USE OF LANDSCAPE ENVIRONMENTAL SETTING FOR PEDESTRIAN TO ENHANCE CAMPUS WALKABILITY AND HEALTHY LIFESTYLE

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ABSTRACT

Malaysian higher learning institutions were designed to create environments conducive for teaching and learning. Campuses are often large ranging from a few hundred to more than a thousand hectares. These require a proper connecting system without undermining the value of a healthy lifestyle. Walking is an element that promotes healthy lifestyle. The aim of this research is to enhance campus walkability within different landscape environmental settings in tropical campus environments. The study investigated and measure Landscape Environmental Setting for Pedestrian (LESP) based principally on physical properties of the landscape setting and its surrounding environment. This study will highlight the tropical campus environment by using pedestrian walkways, with different settings, as a case study. To achieve the objectives, the study used literature review and a case study. The literature reviews and observations help to identify and classify landscape scenarios of various landscape settings. The campuses involved in this study are Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), Universiti Malaya (UM) and Politeknik Port Dickson (PPD). All four institutions were used as a case study to evaluate the existing condition of the pedestrian environment. The key constructs used in the literature review are pedestrian thermal comfort and landscape environment setting. Case study method was used to evaluate the relationship between LESP, pedestrian thermal comfort, and various settings of campus landscape scenarios. The results of the study revealed that different types of LESP have potential in providing a better campus environment and lifestyles. Importantly, the landscape design attributes and characteristics play an important role in the development of a design guideline in the context of sustainable tropical campus environment perspective.

Keywords: Landscape Environmental Setting for Pedestrian (LESP), campus landscape setting, microclimate, walkability.

1 INTRODUCTION

A healthy lifestyle has been proven to lower the risk of being seriously ill. Statistics show that a large number of people died from illnesses related to obesity and overweight [1]. Obesity and overweight persons are exposed to higher risk of diabetes, osteoporosis, metabolic syndrome, high blood cholesterol level, and chronic diseases [2]. One way to reduce these two problems is by encouraging a healthy lifestyle. This can be related to the built environment and health behaviour of a person [3]. For instance, with having school and amenities less than 4oo meters from home, people can choose to walk in their neighbourhood [4]. Physical activities such as walking, jogging, cycling, and swimming are the examples of a healthy lifestyle. Promoting walking and cycling is important when urban population tends to depend on private motorised vehicles for moving around [5]. Motorised vehicles contribute to air pollution, global warming, and climate change [6]. Sustainable transportation such as walking and cycling can help reduce these problems [7]. In the context of the universities, many campuses are places with high concentration of students using motorised vehicles such as motorcycles and cars contributing to traffic congestion, consuming large spaces for vehicle parking, reducing green areas, and lowering the air quality [8]. These affect the wellbeing of the campus communities.

However, promoting walking among the campus community is not an easy task, especially in countries with hot climate like Malaysia [9]. Heat and polluted environment contribute to the fact that not many people prefer to walk. Obviously, this relates to the pedestrian comfort. In other words, if the weather is hot and the air is moist with humidity, it is very unlikely that a pedestrian is going to enjoy walking on campus. The rough definition of pedestrian comfort is the pleasant feeling that people feel when they interact with the environment [10]. Under the umbrella concept of pedestrian comfort is pedestrian thermal comfort [11]–[15]. Walking is the most basic mode of getting from one point to another and the most convenient way for students and staffs to move on campus. Nevertheless, in order to encourage them to walk, the campus built environment has to provide safe and comfortable landscape for walking.

A typical tropical climate has high ambient air temperatures and relative humidity year-round, with a diurnal maximum temperature of 31°C to 34°C and a minimum of 23°C to 26°C [11]. On top of this, the heat increased by 0.25°C in the city areas [16]. Urban areas in Malaysia, Singapore and other tropical cities also experience the urban heat island (UHI) effect because of its urban development [16], [17]. The use of air conditioning in these cities to mitigate high temperatures not only increases energy consumption but worsen the UHI effects [18]. Faced with these conditions, many tropical countries have conducted studies in a bid to manage urban heat at the macro level [19]. However, differences in temperatures measured on sites and by official weather stations highlight the insufficiency of relying on general regional measurements taken by fixed weather stations [20]. This may necessitate the need to calibrate the value of the urban temperatures [21] and to use local micro-scale thermal measurements to verify the thermal experience of outdoor users at parks, squares, and especially on university campuses. Therefore, there is a need to investigate the ambient condition of pedestrian environment influencing outdoor walking comfort.

In addition, there is a need for students to have a restorative and stress-reducing environment through the greening and natural elements on their campuses. Current knowledge proves that a campus environment that has lots of trees and nature can integrate the campus community and consequently improves students' academic achievements [22]. A high quality green environment can also encourage the campus community to walk more. Walking plays a fundamental role in the sustainability of a place and it has many benefits to the campus community [23]. On a walkable campus, students and staffs walk to various destinations such as from hostels to classes, library, etc. [24]. With a good Landscape Environmental Setting for Pedestrian (LESP), there is better cooling effect that can enhance campus walkability [25]. Thus, this paper discusses the investigation and measurement of LESP based principally on the physical properties of the landscape setting and its surrounding environment. This case study will highlight several tropical campus environments by using pedestrian walkways with different environmental settings. The scope also includes the landscape design attributes and characteristics of a sustainable campus environment.

2 METHODOLOGY

In addressing the study, the authors have opted for a qualitative approach. This is due to the fact that in order to determine the characteristics of a sustainable campus, most of the determinants involved are not quantifiable. For instance, one cannot quantify "comfort" or "thermal environment". Similarly, with "heat", when a person is "hot" – this could be due to the heat from the sun or it could be generated by the materials used in the surrounding environment i.e. asphalt as the walkway. Hence, the use of qualitative method eases the path for the researchers to build patterns, categories, and themes from the bottom up and

organising the data into increasingly more abstract units of information. This study employed a review of relevant literature and case studies of four Malaysian campuses: Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), Universiti Malaya (UM), and Politeknik Port Dickson (PPD). The first study objective is to investigate the characteristics of existing campus environments influencing pedestrians' comfort and thermal environment while the second objective is to evaluate the relationship between pedestrians' thermal comfort and the identified environmental settings. The study measures the effects of LESP on walking environment taking into account the influences of landscape elements such as trees, pavements, and man-made shades.

2.1 Case study

As mentioned earlier three Malaysian university campuses (UKM, UM and UPM) and a polytechnic campus (Politeknik Port Dickson – PPD) have been chosen for this case study. These campuses are chosen because they represent established campuses in Malaysia [26]. The case study is to identify the various types of landscape environmental settings in tropical university campuses. UKM, UM and UPM are Malaysian public universities located in the Klang Valley with scattered planning layouts. These are large campuses ranging in areas from a few hundred to more than a thousand hectares. Students and staffs had to rely on walking or either using public or private motorised transport. On the other hand PPD is a medium size higher learning institutions located in the state of Negeri Sembilan that runs Technical and Vocational Education and Training related programs (TVET).

This study was conducted in three phases. First, exploring theories and specifying the knowledge of landscape environment setting attributes that influence pedestrians' thermal comfort, which is supported by literature review and doing an archival analysis. Second, conducting a field study to investigate characteristics available in various existing tropical campus environment that influenced pedestrians' thermal comfort. Finally, measuring the landscape environment setting attributes based on the numbers of landscape elements in the pedestrian environment. The last phase involved the process using the shading comparison to measure thermal comfort on pedestrian. The data collected were analysed by comparing the shades quality and pedestrians' thermal comfort of different environment settings.

2.2 Defining Landscape Environmental Setting for Pedestrians (LESP)

The term LESP is coined for this study. LESP is defined as "everything that can be seen in the pedestrian's walkway surrounding within 3.0 m radius that affect the thermal comfort/behaviour of the pedestrians at the particular type of situation." The term is derived from the definitions of keywords; landscape, environment, and setting. The three meters (3.0m) is based on a study by Ng and Cheng [27]. Fig. 1 shows the example of a LESP, which includes the trees and its canopy, the distance between trees planted in a straight line, and pavements.

2.3 LESP framework

A research framework was developed by the researcher to guide the study and based on the observations of pedestrian walkways in tropical campus environment. This framework divides the landscape elements into four categories and each category is further divided into subcategories as shown in Fig. 2.

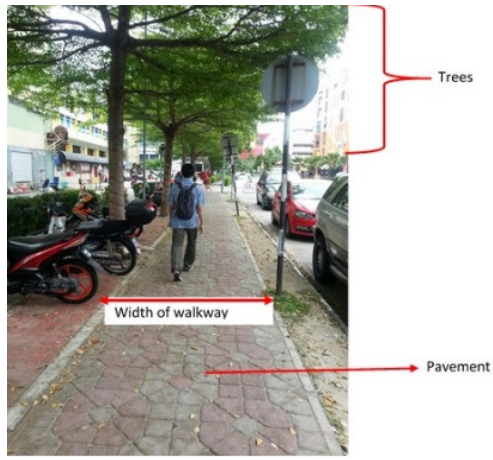


Figure 1: An example of LESP.

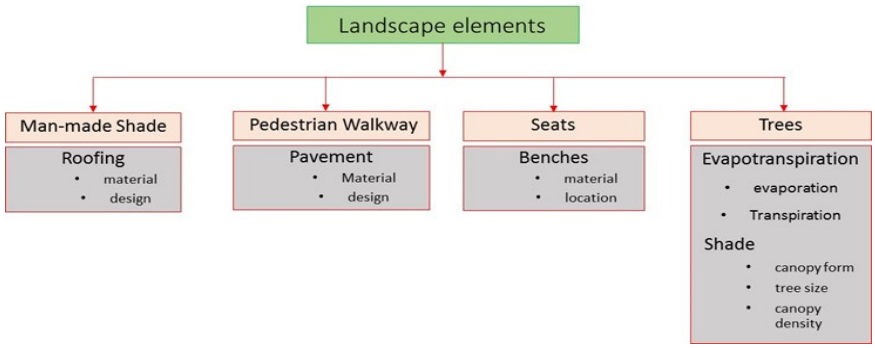


Figure 2: Framework of landscape elements in LESP.

Impacts of landscape elements stated in the framework on pedestrians were analysed from relevant literature. The elements included man-made shade, pedestrian walkway, seats, and trees. The study measures pedestrian comfort on walking environment taking into account the influences of landscape elements such as trees, pavement, seats, and man-made shades.

3 RESULTS AND DISCUSSIONS

Tropical regions' temperatures are constant through-out the year. A clear and sunny day provides a suitable weather condition to examine the influences of landscape elements on pedestrians' thermal comfort and compares their shading profiles.

3.1 Effects of landscapes on pedestrian environment

Several studies have proven that landscape elements have significant effect on people's emotions and health as well as their attitudes and behaviours [28]–[30]. Hard and soft landscapes are two main categories of landscape elements. Hard landscape elements refers to structures and other built elements such gazebos and benches while soft landscape

elements refer to plants (trees, palms, bamboos, shrubs, climbers, ground cover and water plants). Man-made shade is often introduced in pedestrian walkways to provide shelter to the users. Shades are important as they prevent direct sunlight on pedestrians to increase their comfort while walking. Shade makes walking activity more comfortable especially during a hot and humid day. Generally, pedestrian obtained shades from the two types of sources; trees and man-made shades. Thus the study sought pedestrian preferences for the two types of shades. Fig. 3 shows examples of the two types of shades in tropical campus environment. In learning institution such as UPM, man-made shade can be found in many places with the aim of protecting pedestrian from the rain and the hot sun. There are many types of man-made shades with a variety of designs and materials. Fig. 4 shows a variety of man-made shades for pedestrian in UKM, UPM and UM.

A good pedestrian walkway or sidewalk can encourage people to walk if certain guidelines are followed in their design and construction. A good walkway must be separated from vehicle traffic [2]. Crossing areas between pedestrians and vehicles as well as the pavement of walkway can signal danger to users through the differences in finishing materials and surface levels. The pedestrian route can also act as a place of incidental stop and determining the ownership of the area through the different materials and levels used. Fig. 5 shows example of walkways in UKM, UPM, and UM.

Figure 3: Images of shade: man-made shade and shade formed by trees in the pedestrian walkways.

Figure 4: Examples of man-made shades of pedestrian walkways in UKM, UM, and UPM.

Figure 5: Images of walkways in UKM, UM, and UPM.

The choices of walkway paving materials have been a topic of interest among researchers in relation to the urban heat island (UHI) effect. Due to rapid urbanization, natural surfaces such as grass were changed to hard surfaces. This is said to be the major factor of increase in air temperature in urban areas [31]. They highlighted albedo value of pavement material as the main factor in reducing the effect of UHI. Albedo (α) is the reflective power of a material indicated by the percentage of incident radiation reflected by a material [17]. If the value of albedo is high, for example α=0.9, this shows that the materials used in the area are cool paving materials. An example of this is white marble. A low albedo material such as α=0.1 indicates the use of warm paving material e.g. fresh asphalt. The examples of this material is shown in Fig. 5. Walkway's material in UKM, UM and UPM use interlocking paver which bears high albedo value. In contrast, road are made of asphalt which is known to have low value of albedo.

Several researchers have investigated and evaluated the effects of a variety of colours and textures of paving materials to intense sunlight on surface temperature [32]. They revealed that during the daytime all paving materials had a mean temperature higher than that of the ambient air, while at night all surfaces were cooler. The use of high albedo materials in mitigating the bad effect of UHI has been shown by many researchers [33]–[35]. As a result, a guideline has been developed to help urban designers on selection of paving materials [34]. However, the correlation between high albedo materials and their ability to reduce air temperature and determine pedestrian comfort has yet to be established [33], [34], [36], [37].

Field measurement and questionnaire survey was carried out by Rosso et al. [33] in order to investigate thermal comfort and visual pedestrian perceptions about several paving systems i.e. grassland, asphalt, natural stones, and cool stone aggregates. Results proved that cool gravel based surface does not produce thermal discomfort but it produces some visual discomfort due to glare in sunny weather. Their results also demonstrated that grassland is the most preferred, while asphalt is the least favourite material for paving in hot and sunny weather [33]. Erell et al. [34], examined the effects of high-albedo materials on pedestrian heat stress in urban street canyons of four cities with different climate. The cities were Eilat (Israel), Adelaide (Australia), Singapore, and Göteborg (Sweden). Results of the study indicated that although the use of high-albedo materials in canyon surfaces may reduce the air temperature, the reduction is not enough to offset increased radiant load exposed to pedestrians. Thus, it will compromise the pedestrian thermal comfort. They conclude that the use of high-albedo materials for urban surfaces is not significant to the pedestrian.

Seating is one of the walkway furniture to provide resting facility for pedestrian. Street seating include benches, steps or edges of planter beds. In UPM benches are provided along the covered walkways (man-made shading) for the use of pedestrians. This allows pedestrians to break their walking journey. The final landscape elements included in this study are trees.

Trees tend to reduce the radiant heat for pedestrian [38]. The microclimates of pedestrian walkways are closely related to the landscape environmental setting of the walkway such as types and species of trees. This characteristic is found in all campuses: UKM, UM, UPM and PPD. Trees of medium crown such as *Cinnamomum iners*, *Cassia fistula* and *Peltophhorum pterocarpum* are common in those campuses. It is proven that tree canopy density, form, height, and type of species, are able to modify the surrounding indoor and outdoor ambience to be more comfortable [39]. In pedestrian walkways, trees are used as shading devices as they protect the pedestrians from solar radiation. Trees also solve environmental problems such as climate change due to the effects of UHI. Trees are selected according to their characteristics and abilities to solve functional problems and the extent to which these can be accomplished. For example, 33% coverage of the urban area with trees will achieve a 1°C reduction at pedestrian level air temperature [27]. Studies have found that the physical aspects of trees: density, height, form and types of species to be paramount factors that need to be understood and considered in designing urban landscapes [25]. Shahidan et al. [40] highlighted in their book that trees can improve and moderate the environment for climate control through three mechanisms. These are by direct shading, evapotranspiration, and direct wind control.

There are two shading properties of trees; branching/twigs and leaf cover. This creates a canopy density that gives direct shading effect to the pedestrian. They also contribute to the air and surface temperature reduction within the shaded area parameter. Tree canopy that acts as shading device will moderate the heat transfer from direct radiation (sunlight) to the ground, building roof or surfaces/wall (Fig. 6). Each species gives different magnitude of shading intensity depending on the density of the tree canopy. Evapotranspiration is the combination of evaporation and transpiration process in trees or other vegetation living system. It is the process of water converse to air vapour from leaf of plants and ground surfaces. This will remove heat energy from the air. Humidity of the surrounding will increase and thus reduce the surrounding air temperature. Some believe that a tree can act as a natural air conditioner especially in hot climate area. Pokorný [41] highlighted that a single tree can produce the cooling effect of 10 room-sized air conditioners operating 20 hours a day from its evapotranspiration process. Trees also function as wind control in landscape design.

Wind strongly affects human thermal comfort and it is an element of microclimate. Wind is one of the microclimate indicators that can be significantly modified by landscape components [42]. It is very important to consider the wind factor in urban design in order to create a comfortable outdoor environment. One should understand the character of wind because it is extremely difficult to manipulate and to control the outdoor environment. Many researchers believe that by choosing the right types of species and appropriate planting design, trees are able to control wind by obstruction, guidance, deflection and filtration [43]–[45].

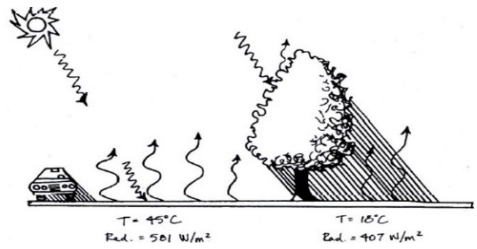


Figure 6: The effect of tree shading on ground surfaces. *(Source: Brown and Gillespie [42].)*

3.2 The types of LESP

The findings from observations have enabled the researcher to propose five categories of LESP as shown in Table 1 and their details shown in Tables 2–6.

In Type 1 pavement is the only landscape element in the walkway environment. It is predicted that pedestrians will feel very hot as there is no shade available. As observed in UKM, UM UPM and PPD, hot environment will lead to heat stress thus not promoting walkability.

Table 1: Categories of LESP.

Type of LESP	Description
Type 1	One landscape element, i.e. pavement
Type 2	Two man-made landscape elements, i.e. pavement and man-made shade
Type 3	Two landscape elements, i.e. pavement and trees
Type 4	A combination of man-made landscape elements and nature, i.e. pavement, trees, and man-made shade
Type 5	Pavement sandwiched between trees, i.e. pavement and two rows of trees

Table 2: LESP Type 1.

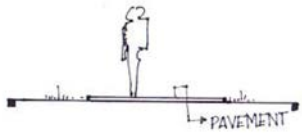
		Hypothesis: very hot

Table 3: LESP Type 2.

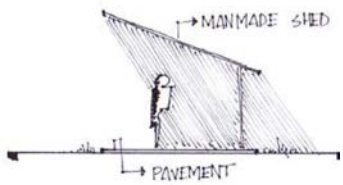
		Hypothesis: hot

Table 4: LESP Type 3.

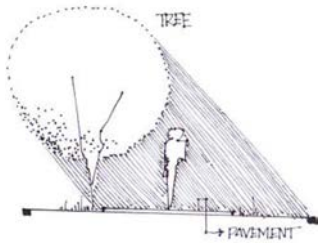
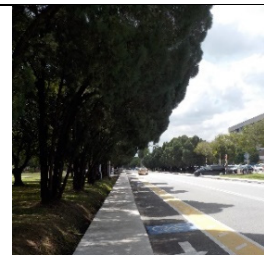
		Hypothesis: slightly warm

Table 5: LESP Type 4.

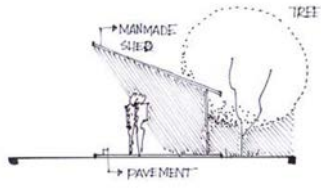
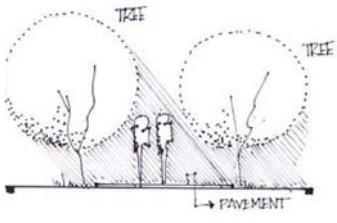
		Hypothesis: slightly cool

Table 6: LESP Type 5.

		Hypothesis: cool

In Type 2 there are two landscape elements in the walkway environment, which are pavement and man-made shading. It is predicted that pedestrians will feel hot even with the man-made shade. This is due to the material used which is metal deck that reflects most of radiation to the surrounding. Metal deck also absorbed heat from solar as it is a good heat conductor. Consequently, as observed in UKM, UM, UPM, metal decks are used as roofing material.

In Type 3 there are two landscape elements in the walkway environment which are pavement and tree shading. It is predicted that pedestrians will feel slightly hot as the trees might provide the comfort needed by the pedestrians. Referring to Fig. 3 illustrated in earlier paragraphs, comparison is made between these two types of shades: LESP Type 2 and 3 in the case-study institutions. Trees, through their evapotranspiration process provides cooling effect where air humidity increases and ambient air temperature decreases. Hence, the shading effects of the trees can reduce the pavement surface temperature from 45°C to 18°C as shown is Fig. 6.

In this Type 4 there are three landscape elements in the walkway environment which are pavement, man-made shading and tree shading. It is predicted that pedestrians will feel more comfortable compared to other LESP. Pedestrian is protected from solar radiation by two kind of shading: man-made shading and tree shading. Shading by trees protect man-made shading from the solar heat.

In Type 5 there are three landscape elements in the walkway environment which are pavement in between two rows of tree shades. It is predicted that pedestrians will feel most comfortable using this type LESP. As previously mentioned, many trees will cause lower ambient temperatures, increases air humidity and reduce pavement's surface temperature. Wind movements that enhance the comfort of pedestrians can also move well through trees' that have two meter clearance from the ground.

A study on thermal comfort in the International Islamic University of Malaysia (IIUM), Kuala Lumpur proved that different sites produced different microclimate (Bakar & Gadi, 2016). The study highlighted that the solar radiation plays an important role in influencing the thermal environment of an area/space. Their results clearly indicate that the thermal environment for the open area is hotter than the semi-shaded area and the semi shaded the area is hotter than the covered area.

The PPD campus sprawls on a 42.89 hectares of land with good landscape and possesses all types of LESP discussed earlier. Fig. 7 and Fig. 8 show examples of LESP in PPD. There were 5130 students enrolled in December 2017/2018. In PPD students are allowed to have motorcycles, cars or bicycles. The statistics from the institution shows that out of 5130 students, only 462 students applied for their vehicle stickers [46]. Hence more than 90% of the students do not own either a car or a motorcycle. Therefore, students have to walk to their destinations on campus.

Figure 7: LESP Type 2, Type 3 and Type 4 in Politeknik Port Dickson.

Figure 8: LESP Type 5 in PPD.

At any one stretch, it is estimated that the walking distance is between 50 meters to 400 metres. Shades are everywhere on this campus either in the form of shade trees or man-made shades. It is evident that the campus provides LESP that is conducive to its users and hence encouraging them to walk rather than depend on motorised transport and this promotes a healthy lifestyle.

Although the researches did not include cost or benefits in this study but results from other similar studies are encouraging. For instance, the study on the effect of street trees on microclimate and air pollution in Bangalore, India by Vailshery et al. [47] showed that air qualities of street with trees was improved by reducing 65% of SO_2 and 30% of Suspended Particulate Matter (SPM). Furthermore, it was also found that the microclimate of streets with trees had lower air temperature and humidity. Amani-Beni et al. [48] reported the impact of urban park's trees on microclimate in hot summer days in Beijing, China. Findings of the study indicated that, the temperature at the park was 0.40°C to 1.12°C cooler during the day, air humidity increased by 2.39 to 3.74% and also reduced human thermal comfort index by 1.41. Another study by Sun et al. [49] proved the impact of lots of trees had given significant influential factor on the moderation of thermal comfort. Trees through their transpiration and provide shading to prevent direct solar radiation and thus improve the thermal comfort. The mean of Physiological Equivalent Temperature (PET) is reduced by 2°C.

4 CONCLUSION

The scope of this study includes the landscape design attributes and characteristics of sustainable campus environment. In short, a sustainable campus environment must consist of shaded walkways either man made shading or shading by trees in order to promote walking or cycling among campus citizens. The findings could lead to further development of a design guideline based on pedestrian thermal comfort in a tropical environment setting. The review of the literature has demonstrated how comfortable thermal walking can be accomplished by designing a suitable landscape environmental setting. At the end of the discussion, the types of LESP were presented, along with the relevant sets of requirements and criteria. This understanding as demonstrated in the previous studies was necessary to be equally understood not only in landscape design pedestrian friendly environment, but also in the walkability/urban design context.

ACKNOWLEDGEMENTS

This work was made possible by funding from IPS Putra Research Fund for post graduate students in Universiti Putra Malaysia. The authors also wish to acknowledge and thank Timurabanun Abdul Hamid who helped to proofread this paper.

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