

## Green roof and its Impact on Urban Environmental sustainability: The Case in Bangladesh.

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*Bangladesh has experienced high economic growth accompanied by rapid urbanization. Urban growth resulted in tremendous increase of energy consumption in building. To justify the usefulness of sustainable green roof strategy is reducing energy consumption. It also encouraged researcher for conducting this research work. The analysis of actual thermal performance of the green roof can provide the information on effectiveness of applying on contemporary houses in Bangladesh. The objective of this research is to evaluate the thermal performance of green roof on residential building in Bangladesh. Imperial studies were performing through measured of internal and external air temperature and humidity data. Findings of the research result show that the green application on building was tend to experience lower indoor temperature then the original outdoor temperature. Maximum indoor and outdoor temperature difference was recorded 6.8°C during field study. So this research work is providing an introduction or preliminary guide line for thermally responsive architecture on the basis of thermal performance of the green application system in Bangladesh. It also provides a sustainable, energy saving, comfortable and healthy environment. Green application on residential building is more appropriate into the contemporary building as a thermal comfort strategy for the modern design of Bangladesh.*

**Key words:** green roof, technology, environmental sustainability, healthy life, Bangladesh

### 1. Introduction

At the turn of the 19<sup>th</sup> to 20<sup>th</sup> century many Asian countries have experienced high economic growth accompanied by rapid urbanization. This growth affect people's aesthetic sense and it influence the architecture of the world. At the same time many 'green' thoughts that all growth and development is undesirable, but other recognize that some development must occur for future. But we need to done our future development with consciousness of sustainability. It is the only one way to save our world from global warming from the view point of rapid urbanization. Architect, town planer, designer, landscape designer have a great influence for sustainable development. There are three major groups of problem for sustainability such as population growth,

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depletion of resource and atmospheric pollution. Energy is the common denominator of items depletion of resource and atmospheric pollution. CO<sub>2</sub> emissions are largely caused by energy use, thus the best measure of CO<sub>2</sub> emissions, therefore sustainability, is energy demand. This is closely linked to the problem of diminishing sources of energy. According to S.V. Szokolay, 2008 the problem can attack from two directions: Reduce energy demands of buildings and Substitute renewable sources of energy as far as possible. Increase in CO<sub>2</sub> from human activity over the past 20 years. Most of the rest is due to land-use change, in particular deforestation. The finding of this research is green roof will be one of the best solutions against deforestation of urban areas in Bangladesh .Without a doubt these cost of a green application on building lot less than if climate change continues its trend.

Urban growth resulted in tremendous increase of energy consumption of building. The building thermal comfort can be realized through building envelope design related to green building design concepts. The 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 research investigates the effectiveness of green application technique for residential building in warm-humid climate of Bangladesh. 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 application on building. There is uncertainty on the usefulness of green application in cooling and maintaining comfort temperature throughout day and night in warm-humid tropical climate of Bangladesh. This study started to justify the evaluation of passive cooling potential of indoor air temperature reduction by applying green roof. These findings of this research can provide further improvements and advancement of knowledge and appropriate design of rooftop greenery system within warm humid climate. The scope of the research is the green landscape or gardening is 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. This research will lead to a discussion on the potential of indoor air temperature reduction by applying green roof and reducing energy consumption for sustainable comfortable and healthy life.

## **2. Statement of Research Problem**

World environment is continuously changing. Population and economic growth, among others, accelerate development everywhere. The increasing number of population and extensive development has changed our environment over the last decades. Our green surrounding gradually disappears as our village turns to city. Fresh and healthy air has been displaced by pollution. Appropriate use of building features and total management of construction process contribute to reduce the air pollution and energy consumption of buildings. Analyzing the

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cooling potential of greenery application on building to maintain sustainability, reducing energy consumption, Urban Heat Island (UHI) effect in dense Dhaka city and Global warming, human well being and healthy, wealthy life of urban residents.

### 3. Brief Review of Literature

Researcher	Methodology	Findings
Onmura et al (2001)	Field measurement on a planted roof in Japan	The surface temperature decrease of around 30–60°C was observed on site
Onmura et al (2001)	Wind tunnel experiment and a numerical calculation	Evaporative cooling effect of the green roof was also confirmed
Niachou et al (2001)	Field measurement of surface and air temperature on a planted roof and complemented by a mathematical approach	Thermal properties of green roofs and energy savings were examined
Elean Palomo Del Barrio (1998)	Mathematical analysis	Thermal behavior of green roofs
Wong, (2007)	Field measurement	Green roofs act as the insulation devices rather than cooling the roofs
Ekaterini Eumorfopoulou (1998)	Calculation to examine the thermal behavior of planted roof	Green roofs can contribute to the thermal performance of buildings but it cannot replace the insulation layer
Onmura (1994 and 2001)	Field measurement on thermal protection techniques of green roof	Reduction in the local air temperature near canopy thus reducing (4–5°C) the incoming heat flux into the building
Del Barrio (1998) and Good (1990)	Prediction	Worth mentioning on the works of thermal performance of green roofs
Dominguez (1998); Lozano (1990); Eumorfopoulou and Aravantinos (2003); Takakura (2000) et al; Capelli et al (1998)	Implementation of green roof in the buildings	Thermal behavior and effectiveness of vegetation covers with different average absorption for solar radiation and diffusive properties
Niachou et al (2001),	Field investigation on green roof and mathematical approach	Both indoor and outdoor thermal properties are considered for thermal performance of green roof.
Hoyano (1988)	Experimental study	Effect of rooftop lawn planting on

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and 1994)		thermal environment and also described for climatologically uses of plants for solar control and the efforts on the thermal environment
Wong (2002).	Field measurement	Thermal benefits of roof top garden

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All these researches support the cooling potential of green application on building through experiment conduct in various parameters. However, there is uncertainty on the usefulness of green application in cooling and maintaining comfort temperature throughout day and night in warm-humid tropical climate of Bangladesh. This research is present the field measurements which compare the temperature cooling effect of green application and original exposed surfaces. These findings lead to a discussion on the potential of indoor air temperature reduction by applying green application. The effective completion of this study provides a single solution of “Green Dhaka city”.

#### 4. Research Methodology

Brief literature review on previous related researches and actual thermal performance study of the selected building both was done in this research. The field measurement was carried out on a six storied residential buildings in Dhaka city. Selected building was design by Ar. Md.A.A. Sayem Khan and Ar. Rumana Rashid (2006).

The garden is an extensive one, which organizes by plants to cover the hard surface; plants are arranged densely. Plants are selected base on their density of foliage. 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 application on building. 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 building was occupied during this period. Description of data logger positions and measured variables installed the selected residence are describe below,

1. 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.
2. Outdoor air temperature and relative humidity was recorded in the outdoor environment, and the position of the logger was 3m above the rooftop surface.

Empirical studies have been performed at a selected building in Dhaka city to find out the result of the direct effect of green application on building as a passive cooling strategy for an energy saving architecture.

## 5. Research Result

### 5.1 Green application on building and well-being strategy of dense urban healthy environment:

The green plants and flora in front of house are influence the feeling of harmony, simplicity and authenticity. Natural green has significant effect on overall life satisfaction and improve the occupant's well being. Satisfaction plays significant role in attachment to a green space, where increase in satisfaction and preference typically influence the attachment levels of human. Comparably attachment to green space is depended upon one's satisfaction towards the physical attributes that green space has to offer in residential building. The Quality of physical environments contributes to attachment of people. According to Relph, (1976), Branderbwg and Carrol (1995) and Stedman (2003a), the attachment formed with places may involve three most dominant factors: Characteristics of the physical environment, Human use and experience with the environment and Social, psychological and cultural interpretations and constructed meanings of people-place interactions.

Green attachment of residents with green verandah in building is participation of urban residents with physical and leisure activities. The quality of physical properties and attributes of the green landscapes including diversity of spaces, and enriches the experiences of users. Studies of place attachment have also focused on people's use of particular places for self and emotion regulation (Korpela and Hartig, 1996). Residents perceive the green space as their favorite place that affords residents relaxation and relief from mental stress. Green roof and green verandah is a place for them to perform physical activity with privacy, safety and security. This is a favorite place, which appears to afford restorative experiences that aid emotion- and self-regulation processes. For example, studies indicated that favorite place is visited to relax, calm down and clear minds (Korpela, 1992).

**Figure 1:** Green application on Building in dense Dhaka city



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Positive emotional feeling towards green environment and concern over them indicate resident develop a sense of belonging towards their green surrounding (figure 1). Sense of belonging is achieved when one has a positive feeling and behavior to maintain or enhance a locale (Hammit et al. 2006). In the study of Mazlina and Ismail 2008, measured based on the perceptions and preferences of residents towards physical attributes of green infrastructure reviewing landscape preference research may add to better understanding of place attachment. Preference, as an expression of human need and desire, has a strong influence on a person's attitudes toward their environment. People's preference for a landscape is grounded in their ability to understand the landscape, and the level of complexity and engagement that the landscape offers (Kaplan et al., 1998), as well as the familiarity of the landscape or their experiences of similar landscapes (Gerson et al., 1977). In other words, landscape preference affects place attachment and is influenced by experience and familiarity (Ryan, 1997). Diversity of natural green landscapes in front of house as green verandah, on rooftop garden, green boundary wall allows more indoor experiential choices for urban residents, resulting in regular contact with various green spaces in dense surrounding environment of Dhaka city. It is always response to local tradition and culture of its time (rumana, 2009).

The coherence of environment including legibility of places and good connectivity allow accessibility and assist way finding and orientation of residents. Familiarity with the green spaces has developed affective-memory and memory-achievement of residents-among others, dependency and possessiveness towards the places. Therefore, they feel that certain places are meaningful to them. (Mazlina and Ismail, 2008). The readability of building's outdoor and indoor environments, for example, green space network in front elevation, visual connection between each green levels, noticeable landmarks and ways that connect to green areas offer a strong knowledge base for familiarity of residents to access and participate in activities with green nature. Natural qualities of the green spaces such as the presence of greenery and water element attract residents to participate regularly in rooftop garden for leisure recreation, and enjoyment of family life to them it is the heart of the building (Rumana, 2009).

Rooftop garden supports their social life, as a space to be comfortable outdoor environment with family and friends. It also develops a sense of self identity and independence, where one can primarily achieve self and emotion regulation viewing different flower in different seasons (Rumana, 2009) and affords restorative experience from demanding everyday activities in urban high rise residential building. These feelings confer satisfaction in which residents are likely to experience strong attachment to the green spaces as suggested by environment behavioral studies such as Fried (1982). The green attachment of residents form the emotional responses on various attributes of green spaces such as fond of the green space, exciting, calm and inspiring place. There is no significant association between age group and favorite place (Mazlina and Ismail

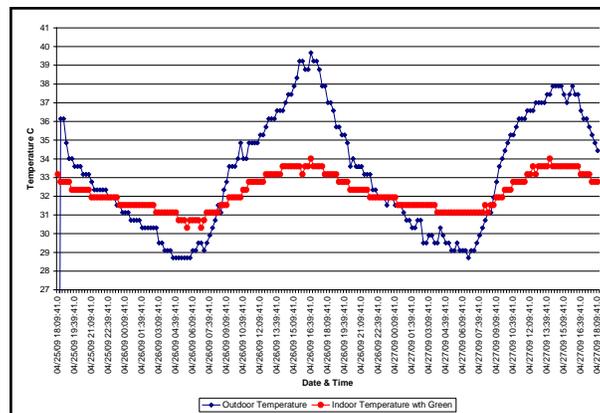
2008). Many researches that demonstrate that there are many aspects of outdoor environments and green spaces that is attractive to people, regardless of age (Ward Thompson, 2007). Within dense urban context roof top garden will be a social gathering space which enhances our social sustainability.

## 5.2 Thermal Comfort achieve by Green application on building in dense Dhaka city

Home is much more than a mere building. It is a place where one has possessions and memories and where one feels comfortable and secure (Heintz, M.K 1975) .The green space and issue of weather improved quality of life, provision of temperature and thermal and visual comfort, has a positive impact on health and quality of life of urban residences. There is significant evidence supporting the notion that quality of life can be improved by improving the quality of indoor environment. Field study of the thermal performance of green buildings and the comfort perception of occupants also abound and offer further insights into the physiological and psychological variables that influence definitions of comfort in the real world. (Wong 2003, Del Barrio 1998, Onmura 2001). The indoor climate is synthetically affected by different factors such as climate character, the allocation of the building, the planning, landscape feature, design solution on envelope structure, the system of indoor furniture's and equipment and the space arrangements.

The thermal performance result of the environmental research on this project concludes that greenery contributes thermal benefit to both micro climates of indoor environment and surrounding outdoor ambient environment of the building. It contributes to reducing energy consumption for cooling load, mitigating the UHI effect in urban environment and also reduces the effect of global warming by controlling the CO2 level.

Figure 2: Profile of outdoor and indoor temperature



Green application can reduce the indoor air temperature 6.8°C from outdoor during the hottest summer period when outdoor is recorded 39.72°C. comfort zone analysis for Bangladesh according to Sharma, Ali and Mallick (1995) during the summer season, the comfort temperature range is between 24 °C to 32 °C while relative humidity range is fixed in 50% (lower limit) to 90% (upper limit). According to the graph profile the indoor temperature of the residence shows that maximum hour of the day is stay within comfort temperature range. It is a desirable condition for the resident.

Proper night ventilation can reduce more indoor air temperature. So the combination of green landscape and proper ventilation can reduce the indoor temperature almost same to the outdoor temperature. It provides a cooling potential of the thermal comfort in indoor environment of the house which is found to be adequate. Green application and landscape within the building is as a passive cooling means for architectural design strategy in Bangladesh. Design of the green structure is easy to construction, economical maintenance and replaceable plants for thermal protection. It's provided a very effective solution for the contemporary building in tropical Bangladesh. Peoples are in habituation for present state of affairs being very energy saving, cost efficient for urban resident and an applicable nature responsive eco-systemic well being. This green building design includes economic and social concerns as well as environmental aspects of sustainability.

### **5.3 Economical and Social Benefits of natural green application on building**

1. Job creation: New jobs will be created through vegetable gardening project.
2. Income generation: Incremental wage increase at seasonal vegetable cultivation in urban area compared to alternative jobs. It is also save a lots of daily market cost for fresh vegetables. We can get fresh foods within urban areas.
3. Trade Balance: Positive trade balance is due to reduction of energy use through the use of air conditioning during summer period.
4. The Efficient use of roof garden: social gathering space, seasonal vegetable cultivation, income source, fresh food supply for urban residents, converts the hard surface into soft green surface.
5. Energy saving: It is an energy saving technology. The green application will lead to technology transfer and which can be replicated. A lot amount of money saves by urban residents in dense Dhaka city.
6. Medical fees saving: By green application on building, people get a sustainable healthy life it will save medical fee also.

## 6. Conclusion

The natural green plants and flora in front of high-rise building presents natural quality, hence, provide a sense of meaning and shaping preference and green attachment of urban residents in dense Dhaka city to the green space. Green network offers residents the ability to make sense of their visual comfort environment. Results have also suggested that residents respond positively towards maintaining the green landscape and environment because it has value to individual and community in urban areas. The natural beauty of the green network in urban environment looking from far away is aesthetically pleasing for residents to immerse. Environmental friendly or sustainable policies were also implemented in the high-rise residential building at Dhaka city, Green building design effort for landscape ecological considerations in built environment.

The result concludes that green application contributes to reducing energy consumption for passive cooling load of residential building in the Bangladesh. It can reduce indoor air temperature during day and night. Green as a passive cooling mean, its related thermal benefits are essential for architectural design strategy in warm-humid tropical climate of Bangladesh

This research work provides an introduction or preliminary guide line for thermally responsive architecture on the basis of thermal performance of the green application system. About little increase of the construction cost compare to a regular construction cost is provide a sustainable, energy saving, comfortable and healthy environment. The green application in building is more appropriate in warm humid tropical climate of Bangladesh.

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