The positive effects of green roofs on environment

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Abstract: Green roof is an engineering system for growing plants vegetation on buildings roofs. This system has many advantages both in urban and smaller scales (buildings). In single building term, green roof results in energy saving. The amount of energy saving is significant in hot climate conditions. By executing green roof, the thermal capacity of roof increases and the temperature fluctuation decreases; leading in turn to cooling the space below roof in summer and reduction of heat energy in winter. In urban scale; too, this system has many environmental benefits besides improving the visual quality and aesthetic specifications. The environmental benefits include controlling air pollution, carbon dioxide and decreasing heat islands. Establishing green roof could be a good solution in dealing with undesirable climate changes in micro-climate scale. This paper analyzes the thermal function of green roof, studies the environmental effects and discusses approaches in improving the positive effects of green roof both on environment and urban spaces.

Keywords: *Green roof, Reduction of thermal islands, Micro-climate, Carbon dioxide control, Thermal function .*

1. Introduction

Green roofs which are made to change the dead space of flat roofs to a dynamic space play an effective role in urban ecologic output and establishing desirable quality in urban life. The effectiveness of green roof is significant in urban scale. Changing the roof of houses to green space improves air exchange between regions in high construction density and the open spaces between them and regulates air humidity. Those roofs, in addition to helping pollution control in cities, have effective roles in exchanging energy and heat between indoor and outdoor. This technology has many advantages, including lowering heating and cooling load, air purification, sewage flow controls, reduction of sound pollution and more important than all, reducing energy consumption in efforts to sustain cities.
The principle of sustain design relies on the point that building as a small part of peripheral nature, should act as an ecosystem and enter into life cycle.
The most important part of a building in energy consumption is the external shell of the building [1] and in the external shell; too, roof has highest surface of contact with outside air and is directly exposed to sun rays; therefore, it is more effective in increasing or reducing energy consumption more than other parts of the building.
One of the approaches discussed for lowering energy consumption is roof garden and if it is designed and executed properly with climatic considerations in its design, could be effective in environmental sustainability.
The goal of this research is to present approaches for lowering heat transfer and subsequently, reducing energy consumption and increasing environmental effects of green roof.
A question raised in the beginning of the research and opened way to the rest of research stage was: "What details could be used to decrease heat transfer and subsequently, lower energy consumption?"
The hypothesis of this research is that "It sees green roof could considerably contribute to lowering heat transfer and causes reduction in energy consumption. In addition, it has impacts on adjusting environment heat through absorbing sunray or lowering air pollutions." This text emphasizes on the role of green roof in lowering energy consumption and studies the

environmental effects of the roof and by analyzing the results, compares the positive effects of green roof on adjusting environment and ordinary roof.

2. Methodology

The research methodology is descriptive-analytical.In the introduction section, the descriptive method and in the analytical section, heat behavior and heat transfer, the analytical method has been used.

3. Analysis of environmental effects of green roof

Without knowledge on environment conditions one could not discuss places covered with plants. Making roofs green requires plants that could resist the harsh and soulless environment of flat roof in low watering, frost, storm and other undesirable climate conditions. Type of plants depends on the type of climate and weather conditions. Therefore, it is important to study various urban climates in this connection. Paying attention to factors such as altitude from sea level, main direction of wind in city…is very useful. In fact, the main causes of bioclimatic changes in large cities could be summarized as follows:

- Low wind blow
- Unnatural changes in city temperatures
- Dusts and pollutions in the air
- Changes in humidity of city air
- Separate circulation of city air
- Blockage of city surface by buildings, asphalt[2]…

Therefore; in order to study environmental effects of green roof, first we study differences of this roof with ordinary flat roofs.

3.1. Brief study of quantity and quality differences of green roof and ordinary roof

Protecting building against heat is one of the characteristics of green roof and could significantly decrease the high thermal load from building in summer. Establishing green roof is a desirable ecological solution that not only helps lowering thermal load of external parts of building; it helps in quality improvement of dense urban centers with little surface of natural environmental. Tree branches protect buildings against sunrays and control temperature and humidity inside buildings. In close places with plant growth on roof, temperature in below spaces is less than temperature above the building.
The difference between roofs with plant growth and ordinary roofs could be divided into two classes of quality and quantity differences. The process of thermal transfer in planted roofs is completely different. Due to their biologic functions such as photosynthesis, perspiration, respiration and evaporation, plants absorb considerable amount of sunray. The remaining solar rays change into thermal load and when they pass through construction elements of roof, they leave impacts on indoor air conditions.

Quantity differences:

- Sound insulation
- Reduction of thermal islands effects
- Lowering air pollution
- Lowering carbondeoxide
- Lowering sewage canal system loads
- Reduction in heat transfer through saving building energy

Quality differences:

- To protect roof shell

- To expand green site and animal organism living environment
- Food production
- Beauty, welfare and hobby
- Improvement of health
- Economy and politics

With respect to the environmental importance of green roofs, descriptions that are more detailed are given on some of its characteristics.

3.2. Reduction of thermal islands effects

Due to having large areas of hard, impenetrable and naked surfaces with no plant vegetation, large cities absorb sunshine heat fast and in turn, act as thermal energy diffusion sources. In such condition, there is a significant difference in temperature of urban city with asphalt and bitumen coverage and regions with plant coverage. Chillers and coolers in cities add to energy consumption and the greenhouse gas phenomena, as the most important factors in ozone layer destruction intensifies [2].

3.3. Lowering air pollution

Green roofs play a positive role in improving air quality because they resist air pollution. On the other hand, plants on roofs absorb heavy metal compounds, suspended particles in air and other organic compounds in environment and disintegrate them. In doing so, they prevent entry of other pollutant particles into floating water and increase quality of natural water reservoirs as well [3].

Plants absorb gas pollutants through their holes, separate pollutants in their leaves and could also disintegrate special organic compounds such as poly-aromatic hydrocarbon in the plant tissues or soil [4]. In addition, they lower surface temperature through coolant extracts and shading that reduce air pollution and in turn reduce photochemical reactions as being a pollutant such as ozone in atmosphere [5].

Only 5.1 square meters live green grass provides sufficient oxygen of one year for one person. One square meter (10.76 Sq.ft) of grass green roof is able to omit 0.2 kilogram of suspended particles in air per years. In addition, 2000 square meter grass in green roof could omit up to 4000 kilogram particles [6].

3.4. Lowering carbondeoxide

Green roofs are effective in lowering carbondeoxide in two ways:

- Carbon is the main element in plant structure and is disintegrated in plant tissues in natural way through photosynthesis and in soil beds through bushes and roots extracts.
- Energy loss through the insulation of buildings and reduce the urban heat island [7].

3.5. Lowering sewage canal system loads

Advantages of green roofs are ecologically several. They protect buildings from sunrays and play important role in concealed cooling. They contribute to cooling spaces below roof in summer by reducing thermal fluctuations on external surface of roof and increasing their thermal capacity; and lowers space below roofs in winter time. Due to reduction in heat loss, green roofs saves energy [8].

- In summer

Roofs without suitable insulation increases temperature in lower part and air conditioners and cooling systems become necessary. A green roof not only acts as a thermal insulator, but also combination and reactions in plants (including photosynthesis, respiration and perspiration),

and the reactions in soil (evaporation and diffusion) lowers amount of sunshine energy by roof layers and consequently, the temperature below surface of roofs reduces.
Based on a study in Chicago, U.S.A. if all roofs of the city change into green roof, there could be an annual 100,000,000 dollars energy saving and a significant decrease in needing air conditioning for buildings. Researches of Nottingham University in this subject show following results [3].

Table 1.Temperature table in summer (www.efbgreenroof.eu)

Average temperature, daily	18.4 centigrade degree
Average temperature below ordinary roofs	32 centigrade degree
Average temperature in green roofs	17.1 centigrade degree

- In Winter

Green roofs reduce heat loss in winter. Plants always keep some air in their roots that act as a thermal insulation layer. Of course, the efficiency of this thermal layer in green roofs depends on amount of moisture they keep. As the roof moisture is higher, the output is reduced and it loss more heat. Therefore, careful calculation of output of the roofs in lowering energy consumption in wintertime is very difficult.
Studies performed in Trend University in Peterborough Canada on temperature below ordinary roofs and green roofs show that using green roofs causes energy consumption lowering in winter. The results obtained from studies show that green roofs are able to control temperature and establish thermal insulation layers. Although the efficiency depends on daily conditions of those roofs, the table below summarizes results of one of the studies [2].

Table 2.Temperature table in winter (www.efbgreenroof.eu)

Average temperature, daily	0.0 centigrade degree
Average temperature below ordinary roofs	0.2 centigrade degree
Average temperature in green roofs	4.7 centigrade degree

4. Results

Through indirect ways such as lowering environment temperature in sub climates, lowering temperature on roof surface (as the effects of plants on environment temperature are higher in drier and hotter climate [9]), lowering the thermal islands and reduction in sunray reflection from roof, green roofs are effective in heat transfer.
Therefore, if a roof is designed in a way that could reduce heat transfer; the thermal capacity of roof increases subsequently and in winter, there is less energy loss from inside to outside and in summer, there is less heat transfer from outside to inside. In green roofs, an increase in layers that intensifies thermal capacity of roof layers, the green roofs plays an effective role in lowering heat transfer and it helps cooling space below roof in summer and in winter, they maintain temperature inside building.
Studies show that there are many factors involved in heat transfer ranging from layers used in green roof to growth environment of cultivated plants on roof. After studies, we concluded that the layer could be stone wool plus resin instead of geotextile. In addition, using stone wool could be effective in culture environment as well.(Fig. 1)

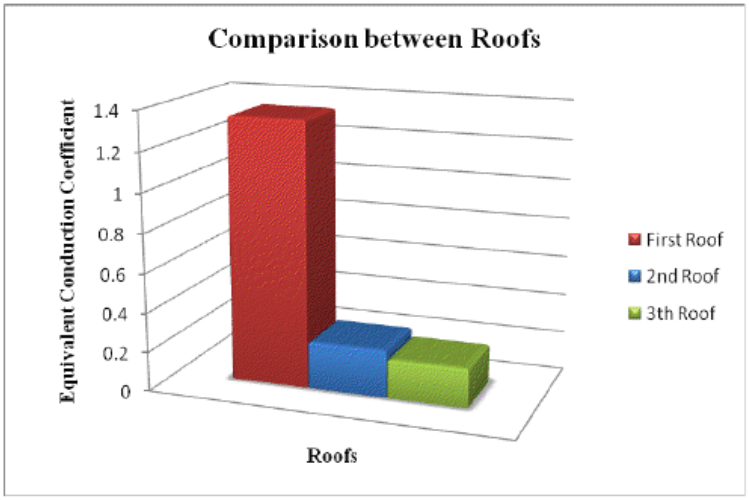

Fig. 1. Comparison between Roofs

5. Conclusion

Studies showed that green roof manages heat transfer and contributes to lowering energy consumption; and subsequently, has great environmental advantages. There are many factors in lowering the heat transfer. Environmental factors, elements used in green roof and cultivated plants are among the most effective factors. The solutions are using stone wool and resin instead of geotextile and using stone wool in agriculture environment.
Since stone wool and resin have high thermal capacity, using it could have an effective role in reducing heat transfer in addition to water proofing potential and this characteristics could be very functional in zero energy buildings. The results of tests performed on conduct factor of ordinary roofs (first roof) , conventional green roof (2^{nd} roof) and stone wool and resin designed green roof (3th roof) revealed the high effectiveness of this layer in lowering conductivity coefficient.

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