Study Regarding Temperature Differences between a Traditional Roof and Green Roof

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Abstract

In the last years a lot of studies were focus on green roofs in different regions and zone on the continent. The study location is in Germany, at the University of Applied Sciences Neubrandenburg and lasted 2 weeks in summer of 2014. To determine temperature were used 6 devices Data Logger LOG. The temperature differences between a green roof and a traditional roof were measured and statistically assured; therefore, it was determined a difference around 3°C between the traditional roof and the green roof. The results of the experiment demonstrate that the temperature recording in summer is lower on the green roof than on the traditional roof in temperate zone. In the current paper are also recording temperature differences between the building height levels.

Keywords: *environment, , elevation,green roof, temperature, traditional roof.*

INTRODUCTION

Vegetation is an increasingly used material regarding sustainable buildings (Eumorfopoulo and Kontoleon, 2009; Fioretti *et al*, 2010), therefore through green roofs and vertical gardens grow green building features and benefits the environment (Perini et al, 2011).

Nowadays, there is a freedom to design an aesthetically pleasing landscaped roof. A roof garden's primary purpose is to provide a place to be among or to view plants (Osmundson, 1999). Moving from sustainability (general) to "green construction" (specific) requires careful planning. Many "simple things to do to save the planet" require only substituting "bad" products for "good" ones (Thompson, 2008).

In the last five years, the term green roof has taken on ecological and social significance beyond its seemingly simplistic description. The term has become an epithet for the reduction of pollution and urban heat islands, for large-scale mitigation of storm water runoff, and for maximum utilization of urban land (Weilwe, 2009). Roof gardens (Manfred, 2001a) can keep buildings cooler, have positive effects for indoor climate (Manfred, 2001b), save energy, extend the useful life of the roof and add beauty and useable space" (Richard M.).

This study focuses on a green roof and a traditional roof in the temperate region in Neubrandenburg, Germany. Regional climate, especially precipitation and temperatures can influence the selection of plant species that can survive in a particular geographic region. Because plants can tolerate low temperatures in horticulture, use zoning categories resistance to frost, so-called " Hardiness Zones" (LUCKETT KELLY, 2009) where Germany is in zone 2 and 3 frost tolerance (Fig.1) (*** Catalogue TGreen Roof Green systems).

The aim of the study regarding temperature differences between a traditional roof and green roof is to establish that the air quality inside buildings could be improved by installing green roofs. The main aspect that will be discussed is about thermal characteristics of both roofs traditional and green in summer days. The paper includes a discussion about the results and the potential green roof benefits to this region.

CASE STUDY ROOF

The green roof at the University of Applied Sciences Neubrandenburg was constructed in 1998 by Ministry of Education submitted by Prof. Dr. Manfred Köhler. This green roof was designed by architect Mansberg and it`s an educational type of roof. This roof has 21528 sq. ft., and a slope of 1%. The system on this roof is Optima and is an extensive green roof. The green roof has 6 growing media, 4 exposition, three types of implementing green roof plant species: seed, spruces, pre produced vegetation mats and two depth of growing medium.

MATERIALS AND METHODS

The experiment was conducted in the city of Neubrandenburg, Germany, on the roof of the University of Applied Sciences. In this building were install two types of roofs: one traditional and one green. Traditional roof (Fig. 2) is made of insulating membrane placed over a substrate, of 10 cm, made of stone for better drainage. The green roof (Fig.3) is composed of insulating membranes for protection against roots and the drainage over the ground was placed a special substrate for green roofs of 10 cm.

The research methods used, to achieve the objectives of this study, are: specialized equipment data logger LOG 32 and SPSS program for statistical interpretation. To determine temperature, were used 6 devices Data Logger LOG 32 (Fig. 4)

These devices were installed as follows: one at 50 cm above the traditional roof, one on the normal roof, one in normal roof substrate, one at 50 cm above the green roof (Fig. 5), one on the green roof (Fig. 6), one in the green roof substrate, one at 50 cm below the ceiling of the 3rd floor and one at 50 cm below the ceiling of the first floor. As a control point located was considered the device above the traditional roof.

These devices were programmed to take measurements every 5 minutes for 2 weeks, for

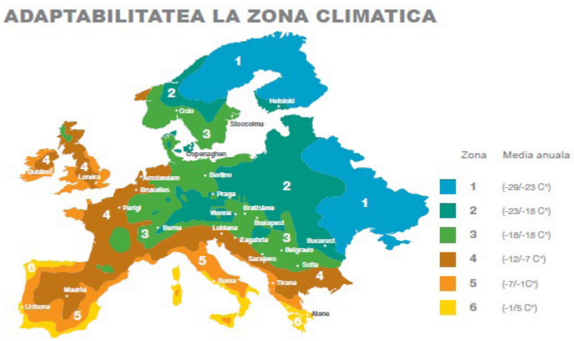


Fig. 1 Climatic zones
Source: *Catalogue TGreen Roof Green systems*

Fig. 2 Traditional roof
Source: *original*

Fig. 3 Green roof
Source: *original*

Fig. 4 Data Logger LOG 32
Source: *original*

how long the experiment lasted, from 06.14.2014 until 27.06.2014. The results interfaces are shown in some graphics.

RESULTS AND DISCUSSION

After analyzing these graphs it was found that on 06.26.2014 there were two extreme temperatures on the traditional roof throughout the experiment as can be seen in Table 1.

From the above graphic it can be seen that on 26/06/2014 at 6:19 p.m. was recorded maximum temperature of 29.1ºC on reference point and the temperature difference between the traditional roof and green roof is approximately 3°C, the same different temperature recorded between the LOG 32 placed on substrate and on ground level. The difference recorded between the traditional roof and green roof is only about 1°C. Minimum temperature differences between the traditional roof and green roof are between 0.2 - 7.4 °C, which means that in the night the temperature of the substrate on a traditional roof will be lower than the temperature of the substrate on a green roof.

In 2012 Slabe T. demonstrate that, in the semi-arid zone, the annual averaged daily and maximum temperatures were 2.0°C and 7.42°C higher, at the control roof gravel than at the green roof substrate surface-air interface. Also, averaged control roof daily minimum temperatures of the gravel surface were by contrast 1.62°C and 2.16°C lower than average green roof substrate surface-air interface minimum and beneath the substrate minimum temperatures.

Following data collection were obtained the next results:

Regardless of elevation used in experience, type of normal roof recorded a temperature significantly negative towards the type of green roof regarded as a control.

Regardless of type of roof used in experience, measurements in the substrate and substrate recorded a temperatures significant increase and positively very significantly to these temperature measurements recorded at 50 cm above the substrate, used as a control.

Fig. 5 LOG 32 placed on 50 cm above the green roof
Source: *original*

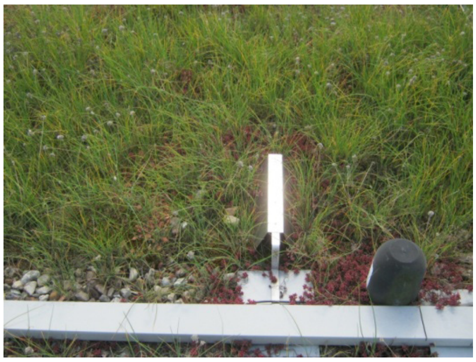
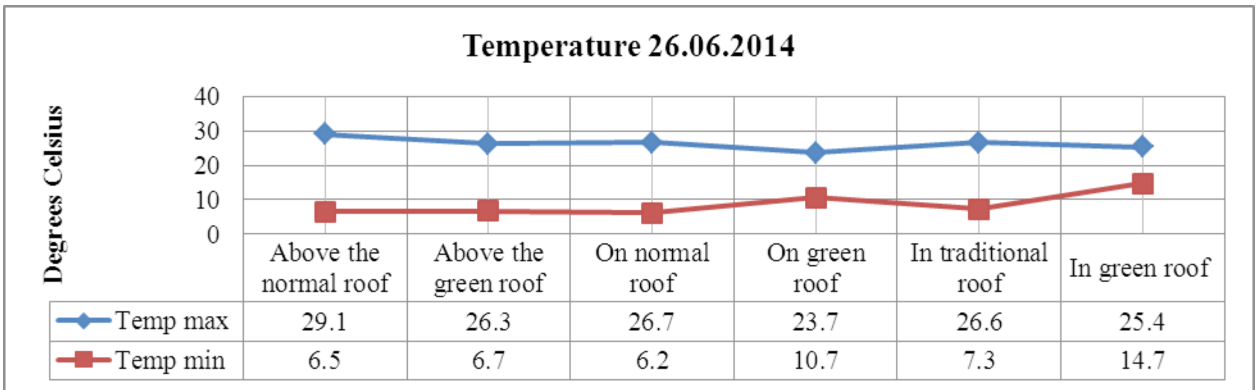


Fig. 6 Log 32 placed onthe green roof
Source: *original*

Tab. 1 Table with temperature extremities in 26/06/2014 – Neubrandenburg



	Above the normal roof	Above the green roof	On normal roof	On green roof	In traditional roof	In green roof
Temp max	29.1	26.3	26.7	23.7	26.6	25.4
Temp min	6.5	6.7	6.2	10.7	7.3	14.7

On the green roof, temperature measured on the substrate and in the substrate is very significant positive versus temperature measured at 50 cm above the substrate taken as a control, while on the traditional roof, temperature measured on the substrate and in the substrate is insignificant versus temperature measured at 50 cm above the substrate taken as control.

The temperature measured at 50 cm above the traditional roof is insignificant compared to temperature measured at 50 cm above the green roof taken as control. Temperatures measured on the substrate and in the substrate are very significant negative on the normal roof to temperatures measured in the same points at green roof, taken as a control.

Tab. 2 Influence of the roof type on air temperature

Symbol	Temperature	%	Difference	Significance
A1	17.27	100.0	0.00	Mt./Control
A2	16.28	94.3	-0.99	000

DL (p 5%) = 0.35 DL (p 1%) = 0.49 DL (p 0.1%) = 0.68

Note: A1 – traditional roof; A2 – green roof

Tab. 3 Influence of the elevation on temperature

Symbol	Temperature	%	Difference	Significance
B1	16.28	100.0	0.00	Mt./Control
B2	16.63	102.1	0.35	*
B3	17.41	106.9	1.13	***

DL (p 5%) = 0.27 DL (p 1%) = 0.35 DL (p 0.1%) = 0.46

Note: B1 – above the green/traditional roof (50 cm); B2 – on green/traditional roof (0 cm); B3 - inside the substrate green/traditional roof (-10 cm)

Tab. 4 Influence of the elevation on temperature, to the same type of roof

Symbol	Temperature	%	Difference	Significance
B1A1	16.16	100.0	0.00	Mt./Control
B2A1	17.14	106.0	0.98	***
B3A1	18.50	114.5	2.34	***
B1A2	16.40	100.0	0.00	Mt./Control
B2A2	16.12	98.3	-0.28	-
B3A2	16.31	99.5	-0.09	-

DL (p 5%) = 0.38 DL (p 1%) = 0.50 DL (p 0.1%) = 0.65

Note: B1A1 – above traditional roof (50 cm); B2A1 – on traditional roof (0 cm); B3A1 – in the substrate of traditional roof (-10 cm); B1A2 – above green roof (50 cm); B2A2 – on green roof (0 cm); B3A2 – in the substrate of green roof (-10 cm)

Tab. 5 Influence of the type of roof on temperature, at the same elevation

Symbol	Temperature	%	Difference	Significance
A1B1	16.16	100.0	0.00	Mt./Control
A2B1	16.40	101.5	0.24	-
A1B2	17.14	100.0	0.00	Mt./Control
A2B2	16.12	94.1	-1.02	000
A1B3	18.50	100.0	0.00	Mt./Control
A2B3	16.31	88.2	-2.19	000

DL (p 5%) = 0.46 DL (p 1%) = 0.63 DL (p 0.1%) = 0.86

Note: A1B1 - above traditional roof (50 cm); A2B1 - above green roof (50 cm); A1B2 - on traditional roof (0 cm); A2B2 - in green roof (0 cm); A1B3 - in the substrate of traditional roof (-10 cm); A2B3 - in the substrate of green roof (-10 cm)

Green roofs help a good thermal insulation, both winter and summer, which imply cost reduction and ventilation air (***Design guide, Diadem; Thadani, 2010). Energy efficiency has been shown to be more significant in summer than in winter (Snodgrass and Linda Mclntyre, 2010). A study shows that the presence of vegetation on the roof can affect the temperature and its variations in the waterproofing membrane. In summer conditions, on a traditional roof maximum temperature reached in the membrane around 14:00 to 66º C, and the maximum temperature reached on the membrane of a green roof was of 38º C, around 18 : 30 (LIU and MINOR, 2005).

CONCLUSION

Temperatures recorded significant differences between the traditional green roof on the substrate and in the substrate, which means that, during the summer, green roof recorded maximum temperatures lower than traditional roof and minimum temperatures higher than traditional roof. Slade T. demonstrates in 2012 that in the semi-arid zone the green roof temperatures were lower in summer and higher in winter.

The current paper demonstrates that in the temperate zone the temperature recording in summer are lower on the green roof than on the traditional roof. Also the paper demonstrate the following advantages of green roofs over traditional flat roofs: a positive influence on the temperature inside a building with green roofs, a positive influence over the environment by naturally cooling and/or heating the interior of a building depending on the climatic conditions.

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