Latvia University of Agriculture
Faculty of Rural Engineering

CIVIL ENGINEERING'13

4th International Scientific Conference

Part II

PROCEEDINGS

Volume 4

Jelgava 2013

International Scientific Conference and Proceedings "Civil Engineering 13" – dedicated to the 150th anniversary of the higher agriculture education in Latvia and the Latvia University of Agriculture, and the 275th anniversary of the Jelgava Palace

The 4th International Scientific Conference „Civil Engineering 13" is organized on a regular basis and this year it was held on May 16-17, 2013. More than 80 reports were presented at six conference sections. Reports were presented by scientists and civil engineering professionals from the Latvia University of Agriculture, Riga Technical University as well as scientists from universities of Lithuania, Estonia, Russia, Poland, Netherlands and other countries. The main research directions represented at the conference were: construction and materials, landscape architecture, land management and geodesy, building and renovation, structural engineering, environment and environmental effects, industrial energy efficiency and others. One of the nowadays research priorities – effective usage and saving of energy resources, received a lot of attention - 10 scientific reports were presented at the "Industrial Energy Efficiency" section.

The conference „Civil Engineering 13" international scientific committee is represented by civil engineering experts and academic staff from Latvia, Lithuania, Estonia, Poland, Finland,Sweden, Czech Republic, Netherlands.

The 4th International Scientific Conference „Civil Engineering 13" Proceedings are developed in a notable anniversary year for all of us – the conference and proceedings are dedicated to the 150 anniversary of the higher agriculture education in Latvia and the Latvia University of Agriculture. The home of the Latvia University of Agriculture is the Jelgava Palace - the largest architectural monument in the Baltic States. The Jelgava Palace this year is celebrating its 275 anniversary years. We are proud that this monument is fundamental and outstanding and it definitely influences also modern building tendencies in Latvia and abroad.

It is important to note that scientific papers from previous International Scientific Conference „Civil Engineering 11" Proceedings were included in the AGRIS, CAB ABSTRACTS, EBSCO Central & Eastern European Academic Source and SCOPUS databases.

Scientific Conference "Civil Engeneering" has become very traditional and I hope that in future it will expand and will provide a collection of excellent researches.

Sincerely,
Dr. sc. ing., prof. Juris Skujans
Rector of Latvia University of Agriculture

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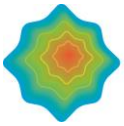
ISSN 2255-7776



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LATVIA UNIVERSITY OF AGRICULTURE
FACULTY OF RURAL ENGINEERING

Department of Architecture and Building
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CIVIL ENGINEERING ’13
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Jelgava 2013

Civil Engineering` 13
4th International Scientific Conference Proceedings, Vol. 4
Jelgava, Latvia University of Agriculture, 2013, 81 pages
ISSN 2255-7776

ABSTRACTED AND INDEXED: AGRIS, CAB ABSTRACTS, EBSCO Central & Eastern European Academic Source, SCOPUS. Note: the data bases select the articles from the proceedings for including them in their data bases after individual qualitative examination.

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Printed in SIA Puse Plus

The collection of articles provides important ideas for further scientific activities and is dedicated to the 150 anniversary of the Latvia University of Agriculture.

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Projekts tiek īstenots sadarbībā ar LIAA Latvijas Investīciju un attīstības aģentūra Investment and Development Agency of Latvia

CONTENT

LANDSCAPE ARCHITECTURE

THE BENEFITS OF GREEN ROOFING FOR LATVIAN BUILDING ENVIRONMENT

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ABSTRACT

Green roofs serve several purposes for a building, such as absorbing rainwater, providing insulation, creating a habitat for wildlife and helping to lower urban air temperatures and mitigate the heat island effect. The modern trend started when green roofs were developed in Germany in the 1960s, and has since spread to many countries. Today, it is estimated that about 10% of all German roofs have been "greened". Green roofs are also becoming increasingly popular in the United States, although they are not as common as in Europe; however, one sees more and more architects opting for green roofs as an alternative to large flat roofs. A green or vegetated roof is not such a traditional roof type for the Latvian building environment. Mainly because of a lot of the ideas that it harms the whole structure, problems with leaking, problems with hydro isolation, too large a weight and a lot of additional maintenance work and costs. And the greatest idea is that this roof type is totally unsuitable for local weather conditions when historically green roofs are widely used in Norway and also in Great Britain where weather conditions are much more harmful for greenery. These ideas mainly are coming from the fear to get into a situation with high risk to maintain a building with a green roof and if it is cost effective. In the present research, review is given on green roofing worldwide and Latvia, different roof systems and describes the benefits of green roof implementation.

Key words: Green roofs, extensive and intensive roofs.

INTRODUCTION

There has never been so much interest in the ecological impact of buildings as there is today. The difficulty is that green is so fashionable that everyone is jumping on the bandwagon, claiming astonishing sustainability or remarkably low-energy consumption (Jodidio, 2009). Buildings are one of the heaviest consumers of natural resources and account for a significant portion of the greenhouse gas emissions that affect climate change. One very old method to improve sustainability is to bury architecture, or to cover it with vegetation. A layer of earth serves as insulation (permits 6° reduction in internal temperatures in summer) and ultimately allows nature to return to its rightful place on a given site. The thermal benefits that green roofs provide may also have indirect benefits for people living or working within the buildings. This has not been researched, but anecdotal evidence from Germany in the late 1990s is of interest. In a survey of staff absence due to sickness at the Bundepost offices in Stuttgart, it was shown that staff in one building demonstrated significantly lower absences than those in others. The only change in the 4-year period that could be identified was that one of the buildings was given a green roof; this building supported lower staff sickness levels. It is possible that the green roof reduced the fluctuation of daily mean temperatures within the upper levels of the building, and/or the vegetation helped cool and moisturize in-going air near ventilation ducts (Fig.1.) (Livingroofs.org). Nowadays, Stuttgart is one of the "greenest" cities.

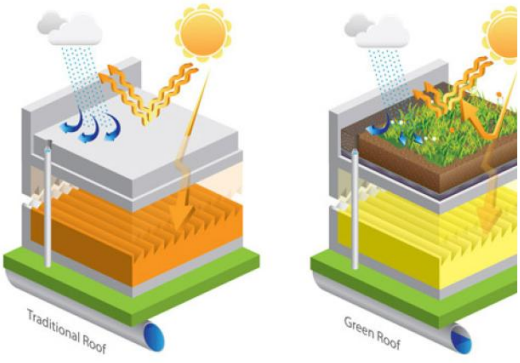

Figure. 1 Green roof versus convention roof comparison (Source: www.greenroofguidelines.co.uk)

Bringing nature into a city center provides relief from an otherwise artificial environment (Jodidio, 2009). Modern humans have a bad habit of replacing naturally occurring water-absorbent soil and plant systems with impervious surfaces as roads, parking lots and roofs (Snell, 2009).

Considering the roof space is generally underused and ugly in most cities, covering it with vegetation is good solution as from the aesthetical point of view and as from an ecological one too. Green roof technology provides an exciting and virtually endless palette of design opportunities for innovators, who can play a key role in the reinvention of miles of wasted roof space on our buildings (Cantor, 2008). Roof gardens and green roofs both belong to a type of roof that supports vegetation, which have numerous social, economic and environmental benefits and can contribute positively to issues surrounding climate change, flooding, biodiversity and declining green space in urban areas (www.thegreenroofcentre.co.uk). Green roofs cost a fraction of a roof garden and are lightweight with thin soil profiles and require minimal maintenance in comparison to roof gardens. Green roofs descended from the vernacular architecture of various centuries in all parts of the globe, whereas roof gardens are known as luxury items of the affluent since the famous hanging gardens of Babylon in ancient Mesopotamia (between 6th and 7th century B.C) (Werthmann, 2007). The Hanging Gardens have been identified as one of the seven ancient wonders of the world. They are described in written records and have been confirmed by archaeological evidence. One record states that the Hanging Gardens: consisted of vaulted terraces raised one above another, and resting upon cube-shaped pillars. These are hollow and filled with earth to allow trees of the largest size to be planted. The pillars, the vaults, and terraces are constructed of baked brick and asphalt (Design Considerations, 2009). Modern green roofs, which are made of a system of manufactured layers deliberately placed over roofs to support growing medium and vegetation, are a relatively new phenomenon. However, green roofs or sod roofs in Northern Scandinavia, Iceland, Great Britain and Canada have been around for centuries for insulation from extreme cold. For example, traditionally, such earth structures were used for partially submerged food, wine/beer cellars and bomb shelters (Ferguson, 2012). In Scandinavia, roofs were covered with sod that was stripped from surrounding grassy meadows. This was done to insulate homes. Underneath the sod are structurally heavy timber beams interspaced with birch bark to act as a waterproofing layer. Eventually, cheaper, lighter, more effective and mass-market based systems were developed to replace sod roofs (The history of green roof technology). Therefore, green roofs are not a new thing, they are an old thing that we have rediscovered. Until 1970, green roofs were regarded as luxurious home amenities. In the same year, Professor Hans Luz, a German Landscape Architect, proposed the use of green roofs as a means of improving the quality of the urban environment (The history of green roof technology). In the beginning of the twentieth century, green roofs experienced a renaissance through the modernist movement. The invention of the flat wood-cement roof was the first key point of the advancement of green roofs to inhabit a new healthy outdoor space by all levels of society (Werthmann, 2007). At the beginning wood-cement roofs in Berlin were covered with a layer of gravel and clay. Through wind seeding grass began to grow spontaneously. Roof gardens became popular on multi-storey buildings in Berlin in the late nineteenth century and continued to be constructed on large city-centre structures throughout the twentieth century (Green roof guidelines). The modern trend started when green roofs were developed in Germany in the 1960s, and has since spread to many countries. In the 19th century, in Germany Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V or The Landscaping and Landscape Development Research Society E.V (FLL) were established. And in 1982 by FLL the first Guidelines were published for Green roofs, where there was included for the first time, information about effective design and planning of green roofs that included soil deepness, grading composition of soil in use, waterproofing and drainage that nowadays serve as a handbook for the correct implementation that is also adopted by other countries. Since that moment, green roof technology covered areas started growing in geometrically progression, not only in Germany, but also all over the world – in Europe, Asia (firstly in Beijing) and the USA. Green roofs are becoming increasingly popular in the United States, although they were not as common as in Europe, except in the last few years, when green roof technology was imported to the USA. Germany supposedly has the highest implementation rate of green roofs in the world, but it took thirty years of research and twenty years of proactive green roof policies to reach the current market rate of about seven percent. At the end the twentieth century, the green roof gained renewed relevance through environmentalism when its varied benefits were recognized as useful for alleviating problems of heavily urbanized areas (Werthmann, 2007). Green roof experts in the German-speaking countries already identified and labeled it as a "simple intensive roof-greening" in the 1970s. In England, the combination is called a "semi-extensive or semi-intensive green roof" (Werthmann, 2007). The terms "extensive" and "intensive" describe the grade of maintenance needed for a specific cultivation system and its degree of sustainability. Green roofs are considered extensive because they should require only a little maintenance and be self-regenerating. There are two types of green roofs defined – extensive and intensive, but in a few of the definitions as well, semi intensive – roof type between intensive and extensive can be found, and a

brown roof type that excludes the preprocessing of vegetation installation (Greenroofs.com). Extensive roofs serve as an ecological covering that provides society with environmental benefits and the building owner with life cycle cost benefits. A description based on the depth of the growing medium on the green roof is: Extensive green roofs typically have a growing medium at a depth of 4 to 6 inches, which may be retrofitted onto an existing building or planned as part of a new construction (Dictionary of terms). A lightweight (0.7 – 2.4 kN/m^2), low-maintenance roof system, with limited choice of plants (often sedum because of their stability on windy, frosty and heat impacted environment, also sedum or stonecrop, comes in many varieties and colors, has very shallow roots and can absorb up to 50% of its weight in rainwater, thereby alleviating drainage problems typically associated with flat roofs) planted into a shallow substrate that is low in nutrients, with less energy efficiency and storm water retention benefits, and also unattractive to some, especially in winter (Werthmann, 2007). Intensive green roofs typically have minimal depth of growing of 15 cm. Intensive green roofs more closely resemble ground level gardens and must be engineered to support the highest level of loading (1.8 - 6.0 kN/m^2) on a building because of it thickness. Generally, the maximum depth of growing cannot be determined because of a wide diversity of applicable plants. Therefore, intensive roofs have a greater diversity of plants and habitats, can be made very attractive visually, have good insulation properties, more energy efficiency and storm water retention capability and longer membrane life. Other disadvantages besides great weight loading on the roof can be mentioned: a need for irrigation and drainage systems requiring energy, water, materials; higher capital and maintenance costs; more complex systems and expertise.

Technical shortcomings like leakage problems of the early roof gardens created an aura of suspicion and avoidance – prejudices that persist up to today.

Methods of exchanging the gravel of ballast roofs for a thin coat (three to five inches) of growing medium were tested. The low weight of the soil made structural reinforcement of the existing roofs unnecessary, thus substantially reducing cost and this minimal type of a “roof greening” provided similar environmental benefits as traditional roof gardens. The thin coating retained and cleaned rain water, cooled and humidified the surrounding air, filtered dust, reduced noise levels, insulated against heat, helping lower urban air temperatures and migrated the heat island effect, provided a habitat for flora and fauna, and prolonged the life expectancy of the roof. The lifetime of a conventional roof is about 20 years, whereas a green roof should last 40 years or longer (Getter, 2006). The technology was widely implemented as a remedy against many problems of urban density, such as frequent flooding, water and air pollution, high energy consumption and non dependence on climate issues as one might assume. For several years, until German intensive green roofing implementation, the roof-top remained a privilege of the wealthy living in historic districts, the democratic promise of the modern movement to build roof gardens for everybody has obviously failed. For example, the Rockefeller Center, built in 1937 had the concept of the Hanging Gardens, which was to give the building occupants a pleasant view of the surrounding greenery (The history of green roof technology). Since the biggest factor was the considerable additional expense of a roof garden compared to a regular roof and the reinforcement of the whole structure that has to hold the weight of the garden.

At the current moment there are 3 different types of green roof systems in use – complete systems, modular systems and precultivated vegetated blankets. Variations between them are generally found in the manner in which the growing medium and drainage layers are treated. The main difference between those types can be defined in how the growing medium and drainage layers are treated. Only several companies offer ready complete systems, but there are only a few companies around the world that work on production of high quality vegetated blankets. There are many construction companies and manufacturers established and ready with predefined technical solutions for the most commonly applicable and the most problematic nodes in green roofs. Those systems and connections are presented together as one full system. In spite of the lack of special standards, green roofs now are designed according to structural regulations. Mainly in Europe, all structural designs are in accordance with the Euro Code, starting with fire resistance, wind and snow loads and finally according to construction structural designs. The most popular guidelines are developed by Fachvereinigung Bauwerksbergrpünung e. V. (FBB) – Germany, Landscape Research, Development and Construction Society (FLL) – Germany, Green roof organization (GRO)) – UK, U.S. Green Building Council (organization that mainly works on LEED) - USA and City of Toronto Building division – USA. Those are main guidelines are widely accepted. Besides, there are a lot of different local guidelines and they are adjusted for local conditions, but mainly they have the same basis.

MATERIALS AND METHODS

Green roofs are not so popular at the moment in Latvia but within the last decade several objects had been built. like, for example, Eastern Latvian creative service centre – Zeimuls or Caran d’Ache located in Rezekne, which was built in 2012 (Fig.2)

and the Shopping center Olympia (Fig.3) located in Riga, which has been open for clients since December 2002.

Figure 2. Zeimuls in Rezekne
(Source:http://www.tirailatvijai.lv/raksts/1384)

Figure 3. Green roof of the shopping centre Olympia
(Source: www.bptam.com)

Figure 4. Photo map of Kipsala, Riga in the year 2001
(Source: Rigas pilsetas dome)

Figure 5. Satellite map of Kipsala, Riga in the year 2012
(Source: www.maps.google.com)

An interesting fact is that many architectural bureaus design constructional objects with green roofs but during the construction process the project is modified and green roofs when finished don't

Figure 6. Green roof of shopping centre Olympia
(Source: photo by the authors, 2012)

appear (www.vilnitis.lv). The shopping center was built in Kipsala in a place where a little forest used to be and the green roof was a target to compensate the lack of a green cut landscape which had disappeared (Fig. 4 and 5). The concept of the project belonged to the Norwegian architects. The initial idea was to green the building where grass, flowers and trees are along the inclined driveway up till the roof; cafes and a children's playground are among the grass, flowers and trees which are situated on the top of the roof (Smilge, 2002). A nice concept taking into account that Kipsala is located in the UNESCO historical centre and the importance of the building design in this area is rather high. Later artist Andris Breze will say that the Shopping centre in Kipsala is strategic mistake; its scale is rather big for this place, which should keep its intimate character (Smilge, 2002). When the project was confirmed to be built, there was an idea that a roof with a green area will be available for access but after 10 years of existence it is not open for walking and has a warning sign for pedestrians. Passing by this building sometimes a question arises, concerning structural problems with the building itself, or the green roof is not properly designed. Nowadays, the roof has only grass on the eastern part of the roof (Fig.3) and no trees, no flowers, no cafes and children's playgrounds on the roof as it was supposed to be.

Taking into account that the Shopping center Olympia was built 10 years ago with such rare roof type for the Latvian building environment and the present condition of the roof was somewhat interesting for observation, the roof itself was easy to access for a visual survey, study for diploma work (Pastars, 2013) has been carried out and the results are shown in present paper.

RESULTS AND DISCUSSION

The eastern side of the roof (Fig.3) is greened and the roof can be classified as an intensive green roof (Fig.6). The assumption was made based on the observation about vegetation on roof (grass) and additionally a test was made to check the depth of the growing media. A test was made using a marked wooden stick with an average depth of 20 cm. Geotextile was used to hold all the vegetation in place where it should be (Fig.7.). All borderlines and junctions were separated from the growing media with a gravel strip, which protects the membrane from root impact in the places where there is the most danger of leaking if not correctly made. The gravel sides also function as drainage system which removes all excessive water to drainage system output. During the roof survey a few possible damages and incorrectly installed system were found.

Figure 7. Geotextile sticking out from gravel (Source: photo by the authors, 2012)

Figure 8. Waterproof membrane with no connection to structural element (Source: photo by the authors, 2012)

The first thing that can be seen, is the inappropriate installation of the waterproof membrane (Fig. 8), which is not glued or connected with another connection type to the structural elements (at least on exposed areas). Also in some places the waterproof membrane is lower than the vegetation or side border gravel. Another exposed thing that may not be the best solution is separation between the growing media and gravel, where for this function a wooden plank is used, that in 10 years time would be rotten and in time it would not be able to normally perform the function it was made for (Fig.9).

After a visual survey it was concluded that a green roof performs certain functions and it also is aesthetically attractive, but expensive too. But if we leave the construction as it is now and vary only

Figure 9. Wooden separation plank (Source: photo by the authors, 2012)

with roof covering materials, then the roof cover should be visually attractive, because it is exposed and you can see it also really close. It should be difficult to resist a situation if someone decides to climb up as it starts directly from ground level. It should be added that roofing material should be appropriate - it should not heat up to high temperatures. The possibility that anyone can burn any parts of body and also reduce heat coming directly from cover to the pedestrians should be excluded. Nowadays, the most popular roof type is metallic because it is cheap, lightweight, easy to install and has long life. There are many types of metallic roofing materials for different type of use for residential buildings and also for public buildings with double coating or with more layer coating. Different profiles and forms are available. But for this particular situation those materials are not good enough because of thickness and not so high scratch resistance. Another option is the usage of expensive metals, which are also thicker. For that application suitable materials are copper and stainless steel. But they are more expensive and also a little bit heavier (in that case this factor can be ignored because an intensive green roof is a few times heavier than metal sheeting roofs). But still it cannot be ignored that this covering in sunny days warms reaching high temperatures and causes discomfort for persons walking near by the roof. The same situation is in the case of usage of insulated sandwich panels. An additional value in comparison with simple roof sheeting is strength and resistance to external forces. In the category of soft roofing materials are all materials, which consist of bitumen or rubber elastic materials. Those are usually used for flat roofs to avoid flowing down on impact of the slope and heat. That

covering is always used for non-accessible roofs because usually it is installed directly on insulation layer. Of course, in some cases it also may be installed on pre-made base material (OSB, LVL or other plate materials). Access usually is allowed only for service staff. The most problematic for this particular situation that roof starts on one level with ground and it means that there is a need for protective hedge and usage of this material would not be accepted by local landscape architects because of aesthetical aspects. Next roof types could be all wooden materials. Usually wood chips, thin boards or shingles treated with special materials or untreated are used as materials. This is really attractive solution and looks nice. But those materials usually are not suitable for public buildings especially with accessible roofs. Usually wooden chips, boards and shingles are used for residential buildings. The main reason for that is high price slow roofing process and usually with not so long warranty time. Now it is the main problem, because everyone would like to build as cheap as possible without any additional repair work. And as one side of this roof is at the same level with the ground this time also will be decreased and it is additional risk for owners and investors. Ceramic or concrete tiles and cement plates can be combined in one another group as an option for roofing and also for shopping center Olympia. Actually this group might be the most appropriate one. The assumption is based on the fact that those are massive materials which in the end form one solid structure with good resistance to external forces and influence of outside conditions. But still it cannot be used for accessible roof because of fragility and bad resistance to momentum impact forces due to which cracks appear, and it means that functionality is lost. Again the problem is that it starts at the same level with the ground and it is difficult to control access. Other non-traditional roofs would not be taken into account, because they are absolutely not suitable for a shopping center. Green roof installed on this particular shopping center is fully acceptable in spite of high price. But by paying this price investors and owners of this building reduced maintenance cost and service time.

CONCLUSIONS

Nowadays green roofs can be found all over the world from the cold North regions and to the hot equatorial regions. Since “green thinking” became more popular, green roofs have become more advanced and also more popular. But there is a lack of scientific data due to insufficient record-keeping and performance monitoring which prevents the costs and benefits of green roofs from being quantified and green roof technology from being adopted. In several cities green roofs are designed due to environmental benefits whereas in some other cities just due to aesthetical aspects. Lack of scientific data can be resolved through design and construction cost tracking, life cycle cost analysis, cost benefit analysis, performance monitoring and research. Lack of market acceptance of green roofs is different and people are typically resistant to changes. Green roofing is not so popular at the moment in Latvia but individual projects mentioned in present paper could encourage developers, architects and engineers to consider green roof in their new design. In summary one main problem for green roofs can be defined – high price that includes not only the cost of the project itself, but maintenance cost as well. On the other hand, there might be a few situations when the construction of green roof is the only and the best possible solution. It always depends on the situation and also on the construction solution. According to the research it definitely can be told that the system may harm the whole structure, there could be problems with leaking, problems with hydro isolation, too large weight and a lot of additional maintenance work and costs have no substantiation. If the roof construction is made at high professional level, green roof can be defined as more immune from the defined problems. All regulations pertaining to qualitative construction are also important and must be taken in account for green roofs. Another greatest fear still is that this roof type is totally unsuitable for local weather conditions. The answer to this problem is really simple. The only thing that should be taken into account is the choice of roof type and greenery that suit the preferred type and clients wishes for maintenance and visual view. Green roofs correspond to all weather conditions and areas. Technically there are only small differences between regular and well known construction, all solutions are made to provide total safety of property owners from possible problems. The companies specializing in the construction of green roofs provide all technical solutions and if the construction is made according to them, the problems of leaking, waterproofing and the like can be successfully avoided. Moreover, green roofs bring along many advantages like absorbing rainwater, providing insulation, creating a habitat for wildlife, helping lower urban air temperatures, mitigating the heat island effect, and ensuring longer service life.

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