HI-SMART: HIGHER EDUCATION PACKAGE FOR NEARLY ZERO ENERGY AND SMART BUILDING DESIGN

MODULE #6

CHAPTER 6: ENVIRONMENTAL, COMFORT AND FIRE PROTECTION ASPECTS

Co-funded by the Erasmus+ Programme of the European Union

6.6.1 INTRODUCTION

The environmental and economic impact of buildings falls mainly under the social and economic pillars of sustainability assessment. The design of buildings in terms of environmental and economic impact is defined by a large number of legislative and standard requirements, which have been developed to ensure the basic functionality of the building in terms of health, safety and comfort. The assessment criteria for these two aspects, i.e. environmental and economic, are rather difficult to establish when assessing the sustainability of buildings, although some certification schemes attempt to do so. The complexity of the issue is illustrated by two case studies on roofs with extensive greenery.

6.6.2 EXTENSIVE ROOF GREEN IN CENTRAL EUROPEAN CLIMATE

The green roofs are mostly seen as architectural components having a positive influence on quality of life, particularly in urban settlement structures. This positive effect is manifested at the macro level through improving air quality and also reducing effect called urban heat islands and at the very buildings by raising their interior comfort, especially floors directly under the roof. The precondition for effectiveness at macro level is particularly healthy green converting carbon dioxide to oxygen, casting a shadow on the flat roof and moisturizing surroundings in summer. In winter, it has particularly aesthetic and psychological importance. Care of greenery is of paramount importance, while in larger areas it may also be quite costly affair. Operation of green roofs may over time exceed possibilities of small investors, which is then reflected in a gradual decline of greenery and counterproductive change of the roof into a dusty surface with negative impacts in the environment. A correct design of greenery reflecting the roof structure and location of the building is therefore very important.

In terms of the quality of the internal environment the greenery itself is more or less insignificant factor, a more important role plays the substrate, which can contribute to the thermal protection of the internal environment in the summer and winter as well. In summer, it is especially its ability to accumulate solar radiation and thus prevent overheating of the under-roof space. In winter time period, the substrate is contributing to the improvement of thermal resistance of the roof structure, even though it has to be ignored within calculation of the roof's thermal resistance as it is not its integral part. From legal point of view, hence, an improved thermal protection of under-roof spaces is a secondary effect of green roof and as such should not play a major role in the decision-making process during the green roof design (even though in case of wooden roofs it can be quite an important factor).

More important is to consider whether the cost of its construction and operation will return in the form of more attractive and healthier environment, but this is easier said than quantified. The essence of green roof is greenery and its positive health and aesthetic effects on humans. It can, however, only be achieved, if the greenery is truly functional. Under the climatic conditions of Central Europe with four approximately equal seasons, cold winters and relatively warm, and often dry, summers are the plants in artificial conditions, under which the green roof can be considered, subject to extreme temperature fluctuations. Even plants typical for the Central European area that thrive in this environment can be difficult to survive. In contrast to the plant roots in the normal ground, the temperature of which oscillates at one meter depth under the ground surface between 0° and approx. 16° of Celsius, i.e. in the range of approx. 16 Kelvin, the roots of greenery planted in roof's substrate are exposed to a much wider temperature range.

6.6.3 CASE STUDY No.1

Using an example of typical green roof with extensive greenery the case study (Kravka, Daněk and Rabenseifer, 2016) shows the course of temperatures in the substrate of green roof during the common winter and summer days and compares it with the temperature course at the same depth below the surface of the common ground. From the study is obvious that the temperature course in the substrate of the green roof has in summer (fig. 6.6.1) far greater fluctuations than the temperature course in the soil of the surrounding terrain at the same depth below the surface (fig. 6.6.2). The selection of suitable plants is therefore extremely important. Their root system is significantly exposed to contradictory requirements. On the one hand, it must withstand dry periods with high temperatures and on the other hand long periods of cold and wetness. Despite the fact that extensive green roofs are often designed without an irrigation system, we recommend to think about it in the project - also with regard to climate change towards higher atmospheric temperatures.
When using subtle plants, it is advisable to plan the vegetation layer thickness of a few centimeters higher than recommended. The period, during which an extensive green roof has primarily fulfill its function i.e. reduce dust and ambient temperature, oxidize and humidify the air, is namely summer.

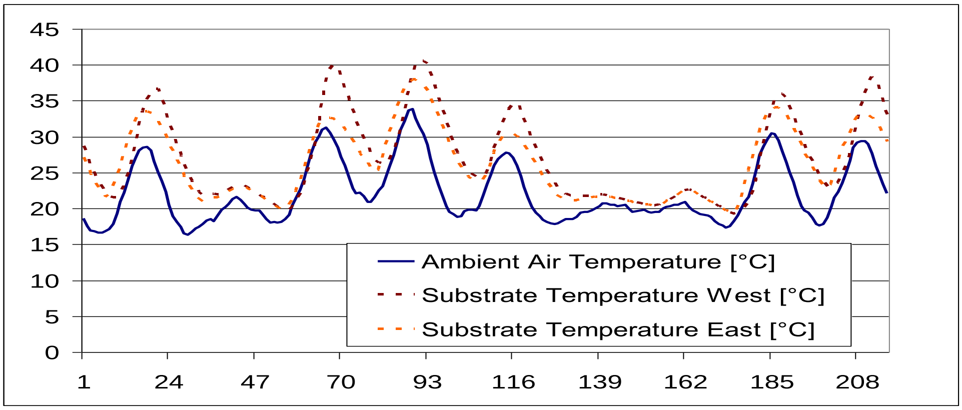


Figure 6.6.1 - Substrate temperatures in 6 cm depth below surface during peak summer days (the time is indicated in hours)

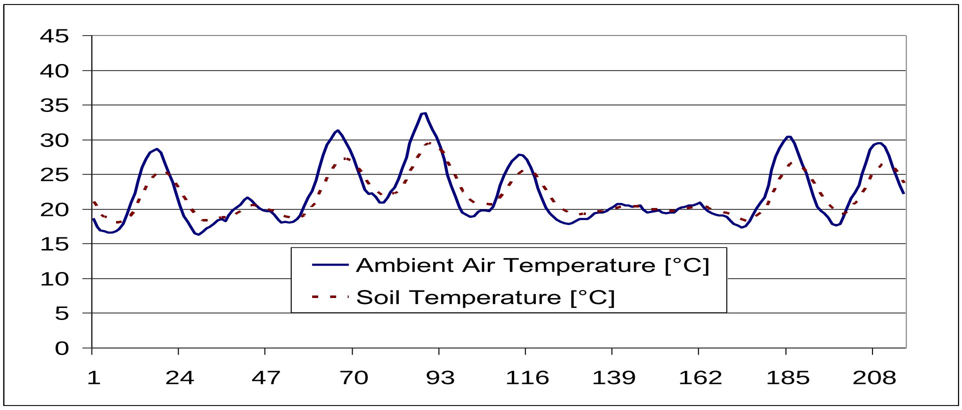


Figure 6.6.2 - Temperatures in 6 cm depth below soil surface of the terrain ground surrounding the building during peak summer days (the time is indicated in hours)

6.6.4 CASE STUDY No. 2

INTRODUCTION

This case study deals with problems of a flat roof with extensive greenery above an underground garage under Central European climate conditions. Infrequent irrigation leads to extremely high temperatures of the substrate in the summer and makes the purpose of this roof pointless. The case study analyzes the reason for the failure of the vegetation part of the roof, which was claimed to be maintenance-free, points out fire safety issues, and suggests improvements that might be considered in similar cases. At the present time, which is marked by the climate change crisis, there is great societal pressure to build green roofs. However, if it is not possible to ensure their perfect functionality, it is perhaps better to use classically proven types of roofs, but with greater reflectivity of the top layer surface.

CASE STUDY

First, the aim was to find out what the temperatures of the different surfaces of a green roof are. Furthermore, we wanted to know the correlation between the temperatures of these surfaces and their estimated reflectivity. Measurements using a Voltcraft infrared thermometer were performed on a green roof above an underground garage in Bratislava (Fig. 6.6.4) during peak summer. The reflectivity of the individual materials was estimated on the basis of information from the literature (Decrolux, 2021). The section through the roof layers estimated on the basis of the inspection is in Figures 6.6.6 and 6.6.7, i.e., part of the greenery. The gravel and terrace part of the roof changed only from the filter layer / waterproofing upwards. The gravel finish was self-explanatory. The terrace part consisted of concrete tiles on support pedestals laid on the waterproofing.

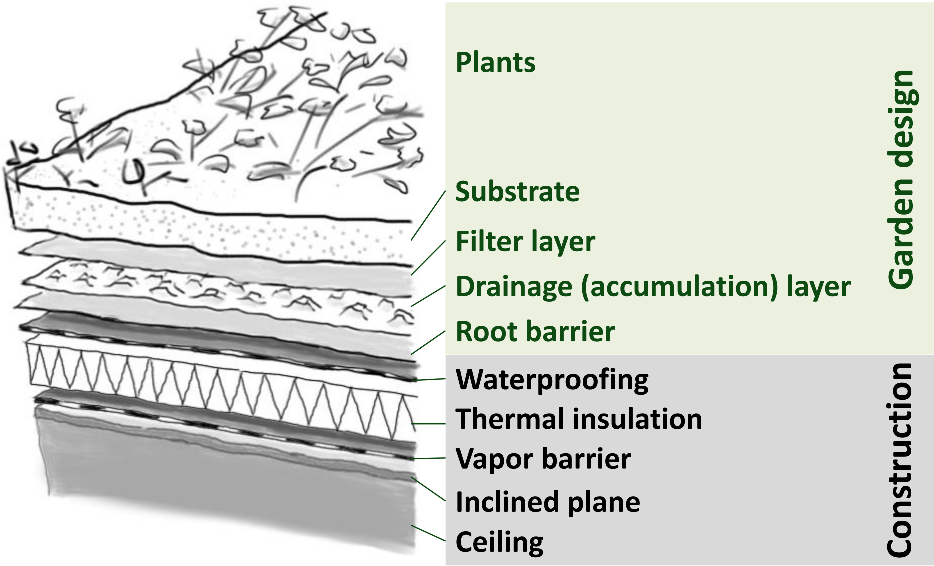


Figure 6.6.3 - Layers of a typical vegetation roof (the thickness of the substrate for extensive greenery usually ranges from 6 to 20 cm)

The measurements clearly depict the lowest temperatures indoors, which are followed by outdoor air temperatures. As is clearly visible from the measurements (Fig. 6.6.5), the temperatures on the substrate / dry lawn were the highest followed by the temperatures measured on the concrete tiles and light gravel. These results support the ideas mentioned in this article, more specifically, the influence of the colors of materials on surface temperatures, since, as is visible in the picture, the flat roof had the highest surface temperatures measured on the substrate/lawn, which is quite the opposite of the desired state.

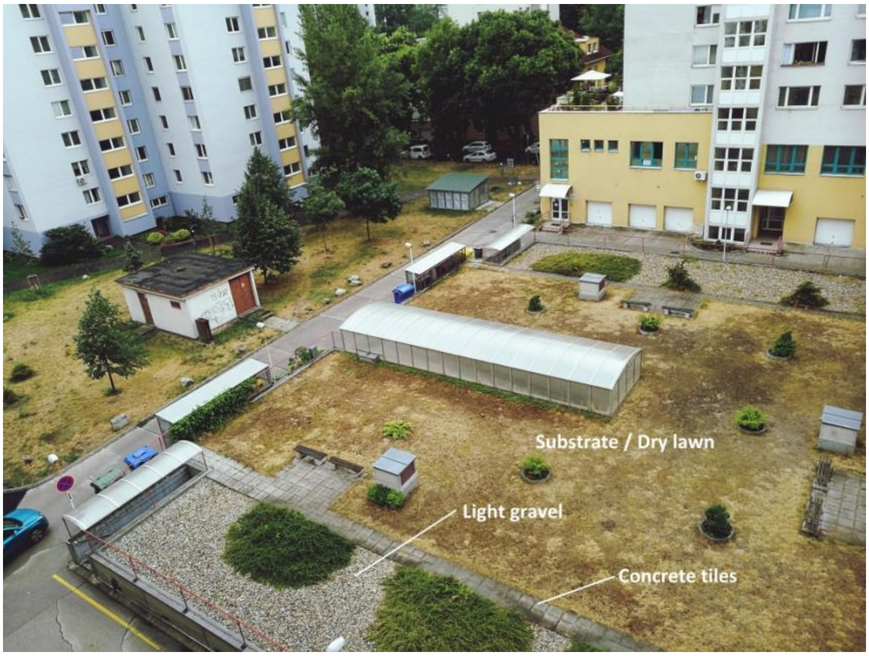


Figure 6.6.4 - Top view of the green garage roof

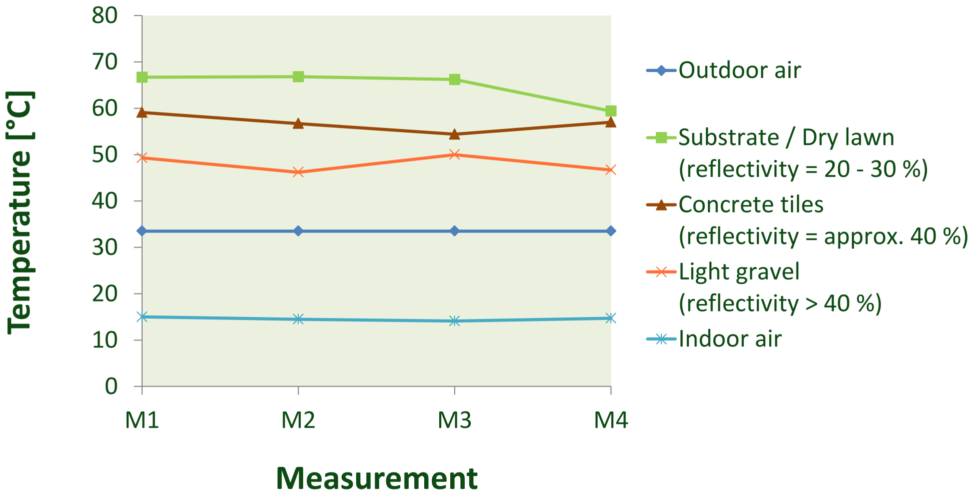
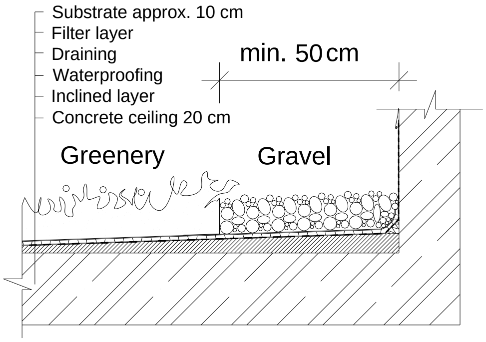


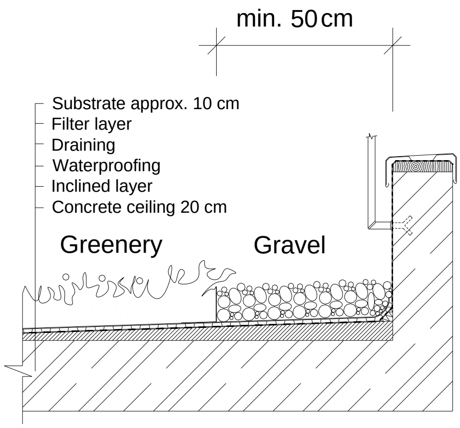
Figure 6.6.5 - Temperatures on the garage roof on an early July afternoon, measured using the Voltcraft infrared thermometer; the brackets contain the amount of reflectivity based on the literature sources (Decrolux, 2021); the real value may slightly differ

The roof also shows several commonly known design mistakes such as a non-existing strip of gravel layer around the ventilation shaft from the garage (Fig. 6.6.6) and the incorrect anchoring of the handrail to the construction (Fig. 6.6.7).



and as it should be ...

Figure 6.6.6 - Missing strip of gravel layer around the ventilation shaft; the section through the roof layers under the greenery corresponds with the existing state



and as it should be ...

Figure 6.6.7 - Handrail incorrectly anchored to the construction; the section through the roof layers under the greenery corresponds with the existing state

In the case depicted in Fig. 6.6.7, the vertical wall terminating the roof should be higher, and the railing should be anchored to the side. A protective gravel strip in close proximity to the vertical wall is also missing. It should protect the bend of the waterproofing.

6.6.5 CONCLUSIONS

In the climatic conditions of Central Europe with four seasons of approximately the same length, including cold winters and relatively warm, and often dry, summers, plants are grown on roofs with extensive vegetation exposed to extreme temperature fluctuations. Even plants typical of the Central European area that thrive in this environment can find it difficult to survive. In contrast to plants rooted in a common soil, the temperature of which oscillates throughout the year at a depth of one meter under the surface between 0° and approx. 16° C, i.e., in the range of approx. 16 Kelvin, the roots of vegetation planted on roofs are exposed to a much wider temperature range. From the study of a typical roof with extensive greenery described, it is obvious that temperatures on a roof may be exceedingly high during the peak summer. The selection of suitable plants is therefore extremely important because their root system is exposed to highly contradictory requirements. On the one hand, it must withstand dry periods with high temperatures and, on the other hand, long periods of cold and wetness. When growing more sensitive plants, we also recommend a vegetation layer with a thickness of a few centimeters higher than recommended. The period during which an extensive green roof primarily fulfils its function, i.e., reduces dust and the ambient temperature and oxidizes and humidifies the air, is namely the summer.

Even though extensive vegetated roofs are considered (and promoted) in Central Europe as maintenance- and irrigation-free, they need both year round maintenance and regular irrigation during the summer months. The inclusion of an irrigation system and green maintenance in a roof project is highly desirable, especially with regard to predicted climate change with higher atmospheric temperatures.

If ensuring the regular maintenance and irrigation of roof greenery is not possible, then a classic flat roof with a highly reflective upper surface is certainly a more suitable solution. Such a roof can reduce the temperature of the roof surface by 10 - 15 K compared to a non-functional substrate and, hence, contribute more to the reduction of the heat island effect.

When planning the details of a green roof, special attention must be paid to fire safety, protection against the growth of roots, and the selection of suitable plants (not simply some kind of succulents). The design of green roofing is a complex matter, which requires a highly professional attitude and strong cooperation between the architect/planner on the one hand and the garden designer on the other hand. Even though there is not too much standardization and legislation regarding roof vegetation, the recommendations of specialized professional associations should be followed.

6.6.6 REFERENCES

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