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# History of vegetation roofs in the Czech Republic

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**Abstract.** This article is mainly focused on the development and history of vegetation roofs in the Czech Republic. In the article is summarized history of green roofs in Czech republic from the oldest vegetation roof. Subsequently, it contains the significance of the function of vegetation roofs and the general classification according to the types of buildings including their description and price. Last but not least, there has been described the reconstruction of the oldest vegetation roof in the Czech Republic on the building. Also there has been described a modern design and reconstruction of the roof garden. At work I have been able to summarize all the advantages and disadvantages of vegetation roofs compared to classical roofs. The results of this work provide a detailed view of the development of vegetation roofs and on the basis of the work it is possible to suggest possibilities for accelerating work on vegetation roofs.

## 1. Introduction

The population of the planet is still increasing, and so the areas in our neighbourhood are increasingly being used for human settlements and the construction of industrial, commercial or administrative buildings. At the outskirts of the city, new quarters are emerging that degrade fertile soil and destroys the ability of the landscape to naturally retain water. The water that we come **across** is therefore missing throughout the chain of natural cycles, and people are forced to pump away more and more water from underground supplies that are not naturally replenished to they original volume. However, we have other variant of how to rehabilitate these areas despite the green areas, especially thanks to green architecture. Whether using parks, green facades or above all, using vegetation roofs.

There are many questions about vegetation roofs, such as: Are they useful? Do they have a tradition in our country? Can we use their benefits or are they perceived as unnecessary luxury? How is the construction of green roofs going in Czech Republic? Is it fast enough and effective or slow and unnecessarily expensive? These are just a few questions that probably can not be answered satisfactorily and adequately within one article. Nevertheless, the task of this article is to clarify at least a few of these questions and to show how the construction of green roofs within the Czech Republic has developed in the last decades or hundreds of years. What success has been achieved in this field and what progress has been made in building materials and time necessary for build this type of roof.

## 2. Theory

### 2.1. History of green roofs

In the very beginning, it is necessary to look into the history of vegetation roofs in the Czech Republic. There is no vegetation roofs from past times, as is the case in the northern part of Europe where, at the turn of the antiquity and the Middle Ages, the first human dwellings with green roofs were created and their tradition is still alive in these countries. Where they were built mainly due to good thermal



insulation properties, when it was necessary to keep the dwellings with the most stable temperature as possible during hot summers and cold winters. As far as the territory of the Czech Republic is concerned, the oldest known green roof is dated to a time that is much closer to us. It was designed in year 1863 by the architects Josef Žák and Ferdinand Wenzel. This roof was designed as a terrace above the building of horse stables at the renaissance chateau in Lipník nad Bečvou. The roof was further upgraded to its present form, which corresponds to the 1910 modifications, when the roof terrace was rebuilt into a reinforced concrete slab. Because the roof was originally terrace of the castle, the roof about which we are talking here was constructed as intensive green roof. On the surface of which are found many paths created with the help of a mixture of sand, clay and crushed limestone. At present, the terrace serves as part of the chateau park in Lipník nad Bečvou. The castle itself is used as the seat of the city office. On this roof can be well presented the development of green roofs in the Czech Republic because roof has been recently reconstructed by using modern materials and procedures to continue to serve its original purpose. Since 1863, other green roofs have been created, especially as roof gardens at castles and for buildings meant to nobility. Perhaps for this reason, green roof are seen as unnecessary luxury. For example, it is worth mentioning the terrace at Konopiště Castle, where was a terrace with vegetation - lawn and trees. However, this roof garden had to be reconstructed several times due to frequent leaks. Further green roofs then began to emerge in the first half of the 20th century. Many of them have been preserved until today, such as the Roof Garden at the Union Bank in Brno or at the Baťa factory in Zlín. In the second half of the 20th century other green roofs were built mainly in public and representative buildings such as the Prague Castle Riding Hall, the Thermal Hotel Terrace in Karlovy Vary, Prior House in Brno ...). In the years since the end of the 2nd world war by the 1990s, about 15,000 ha of green roofs had been created in the Czech Republic. Since the beginning of the nineties there has been an increase in the number of green roofs in our country. However, their growth can be calculated in percentages, and we are still lagging behind neighboring countries like Germany and Austria. <sup>[2]</sup>

## *2.2. Benefits and disadvantages of green roofs*

Before process of building the vegetation roof, it is necessary to focus on its importance and its function. Vegetation roofs have many categories. First of all, it is worth mentioning the function of urban and landscaping. This means that green roofs are places created for relaxation, which are increasingly lacking in city centers. This type of roofing can also be used to extend the living space for other animals and therefore not only for humans. Last but not least, they are also involved in increasing the number of greenery in the countryside. Functions that should be mentioned includes the environmental functions of vegetation roofs as roof vegetation significantly contributes to slowing air movement and thus reduces dustiness of the environment. It is also involved in the retention of rainwater and thus its return to the cycle of water in the nature. Plants are able to absorb pollutants from rainwater - especially copper and lead, which are thus prevented from further penetrating into the lower waters and rivers. They also contribute to the increase of air humidity due to retention and subsequent evaporation of water, which further contributes to the reduction of temperature fluctuations. <sup>[4]</sup>

It is also necessary to address with the building advantages and disadvantages of green roofs. As an obvious advantage, is their aesthetics function within the city environment. However, this is not the only benefit of the green roofs. It is also necessary to mention the other benefits of green roof constructions. Vegetation layer is an additional thermal insulation of the roof, where the decrease in thermal losses of the roof in the case of planting is counted by 10 to 30%. The vegetation layers have a significant role in the protection of waterproofing layer against degradation due to ultraviolet radiation, infrared radiation and temperature fluctuations (with temperatures ranging from -3.6 ° C to 65 ° C on conventional roofs). In the case of vegetation roofs this range ranges from - 0.8 ° C at 30 ° C. Effect of this is a significantly lower stress of the waterproofing layer due to temperature variation has been demonstrated. The vegetation itself can also be used to improve the acoustic properties of the roof where the sound absorption of the roof structure is better by 3dB. The substrate itself has a function as an additional impact insulation. The retention capabilities of green roofs are used to reduce the load on the sewerage network, where a reduction in load on extensive vegetation roofs is measured by up to 30% and in

intensive vegetation roof even up to 50%. Last but not least, it is necessary to mention the protection, which the structure provides for the load bearing and the waterproofing layers in front of mechanical damage or for the better efficiency of the photovoltaic panels. However, thanks to these benefits the green roofs can be seen as ideal solution of many problems but they also have some problems and disadvantages. workload in their construction. Work as such can then be associated with a further disadvantage, and this is a need for a high-quality execution where in the case of a poor performance of the vegetation stack there is a risk of water leakage into construction structures. Separate risk is then vegetation where some types of plants could cause allergies, and the effect of leaves, flowers and branches is subject to biological contamination. In particular, in the Czech Republic is no financial support for construction of green roofs, as opposed to, for example Germany, where are many programs for support of creation of new green roofs. To defend the Czech Republic there is one grant program which is called Zelená úsporám (Green Savings) which the last stage supports construction of vegetation roofs thanks to their water retention. Between the other disadvantages of green roofs which we can call purely as constructional or aesthetic ones is their higher cost compared to the classical roof and higher workload in their construction. Workload as itself can then be associated with a further disadvantage, and this is a need for high-quality execution where in the case of a poor execution of vegetation layers is there a risk of water leakage into the construction of building. Separate risk is a vegetation as itself, where some plant species can cause allergies, and the fall of the leaves, flowers and branches are biological contamination of surroundings. <sup>[11]</sup>

### 2.3. Types of green roofs

Another very important parameter for construction of green roof is need of choose right type. Which is very important due to different prices of every type of green roof. There are four basic types of green roof as biotope green roof, extensive green roof, semi-intensive green roof and intensive green roof.

For the biotope vegetation roof, we are not counting with foundation of vegetation and area of roofs is free for natural raid of plants seeds. There are savings of the purchase of seeds and care of vegetation layer. The optimum substrate height is from 6 to 12 cm. Maintenance consists of removing unsuitable plants once or twice per year. The approximate price of biotope green roof is by 55,50 to 91,56 EUR/m<sup>2</sup>. <sup>[2]</sup>

In the case of extensive green roof is being considered with minimum maintenance of vegetation (approximately two times per year). Considered substrate height is from 2 to 20 cm. This type of roof is mostly used for non-walkable roofs. Plants usually used for this type of roofs are mosses, sedums, nonskarks, some types of herbs and grass which likes dry climate. Price of these roofs is approximately 56,00-128,60 EUR/m<sup>2</sup>. <sup>[2]</sup>

For the construction of semi-intensive green roof are also used with unpretentious greenery but roofs are mostly designed as walkable. Vegetation on these roofs are primarily different types of grasses, herbs and shrubs. Substrate height is between 15 and 30 cm. Price of semi-intensive roof is around 67,40-179,20 EUR/m<sup>2</sup>. <sup>[2]</sup>

Intensive vegetation roofs are characterized by the need for constant care and maintenance. Height of substrate is more than 30 cm, where the only limitation is possible depth for roots of vegetation and height of the trees which shouldn't be higher than 10 m. Intensive green roofs are possibly used even in agriculture. Orienting costs of intensive vegetation roof is about 89,60-307,80 EUR/m<sup>2</sup>. <sup>[2]</sup>

A lot of other, diversification of green roof are mostly influenced by designer of roof. Whether it is roof accessibility, its function or the slope of supporting structure where is necessary to say that the vegetation roof can be applied to almost any building and any pitched roof but with higher slopes it is more difficult to make a good design which also increasing cost and length of building. There, are also different possible diversification of vegetation roofs but these are almost impossible to change at the construction stage. For example, it can be roofs in line with the terrain. <sup>[4]</sup>

### 2.4. Case study

If we will talk about construction of green roofs as itself, we need to go back to the beginning of this article and of the green roofs in Czech Republic, where is mentioned chateau in Lipník nad Bečvou where in the year 2005 was reconstructed the first green roof. For this reconstruction was used modern procedures in order to preserve roof garden after the construction work. At the beginning of the works had to be pumped out the existing soil. That revealed waterproofing layer which was made by asphalt bands (height of layer was around 30 cm) which were found still in condition. As a result, the original waterproofing was repaired with a vapor permeable primer and PE foil. Thermal insulation was choosed as a foam insulation EPS 100 and the last layer was from waterproofing membrane which was led through balustrade to the drainage where it was finished by copper plating. Then was finalized the composition of intensive green roof by separation geotextiles, nano-foil hydroaccumulation layer, other geotextile separation, topsoil and vegetation substrate. In order to prevent the soil from being channelled into the drainage was created a vertical dilatation layer around the perimeter of drainage from a shaped hot dip galvanized expanded metal. An important detail which was constructed was dilatation to prevent lateral pressure to balustrade which was made by applying of vertical stripes by compressible material in the composition of individual layers. Because roof is an intensive green roof, it is possible to find sidewalks on its surface, which were formed by mixture of clay, sands and crushed limestone to prevent growth of the grass. Sidewalks were separated from soil by vertical hot dip galvanized sheet metal (8 mm). With dilatations by 3 m. In the middle of the area there is a fountain that has been dismantled and replaced by a replica. Garden was also designed for easy maintenance. Reconstruction of roof garden which has area 680 m<sup>2</sup> was finished in the September of 2006. <sup>[8]</sup>

### 3. Conclusion

As we can see from the data collected in Czech Republic there is still growing number of realizations of green roofs. Especially extensive green roofs for family houses. If we will talk about case of intensive vegetation roofs than this type of green roof is mostly constructed on the representative or commercial buildings. If we will talk about private construction sector, however it is still only the realization within the framework of several tens of houses per year in the whole country, which is still a few compared to the countries like Germany or Austria. If we would like to compare costs for vegetative roofs to classic types of flat roof construction than we can't make a green roof under 54,55 EUR/m<sup>2</sup> but cheapest type of flat roof with waterproofing layer made by mPVC foil and thermal insulation by EPS 100S with thickness 180 mm has cost 30,20 EUR/m<sup>2</sup>. In the subject of pitched roof is costs of typical construction even smaller. We can see that the price of vegetation roofs is still an important factor for their wider expansion in Czech Republic. However, at present it is possible to apply for a subsidy of up to 19,50 EUR/m<sup>2</sup> form the state grant program Zelená úsporám, which reduces the price of the vegetation roof to 35,06 EUR/m<sup>2</sup>. The green roof is still the most expensive variant, but it is not almost double of costs against other types of roofing. And benefits which green roof providing to house and his surrounding are their biggest benefit.

Other problem which green roofs has is their hard construction and construction time. In the case of construction classic roofs, they are completed at the last day of realization but in the case of green roof we have to count also with time which we need to growth of grass or other greenery to have a fully functional green roof. Of course, we can use the grass carpets, but this solution is not financially effective and not everyone can afford them. Also, the transport of the material itself is very expensive and laborious, especially on roofs that are not constructed in contact with the terrain, where the construction can be helped by heavy machinery transporting the vegetation substrate and soil directly to roof. But if we doesn't have this possibility, then is needed to transport all of soil and substrate on the roof manually. In almost every case we also have to transport manually all plants on the roof. In the Czech Republic is not currently any possibility of speeding up and making these constructions more efficient. If we will look at abroad, we can see the effort to simplify whole process, which is only at the beginning and leads especially to the prefabrication of the individual parts. These are prefabricated panels that are planted with sedum and herbs in pre-treatment process. These parts are transported to a building where they can

be simply moved on the roof and make a finalized look of vegetation layer. That means a great saving of time within the time of construction.

Unfortunately, these technologies are not available within Czech Republic, so the time labor and financial demands for construction of vegetation roofs are still relatively higher than for classical roofs. However, if we will talk about benefits the green roofs overcomes the classical roofs thanks to the need of water retention and cooling of the city centers in the summer period, it is possible to count with their constant development. If we can simplify their construction, then we can be convinced about that their popularity will rise.

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