Building a Green Roof in Lithuania

James N. Ferguson[1*]

[1] *Senojo Miesto Architektai (SMA), Šv. Ignoto 5, LT-01120 Vilnius, Lithuania*

** corresponding author: ferguson_vilnius@yahoo.com*

crossref http://dx.doi.org/10.5755/j01.sace.1.1.2612

Green roofs are relatively new to Lithuania. Traditionally, such earth structures were used for partially submerged food cellars and bomb shelters. However, one sees more and more architects opting for green roofs as an alternative to large flat roofs. The advantages are many fold. A green roof is not only a pleasing aesthetic alternative, but it helps retain thermal energy and provides for better surface drainage for expansive roofed structures. This paper examines the origins, basic principles and benefits of green roofs, noting examples and a chart indicating various green roof systems. The international standard is largely set by the Forschungsgesellschaft Landschaftsentwicklung Landshaftsbau e. V., or more simply FLL, first developed in Germany in the 1970s. I have designed five green roof projects in Lithuania. Two are located in Trakai, two in Vilnius, and one in the Ignalina region. Precedents are cited, along with photos, technical drawings, structural details, materials specifications and the ecological benefits these roofs provide in urban and rural environments. In conclusion, green roofs are a relative low cost alternative to flat roofs, which provide greatly enhanced benefits. As a result, European cities have set targets for the percentage of green roofs constructed each year, and the European Union has offered financial aid and assistance in meeting these targets. Hopefully, this will encourage more Lithuanian developers, architects, and engineers to consider green roofs as a viable solution.

Keywords: *Green roofs, sustainable design, architecture.*

1. Introduction

It has been a long uphill battle to interest clients in green roofs, solar power and other forms of passive energy roofs, since I came to Lithuania in 1997. My first major commission came in 2005, when asked to re-design an antique automobile museum in Trakai. The client had to go underground with his museum to satisfy Trakai historic planning ordinances and what better way to top such a museum than with a green roof that melded into the surrounding landscape with guest houses built atop in the traditional style, effectively disguising the 4000 sq. meter museum below.

Since that time, I've had the opportunity to design several other green roofs, ranging from a residential complex in Užupis to a roof top for the ruins of a 19th century stone barn at Paliesiaus estate in the Ignalina region (Fig. 1). Currently, I am working on a green roof for a new sports hall for the American International School

Fig. 1. *Paliesiaus estate, Ignalina region*

of Vilnius. Surprisingly, what links all these roofs is not their environmental benefits, but rather their adaptability to historical sites in urban, small town and rural settings.

The last 7 years have seen the proliferation in sustainable design in Lithuania, due to greater awareness in alternative forms of construction and increased availability of products in the country. There is even now a solar panel manufacturing plant outside Vilnius, which should make these panels more affordable in the years to come. In this paper I will demonstrate the advantages of a green roof over traditional roof types, and how such roofs can be integrated with other passive energy systems like solar panels to reduce energy needs.

2. Origins

The green roof is certainly nothing new. Roofs made of earth go back to prehistoric times and were used for habitation and food storage. A thick green roof provided protection against piercing cold or searing heat, with examples found as far distant as Norway and Tanzania. Thick mud walls combined with a timber frame and earth roof served as the basis for the famous Pueblo architecture of the American Southwest. A reed underlayer would swell during rains to become virtually waterproof against the elements.

These traditional forms of architecture gave way to other forms over the centuries. Roof gardens were revived in the late 19th and early 20th century. These terraced roofs were seen as a luxurious addition to city hotels as well as rural mansions, offering great views across the city and country estates. Le Corbusier was the first modern architect to champion the roof garden in his *Immuebles-Villa* of 1925, and incorporated roof gardens into his early villa designs. However, as Christian Werthmann noted in his book Green Roof – A Case Study, Le Corbusier's vision gained little traction, despite the popularity of flat roofs among developers.

It wouldn't be until the 1970s that green roofs took hold in Germany, with advocates stressing its environmental benefits. A number of pioneering studies were done in regard to effective waterproofing materials, the best organic covers and the benefits such roofs provided. The Forschungsgesellschaft Landschaftsentwicklung Landshaftsbau e. V., or more simply FLL, was formed during this time with a commitment to green roof design. Studies revealed the most drought-resistant plants with the least amount of subsoil for lightweight, low-maintenance roofs that would "green" cities like Stuttgart. Today, Germany leads the world in adding approximately 8 square kilometers of green roofs per year, which amounts to 7% of all new roofs in the country.

3. Basic principles

There are essentially two types of roofs with vegetation – the green roof and the roof garden. The green roof is an extensive roof with minimal soil mix or mineral substrate supporting a thin layer of vegetation, usually sedum, which requires little maintenance. The roof garden is more intensive, using a greater amount of topsoil to allow for a richer variety of plant life and formation of small hills, and is usually accessible to people. There are many hybrid forms, adapted to specific environments.

The green roof is the most common as it is the most cost-effective. There is little additional cost in providing a thin layer of topsoil to support sedum, which can survive in most locations. 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. The lightweight roof (37 kg/m^3) can be adapted to virtually any building without added structural support. It comes in blankets that can be rolled out on a minimum of 20 mm of mineral substrate. It also comes in easy to grow kits for smaller roofs. Typically, these roofs are not accessible and require minimal upkeep.

The garden roof offers a wider range of opportunities, especially for those who want to make the roof an active part of the building, as Le Corbusier had envisioned in his *Five Points of Architecture*. A minimum of 150 mm of topsoil is required to grow a greater variety of plant life. This of course adds considerable weight to the roof and would require additional structural reinforcement. However, the benefits often outweigh the costs, as the roof literally becomes an extension of the building and can be used in a number of creative ways, as was the case with Le Corbusier's La Tourette monastery in southern France.

Hybrid roofs combine features noted above as well as introduce additional elements such as small structures and passive energy systems like solar and wind power. A great number of creative designs have been proposed, such a MVRDV's Dutch Pavilion for the Hanover Exposition of 2000, which was an artificial ecosystem based on various Dutch landscapes with modern wind turbines.

4. Benefits

These roofs provide a number of positive features. Typically they are seen as ecological improvements, providing an additional layer of green to a city, or melding a building into a rural landscape so that it looks less intrusive.

The major benefit of a green roof is stemming the flow of water off a roof. Hard roofs offer no resistance to rain water. During a heavy rainstorm, massive amounts of water flood an often overloaded city drainage system. A green roof or garden roof absorbs and filters rainwater, relieving the amount of water flowing into a rain water drainage system.

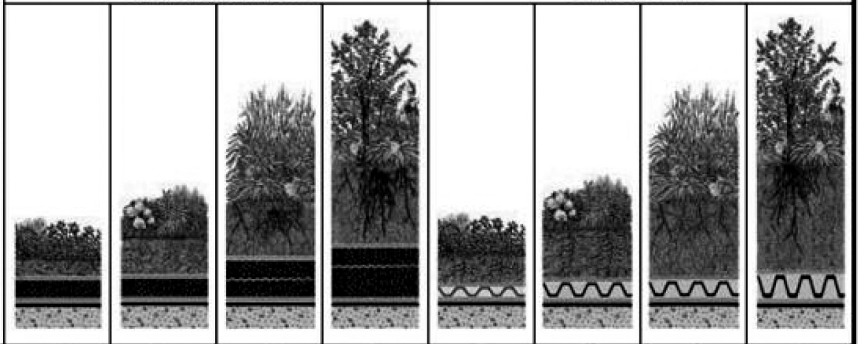
Another benefit is noise reduction. It has been shown that a typical lightweight green roof reduces sound by 5 decibels. The thicker the roof garden the more noise is dampened. This is particularly beneficial in loud urban environments.

A thin sedum-covered rooftop blocks out UV light, increasing the life of the waterproof membrane. The roots do not penetrate membranes, but an additional protective layer is advisable for wind blown seeds that may take root on the roof.

A green roof also serves as a passive roof covering that lessens heat gain. Typical roof surface materials often absorb heat and make a building harder to ventilate and

Table 1. Green roof systems (conversion factor 1 inch = 2.54 cm)

GREEN ROOF SYSTEMS according FLL



	SYSTEMS WITH GRANULAR DRAINAGE				SYSTEMS WITH DRAINAGE PLATES			
system designation	G1	G2	G3	G4	P1	P2	P3	P4
typical plants	sedum herbs	sedum herbs perennials	perennials grasses shrubs	grasses shrubs trees	sedum herbs	sedum herbs perennials	perrenials grasses shrubs	grasses shrubs trees
extensive soil mix	2"	4"	-	-	3"	5"	-	-
intensive soil mix	-	-	6"	9"	-	-	8"	12"
separation fabric	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"	1/8"
granular drainage	2"	2"	4"	6"	-	-	-	-
drainage plate	-	-	-	-	1"	1-1/2"	1-1/2"	2-1/2"
drainage mat	-	-	-	-	-	-	-	-
protection mat	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"
nominal thickness	4"	6"	10"	15"	4"	7"	10"	15"
dry weight	19 lbs/ft^2	28 lbs/ft^2	45 lbs/ft^2	69 lbs/ft^2	14 lbs/ft^2	23 lbs/ft^2	34 lbs/ft^2	52 lbs/ft^2
saturated weight	26 lbs/ft^2	41 lbs/ft^2	70 lbs/ft^2	105 lbs/ft^2	23 lbs/ft^2	37 lbs/ft^2	57 lbs/ft^2	85 lbs/ft^2
minimum slope	0:12	0:12	0:12	0:12	1/4:12	1/4:12	1/4:12	1/4:12
maximum slope	1:12	1:12	1:12	1:12	1:12	1:12	1:12	1:12
water retention/**Year***	50%	60%	70%	80%	50%	60%	70%	80%
irrigation system	-	-	subsurface	subsurface	-	-	surface	surface

*** conservative numbers**

cool in warm months. Even the lightest green roof is a vast improvement over typical asphalt and gravel flat roofs. A thicker roof garden would provide an additional layer of thermal insulation in winter.

Still the greatest benefit is increasing the amount of green space in a city. It has been shown that cities with the largest percentage of green roofs, like Stuttgart, have actually seen a slight ambient decrease in air temperature. Typical roofing materials increase the heat in a city, making some cities incredibly stifling during the hottest summer months. Active roof gardens not only increase the biodiversity of a city, but provide a new level of agricultural gardening in densely packed cities. All this additional vegetation also helps absorb the high levels of carbon dioxide common in metropolitan centers.

5. Projects

The Urban Green Roof

I've had the opportunity to design two urban green roofs in Vilnius. Both share the similar feature of being extensions of the surrounding hillside, as to satisfy municipal zoning conditions. The first was a terraced garden roof for a residential complex in Užupis. The client wanted 40 individual units built into a hillside with underground parking. There was a limited amount of space to achieve the number of units the client desired. I used a green terrace to provide for a second level of outdoor living for the units above. As this would all be active space, I proposed the structure be designed to support a minimum of 30 centimeters of topsoil with a combination of terrace features. Unfortunately, the project was not realized due to the economic crisis of 2008.

Since then I have been working on a new sports hall for the American International School of Vilnius. The school is located on a narrow strip of land on the north side of Subačius St., neighboring two historic monasteries. There was a limited amount of space between the school and the steep hillside which was under protection. We were able to get preliminary approval from the municipal planning and the cultural heritage departments by burying the sport hall into part of the hillside, which had once served as a playground. The sports hall literally became an extension of the hillside with an earth roof, making it invisible from the air.

We recently completed a preliminary technical project, pending approval of the Detail Plan. The roof structure is made from 10 cm deep corrugated metal sheets supported by pre-fabricated steel trusses at 6 meters on center. A 5 cm air space separates the insulated layer from the earth roof, with drainage filtered to a channel at the juncture with the hillside, which feeds into the storm water drainage system.

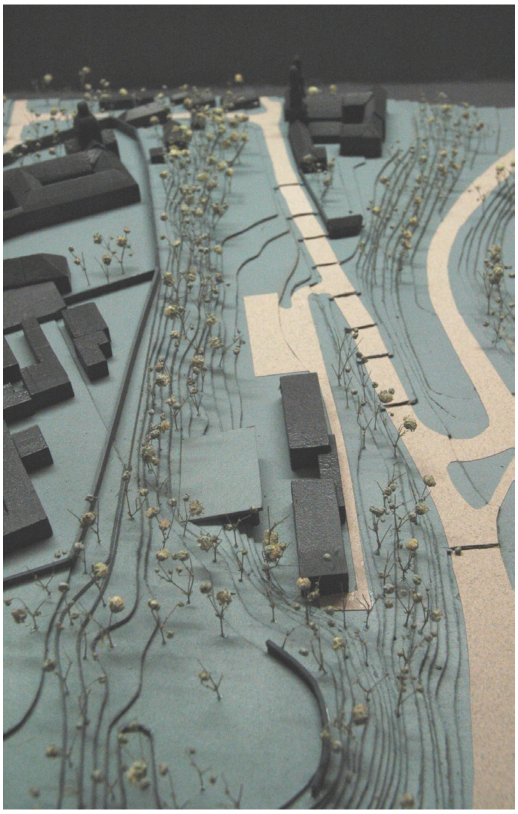


Fig. 2. *Site Model*

Both projects presented numerous challenges. As is often the case in such projects, the developers wanted to maximize the building intensity of the site. Both sites were irregular in shape and didn't allow for conventional building solutions. The green roofs grew out of largely pragmatic responses to the sites, not ecological ones. Once the clients became interested in the ecological benefits, the focus shifted toward creating sustainable designs that in the first case would attract prospective homeowners and in the second case EU funding. The school is now seeking funding for a geothermal system to heat and cool the school and sports hall.

Going Underground

Two other opportunities for green roofs arose in Trakai, where my wife and I have done several small projects and have an ongoing site improvement project with the Trakai National Historic Park at Užutrakis.

We were first approached by a client looking to expand an antique automobile museum he had received approved for construction. He owned a highly visible site with an historic brick house at one corner that had to be restored to its original appearance. His collection of antique cars had greatly increased since he first considered the project and had since bought neighboring parcels of land, which allowed him up to 4000 square meters of underground area. The city was keen on the idea, as they felt it would be a valuable new tourist attraction, but the national park was skeptical of such a large underground structure and roof top. We alleviated the national park's concern by landscaping the roof top in keeping with the contours of the original site.

The roof structure is a two-way reinforced concrete slab with reinforced concrete columns with massive reinforced capitals. The structural engineer expressed concerned over the load of the landscaping on the roof slab, but there are many ways to alleviate such loads by forming contours and hills out of lightweight materials and laying a relatively light subsoil on top, using the hidden space for light wells or storage. Christian Werthmann noted the innovative ideas of Michael Van Valkenburgh in the green roof he designed for the existing headquarters of the American Society of Landscape Architects in Washington, DC. Construction began in 2006 with one-quarter of the underground structure complete by 2008, at which time work was suspended due to the crisis. The owner continues his efforts to secure financing to complete the project.

During this time we received a commission for a second large project in Trakai, the reconstruction of the Nendre restaurant into a hotel and spa complex, approximately 2500 square meters. The greatly expanded structure grew out of the original footprint of the building and continued along the ridge facing the lake. The green roof would have risen from grade to the high point of the roof. It was quite a departure from the traditional forms that the national park advocated, but we were able to convince the park that this was the best solution to the site as it would have a low profile toward the castle and be far less intrusive than is the original Nendre structure. Unfortunately, the client chose not to proceed with the project beyond the approved Proposal and Detail Plan.

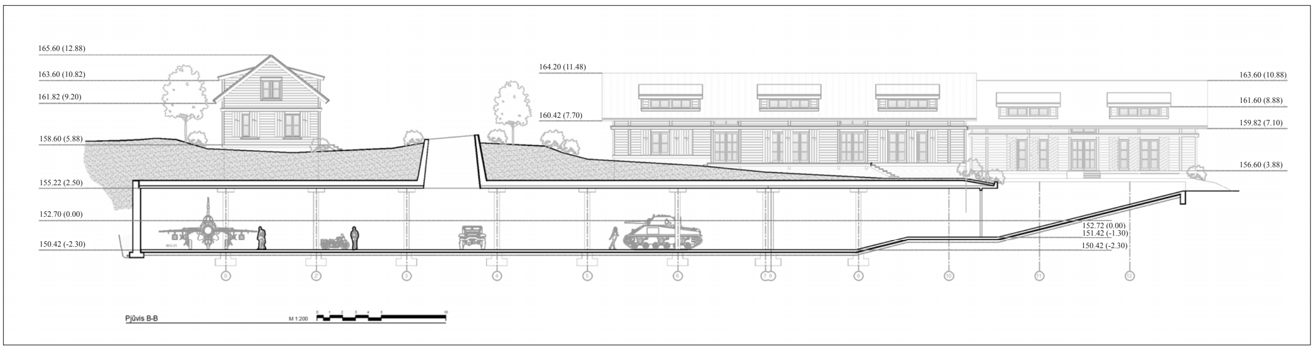


Fig. 3. *Site section*

A Protective Green Roof

We were approached to design a country tourism complex on the grounds of the former Paliesiaus estate in the Ignalina region in 2008. The only remaining structures were two stone barns that served the estate, both in very bad condition. The first barn (see figure 1) was able to be restored, since it still had its structure relatively intact, but the more interesting semi-circular barn was in a complete state of ruins. The question became whether to reconstruct the second barn to its original appearance or take another approach. I suggested stabilizing the ruins and placing a green roof over the structure to protect it. The three wedge-shaped rooms could be converted into a spa to serve the guest rooms in the other restored barn. Both the Cultural Heritage Dept. in Utena and the city commission in Ignalina liked the idea and approved all the documents.

The shed roof is approximately 900 square meters in area and is constructed from glu-lam beams atop similar glu-lam girders, supported by 33 cm diameter wood laminated columns, with an 8 cm insulated layer and a 10 cm ventilated air space below the 15 cm earth covering. The ventilated air space will help to avoid condensation between the insulation and the earth covering. Construction began in late 2011, and the first part of the project should be complete by January, 2013.

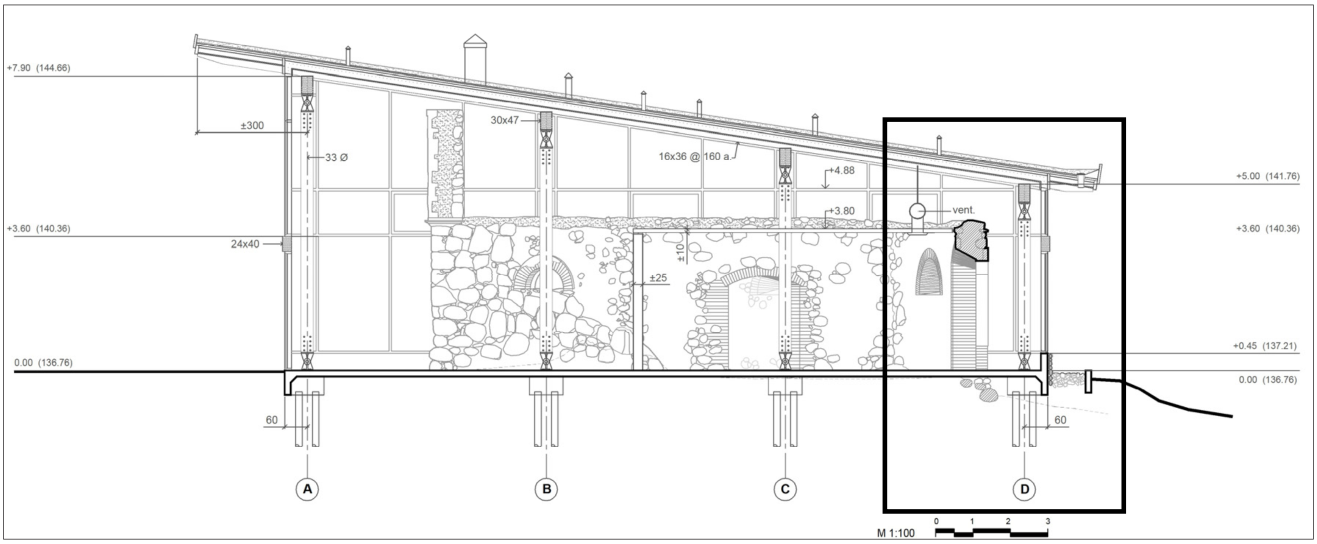


Fig. 4. *Section drawing*

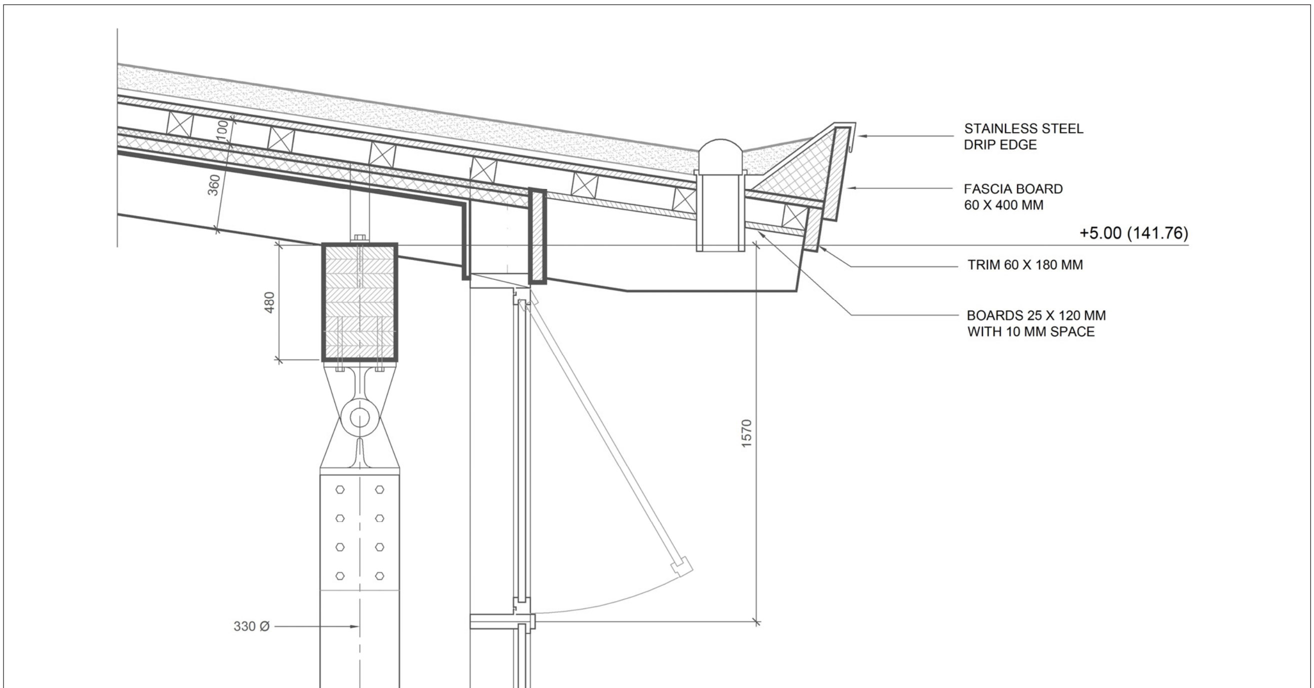


Fig. 5. *Roof detail*

6. Conclusions

The green roof is a relatively low cost solution that has been demonstrated to have many benefits to the building owner, both in terms of pragmatic concerns and environmental impact. Yet, there is only a relative handful of earth roofs in Lithuania. Waterproofing remains the principal concern, but lightweight sedum roofs can be installed on virtually any existing flat roof, increasing the life span of the roof, reducing heat gain, and easing storm water drainage. William McDonough and Michael Braungart noted in their book, Cradle to Cradle, that they convinced Ford Motor Company of the benefit of green roofs, retrofitting sedum roofs on existing manufacturing plants, greatly reducing cooling costs in summer.

New roofs can be designed with greater landscaping loads in mind and formed into existing hillsides or used to "conceal" buildings in urban and historically significant locations. We found that building context models for the American International School and the Užupis housing project convinced city and cultural heritage department officials that the new proposed buildings would have a relatively low impact on sensitive sites.

However, it is important to think beyond individual solutions and pursue broad range planning, as has been the case in Stuttgart, Germany, where city officials have set long term goals for the percentage of green roofs. The EU is now actively promoting green roofs in new construction across Europe. Similar measures can be adopted in cities in Lithuania, which would encourage developers, architects and engineers to consider green roofs in their new designs. The Forschungsgesellschaft Landschaftsentwicklung Landshaftsbau (FLL) provides the necessary standards. The main website is in German, but various translations can be found on other websites. (I. Gurauskiene, 2006, Eco-design methodology for electrical and electronic equipment industry).

References

Betsky A. 2002. Landscrapers: Building with the Land. Thames and Hudson.

Breuning J., Yanders, A. 2008. Edition of the Green Roofing Guideline, Introduction to the FLL Guidelines for the Planning, Construction and Maintenance of Green Roofing.

Costanzo, M. 2006. MVRDV: Works and Projects 1991-2006, Dutch Pavilion. Skira.

Margolis L., Robinson, A. 2007. Living Systems. Birkhäuser.

McDonnough W., Braungart M. 2002. Cradle to Cradle. North Point Press.

Werthmann Ch. 2007. Green Roof – A Case Study. Princeton Architectural Press.

Individual projects cited as examples can be viewed at: http://www.ferguson-studio.com (accessed 17 May 2012).

Received 2012 06 21
Accepted after revision 2012 09 03

James N. FERGUSON – architect at Senojo Miesto Architektai (SMA).
Address: Senojo Miesto Architektai (SMA), Šv. Ignoto 5, LT-01120 Vilnius, Lithuania.
E-mail: *ferguson_vilnius@yahoo.com*