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Technology of Implementation of the Pitched Green Roof on the Testing Building EnviHut

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Abstract

The idea of green roofs with simple application aims for expansion of using green roofs in the contemporary construction industry. The local climatic conditions of larger urban units may be positively affected due to numerous incidences of these structures. The application of environmentally friendly materials of green roofs dramatically increases economic costs of a whole project in this time. This article describes one of the possible solutions that would minimize the effect of the negative aspects mentioned above. The technology of testing installation was carried out in a residential research project EnviHUT. The inclination of the gable roof is 30°. The project EnviHUT is designed as a self-sufficient mobile unit that can be used for example as a weekend recreation facility. A more detailed description of the testing installation is a part of this article. The process of continues monitoring is regularly restored by the team of Brno University of Technology and more information is indicated on the website. Three variants of green roofs - extensive sedum roof, biodiverse semi-intensive roof and roof made up from turf carpets were implemented on the described building EnviHUT. Each layer's set of the examined vegetation layer system shows different building-physical characteristics and also different properties from architectural and also botanical perspectives. The tested vegetative-retention mats are made from recycled polyester fibres and they are a part of all the above mentioned variants of green roofs. This solution allows to simplify and speed up the installation of the pitched and flat green roofs and it also provides a high level of protection of waterproofing layers during installation.

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The partial retention tests were carried out on the comparative elements and they proved required retaining capability of water in the roof system. Different anti-sliding systems were optimized for each variant of green roof. The main monitored periods are: the period shortly after the installation of vegetation, changes over the first year of existence and the last is the gradual process of consolidation of the entire installation.
This article selects the main benefits and weaknesses of basic stability and technology of the various tested variants of green roofs and their systems against sliding the vegetation part. Material characteristics of the vegetative-retention mats and methods of installation and type of green roof are recommended by the research team based on monitoring of the testing building EnviHUT.

1. Introduction

The installation of many different forms of green roofs is currently a more and more demanded roofing construction. Many of these green roofs have been mapped and measured, although a lot of solutions usually belong to the category of atypical luxury structures that are part of the attractive but also economically demanding and complicated houses. The team of a research project EnviHUT is looking for a simple solution that would allow expansion of uncomplicated installations, e.g. in the satellite towns of major conurbations. (Wolch, J. R., Byrne, J., Newell, J. P., 2014) The main target building unit is a detached house with a ground-plan area of approximately 180m^2. The testing building EnviHUT is a full-scale model (Fig. 1) that the authors considered as the minimum reference structure which is possible to monitor and evaluate with regard to boundary conditions. The building is conceived as a simple mobile container dwelling which can serve as a self-sustainable holiday cottage in areas with limited energy resources.

Experts discussed the issue of comparable assessment of quality and benefits of small and large projects in the field of green infrastructure at the 1st European Urban Green Infrastructure Conference 2015 in Vienna. Part of participants supported the necessity of development of simple small units that can create efficient urban areas by larger expansion. One of the main spokesmen of this gathering was prof. Dr. Tony Pereira (Climate Reality Project Leader UCLA), who lectured on the issue of eco sustainability. [1] The group recommended a deeper analysis of simplified systems for ecological constructions, [7].

The concept of examined variants is designed with an emphasis on a simple installation and a possible implementation of do-it-yourself. The polyester retention mat (hereinafter referred to as the "PES mat") protects the previously built-in roof layers against mechanical damages and also enables easier and safer movements during the application of the vegetation part.

2. EnviHut and a basic description of installed green roofs

The EnviHUT project is built mainly from local natural or recycled materials as a part of a doctoral research in the science centre AdMaS. Only renewable energy sources (nowadays solar and wind energy) are used for the operational running of the building.

The gable roof structure has an inclination of 30° and it is divided into three sections. The first section has a layer's set composed of PES mats - thickness 60 mm that builds up the vegetative-retention layer. The geocell system, which is designed as an anti-slip system, is filled in by a crushed substrate with a height of 80 mm. This system presents a poor green roof. The middle segment is based on the Swiss concept and represents a biodiverse roof. [4] This green roof is also made up of the PES mats (thickness 40 mm or 60 mm) and the anti-slip system, which is assembled from wooden boards and a supportive net. The following layer of natural soil from excavation has a thickness of 180 mm. Turf carpets accompanied by seeds from wild plants (poppies, chamomile etc.) were used to accelerate the growth of vegetation. Icelandic concept of implementation of pitched green roofs represents the last section. Turf carpets are laid on the vegetative-retention layer with various thicknesses. There are 2 cm of native soil with a supportive net in between. The first two turf carpets are laid with roots upwards and the external turf carpet is placed with roots downwards. This solution makes resist and stable system that is able to withstand extreme weather conditions. Each segment is supplemented by the moisture sensors in the soil (8 cm under surface) and temperature sensors, which are positioned above the surface. Roof planes are oriented to the north (NNE) and south (SSW).

Figure 1.: Anti-sliding system of extensive sedum green roof and EnviHUT roofing.

3. The installation of green roofs

Installation of the supportive constructions and vegetation layers was held in late September and October in 2015 during droughts. Three kinds of anti-slip systems were set for the study of installation and all particular solutions are described in the following chapters.

3.1. Installation of the vegetative-retention mats

Installation of the vegetative-retention mats (dimensions 1.2 x 0.8m) is made by gluing onto the waterproofing hydro-insulation in the longitudinal direction. The longitudinal direction is more appropriate because are reduced mutual slits in the entire layer. The surface of the hydro-insulation must be equipped with laminated polyester membrane (120 g/m^2). If the hydro-insulation has a surface made up from a polyethylene layer, the PE layer has to be burnt off.   The low-expansion polyurethane foam was used as an adhesive that was applied in the vertical direction in every 20 cm. The low-expansion polyurethane foam was used because of its increased resistance against mildews, limited growth of fungus in connection and also high adhesion with the underneath surface. Mats were shortly loaded for the duration of 2 minutes, because of the reduction of the mutual slits, non-glued slits. The PES mat can be formed by simple cutting with an angle grinder. Amount of collected water [2] in monitored green roofs can be model due to the different thickness of the PES mats (thickness 40 mm - filling density 4000 g/m^2; thickness 60 mm - filling density 6000 g/m^2). The thicker mats were used on the whole south side and at the ridge width of 80 cm on the north exposition. PES mats with lover retention capacity were glued at the remaining surface. Installation of the anti-slip systems, substrate or native soil and vegetation followed not before 12 hours after the gluing.

3.2. Anti-slip systems, substrate and vegetative layers

The main emphasis of the research was put on geometrical distribution and forms of the anti-slip systems. Some of the previously designed elements were substituted for cheaper and more simple shapeable materials (also because of the prototype testing building).

3.2.1. Extensive sedum green roof with the anti-slip system fixed by geocells

The installation of the geocells was anchored to an additional frame element closed to the ridge and sides of the roof. The ridge was partly (20%) overlaid with the net of geocells shown in Fig. 2. Afterwards the roof plain was filled from the ridge to the eaves with an original crushed roof substrate of Czech producer.

Figure 2.: Anti-sliding system of extensive sedum green roof and EnviHUT roofing.

This described installation was not personally realized by the research team and it was entrusted to the professional roofing company. The authors would change the direction of the filling of the geocells despite of more complicated working process. The installed way does not enable to accomplish efficient compaction. There was a great volume changes caused by unequal consolidation shown in Fig. 3 depending on the changeable shape of single connected cells. The initial growth of vegetation was slowed down because of the closed installation before dormancy (October 2015). The surface was exposed to mild winter conditions during following months. Small surface landslips appeared on both expositions (NNE) - (SSW) at the end of the winter season. This problem could be compensated by modification of the substrate composition, especially by modifying the size of grains. The installed substrate lacked greater stabilizing supporting fractions (16 - 32 mm). Prevailing solid uncrushed expanded clays and shales were contained at least in 5 of the 35 delivered bags (each 40 l). It is very important for the installation continuous monitoring of used substrates (especially packing in bags).

Figure 3.: Example of unequal consolidation of the substrate and geocell.

3.2.2 Biodiverse semi-intensive green roof with the longitudinal anti-sliding system

This anti-sliding system is a combination of fine wire mesh, dense jute net and boards installed every 80 cm parallel with eaves. These boards were placed perpendicularly to the roof plain straight on the PES mats. The geometric dimensions of the anchoring elements for consolidated height of 16 cm native soil follow:

3.2.2.1 Board elements

- The height of the board - ¾ of the height of the consolidated soil i.e. 12 cm.
- Drainage holes - diameter 10 mm, longitudinal located every 20 cm and 2 cm above the bottom edge of the board.

3.2.2.2 Wire mesh size 13 mm, anchoring clamps only on the longitudinal anchoring elements.

3.2.2.3 Jute net

The jute net was placed on compacted soil (compaction every 4 cm) at a height of 14 cm, 2 cm above the top of main board elements. The jute net was not anchored close to the ridge and their stability was secured by mutual ballast from both sides of the pitched roof.

The installed net was subsequently covered with another 5 cm of soil and repeatedly tamped down. The realization continued with placing of turf carpets in single layer. This progress was enforced by the requirement of fast development of vegetation in a short period to get comparable evaluation and valuable analysis. The testing segment was sown by meadow mix seeds in the spring of 2016 due to the enrichment of vegetation.

Figure 4.: Anti-sliding system of the biodiverse (left) and of the Icelandic green roof (right).

3.2.3 Icelandic turf green roof with simple net anti-sliding system

This solution is particularly suitable for an investor who requires an immediate greenish roof or if the roof has a very steep inclination. The installation of this green roof is basically very similar to the installation described in chapter 3.2.2 and it consists in the sequential installation of every single turf layer. The installed turf carpet always overlapped with the underlay turf carpet by half shown in Fig. 4. [5,6] The turf green roof is considerably faster to install than the previously described solution (twice faster than the variant 3.2.2).

4. Conclusions

After 6 months of testing the Icelandic turf green roof could be regarded as the most effective solution. The biggest advantage is an immediate and almost a full functional behaviour. This solution is appreciated by potential investors and it also shows interest in installation of this variant of green roof. Most of building owners are not willing to invest their resources into the slowly growing biodiverse green roof, although materials of this variant are cheap and easily accessible. It is also necessary to consider the time-consuming realization. The extensive sedum green roof requires a careful installation procedure because of the susceptibility to volume changes and landslides of substrate. Installation of this type of pitched green roof cannot be recommended in a late autumn period, because of the erosion of the surface caused by aggressive winter climatic conditions. The growth cycle of sedum does not enable wider development of vegetation in this time. This installation requires more care in the following spring e.g. equalizing the surface and landslides, adding more substrate etc. The research team also recommends proceeding of realization from the eaves to the ridge, although there is limited workspace. The workspace could be increased by simple installation of working platforms. All the used anti-sliding systems have prevented sliding of the whole structures of installed green roofs. The entire building EnviHUT will continue to be monitored and specialists will be notified of the results of long-term testing and measurements.

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