
**UNIVERSITI PUTRA MALAYSIA**

# *DIFFERENCES IN THERMAL COMFORT AT BUS STOPS WITH POLYCARBONATE AND OPAQUE ROOFING AT UNIVERSITI PUTRA MALAYSIA, SERDANG, MALAYSIA*

**DANIAL GOSHAYESHI**

**FRSB 2013 4**

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**By**

**DANIAL GOSHAYESHI**

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

**November 2013**

## DEDICATION

To my dear parents who gave me the opportunity to experience life, their love, and affability

&

To my lovely sister who always make me confident with her patronage and blithe

&

To my beloved wife who is my mainstay forever

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

**DIFFERENCES IN THERMAL COMFORT AT BUS STOPS WITH POLYCARBONATE AND OPAQUE ROOFING AT UNIVERSITI PUTRA MALAYSIA, SERDANG, MALAYSIA**

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**Chairman: Mohamad Fakri Zaky Bin Jaafar, PhD**

**Faculty: Design and Architecture**

The quality of outdoor and semi-outdoor spaces influences on well-being and performance of people. Among many factors, thermal condition plays significant role in satisfaction of individuals in such spaces. Although the exploring human thermal comfort in outdoor and semi-outdoor spaces, especially in equatorial climatic condition, is vital, the numbers of studies which mainly focus on this context are few. This fact shows the need of evaluating human thermal comfort in hot and humid climate by taking into consideration the objective microclimate factors along with subjective parameters. Bus stops as a semi-outdoor space can greatly affect the thermal comfort of passengers during the day. Among many elements, roofing material of bus stops has profound effects on thermal sensation of individuals. Consequently, a quantitative field study was implemented in this study in order to assessment the human thermal comfort differences between installing Polycarbonate translucent plastic and opaque roofing cover in bus stops of University Putra Malaysia campus and understanding the thermal preferences of users. Hence, the measuring of four principal microclimatic factors (i.e. air temperature, wind speed, mean radiant temperature and relative humidity) together with subjective questionnaire survey were conducted in order to evaluating thermal sensation and thermal preferences of respondents, simultaneously.

This study utilized Physiological Equivalent Temperature (PET) as an appropriate thermal index for assessing environmental thermal condition in outdoor and semi-outdoor spaces. The results of this study reveal that opaque roofing material provides better thermal condition for passengers both objectively and subjectively comparing Polycarbonate roofing sheets. The average values of air temperature and PET for

Polycarbonate roofing material is higher than opaque station but the humidity values for opaque is places in higher level. The results of questionnaire survey revealed that respondents under bus shelter with opaque roofing material felt more comfortable thermal condition than those under Polycarbonate shelter. Also, it is shown that subjective parameters play significant role in human thermal comfort in semi-outdoor spaces, so, it is needed to take into account the subjective factors for the future studies. Furthermore, this study shows that people in Malaysia can tolerate in higher thermal condition comparing those in Europe or Taiwan. Moreover, the result of this study illustrates that shading has a significant effects on thermal satisfaction of people and well-covered spaces provide better thermal environment for users. The findings of this study can be applied in the future design decision-making concerning outdoor and semi-outdoor spaces for providing thermally comfortable non-indoor spaces which can be leaded to increasing the usage of such spaces. In conclusion, the findings of this study contribute towards improving the quality of bus stops as semi-outdoor spaces for passengers in Tropical climate of Malaysia for enhancing the quality of life in urban areas.

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

**PERBEZAAN KESELESAAN TERMAL DR ANTARA BUMBUNG POLIKABONAT DAN BUMBUNG LEGAP DI PERHENTIAL BAS DI UNIVERSITI PUTRA MALAYSIA SERDANG**

Oleh

**DANIAL GOSHAYESHI**

**November 2013**

**Pengerusi: Mohamad Fakri Zaky Bin Jaafar, PhD**

**Fakulti: Rekabentuk dan Senibina**

Kualiti persekitaran luar dan separa luar mempengaruhi keselesaan dan prestasi manusia. Dalam pelbagai faktor, haba memainkan peranan yang paling ketara dalam keselesaan individu dalam persekitaran. Walaupun kajian terhadap haba yang sesuai untuk manusia di kawasan luar dan separa luar terutama di kawasan khatulistiwa adalah penting, tetapi jumlah kajian yang berkaitan dan fokus kepada bidang ini adalah sedikit. Fakta ini menunjukkan bahawa keperluan menilai keselesaan haba untuk manusia dalam iklim panas dan lembap adalah penting dengan mengambil kira faktor-faktor mikro-iklim dan parameter. Perhentian bas merupakan ruang separa luar yang banyak menjejaskan keselesaan haba kepada penumpang pada siang hari. Antara pelbagai unsur yang terlibat, bahan pada bumbung perhentian bas mempunyai kesan yang mendalam terhadap haba individu. Oleh itu, kajian kuantitatif telah dilaksanakan dalam kajian ini untuk menilai perbezaan keselesaan haba manusia antara dengan memasang plastik polikarbonat lutsinar dan penutup bumbung legap bagi perhentian bas di kampus Universiti Putra Malaysia dan di samping memahami keutamaan haba kepada pengguna. Oleh itu, pengukuran empat faktor utama iklim mikro (suhu udara, kelajuan angin, suhu purata, dan kelembapan relatif) bersama-sama dengan soal selidik telah dijalankan dalam usaha untuk menilai haba dan keutamaan haba pengguna secara serentak.

Kajian ini menggunakan Suhu Setaraf Fisiologi (PET) sebagai indeks terma yang sesuai untuk menilai keadaan haba alam sekitar di kawasan luar dan separuh luar. Hasil kajian ini menunjukkan bahawa bahan bumbung legap menyediakan keadaan haba yang lebih baik untuk penumpang secara objektif dan subjektif berbanding dengan kepingan atap polikarbonat. Nilai purata suhu udara dan PET untuk polikarbonat bahan bumbung adalah lebih tinggi daripada stesen legap tetapi nilai-nilai kelembapan untuk legap adalah tempat di peringkat yang lebih tinggi. Manakala, hasil borang kaji selidik menunjukkan responden di bawah perhentian bas yang menggunakan bahan bumbung legap memberi keadaan haba yang lebih selesa daripada reponden di bawah perlindungan Polikarbonat. Ia juga menunjukkan bahawa parameter subjektif memainkan peranan yang penting dalam keselesaan haba manusia dalam ruang separa luar, jadi, ia diperlukan untuk mengambil kira faktor-faktor subjektif untuk kajian masa hadapan. Tambahan pula, kajian ini menunjukkan bahawa orang Malaysia boleh bertolak ansur dalam keadaan yang haba lebih tinggi berbanding orang di Eropah atau Taiwan. Selain itu, hasil kajian ini menggambarkan teduhan mempunyai kesan yang besar ke atas kepuasan haba manusia manakala ruang yang dilindungi menyediakan persekitaran haba yang lebih baik bagi pengguna. Hasil kajian ini boleh digunakan untuk mereka bentuk keputusan di masa hadapan bagi persekitaran luar  dan separa luar dan menyediakan haba yang selesa bagi persekitaran luaran yang boleh membawa kepada peningkatan penggunaan ruang tersebut. Kesimpulannya, kajian ini menyumbang ke arah meningkatkan kualiti perhentian bas sebagai persekitaran separa luar untuk penumpang dalam Malaysia yang iklim Tropika dan meningkatkan kualiti hidup di kawasan bandar.

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I am really grateful to my honorable supervisor, Dr. Zaky Jaafar, Dr. Mohd Fairuz Shahidan who supported me with their knowledge and proficiency during master degree.

I would like to express my extreme gratefulness to my beloved family who are motivating me in all stages of my life with their love, support and guidance.

**APPROVAL SHEET 1**

I clarify that a Thesis Examination Committee has met on ……..…… to conduct the final examination of Danial Goshayeshi on his thesis entitled "**HUMAN THERMAL COMFORT DIFFERENCES BETWEEN INSTALLING POLYCARBONATE AND OPAQUE ROOFING MATERIALS IN BUS STOPS OF UPM**" in accordance with the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

**Name of Chairperson, PhD**……..…
Title……
Name of Faculty……
University Putra Malaysia

**Name of Examiner 1, PhD**…….……
Title……...……
Name of Faculty……...……
University Putra Malaysia
(Internal Examiner)

**Name of Examiner 2, PhD**…….……
Title……..……
Name of Faculty…….……
University Putra Malaysia
(Internal Examiner)

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

**Mohamad Fakri Zaky BIN Ja'afar, PhD**
Senior Lecturer
Faculty of Design and Architecture
Universiti Putra Malaysia
(Chairman)

**Mohd Fairuz BIN Shahidan, PhD**
Senior Lecturer
Faculty of Design and Architecture
Universiti Putra Malaysia
(Member)

**Nur Dalilah BINTI Dahlan, PhD**
Senior Lecturer
Faculty of Design and Architecture
Universiti Putra Malaysia
(Member)

**BUJANG BIN KIM HUAT, PhD**
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 13 November 2013

**Declaration by graduate student**

I hereby confirm that:

- This thesis is my original work;
- Quotations, illustrations and citations have been duly referenced;
- This thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- Intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
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- There is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature:_____ Date: 13 November 2013

Name and Matric No.: Danial Goshayeshi (GS29737)

**Declaration by Members of Supervisory Committee**

This is to confirm that:

- The research conducted and the written of the thesis was under our supervision;
- Supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Ruled 2013 (Revision 2012-2013) are adhered to.

| | | | |
|---|---|---|---|
| Signature: | | Signature: | |
| Name of Chairman of Supervisory Committee | MOHAMAD FAKRI ZAKY BIN JA'AFAR, PhD | Name of Member of Supervisory Committee | MOHD FAIRUZ BIN SHAHIDAN, PhD |
| Signature: | | | |
| Name of Member of Supervisory Committee | NUR DALILAH BINTI DAHLAN, PhD | | |

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