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Financial and Environmental Benefit of Pot Plants' Green Roof in Residential Building in Bangladesh

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The green roof design concept aim is to reduce the heat gain and minimize the cooling load for the mechanical air-conditioning, it is one of the primary focuses in the building energy policy now a days. This paper investigates also the financial benefit of green roof for residential building in warm-humid climate of Bangladesh. A field experiment was conducted from April to December, 2009 in a seven storied high-rise building in Dhaka city. The field measurements were done on the same type of two rooftops; one was bare roof and another with green. For compare the direct effect of green roof and bare roof within the same outdoor ambient environment. The physical measurements were carried out using air temperature and humidity data loggers and surface temperature data loggers. Internal and external air temperature and relative humidity were measured for evaluate the thermal performance of green roof. The field study concludes that the passive cooling of green roof is recognized as one of the effective energy saving means in buildings under warm-humid climate and also it can give a lot of financial support for urban residents.

Key words: Energy saving, Pot plants, Green roof, Thermal performance, Thermal comfort

1. Introduction

In development-based economy era of Bangladesh has exhibited the quickest urban development catch-up ever observed in Dhaka city. The common denominator items depletion of resource and atmospheric pollution that is energy. CO_2 emissions are largely caused by energy use, thus the best measure of CO_2 emissions, therefore sustainability, is energy demand. Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development -- social, economic, and environmental -- including livelihoods, access to water, agricultural productivity, health, and population levels related issues. None of the Millennium Development Goals (MDGs) can be met without major improvement in the quality and quantity of energy services in developing countries' – UNDP. The aim is to improve the indoor environment for better living quality of life and to identify the financial benefit of the green roof on building in dense Dhaka city. The objective of this research is therefore to explore the

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thermal performance of green roof and experimental vegetables cultivation system on rooftop in warm-humid tropical climate in Bangladesh. Through such field measurement, it is desirable to find out the answer of the question - What is the quantity of reduction of temperature caused by green roof in the building? How much financial benefit people get from the green roof. The scope of the research is the green roof will be a component of the building. For understanding the thermal performance of rooftop greenery of buildings in urban areas and to promotes it into the contemporary building as a thermal comfort strategy for the modern design. These findings of this research can provide further improvements and advancement of knowledge and appropriate design of rooftop greenery system and the financial benefit of green roof within tropical climate.

2. Methodology

The field measurement was carried out on a rooftop of a seven storied residential building in Dhaka. The rooftop garden is organizes by 80 nos. of pot plants to cover the roof surface; plants are arranged densely, shows in figure 1 the layout of the rooftop garden. Pot plants are used for this research because it is easy to maintain, cost effective to construct, easy drainage of rain water and less affects on the roof surface. Plants are selected base on their density of foliage. The measurement were done on two phase. The first phase of measurement was carried out when the roof top was empty. After the rooftop garden was built the second phase of the experiment was conducted. In this second phase the field measurements were carried on the same type of two roof top, one was bare roof and another with pot planted green roof. For compare the direct effect of green roof and bare roof within the same condition of the outdoor ambient environment.

Figure 1: Bare roof top, roof top greenery (Source: Author)

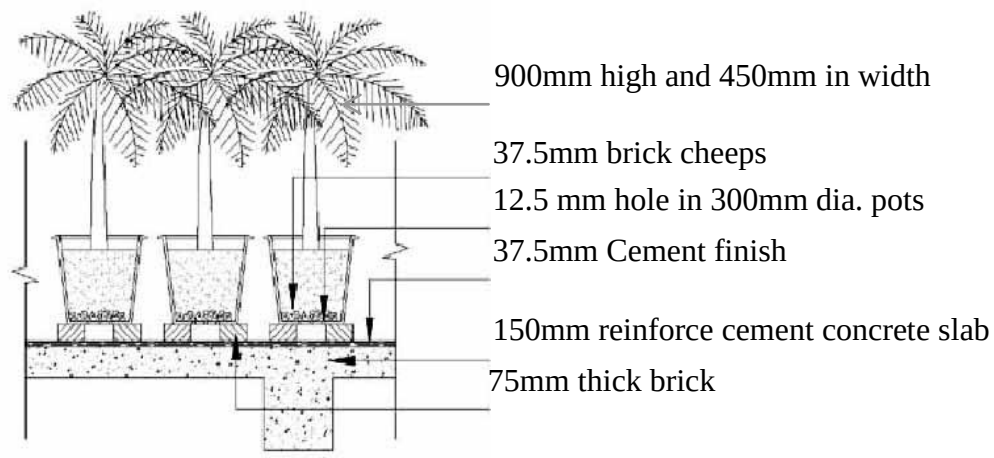

Figure 2: Section of construction of the green roof top (Source: Author)

The physical measurements were carried out using air temperature and humidity data loggers and surface temperature data loggers. The temperatures for both internal and external were recorded at every 15 minutes interval. The data were averaged for every hour to obtain the hourly values. The positions and the measured variables of the data loggers are described below. The building was occupied by the family during both periods. Description of thermal data logger positions and measured variables installed in the tested residential building

1. Rooftop surface temperature was recorded from rooftop surface under the shade of green plants and without shade of green plants.
2. Earth surface temperature of the pot plants was recorded from the top level of the pot earth surface under the shade of green plants.
3. Indoor ceiling surface temperature was recorded from the test room indoor ceiling surface.
4. Indoor air temperature and relative humidity was recorded inside the test room, and the position of the logger was 1.5m above the floor level.
5. Outdoor air temperature and relative humidity was recorded in the outdoor environment, and the position of the logger was 2m above the rooftop surface.

3. Result

3.1 Green roof as an energy saving mean

The thermal performance of green roof and bare roof was compared to justify the green roof abilities on reducing indoor air temperature of the residential building and the surrounding environmental effects on micro climate of the ambient environment. The result is analyzed by comparing the internal and external surface temperature, ambient air temperature and relative humidity.

The thermal performance of the green roof evaluation with reduction of indoor air temperature in the building is extent over the validation of cooling energy

potential. Effect on indoor air temperature is also shown in figure 3. It is found that the maximum indoor air temperature is reduced 4.5°C by green roof. However the reduction of air temperature follows a pattern with a maximum reduction observed in peak heating period 2:30 pm to 3:30 pm and minimum in off sunshine period. Also the temperature fluctuation is in the heat flukes entering are very less for green roof as compared to bare roof. Green roof plays a vital role for thermal protection which may reduce the energy load applied to building through reducing the use of air condition to achieve comfort.

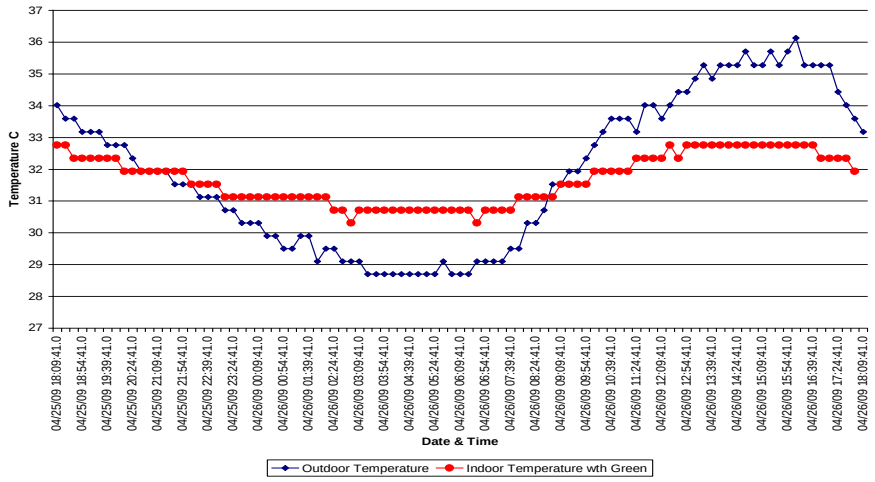

Figure 3: Profile of outdoor air temperature and indoor air temperature with green roof and bare roof. (Source: Author)

3.2 Financial benefit of green roof

3.2.1 Saving from daily electricity bill-application of green roof reduce the indoor air temperature with in comfort range. It influences the use of eclectic cooler and air conditioning of the indoor space. So it can reduce the energy demand of the building which is saving a lot of money from daily electricity bill of the urban residents

3.2.2 Saving of worth -the green roof plants generate oxygen and provides worth for air pollution control and soil erosion. Green roof reduce the carbon level for controlling the global warming.

3.2.3 Mitigating UHI effect in the urban area- With rapid urbanization, there has been a high growth in population and buildings in cities. High concentration of buildings actually creates many environmental issues, such as Urban Heat Island (UHI) effect. The UHI effect is started mainly due to the loss of green areas in the urban environment. Green strategically placed around roofs can be considered as a complement of urban greens. These are providing visual enhancement, air and noise control, this natural solution also contributes to the thermal benefits in buildings and their surrounding environments. Greenery placed around buildings serves to reduce the surface temperature through direct

shading of hard surfaces as well as cool the ambient air through consuming solar heat gain for transpiration and photosynthesis. The shaded surfaces also emit less long-wave radiation due to lower surface temperature (Wong, 2002). All these will contribute to lower energy consumption for cooling and mitigating UHI effect in the urban environment.

3.2.4 Income generation way- Green roof can convert the roof top into a seasonal vegetable garden. Through sealing this seasonal vegetable within neighbor is an income source also.

3.2.5 Saving cost for daily grosser food- Seasonal vegetable garden is supply fresh vegetable for urban residents which are very important for healthy life. It is save a lot of money to buy fresh vegetable from market.

3.2.6 Saving from medical fees- A considerable body of research shows that either contact with nature, viewing nature or participating in nature can generate positive and progressive effects to well being. This research also posits that nature provides many benefits to human functioning and well-being. The term ‘health and well-being’ is used by WHO (1948) in which health is defined as "a state of complete physical, mental and social well-being including in biological, sociological, economical, environmental, cultural and political factors", whereas, the term `well-being' includes material security, personal freedoms, good social relations and physical health (Millennium Assessment, 2003).

3.2.7 Increase the house rent- The green roof beautifying the environment and enhancing the natural image of the building providing amenity space for residents. Adding identity and enhancing the aesthetic appeal of a building and improvement of the micro-climate. So the demand of the house is increase for green roof in urban.

4. Conclusion

Green roof is a energy saving mean. Its related thermal benefits are essential for architectural design strategy in warm-humid tropical climate of Bangladesh. The field study concludes that the passive cooling strategy of green roof is recognized as one of the effective, sustainable and energy saving means to reduce indoor temperature, thus cooling load of buildings under warm-humid tropical climate. Roof top greenery is an applicable nature responsive eco-systemic well being. Roof top greenery design is the implementation of balance between sustainable development and architecture at urban areas in Bangladesh. The application of green roof on building is also encourage the reduction of UHI effect of Dhaka city, protection of global warming by reducing the Carbon level, changing in the microclimate of the surroundings and improving the economical and financial development of the city.

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