EFFECT OF PAVEMENT MATERIALS ON SURFACE TEMPERATURE IN PRESINT2, PUTRAJAYA, MALAYSIA

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EFFECT OF PAVEMENT MATERIALS ON SURFACE TEMPERATURE IN PRESINT2, PUTRAJAYA, MALAYSIA

By

REZVAN SADAT BENRAZAVI

Thesis Submitted to the school of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Urban Planning and Design

March 2015

Dedicated to

My dearest parents

Whose unconditional love and care has always been with me throughout my life

To my brothers who have never given up on me and helped me to traverse the complicated path of growth, and

To my sister, my best friend and the greatest source of inspiration in my life

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

EFFECT OF PAVEMENT MATERIALS ON SURFACE TEMPERATURE IN PRESINT2, PUTRAJAYA, MALAYSIA

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REZVAN SADAT BENRAZAVI

March 2015

Chairperson: Associate Professor Kamariah Binti Dola

Faculty: Design and Architecture

Changing ecosystem and natural habitats with manmade infrastructures and surface materials lead to higher temperature in cities and urban areas than surroundings. As cities are mostly paved by materials, surface temperature mitigation should be considered as a crucial strategy for urban planners and designers to minimize surface temperature. Using 'cool materials' could lead to pavement to maintain cooler temperature and radiate less heat. This results in lower surface temperature. In this regard, this study attempts to analyze and compare the thermal behaviour of most dominant pavement materials in Putrajaya Boulevard and its surroundings at three different locations and different times. Several steps were taken: field measurements, field observation, informal interview, getting classified map, finding out the most dominant materials, measuring pavement surface temperature, and analysis of data through comparing surface temperatures to identify the most proper pavement material with lowest surface temperature in coolest landscape environment. The most dominant pavement materials identified are; 1.Blue Impala (polished granite), 2.Rosa Tanggo (polished granite), 3.Fontana Concrete, and 4.Asphalt) at three different landscape environments (open space, near water, under shade) was measured and compared (with E60 Infrared thermal imaging camera) for one month (from 6:00 to 24:00 in six consecutive time intervals). Based on comparative study, it was revealed that pavement materials with higher albedo and lower emissivity like Blue Impala were 15.5 ºC cooler than asphalt in 'open space' during 12:00-15:00. Additionally, 'under shade' location was the coolest landscape

environment for all pavement materials. This study concurs with previous works in which trees and shades help to reduce surface temperature in tropical climate. However, 'near water' location gave mixed results as Blue Impala and Rosa Tanggo recorded increase in temperature in contrast to Fontana Concrete and asphalt that showed reduction in temperature. Ultimately, this study provides a systematic reference for future designing and planning on pavement for surface temperature reduction in urban areas to mitigate urban heat island effect.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk mendapatkan Ijazah Sarjana Sains

KESAN BAHAN TURAPAN DI ATAS SUHU PERMUKAAN DI PRESINT2, PUTRAJAYA, MALAYSIA

Oleh

REZVAN SADAT BENRAZAVI

Mac 2014

Pengerusi: Professor Madya Kamariah Binti Dola

Fakulti : Rekabentuk Dan Senibina

Perubahan ekosistem dan habitat semulajadi dengan infrastruktur buatan manusia dan bahan permukaan mengakibatkan suhu di bandar-bandar dan kawasan Bandar lebih tinggi berbanding persekitarannya. Memandangkan kebanyakan Bandar diturap oleh bahan-bahan, pengurangan pada permukaan suhu harus dipertimbangkan sebagai salah satu strategi penting kepada perancang Bandar dan pereka bentuk Bandar untuk meminimumkan suhu permukaan. Menggunakan 'bahan-bahan sejuk' membolehkan turapan permukaan mengekalkan suhu lebih sejuk dan pengeluaran haba yang kurang. Ini menyebabkan suhu turapan permukaan yang lebih rendah. Dalam hal ini, kajian ini bertujuan untuk menganalisa danmembandingkan sifat terma bahan-bahan turapan permukaan yang paling dominan di Putrajaya Boulevard dan persekitarannya pada tiga lokasi dan masa yang berlainan. Beberapa langkah telah diambil: pengukuran di tapak, pemerhatian lapangan, temuduga tidak rasmi, mengambil klasifikasi peta, mengenal pasti bahan-bahan turapan yang paling dominan, mengukur suhu permukaan, dan menganalisis data melalui perbandingan suhu permukaan bagi mengenal pasti bahan turapan yang paling sesuai dengan suhu permukaan terendah dalam persekitaran landskap yang paling sejuk. Bahan-bahan untuk turapan paling dominan yang dikenalpasti adalah; 1.Blue Impala (granit yang berkilat), 2.Rosa Tanggo (granit yang berkilat), 3.Fontana Concretedan 4.Asphalt) pada tiga persekitaran landskap yang berbeza (kawasan terbuka, berhampiran dengan air, di bawah naungan) telah disukat dan dibandingkan (dengan menggunakan kamera pengimejan haba Inframerah E60) untuk jangka masa sebulan (dari 6:00 hingga

24:00 dalam enam selang masa berturut-turut). Berteraskan perbandingan kajian, adalah dikenal pasti bahawa bahan-bahan turapan dengan albedo yang lebih tinggi dan kepancaran lebih rendah seperti Blue Impala adalah 15.5 ºC lebih sejuk berbanding asfalt yang terletak di 'kawasan terbuka' pada waktu 12:00-15:00. Di samping itu, lokasi yang berada 'di bawah naungan' merupakan persekitaran landskap yang paling sejuk untuk semua bahan-bahan turapan. Kajian ini bersetuju dengan kajian terdahulu di mana pokok dan naungan membantu mengurangkan suhu permukaan pada iklim tropika. Walaubagaimanapun, lokasi yang berhampiran dengan air member keputusan yang berbeza di mana, Blue Impala‟ dan „Rosa Tanggo‟ mencatatkan peningkatan suhu jika disbandingkan dengan „Fontana Concrete‟ dan asfalt yang menunjukkan pengurangan suhu. Akhirnya, kajian ini telah menghasilkan satu rujukan yang sangat sistematik dalam rekaan dan perancangan permukaan yang boleh mengurangkan suhu permukaan pada masa hadapan untuk kawasan Bandar bagi mengurangkan kesan pulau haba di bandar.

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I would also like to extend my profuse appreciation to my Co-supervisor Lar. Asraf Abdul Rahman, whose limitless support and motivation illuminated the pathway of academic research for me.

Approval Sheet

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:

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Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

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- the research conducted and the writing of this thesis was under our supervision;
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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Urbanization results in dramatic population growth and replacing natural and open spaces with structures and buildings which are being paved and covered by different types of materials. The surfaces absorb solar energy and heat up urban areas several degrees higher than the rural areas and cause climate changes. Synnefa, Santamouris, & Livada (2006)stated that the heat island changed the microclimate and built up urban areas hotter than the surroundings area.

As Santamouris, Papanikolaou, & Livada (2001)explained that the surfaces of buildings and streets emitted radiation that entrapped in street canyon. Even more, the amount of solar radiation that surfaces are absorbing is increased as the direct result of multiple reflections from street and buildings surfaces. Oke, Johnson, Steyn, & Watson (1991) supported the idea by defining in a typical city the heat island expands after sunset whereas the rural area cools exceedingly since the latent heat in city canyon is releasing slowly. Additionally, the city canyon is enclosing by vertical surfaces that radiate to the sky screen and downward to the floor. Therefore, the cooling process for urban areas is much slower than rural surrounds with the nearly horizontal skyline and that produce the impact temperature differentiate between two areas.

Sham (1991) one of earlier investigation in tropical UHI in Kuala Lumpur, Malaysia also agreed with Nieuwolt (1966) findings and supported the idea of warmer urban areas. Sham (1991) findings on clear and sunny days revealed that the air temperature of urbanized regions was 4.4-5 ºC or 8-9 ºF higher than its surroundings. Besides, on cloudy days this difference was just around 2-2.2 ºC (3.54 ºF). He mentioned that the usage of much more dark colour surfaces in cities was the most characteristics that attributed to modern urbanization and trapping hot air at the body level of urban structures, which caused the most stunning impact in providing hot constant microclimate. To be specific for studying in Malaysia case for selected cities, majority of studies in this issue was generated by Sham (Sham,1991; Sham 1973). Concisely, he determined that in Kuala Lumpur the heat island causes 6 º C higher temperatures in urbanized areas than rural on a clear day. Besides, there are also other climatological studies in Malaysia to analyse UHI behaviour and implication on the future of urban development (Elsayed, 2006). It’s been recognized that even though so many studies have done on temperate climate there is a significant lack of studies on tropical climate and proper suggestions to consider urban planning and design for developing, modifying, and managing our cities of tomorrow. This study will focus on different pavement materials and their behaviour and effect on surface temperature at Putrajaya.

1.2. Study solar radiation and extra-terrestrial radiation

Brown & Gillespie (1995) explained solar radiations out coming radiation from sun with a wide wavelength and varying intensity that is divided in three categories: Ultraviolet, visible, and infrared photons that Ultraviolet (UV) light is the wavelength of sun light that is shorter than visible light and most of these photons are filtered by ozone layer. It is invisible for human and potentially damaging effect to eyes and skin. Visible light is a radiation for human and the wavelength is between ultraviolet and infrared radiation. This light is responsible for photosynthesis. Infrared (IR) light is a radiation beyond the red wavelength in visible spectrum. Planets do not use it for growth and leaves reflect or transmit it. However, terrestrial radiation is invisible for human and its wavelength is longer than solar radiation. It is emitted by all objects/surfaces on earth and atmosphere, and is detectable both in day and night. This radiation is so important for microclimate and site designation.

The Figure 1.1 shows the wavelength of solar radiation that captured by earth and terrestrial radiation emitted. It should be noted that there is no overlap between these two curves and they are almost identical.

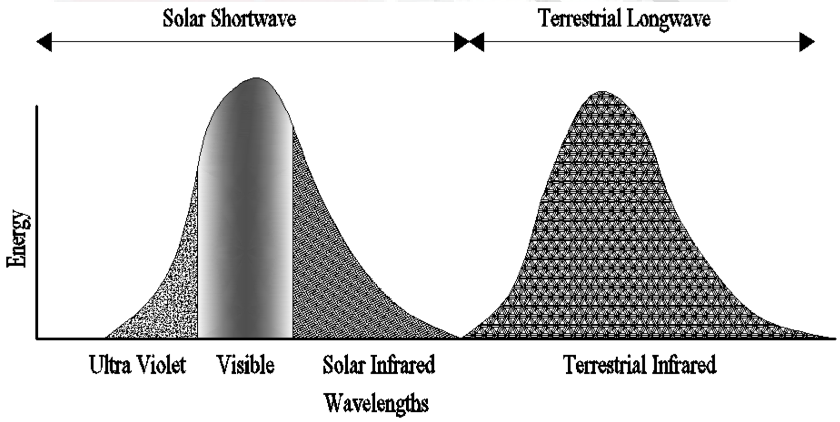


Figure 1.1 Solar radiation and terrestrial radiation wavelength.
(Source: Brown & Gillespie, 1995)

1.2.1. Study Site Location and Climatic Descriptions

The study was accomplished in Putrajaya Boulevard and its surroundings (Persiaran Perdana Boulevard), a public thoroughfare with the length of 4.2km and the width of 100m in the new federal administrative center in Putrajaya, Malaysia. This site is enclosed with man-made and artificial lake. The area is categorized in three Presints named: Presint2, 3 and 4 which is showed inFigure3.2.The coordinate of this area is Lat. 2º55'N, Long. 101º42'E, which is situated 25km south of Kuala Lumpur as the capital city of Malaysia. The climate condition in Putrajaya is hot and humid with average 27.5 ºC temperature and humidity of 62.6% annually. The sunlight of this area is on the average of 6.1 hour for each day, and 4.96Kwh/m^2 for each year. The wind in Putrajaya is generally light and the speed is varied from 0.5 t0 7.5 m/s. it should be mentioned that the wind movement is mostly week and can be considered statistic (MMD, 2013; Azhari et al, 2008).The Figure 1.2 showed the location of Putrajaya in Malaysia respectively.

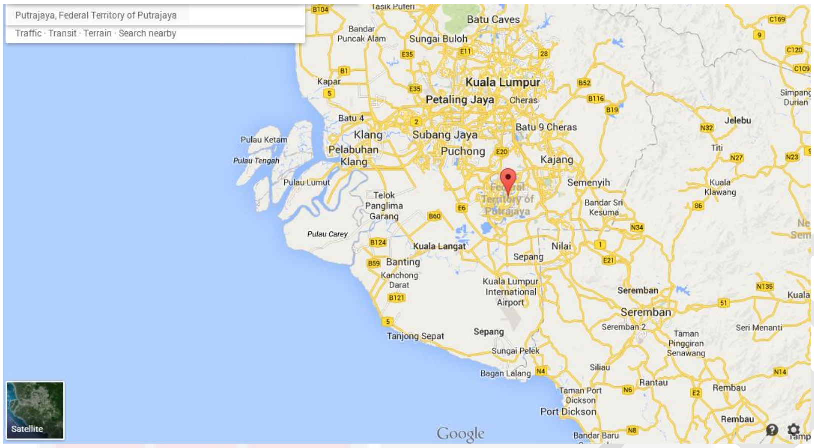


Figure 1.2 Location of Putrajaya in Malaysia (Source: Google Earth, 2014)

Putrajaya is located in 25 km far from the south of Kuala Lumpur as the capital of Malaysia. As the capital city, it needs to portray a good image of the nation. The Putrajaya federal territory is specified in Figure 1.3.

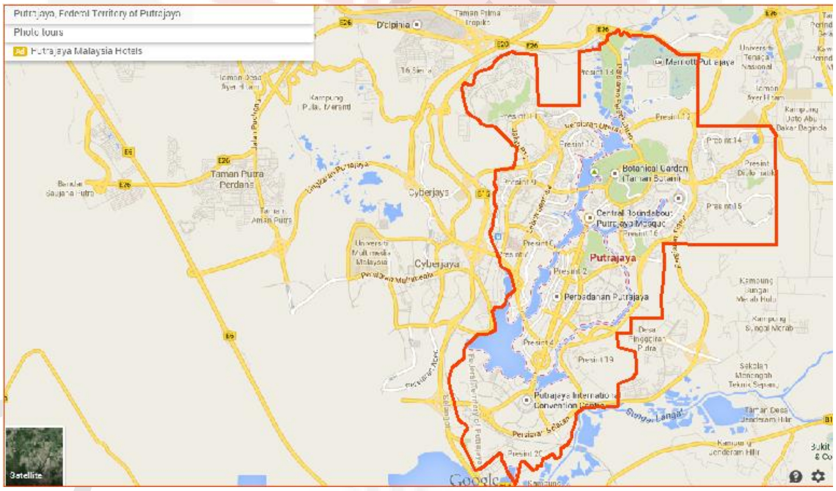


Figure 2.3Putrajaya Federal Territory in Malaysia
(Source: Google Earth, 2014)

Although, Putrajaya was designed with beautiful buildings, lakes, parks and gardens, the heat especially during noon time was observed to be unbearable and temperature record from Malaysia Meteorological Department showed as well (MMD, 2014). Since it is the capital city and the federal administrative centre of Malaysia, it receives many international dignitaries, centre for many special events and a tourist attraction.

According to the report that Krishnan (2007) revealed in The Star newspaper http://www.thestar.com.my/ :

"...Putrajaya literally, is 5 °C hotter than other cities in the Malaysia such as Kuala Lumpur, Penang and Johor Baharu. Rapid urbanization and development in Putrajaya lead to urban heat island with limited green areas and cutting trees in jungles and paving cities with man-made surfaces such as concrete, asphalt, and bricks. New pavement materials increase surface temperature up to 40 ºC and result in hot day and night. Putrajaya is hot, humid summer around the year and planned as a garden city with area of 1,826.5ha that 37.0 % of city area was dedicated to green and open spaces, and 600 Ha or 12% of Putrajaya is belonged to lake and wetlands, however this was not enough to prevent temperature increase ....."

The UHI problem and temperature increase in the worst case scenario occurred in the public artery named Putrajaya Boulevard (refer to Figure 1.4). This thoroughfare spread in the centre of federal administrative area that is 4.2 km long and 100m wide. Due to this reason, this study therefore selects Putrajaya Boulevard and its surroundings as a case for further study.

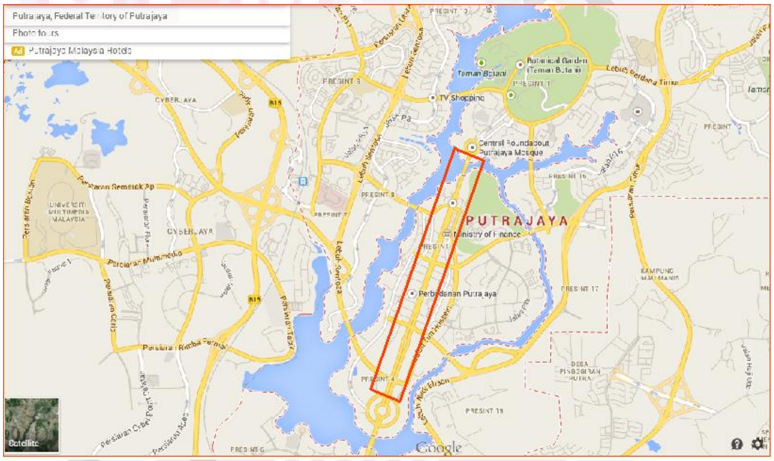
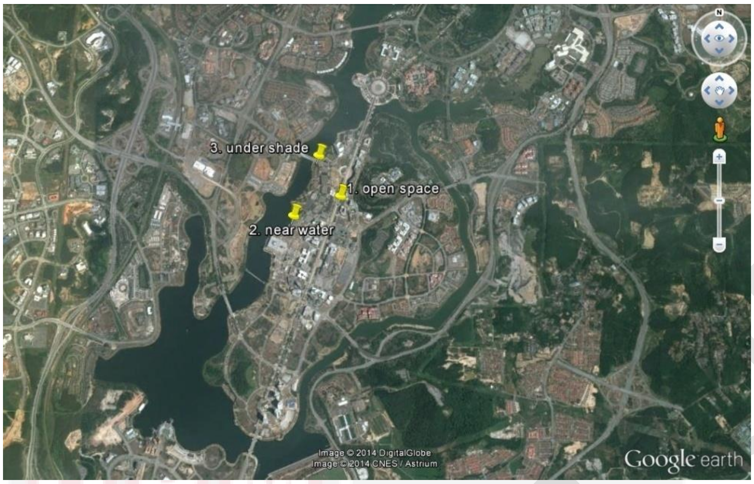


Figure 1.4 Putrajaya Boulevard Location in Putrajaya
(Source: Google Earth, 2014)

The Presint 2 in Putrajaya and its surroundings is selected to complete this research that the classified map and pattern of this area was obtained from Perbadanan Putrajaya.

Figure 1.5 indicated three different locations in Presint2 Putrajaya; open space, near water, and under shade locations. These three different locations are selected to monitor thermal behaviour of most dominant pavement materials (Blue Impala (Polished Granite), Rosa Tanggo (Polished Granite), Fontana Concrete, and asphalt) under different landscape environmental circumstances.



, **Figure 1.5 Three locations in Putrajaya Boulevard and its surroundings**
(Source: Google Earth 2014)

Putrajaya and its surroundings was designed as a focal artery in Putrajaya with main access to other parts of city, it is also acts as an attractive public designed thoroughfare for tourist industry that is the integration of aesthetic and function.

1.3 Statement of the Problem

The problem of high temperature at Putrajaya Boulevard compared to its surrounding area is the main focus of this research. It is mentioned that this are paved with ground materials that are low in albedo and highly absorb direct and indirect radiation. This is due to high usage of asphalt for road lines and hard surface materials such as concrete and brick to pave that result in increasing surface temperature dramatically (Krishnan, 2007) .While it was acknowledged that the area is mostly paved and pavement partly contributes to temperature increase. This research attempts to compare the surface temperature and effect of different pavement materials during day and night at different locations (open space, under shade, and near water). Also, it attempts to measure and compare the surface temperature of most dominant pavement materials in different conditions (location and time).

1.4 Research Questions

As it was noted, pavements can be a part of solution to mitigate UHI effect and specifically reduce air temperature in urban areas. For this research, practically some preliminary questions are needed to be considered:

1) What are the thermal performances of different pavement materials?
2) What are the thermal behaviour of different pavement materials when apply in different urban landscape environments?
3) Which pavement material showed lowest surface temperature in different landscape environment?
4) Which urban landscape environment increase surface temperature?

The main research question for this study is stated below:

> *Main RQ:* Are different pavement materials creating different surface temperature in Putrajaya Boulevard and its surroundings?

To answer the main research question there are two sub-research questions:

> *Sub-RQ1:* How to measure and compare the surface temperature of different pavement materials in different time and locations?

> *Sub-RQ2:* Which pavement material create the lowest surface temperature and under what condition?

1.5 Research Objectives

There are two objectives for this research, which are explained as follows:

i) To measure and compare surface temperature and air temperature of different materials in different conditions (location and time).
ii) To identify which pavement material create the lowest surface temperature and under what condition

1.6 Research Methodology

Previous studies which used comparing surface temperature to find out the proper surface materials, are as follows; Radhi, Assem, and Sharples (2014) used experimental measurements to assess the surface temperature of 32 materials in Bahrain. In addition, Carnielo and Zinzi (2013) applied experimental analyses to measure and calculate the surface temperature of cool asphalt material under sun radiation to reduce surface and air temperature. In this regard, the experimental evaluation was selected to compare and record different pavement materials' surface temperature in this research.

The step by step of completing this study research is explained in chapter 3 in details.

The process of conducting this research involves three parts: First, exploring theories and specifying the knowledge of temperature reduction through the materials of pavement, that is supported by literature review and doing some archival analysis. Next, conducting field study to measure and compare the temperature of most dominant materials in various time and locations (open space, shade and near water) in Putrajaya Boulevard and its surrounding. This was done by using infrared thermal imaging camera (FLIR E60) to measure surface temperature of different pavement materials. Finally, analysing and interpreting findings and recommending and determining how the proper materials can relate to temperature reduction that is supported by graph drawings and infrared images.

1.6.1 Research Framework

To achieve the objectives of study there are five components that create research framework, as shown in Table 1.1.

(1) Doing field measurements/ field observation

In the first step of research framework, field measurement on width and length of Putrajaya Boulevard, dimension and number of different pavement materials, the applied location of different pavement materials in different landscape environment (open area, near water, under shade) was observed.

In addition, field observation on the pavement materials colour, texture, and construction was recorded to achieve information on the condition of materials. In addition, different microclimate landscape in Putrajaya was observed to understand the microclimatic differences in this city. Accordingly, this observation was directed to choose proper landscape environments (open area, near water, under shadow) for inspecting different function of different pavement materials in different times and microclimates.

(2) Getting classified map / finding out the most dominant materials

Following collecting classified maps, plans, sections, and build drawing of Putrajaya and specifically Presint2 of Putrajaya Boulevard, and information on Putrajaya Boulevard and its surroundings were obtained that represented on many different aspects of shaping this city. Some of classified maps, drawings and pavement materials properties were analysed in great detail to be used for this study.

Consequently, the name and pattern of pavement materials used in Putrajaya Boulevard and its surroundings were calculated to find out the most dominant materials that were used in paving urban infrastructures in Putrajaya.

(3) Process of finding appropriate equipment to gather data

By the time of finding out the most dominant materials, it was time to recognize the best equipment to gather surface temperature accurately. In this respect, Prof. Dr. Ratnasamy Muniandy, and Dr. Eltaher Aburkaba (Pavement Material Specialist) in Department of Civil Engineering, Faculty of Engineering, University Putra Malaysia were consulted to find out different equipment to measure and record pavement materials properties. Consequently, various tools and equipment were experimented in “Civil Engineering Laboratory” in different condition conditions to identify the most accurate equipment to achieve the most accurate surface temperature. However, the Department of Civil Engineering (highway) could not provide the best equipment and finding it out was another challenge to overcome.

In that case, Dr. Eltaher Aburkaba introduced the researcher to one company, “Techrentals Malaysia” (http://www.techrentals.com.my/) to rent the selected equipment (Flir E60 infrared Thermal image Camera). This camera is one of the best in its kind with high accuracy rate and up-to-date technology. The researcher was trained on how to use the camera and was given specific days to collect data using the camera as the camera is very expensive an so does the rental fee.

By having appropriate equipment on specified time duration it was time for gathering data.

(4) Going to the field study in different time and locations in one month

By understanding three previous steps; different microclimates and time span was outcome of step one, specified pavement materials (three materials and asphalt) was result of step two, and the most accurate equipment was outcome of step three.

Accordingly, gathering surface temperature within one month was started to find out the impact of different landscape environment (as different microclimate influence) on different pavement materials during six time span each three hours interval from 6:00 am in the morning to 12:00 am at night.

Eventually, data was recorded in three different locations (open space, shade and near water),in 28 consecutive days from 20 January 2014 to 10 February 2014 each three hours from 6:00 am to 12:00 am on four pavement materials simultaneously. Under those circumstances, the 1th February temperature records were selected as a random day in a hot sunny day and not cloudy at both day and night.

In addition, information on air temperature of Putrajaya was obtained from the Malaysian Meteorological Department (MMD) to give minimum, maximum, and mean air temperature of Putrajaya Boulevard and its surroundings hour by hour for each 24 hours in one month. The air temperature is required to find out air temperature and surface temperature differences, and to make comparison between air temperature and each pavement material's surface temperature. This comparison helps to understand the impact of applying different pavement materials on planning and designing outdoor microclimate.

(5) Data analysis and interpretation/ Comparative study/ Conclusion

All things considered, surface temperature in degree centigrade are sum up in drawing graphs and writing tables to have a wide look on different pavement materials thermal performance. By summarizing all data and illustrating them, it was time to do comparison analysis between different pavement materials' behaviour in different microclimates. Figuring out thermal performance of different pavement materials in open space, near water, and shade locations to contribute thermal functionality in different landscape environments.

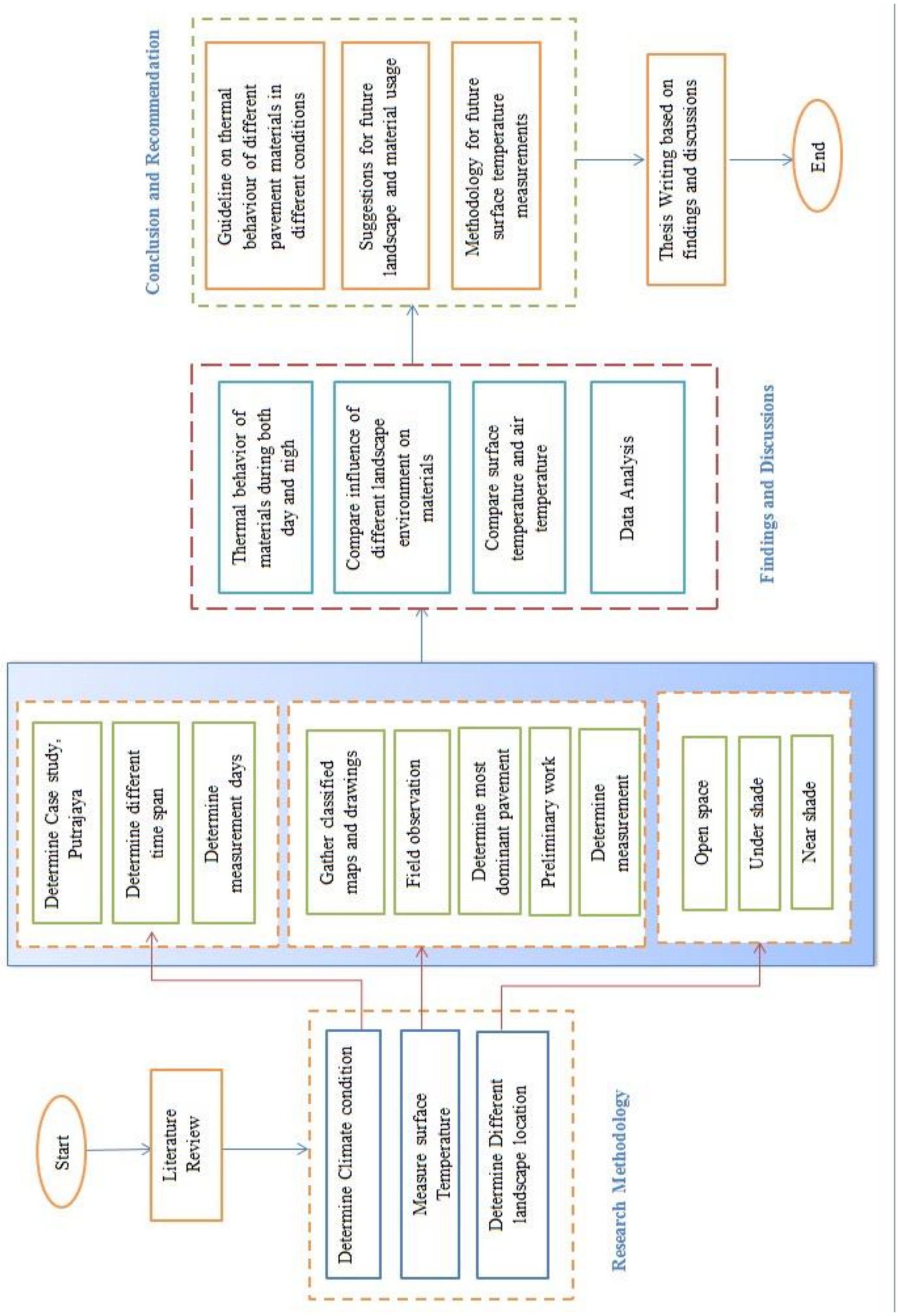


Table 1.1Research Framework

1.7 Scope and limitation of the research

The goal of this study is to compare the effect of different pavement materials in different times and locations for reducing the near surface temperature of local area. The primary focus of this study is on the pavement material's temperature behaviour during day and night, and different locations (open space, shade and near water) only at selected locations in Putrajaya Boulevard and its surrounding. It should be mentioned that as the main focus of study is on the street level. This kind of confining provides a better approach to the horizontal impact and near ground level. In this direction, the investigation is incorporated in the impact of different selected pavements materials on the surface temperature.The field measurements to surface temperature, for raising the accuracy of data, were conducted on clear and sunny days. According to time limitation and cost, and equipment rental policy, data collection was accomplished in one month during the peak average air temperature and dry season of Malaysia a tropical climate. Albeit, the climate condition in study areas is almost consistence during the field study.

As the study was conducted during 28 days from 20 January 2014 to 10 February 2014 in hot and humid climate condition of Malaysia, the surface temperature validity is limited to this time span.

1.8 Importance of Study

The aim of this study is to explore pavement materials thermal performance, and focus on how this study contributes to Putrajaya, urban design and landscape architecture in general. The most important gaps that lead to conducting this study are listed as follows;

- The study gives a reference of recording surface temperature for the future measurements at Putrajaya.
- Many studies on recording climatic impact were done on mesoscale (Taha, 1997; Xian, 2008; Grimmond et al., 2010; Radhi et al., 2014), but this study for having more accurate data was done on microclimate scale.
- The studies that have been accomplished on urbanization effect in Malaysia focused on general air temperature(Sham, 1991; Tso, 1996; Krishnan, 2007; Tan, Lim, MatJafri, & Abdullah, 2009; Shaharuddin, Noorazuan, Yaakob, Kadaruddin, & Mohamod, 2011; Elsayed, 2012; Salleh, Abd.Latif, Mohd, & Chan, 2013; Md Din et al., 2014; Nur, Sanusi, Azlan, & Zamri, 2014, however this study has been conducted on recording surface temperature of pavement materials
- The studies that have been done previously on climatic impact of Putrajaya were on thermal comfort in various layout of building (Md Din et al., 2014), or compared land cover of Putrajaya from 1999 to 2009 (Salleh, Abd.Latif, Mohd, & Chan, 2013). But this study was carried out in surface temperature and on the pavement materials impact, which potentially bring intervention on reducing surface temperature .
- This study was conducted on specified pavement materials and illustrated thermal performance of this materials during both day and night that is precious information for understanding thermal behaviour of these four

selected pavement materials under different landscape environments for future applying cooler pavement materials near the best ambience environment .

- The findings of this study can be used in Putrajaya and whole Malaysia as these pavement materials are completely popular in Malaysia.

Among all the features that mentioned, the most significant contribution of this dissertation is a reference for recording surface temperature of pavement materials during both day and night in different landscape environments. The results of this study are useful for climatic environment study all around the world and can be used to compare with temperate and other climate condition for understanding thermal behaviour of these pavement materials.

1.9 Organization of Thesis

In the first chapter of study, research framework and problem statement is indicated that is followed by the second chapter to carry out literature review and finding theories. In the third chapter as the unit of analysis and determination of knowledge the required field measurement and comparative study will fulfilled. By the forth chapter the findings and discussions is provided in order to direct to the fifth chapter as the conclusion of study.This study is organized in five chapters whose details are explained as follows:

Chapter 1: Firstly, there is a journey through the background of the study. Then the problem, research question and research objectives are expressed.

Chapter 2: This chapter explains the structure of studied literature toward collecting sufficient information on previous studies, existing knowledge and theories associated with the subject of this research. This process provides construct to carry out the research.

Chapter 3: In this chapter selected research methodology and its relevant components are explained in detail. The approach adopted in this research to solve the stated problem is based on Creswell (2008) experimental methodology.

Chapter 4: In this chapter, the procedure of data collection through field measurement in experimental study is explained. As a result, at the end of this chapter the objective of this study and therefore the sub research question is answered. Furthermore, by comparing data thermal behaviour of different pavement materials was abstracted.

Chapter 5: This chapter concludes all the findings related to the proposed knowledge activity, limitation of study, knowledge contribution and future studies are explained.

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EVALUATION TEMPERATURE OF PAVEMENT MATERIALS FORTEMPERATURE REDUCTION IN PUTRAJAYA

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ABSTRACT

The rapid urbanization is known as the global phenomenon as a result of human progress that change current and prototype of living with modern style results in heated urban areas compare to their rural surrounds. This effect is called Urban Heat Island (UHI) that reshapes natural temperature of certain built areas as compared to surrounding areas. As cities are paved by materials, this last touchable and visible part of each building, street, sidewalks and so on has a crucial part in determining the temperature of living area. As a matter of fact, by using 'cool materials' with higher albedo and less absorption of sun radiates, the surfaces maintain cooler and radiate less heat to ambient which result in better air quality and temperature reduction. This study attempts to evaluate the sustainability and impact of materials used in outdoor urban spaces in order to contribute improvement for surface temperature in Putrajaya. The aim of this paper is to find possibility to identify and assess the cool materials for controlling thermal condition of urban pavements. In such case, the current materials of **PersiaranPerdana**are chosen to study and document thermal behavior of these materials during both day and night to recommend better functional pavement materials for future development. Such cool materials can influence the thermal effect of rapid urbanization, and decrease side effects of Urban Heat Island in Putrajaya.

Keyword: Pavement materials, Putrajaya, Urban Heat Island