

THERMAL PERFORMANCE OF GREEN ROOF AT DHAKA CITY
IN BANGLADESH

RUMANA RASHID

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Architecture)

Faculty of Built Environment
Universiti Teknologi Malaysia

OCTOBER 2012

To:

*My Beloved Father, Mother
and
My Husband, Son and Daughter.*

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious, the most Merciful, for giving me the determination and will to complete this study.

My deepest gratitude goes to my main thesis supervisor Prof. Dr. Mohd. Hamdan Bin Ahmad for his valuable and close supervision, guidance, comments, resources, encouragement, motivation, inspirations and friendship rendered throughout the study.

A special thanks to Mdm. Halimah Yahya for her assistance in obtaining the required weather data and also for her friendship and support.

My sincere gratitude also goes to those who have provided assistance in many ways at various occasions: Dr. M.A. Mukhtadir, Deen and Head of the Department of Architecture, AUST.

My heartiest and utmost gratitude goes to my dear father, mother and sisters and brother in law for their patience, sacrifices, understanding, constant concern, moral support and prayers during the course of my study.

I would like to say special thanks to Abdul Mumit, M.B.A. (Cambridge University) Lecturer, North –South University, for Language correction.

I would like to thanks to the team member Md. Tahsin Morshad (Sajin), Soheli and Titash for their endless help in data collection at student family apartment, UTM in Malaysia.

I would like to say thanks Md. Sazzad for his great help to making the turnitin evaluation of the thesis.

I would like to say special thanks to Dr. Hasanuddin Bin Lamit, Associate Professor, Universiti Teknologi Malaysia, for final language correction.

Finally I would like to say utmost special thanks to my husband for his continuous support, inspiration and encouragement towards the completion of the thesis.

ABSTRACT

Sustainability development is one of the main issues today around the world. Appropriate use of building design strategy of construction process contributes to reducing the consumption of building energy. Green roof can play a positive role to reduction of roof surface temperature and air temperature that can be translated into energy saving means. The aim of research is to investigate the thermal performance of the green roof and the changes that occurs in the indoor thermal environment with diurnal variation of the room during summer and winter season in subtropical Bangladesh and tropical Malaysia. This research was conducted through field measurement. The pilot study was conducted in Malaysia for two weeks before the main field study was done in Bangladesh for duration of one year. The main reason of the pilot study was to clarify the instrumentation. The pilot study results indicated that the green roof is more effective than bare roof in tropical climate. The pilot study suggested a good potential of similar green roof strategy for Bangladesh. To evaluate thermal performance of green roof in Bangladesh, some quantitative data analysis is necessary before large-scale implementation of green roof can be introduced. To meet these requirements, field measurements were carried out locally on selected buildings in Dhaka city. Three building were selected for field study, two buildings with green roof and another was a reinforce cement concrete (R.C.C.) bare roof. A set of thermal data loggers were installed to record the air temperature of indoor, outdoor and surface temperature. Data collection was carried out for duration of two months in winter and five months in summer. Thermal performance evaluation was done by comparative study between green roof and typical concrete bare roof. This research also evaluates U-value and RTTV calculation of different types of green roof and bare roof. The research found that green roof on contemporary building has better thermal performance and comfortable compare to bare roof in summer season. During winter, occasionally green roof reduces the indoor temperature to below comfort zone. It also noted that the thermal performance of green roof depends on the different type of design strategy. Constructed sunken, raised, exposed and organized pot plants green roofs can reduce indoor air temperature to 3.67°C, 1.22°C, 2.49°C and 6.8°C compare to outdoor air temperature. Green roofs also achieve a remarkable surface temperature reduction around 27.63°C. As part of an integrated system of green roof, denser plants can offer a better evaporative cooling impact to the micro-climate. This research suggests that the rooftop garden is one of the natural ecological solutions for reducing the effect of *Urban Heat Island (UHI)*. This study concludes that the use of green roof on contemporary buildings of Bangladesh have significant impact on the overall indoor thermal performance. Thus, contemporary buildings should consider employing this sustainable green roof to achieve thermal comfort environment.

ABSTRAK

Kelestarian pembangunan adalah salah satu isu utama hari ini di seluruh dunia. Strategi reka bentuk bangunan yang bersesuaian dalam proses pembinaan menyumbang untuk mengurangkan penggunaan tenaga bangunan. Bumbung hijau boleh memainkan peranan yang positif kepada pengurangan suhu permukaan bumbung dan suhu udara yang boleh diterjemahkan sebagai kaedah penjimatan tenaga. Tujuan kajian adalah untuk menyelidiki prestasi terma ada bumbung hijau dan perubahan yang berlaku dalam persekitaran tertutup dengan perubahan terma harian bilik semasa musim panas dan musim sejuk di subtropika Bangladesh dan tropika Malaysia. Kajian ini telah dijalankan melalui pengukuran lapangan. Kajian rintis telah dijalankan di Malaysia selama dua minggu sebelum kajian lapangan utama yang telah dilakukan di Bangladesh untuk tempoh satu tahun. Tujuan utama kajian rintis adalah untuk memperjelaskan instrumentasi. Hasil kajian rintis menunjukkan bahawa bumbung hijau adalah lebih berkesan daripada bumbung terdedah dalam iklim tropika. Kajian rintis telah mencadangkan potensi yang baik untuk strategi bumbung hijau yang serupa untuk Bangladesh. Untuk menilai prestasi terma bumbung hijau di Bangladesh, beberapa analisis data kuantitatif adalah perlu sebelum pelaksanaan berskala besar bumbung hijau boleh diperkenalkan. Bagi memenuhi keperluan ini, pengukuran lapangan telah dijalankan pada bangunan tempatan yang dipilih di bandar Dhaka. Tiga bangunan telah dipilih untuk kajian lapangan, dua bangunan dengan bumbung hijau dan satu lagi adalah bumbung kosong konkrit simen bertetulang (RCC). Satu set pencatat data haba telah dipasang untuk merekodkan suhu udara suhu dalaman, luaran dan permukaan. Pengumpulan data telah dijalankan untuk tempoh dua bulan di musim sejuk dan lima bulan di musim panas. Penilaian perbandingan prestasi terma telah dilakukan dengan kajian perbandingan antara bumbung hijau dan bumbung konkrit tipikal terdedah. Kajian ini juga menilai pengiraan nilai-U dan RTTV pada beberapa jenis bumbung hijau dan bumbung kosong. Kajian ini mendapati bahawa bumbung hijau di bangunan kontemporari mempunyai prestasi terma yang lebih baik dan selesa berbanding dengan bumbung terdedah di musim panas. Semasa musim sejuk, kadang-kadang bumbung hijau mengurangkan suhu dalaman di bawah zon keselesaan. Ia juga menunjukkan bahawa prestasi haba bumbung hijau bergantung kepada perbezaan jenis strategi reka bentuk. Pasu tumbuhan dibina tenggelam, dibangkitkan, terdedah dan disusun di bumbung hijau boleh mengurangkan suhu udara tertutup kepada 3.67°C, 1.22°C, 2.49°C dan 6.8°C berbanding dengan suhu udara luar. Bumbung hijau juga mencapai pengurangan suhu permukaan yang luar biasa di sekitar 27.63°C. Sebagai sebahagian daripada sistem bersepadu bumbung hijau, tumbuh-tumbuhan yang lebih padat boleh menawarkan penyejukan penyejukan yang lebih baik kesan kepada iklim mikro. Kajian ini menunjukkan bahawa taman atas bumbung adalah salah satu penyelesaian ekologi semulajadi untuk mengurangkan kesan *Urban Heat Island (UHI)*. Kajian ini merumuskan bahawa penggunaan bumbung hijau di bangunan kontemporari di Bangladesh mempunyai impak yang besar ke atas keseluruhan prestasi terma dalaman. Oleh itu, bangunan kontemporari harus mempertimbangkan untuk menggunakan bumbung hijau lestari bagi mencapai persekitaran keselesaan terma.