/2023.

Green areas are mainly made up of mosses, which are well resistant to very low temperatures. Higher temperatures on the roof can only be measured on the ventilation openings and air conditioning chimneys (Fig.10).

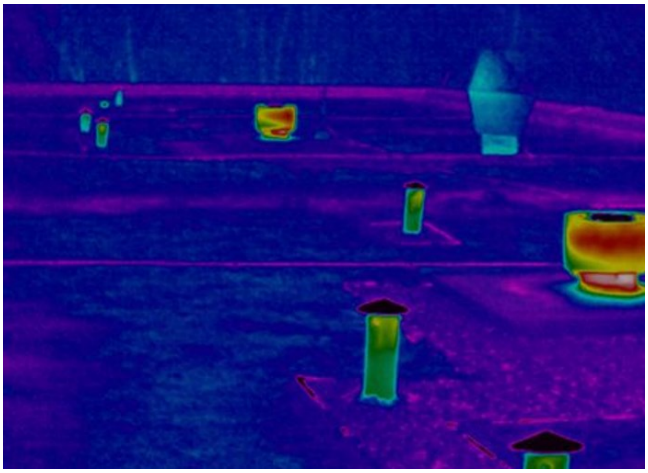

Fig. 10. Thermovision of green roof in 02/2023.

Fig. 11. Perennials and hardy stonecrops.

The plants, which are waiting for more favourable conditions to grow, still look wilted (Fig.12).

Fig. 12. Perennials and hardy stonecrops.

5 Conclusion

The condition of the roof corresponds to the nature and type of the extensive green roof. In the summer months, the greenery on the roof is rather subdued due to the lack of water, but it still fulfils an aesthetic function. In contrast to the winter season, where the vegetation is dormant and looks unsightly. Control measurements of vegetated roofs in Brno show higher saturation percentages in the spring, and this is also reflected in the visual appearance of the roof. After a minimum year of data collection, it will also be possible to determine more precisely when and at what intervals it is optimal to perform green roof maintenance depending on the state of moisture of the substrate layer.

This article was created with the support of the Faculty of Civil Engineering of the University of Technology in Brno, Institute of Technology, Mechanization and Construction Management.

References

1. J. Šimečková. *Green roofs – Hope for the future II,* **44**, 6 (2006)
2. K. Čechová, D. Kozáková. *Heat Island of the city. Nika: Nature magazine about environmental protection* [online]. **44**, 30 (2018)
   Available: http://www.nika-casopis.cz/data/files/18-12.pdf
3. Dek, *Greendek trávníková koberec TR K 20* DEK. **2**, 1 (2022) Praha,
   Available: https://cdn1.idek.cz/dek/document/808884467
4. M. Sněhota, J. Hanzlíková, M. Sobotková, P. Moravcik. *Water and thermal regime of extensive green roof test beds planted with sedum cuttings and sedum carpets.* **21**, 5 (2021).
5. Skala V, Dohnal M, Votrubova J, Vogel T, Dusek J, Sacha J, et al. Hydrological and thermal regime of a thin green roof system evaluated by physically-based model. Urban For Urban Greening 2020;48.

6. S. Konasová, The benefits of vegetated roofs in reducing the excess heat in three urban areas with different climate conditions. Advances and Trends in Engineering Sciences and Technologies III- Proceedings of the 3rd International Conference on Engineering Sciences and Technologies, ESaT 2018; 2019.
7. K. Nečadová, P. Selník, H. Karafiátová, Differential substrate subsidence of the EnviHUT project pitched extensive green roof. MATEC Web of Conferences; 2016.