UNIVERSITI PUTRA MALAYSIA

EFFECTS OF TRANSMITTED SOLAR IRRADIANCE ON PREDICTED MEAN VOTE IN PERIMETER ZONE OF WEST-FACING LECTURE ROOMS WITH UNPROTECTED GLAZED WINDOWS

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By

IJHAR HIDAYAT RUSLI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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To my parents

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in partial fulfilment of the requirement for the degree of Master of Science

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July 2011

Supervisor: Associate Professor Ir. Nor Mariah Adam, PhD

Faculty/Institute: Institute of Advanced Technology

One of the methods employed in creating a sustainable built environment is the maximisation in usage of daylighting through glazed walls. From an energy efficiency standpoint, such measures have been proven beneficial through the reduction in energy demand in several aspects. The same, however, cannot be said regarding the thermal comfort levels of occupants seated nearby the glazed walls, affected by the transmitted solar irradiance wherein only a limited number of studies have been conducted on the particular subject matter. To make matters worse, buildings and their enclosures cannot always be built with their orientation as the number one priority and as a result a significant amount of heat gain to the enclosure is almost imminent. This dissertation presents a semi-empirical study of the shift in thermal comfort conditions, expressed in terms of the predicted mean vote (PMV), expected to be inflicted upon an occupant hypothetically seated nearby a glazed wall and subjected to transmitted solar irradiance within the context of the hot-humid

tropical climate. The sun's geometrical positioning in relation to the occupant's was considered for different hours of a day throughout a year. The objective of the study is to determine the combined effects of 1) the intensity of the solar irradiance transmitted through the glazed wall and 2) the geometrical positioning of its source on the thermal comfort levels of the occupant. Measurements of the intensity and temporal distribution of the irradiance transmitted through the glazed wall were conducted using a pyranometer connected to a data acquisitioning system. The shift in radiation-induced thermal comfort conditions were quantified using a mathematical model cited by the literature. Statistics of the intensity of irradiance transmitted through the glazed wall have been determined and discussed. Inter- and intra-month comparisons were conducted of the thermal comfort levels of the occupant subjected to the irradiance for different hours of the day. It was determined that peak values of the irradiance transmitted through the windows averaged between 40 – 50 W/m^2 occurring between the hours of 15:00 – 16:00 h local time. Throughout the year, the sun-occupant geometrical relation was determined to be maximised in the months of June and July; for any given day it is maximised towards the end of the day. Coupling of these two findings showed that the predicted mean vote would see an increase between 0.1 – 0.5 units on the 7-point comfort scale occurring between 16:00 – 17:00 h local time. Objectively, under the tested circumstances, thermal comfort could be maintained within acceptable limits.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan untuk Ijazah Master Sains

KESAN SINARAN SURIA TEMBUS TERHADAP UNDIAN PURATA RAMALAN PADA ZON PERIMETER BILIK KULIAH MENGHADAP BARAT DENGAN TINGKAP BERKACA TIDAK TERLINDUNG

Oleh

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Julai 2011

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Salah satu kaedah yang diamalkan dalam menyediakan bangunan berpersekitaran lestari ialah penggunaan pencahayaan semulajadi melalui tingkap. Kaedah tersebut telah terbukti bermanfaat dari segi penggunaan tenaga yang efisyen melalui pengurangan permintaan tenaga daripada pelbagai aspek. Walaubagaimanapun, manfaat yang serupa tidak dapat diperkatakan berkenaan dengan keselesaan terma penghuni yang ditempatkan berhampiran dengan tingkap dan dipengaruhi oleh sinaran suria tembus, di mana hanya beberapa kajian telah dilakukan bagi mengenalpasti kesan-kesannya. Desakan terus bertambah apabila mengambilkira bahawa bangunan tidak dapat sentiasa dibina dengan mengutamakan orientasi mengakibatkan kuantiti haba yang banyak terlalu mudah untuk menembusi dinding bangunan. Disertasi ini membentangkan kajian semi-empirik berkenaan dengan perubahan keadaan keselesaan terma, dinilaikan melalui indeks undian purata ramalan (*Predicted Mean Vote*, PMV), yang dipercayai akan bertindak ke atas

seseorang individu yang diandaikan ditempatkan berhampiran dengan tingkap dan terdedah kepada sinaran suria tembus bagi iklim panas-lembab tropika. Posisi geometrik relatif matahari dengan kedudukan individu tersebut telah diambil kira untuk pelbagai waktu dalam satu hari bagi tempoh setahun. Objektif kajian adalah bagi menentukan gabungan kesan 1) keterikan sinaran suria yang menembusi tingkap dan 2) kedudukan geometrik sumbernya terhadap tahap keselesaan terma individu tersebut. Pengukuran tahap keterikan dan taburan berasaskan masa sinaran suria tembus telah dilaksanakan menggunakan *pyranometer* yang dihubungkan kepada sistem pengumpulan data (DAQ). Perubahan tahap keselesaan terma yang disebabkan oleh sinaran suria tembus telah dinilaikan dengan aplikasi model matematik yang diperolehi daripada rujukan. Indeks-indeks statistik bagi keterikan sinaran suria yang tembus telah ditentukan dan dibincangkan. Perbandingan inter- dan intra- telah ditentukan untuk tahap keselesaan terma bagi individu tersebut untuk pelbagai waktu dalam sehari. Dapatan kajian menunjukkan nilai puncak purata bagi keterikan sinaran suria yang menembusi tingkap adalah di antara 40 – 50 W/m^2 dan berlaku di antara 15:00 – 16:00 h. Nilai tahunan bagi perkaitan geometri di antara matahari dan individu menunjukkan maksima pada bulan Jun dan Julai; nilai harian pula menunjukkan maksima apabila menghampiri penghujung hari. Gandingan kedua-dua dapatan menunjukkan bahawan indeks PMV akan meningkat di antara 0.1 – 0.5 unit pada skala keselesaan 7-titik. Tertakluk kepada keadaan-keadaan yang teruji dalam kajian ini, secara objektifnya keselesaan terma dapat dikekalkan dalam tahap yang boleh diterima.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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IJHAR HIDAYAT RUSLI

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TABLE OF CONTENTS