COOLING POTENTIAL OF PASSIVE ROOF TREATMENTS ON THE CONCRETE FLAT ROOF IN PENANG, MALAYSIA

by

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POTENSI PENYEJUKAN RAWATAN BUMBUNG SECARA PASIF KE ATAS BUMBUNG KONKRIT RATA DI PULAU PINANG, MALAYSIA

ABSTRAK

Peningkatan suhu global akibat pemanasan global telah memberikan impak besar ke atas persekitaran dan penghuni bangunan. Kepekatan gas rumah hijau yang lebih tinggi di atmosfera, terutamanya karbon dioksida (CO_2), diandaikan sebagai penyebab kepada fenomena berkenaan. Suhu luaran dan dalaman yang lebih tinggi mengakibatkan penggunaan tenaga yang tinggi di dalam bangunan akibat daripada penggunaan alat penyaman udara serta lain-lain sistem pengudaraan mekanikal secara berlebihan. Salah satu kaedah berkesan untuk mengatasi masalah ini ialah dengan melaksanakan sistem penyejukan pasif ke atas elemen-elemen bangunan. Kajian lalu menunjukkan bahawa teknik-teknik penyejukan pasif menggunakan teknologi bumbung hijau, bumbung dua lapis, dan bumbung reflektif (bumbung putih) boleh memberi impak positif ke atas persekitaran bangunan. Sungguhpun begitu, potensi penyejukan teknologi berkenaan berbeza bergantung kepada reka bentuknya dan iklim. Oleh yang demikian, satu kajian perbandingan ke atas teknologi penyejukan pasif berkenaan telah dijalankan di dalam penyelidikan ini bagi menyiasat keberkesanan teknologi-teknologi tersebut dalam iklim di Malaysia. Satu siri kajian ujikaji lapangan telah dijalankan ke atas bumbung rata sebuah bangunan kediaman setingkat, dalam keadaan cuaca sebenar. Persekitaran luaran dan dalaman telah dipantau di dalam penyelidikan ini bertujuan menilai rawatan penyejukan bumbung secara pasif yang paling berkesan di antara bumbung hijau tumbuhan berpasu (bumbung dengan tumbuhan berpasu), bumbung dua lapis (bumbung dengan ruang pengudaraan selebar 6 inci) dan bumbung putih. Hasil kajian menunjukkan kesan penyejukan yang signifikan bagi semua strategi. Perbezaan suhu udara

dalaman-luaran yang paling tinggi, yang merupakan kriteria utama dalam penentuan kesan penyejukan, telah diambil kira dalam penyelidikan ini. Bumbung dua lapis mempamerkan perbezaan purata suhu dalaman-luaran yang paling tinggi, iaitu 4.97°C, diikuti oleh bumbung hijau tumbuhan berpasu (4.22°C) dan bumbung putih (3.30°C). Bumbung asal yang kosong menunjukkan perbezaan purata suhu udara dalaman-luaran yang paling rendah iaitu 3.00°C. Tesis ini juga membentangkan hasil penyerapan CO_2 oleh pokok-pokok bumbung hijau yang diletakkan di atas bumbung rata. Hasil kajian menunjukkan bahawa jumlah penyerapan CO_2 oleh 102 buah pasu pokok *Ipomoea pes-caprae* yang diletakkan di atas bumbung rata berkeluasan 11.90 m^2 adalah dijangkakan sebanyak 0.057 tan setahun.

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ABSTRACT

The rise in global temperature due to global warming has a major impact on the environment and building occupants. The higher concentration of greenhouse gases, in the atmosphere, especially carbon dioxide (CO_2), is thought to be the reason for this phenomenon. Higher outdoor and indoor air temperatures lead to higher energy consumption in buildings due to the excessive use of air conditioning and other mechanical ventilation systems. Implementing passive cooling systems into the building elements can be a promising way to overcome this problem. From the literature, passive cooling techniques using green roof, double roof, and reflective roof (white roof) technologies could have a positive impact on the building environment. However, the cooling potential of these technologies varies depending on their design and the type of climate. Therefore, in order to investigate the effectiveness of these technologies in the Malaysian climate, a comparative study of these passive cooling technologies is carried out in this research. A series of field experimental studies has been carried out on a real building, i.e., on the flat roof of a single-storey residential building, in the actual weather conditions. The indoor and outdoor environments were monitored in this research to evaluate the most effective passive cooling roof treatment between the potted plant green roof (roof with potted plants), double roof (roof with 6 inches ventilated air gap) and white roof. The results show a significant cooling effect for all strategies. The highest indoor-outdoor air temperature difference, which is the main criteria in determining the cooling effect, is taken into account in this research. The double roof exhibited the highest average indoor-outdoor temperature difference, which was 4.97°C, followed by the potted

plant green roof (4.22°C) and the white roof (3.30°C). The existing bare roof demonstrated the lowest indoor-outdoor air temperature difference, which was at 3.00°C. This thesis also presents the results of CO_2 uptake by the green plants installed on the flat roof. The result shows that the amount of CO_2 uptake by 102 pots of *Ipomoea pes-caprae* installed on 11.90m^2 flat roof was predicted 0.057 tonnes per year.