UNIVERSITI PUTRA MALAYSIA

EFFECT OF SELECTED SHADING DEVICES ON OFFICE ROOM TEMPERATURE

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BY

ALI MOHAMED A. WAHHAD

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

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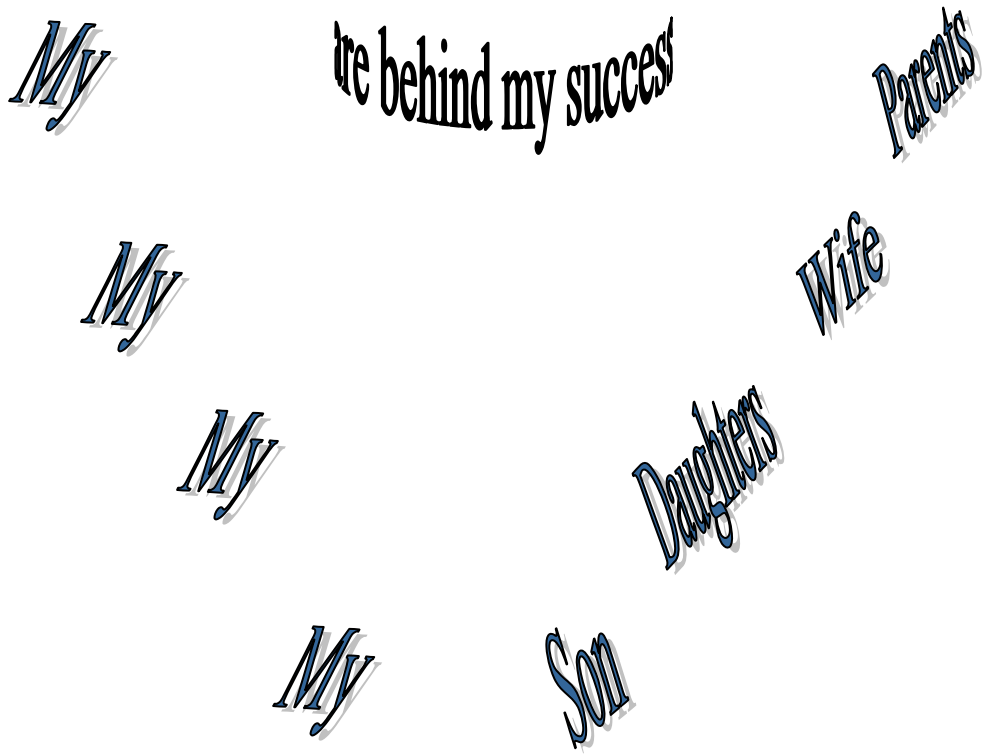
To whom their true love and support



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

EFFECT OF SELECTED SHADING DEVICES ON OFFICE ROOM TEMPERATURE

By

ALI MOHAMED A. WAHHAD

2008

Supervisor: Associate Professor Nor Mariah Adam, PhD

Faculty: Engineering

This study investigated the effects of selected shading devices on office room temperature at Universiti Putra Malaysia. The experimental and simulation results were presented to show the thermal effects of coating systems used. Initial work for a duration of two months showed that high temperatures occurred at 10:00, 1200 and 14:00 hours. This frequency of measurement is similar to that of Etzion and Erell (2000). Thermocouple wires were used to measure the air temperature in an office of size 4.03 m x 3.82 m x 2.60 m (length x width x height). The window was a vertical glass plate with thickness 5 mm, height 1.53 m and width 2.12 m and it was facing northeast. Coating materials used were plain glass pane thickness 5 mm (control), tinted film, silver film, and blinds. Results showed that the differences in temperature between the inside and outside of the office were 4.4^{o}C, 3.8^{o}C, 3.5^{o}C and 2.9^{o}C for silver film, blinds, tinted film and clean

glass (5 mm), respectively. Comparison between simulated and experimental results showed a reasonable agreement, ranging between 0.2 to 10 %. The external air velocity ranged between 0.19 and 0.45 ms^{-1} and relative humidity between 22.7% and 77.5 %, while the average air velocity in the office ranged from 0.03 to 0.05 ms^{-1} and relative humidity from 57.2 % to 66.8 %. The simulated results for internal air temperatures of the office ranged from 28^{o}C to 29^{o}C. In terms of cost, the blinds gave value for money with every temperature drop for temperature difference between internal and external temperatures. In addition the blinds could be easily fixed.

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

KESAN PERANTI PELE KAT TINGKAP TERHADAP AGIHAN SUHU BILIK

Oleh

ALI MOHAMED A. WAHHAD

2008

Penyelia: Profesor Madya Nor Mariah Adam, PhD

Fakulti: Kejuruteraan

Kajian ini telah menyelidik kesan bahan yang ditampal pada tingkap pada taburan suhu di dalam sebuah di Universiti Putra Malaysia. Hasil eksperimen dan simulasi dibentangkan untuk menunjukkan kesan haba sistem penyaduran. Ujian selama dua bulan menunjukkan suhu tinggi berlaku pada jam 10 pagi, 12 tengahari dan 2 petang. Waktu tersebut ádalah sama dengan kajian Etzion, and Erell (2000). Wayar termogandingan telah digunakan untuk menyukat suhu udara di dalam pejabat berdimensi 4.03 m x 3.82 m x 2.60 m (panjang, kelebaran dan ketinggian). Tingkap tersebut pula merupakan satu plat kaca yang menegak dengan ketebalan 5 mm, ketinggian 1.53 m dan kelebaran 2.12 m menghadap arah timur laut. Bahan-pelekat digunakan adalah kaca jendela setebal 5 mm (kawalan), filem berwarna sedikit, filem perak dan bidai. Keputusan menunjukkan

bahawa suhu perbezaan antara di dalam dan di luar pejabat tersebut adalah masing-masing 4.4^{o}C, 3.8 ^{o}C, 3.5^{o}C dan 2.9^{o}C bagi filem perak, bidai, filem berwarna sedikit dan kaca jendala (5 mm). Perbandingan antara hasil simulasi dan eksperimen menunjukkan satu persetujuan yang munasabah, iaitu julat dari 0.2% hingga 10%. Kelajuan udara luar berjulat antara 0.19 dan 0.45 ms^{-1} dan kelembapan bandingannya adalah antara 22.7% dan 77.5 % , sementera kelajuan udara dalam pejabat berjulat dari 0.03 hingga 0.05 ms^{-1} dan kelembapan bandingannya adalah dari 57.2 % hingga 66.8 %. Hasil simulasi untuk suhu dalam pejabat adalalah di antara julat 28^{o}C hingga 29 ^{o}C. Dari segi kos, bidai adalah yang berpatutan nilainya dengan setiap darjah keturunan suhu perbezaan antara suhu luar dan suhu dalam pejabat. Tambahan pula bidai dapat dipasang dengan mudah.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment on the requirement for the degree of Master Science. The members of the supervisory committee are as follows:

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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 institutions.

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ALI MOHAMED A. WAHHAD

Date:

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LIST OF ABBREVIATIONS

A	Area, (m^2)
C	Specific heat, (J / kg K)
d	Thickness of glass, (m)
C_p	Specific heat, (J/kg K)
g	Gravitational acceleration, (m/s^2)
G_{rL}	Grashof number
h	Heat transfer coefficient, ($W/ m^2 K$)
k	Thermal conductivity, (W/ m.K)
Nu	Nusselt number
q	Heat flux (W/m^2)
Ra	Rayleigh number
Re	Reynolds number
t	Time (second)
T_∞	Air Température, (^oC)
T_{sur}	Surrounding Temperature, (^oC)
Δ_T	Temperature difference, (^oC)
T_S	Surface Temperature, (^oC)
q	Solar radiation intensity passing through glass, (kJ)
$Q_{CONV.}$	Convection heat flow, (W)
$Q_{rad.}$	Radiation heat flow, (W)
SHGC	Solar Heat Gain Coefficient

SC	Shading coefficient
VT	Visible Transmittance
V	Volume (m^3)
X	Local position along the X-direction under coordinate
Y	Local position along the Y-direction under coordinate

Greek

α	Thermal diffusivity, (m^2/s)
ρ	Density (kg/m^3)
η	Total transmittance, (N/m^2)
ε	Emissive of Materials
μ	Dynamics viscosity (N/m s)

Subscript

∞	Ambient
α	Absorptance of glass window and glass with film
σ	Stefan–Boltzmann constant,($W/m^2 . K^4$)
τ	Transmittance of glass window and glass with film

CHAPTER 1

INDRODUCTION

Windows have long been used in buildings for the provision of day lighting as well as for supply of fresh air in the summer. Studies have shown that the health of human beings has improved through better hygiene in homes by increasing ventilation and access to daylight - Burberry (2004) and Gregg (2006). However, windows have become sources of unwanted heat loss or heat gain depending on the season.

In Malaysia windows for buildings have undergone a technological revolution since the adoption of steel structures for buildings in the 1990s, when steel plants were introduced into the country. This has resulted in the higher usage of glass panes for buildings. With the introduction of the district cooling system, it has been possible to maintain the internal temperatures of glass buildings well below 24^{o}C at lower cost as employed by the Petronas Twin Towers, KL Tower, KL International Airport and the KL Sentral buildings.

Clear glass has been the primary material available for windowpanes. Traditionally glass has long-term durability, almost perfect surface finish and excellent transmission of daylight. For energy saving measures, windows can be double-glazed or even triple glazed, and this also helps in the reduction of day light transmission in the interior of the building. In Malaysia, where glare and high incidence of sunlight occur, laminated shading materials are common in cars and these ideas are incorporated into buildings.

1.1 Importance of Study

Since Malaysia is located in the equatorial belt, where the weather is hot and humid throughout the year, modern large office and commercial buildings have huge heat loads for the air-conditioning systems. The glass windows are installed to serve as physical and visual connection to the outside environment as well as to enhance the appearance of buildings. One passive method of reducing heat load and glare is through the use of laminating shading materials on the glass. With the increase of fuel prices, passive cooling contributes significantly to energy savings for building owners.

1.2 Problem Statement

The design and construction of buildings in Malaysia has followed the Uniform Building by-law (1984). This is a prescriptive code adopted by many countries throughout the world. Clause 39 of the code states that,

"*Every room designed, adapted or used for residential, business or other purposes except hospital and schools shall be provided with natural ventilation by means of one or more windows having a total area of not less than 10% of the clear floor area of such room and shall have openings capable of allowing a free uninterrupted passage of air of not less than 5% of such floor area.*"