THE EFFECT OF LANDSCAPE DESIGN ELEMENTS AND MOSQUE DESIGN ON THE THERMAL ENVIRONMENT OF MAIN PRAYER HALL: A CASE STUDY OF TUANKU MIZAN ZAINAL ABIDIN MOSQUE, PUTRAJAYA

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ABSTRACT

Climate plays a vital role in thermal comfort environment. In hot and humid climate, the increment of air temperature is normally associated with the associating phenomena of the urban heat island and green house effect. Studies have pointed out that the external features of the surroundings have a direct impact on the internal thermal environment of buildings which requires a profound perception on environmental parameters such as air temperature, relative humidity, wind speed, and solar radiation. Implementation of bioclimatic design ought to be integrated as it may have an impact on the indoor thermal environment of buildings. Thus, this research paper aims to investigate the influence of landscape surface materials and mosque design towards the indoor thermal environment of the mosque in Putrajaya, Malaysia. Several research methods have been applied such as survey questionnaire, site inventory, observation, and measuring the environmental parameters such as air temperature, wind speed, relative humidity, and solar radiation. Some of the findings show that the concrete slab material of the outdoor landscape design absorbs more heat, which the highest reading is more than 50°C, and secondly the internal spaces reading of air temperature beside the pool areais lower which is at 27°C compared to the air temperature within the main prayer hall which is at 31°C.Hence, the paper will establish that landscape design elements such as the hard surface materials do have an impact towards the indoor thermal environment of the main prayer hall.

Keywords: *Hot-humid climate, indoor thermal environment, landscape design material, mosque design*

1.0 INTRODUCTION

Climate has a great influence to be considered in any design in creating a thermally comfortable environment where as any changes on it will also affect the comfort level in the indoor and outdoor area. In countries that fall under the categories of hot and humid zone, high air temperature and relative humidity throughout the year are the common conditions that characterize this climatic area (Chenvidyakarn, 2007). Generally, people living within this climatic condition are trying to lower down the ambient temperature in order to achieve lower comfort level thermally. However, looking at the current situation especially in the urban area where certain phenomena such as urban heat island (UHI) and green house effect (GHE) occur, people within this area are struggling more to achieve their comfort level thermally. This is due to the fact that the urban area is facing an increasing air temperature from its relative rate due to the rapid urbanization and the increasing numbers of the hard surface material which absorb and release the heat gain from the solar radiation.

This research study was conducted at the main prayer hall of Tuanku Mizan Zainal Abidin Mosque in Putrajaya as Figure 1 and Figure 2 shows the key plan and location plan of the mosque. Putrajaya has been identified as a new UHI area as reported by Krishnan (2007) by which its air temperature has increased to 5°C hotter compared to the other cities with most of the area are covered with the pavement materials. Thus, it is interesting to investigate the ability of the mosque to create a preferable internal thermal environment within the UHI condition at the hot-humid zone since the mosque is applying the passive design approach by taking advantage of the local microclimate at the surrounding environment such as daylight and wind movement to maximize energy saving while improving comfort level. The purpose of this study is to investigate the influence of landscape design elements, such as the surface materials, and the building design towards the indoor thermal environment in the

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main prayer hall of the mosque. Henceforth, the objectives of this study are to study about the external and internal design elements of the mosque such as the size of the openings, and outdoor landscape materials. This study also seeks to look into the layout material of the landscape design of the mosque in order to find out its effect on the local microclimate. More specifically, this study hopes to find the correlation between the effects of reflected heat from landscape surface materials on the indoor thermal environment in the main prayer hall.

Figure 1: Key plan of Tuanku Mizan Zainal Abidin Mosque

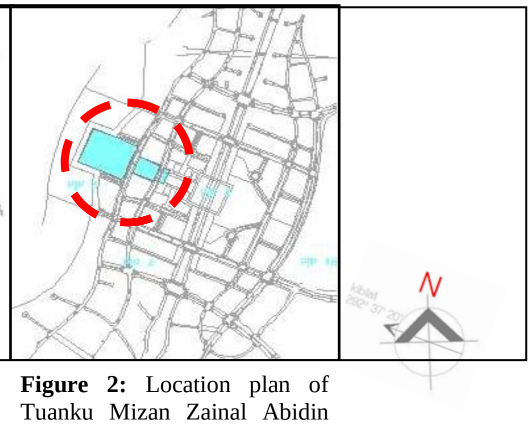


Figure 2: Location plan of Tuanku Mizan Zainal Abidin Mosque

2.0 CORRELATION OF ENVIRONMENTAL ISSUES WITH URBANIZATION

Urban heat island and green house effect are among the environmental issues resulted from rapid urbanization in a city. Urban heat island can be understood as the increment of urban temperature compared to the countryside temperature (Shahidan, 2011). The Inter-Ministry Coordination Committee to Mitigate Urban Heat Island (2004) identified two factors causing the occurrence of this phenomenon which are the anthropogenic heat emission from human activities and the increasing of hard surface covering with more building along with the construction of roadways. Sheweka and Magdy (2011) added this situation is worsen when there is “change of the land profile where more impervious surfaces such as asphalt, concrete and glass are found rather than grass or green area”. On the other hands, the greenhouse effect refers to a phenomenon where the emission of greenhouse gasses in the air such as water vapor causes the temperature to become warmer (Kevin et al., 2000).

Climate of Malaysia

Malaysia is located at the equatorial line which making it as one of the tropical countries falling under the zone of hot – humid. The Malaysia Meteorology Department (2009) stated that this country experiences an annual average temperature ranging from 27°C - 32°C, with an average relative humidity recorded are 80% throughout the year. Chenvidyakarn (2007) mentioned that with this yearly rate of high temperature and high humidity, it is quite difficult to design a building with a passive means. Chenvidyakarn (2007) added that this situation happens because climatic condition requires the occurrence of both active cooling and dehumidification in a building to make them inhabitable for most of the time.

Thermal Comfort and Influencing Factor

ASHRAE Standard 55(2004) defines thermal comfort as “...that condition of mind which expresses satisfaction with the thermal environment. Because there are large variations, both physiologically and psychologically, from person to person, it is difficult to satisfy everyone in a space.” Influenced by the local microclimate, and environmental and personal aspects, it can be understood that different people may have their own preference of comfort level even though they are located at the same place. Koch-Nielsen (2002) mentioned that in order for human to keep maintaining his internal body temperature at the range of 36.5°C-37°C, the heat exchange process with the environment is necessary through the process of convection, conduction, long-wave radiation, and evaporation. A thermally comfortable environment for the indoor and outdoor of a building is created based on sixbasic factors influencing the comfort of an occupant's space which can be separated into environmental and personal factors. The first factor consists of air temperature, relative humidity, wind, and radiation, while the personal factor is influenced by the rate of human activity and clothing insulation (ASHRAE Standard 55, 2004).

Commonly, the basic understanding on air temperature is that the rateis the lowest just before sunrise and is the highest when the effects of direct solar radiation and high air temperature are combined during two hours after noon (Koch-Nielsen, 2002).Koch-Nielsen (2002) added that the percentage of cloud coverage also influences the heat exchange at surface between day and nightwhen the air which is the nearest to the ground obtains the highest temperature as surfaces are heated by solar radiation.For a naturally ventilated building located at the hot-humid area, generally, an air temperature that ranges from 24°C to 29°C with the preferable of 26.5°C and 80% relative humidity is the best rate that suits Malaysia climatic condition (Ismail and Abdul Rahman, 2010).Olgyay (1963) mentioned that pleasing air movements can be effective to cool the body. He asserts that the air movement"...does not decrease temperature but causes a cooling sensation due to heat loss by convection. However, this rise slows as higher temperatures are reached".Furthermore, the amount of solar radiation experienced in an area may varydepending on its geographical location and its local weather conditions. Basically, solar radiation will be affected according to a series of occasions "...the length of the day, the angle of the sun's ray to the ground, the distance from the sun, the cloud coverage and the quality of the atmosphere through which the radiation passes"(Koch-Nielsen, 2002).Under the factor of clothing insulation,the types of clothing chosen are important since it gives effect to the level of heat gain and heat loss between the people and their environment even though the architect cannot control the preference of clothes worn. Clothing is useful for human in giving thermal protection from the change of environmental condition, limiting heat transformation from human body to the surrounding environment, encouraging the process of sweating and perspiration, and maintaining thermal balance between the body and the environment when heat losses to the atmosphere. The last factor that may influence the human comfort is the human metabolic rate where as the different level of activity conducted can give different energy produced. In short, if the level of activity is higher, the heat will gain as well. The amount of heat emitted to the surroundings and absorbed by the body can be controlled by controlling the level of activity that suits to avoid thermal imbalancein order to achieve comfort .

Pavement Material In Influencing Thermal Environment

Parking lot is an example of open, paved urban areas which absorb up to 85 % of the solar radiation and others are directly used to heat the air. However, the area which has absorbed heat also will later on heat the air temperature. Thus, there is certain numbers of hardscape which is pavement materials that absorb more heat which will cause the increasing of thermal discomfort towards human being.Environmental Literacy and Inquiry (2010) mentioned that the lighter-colored materials and porous materials are two types of cool paving materials that are very essential in acting as solar heat absorbance while transmitting the heat productivity to the surroundings. The lighter-colored paving can be characterized as a material thathas high solar reflectance and light color surface which are white, light gray, beige, and terra cotta. On the other hands, the porous pavement materials "allow water to filter into the ground and keeping the pavement cool when moist. Permeable pavements can be constructed from a number of materials including concrete and asphalt, filled with soil, gravel, and grass" (Environmental Literacy and Inquiry, 2010).

Mosque Design In Influencing Indoor Thermal Comfort

For a naturally ventilated building, there are few design strategies that can be applied which "*involve appropriate orientation and spatial organisation, shading, and appropriate use of materials, colours, textures, and vegetation"* (Chenvidyakarn, 2007). Wongfun et al (2006) mentioned that minimizing solar gain and maximizing ventilation can be achieved "…by orientating the longer sides of the building to intercept prevailing winds and the shorter sides to face the direction of the strongest solar radiation". Other than that, solar gain occurs through the windows and on the opaque parts of the building envelope which act as the major components that increasing the internal air temperature by raising the surface temperature at the indoor area. So, creating effective shading is highly important by "…intercepting the solar radiation from directly passing through the building envelope with the use of external shading devices such as an appropriately orientated high-pitched roof which affords self shading and allows only one side of itself to receive direct solar radiation at a time is another possible shading technique" (Sumanon, 2008). Other than that, "…the use of high reflectance interior surfaces with light colours, or light shelves is also beneficial in reflecting the daylight to go deeper in the interior area while reducing daylight penetration" (Chukiatman, 1998). Also, the use of louvers as one of the movable shading devices and vegetation such as trees, climbers, high shrubs and pergolas is also recommended in providing effective shading for the building's windows and walls. Vegetation is essential because of its ability to moderate the surrounding temperature and reduce the use of cooling devices in a building.

Ground area covered by the vegetation is beneficial in reducing heat gain from solar radiation and long-wave radiation reflectance. Besides, the evapo transpiration process helps cooling the surrounding temperature and surfaces. "The climbers over the walls can reduce the wind speed next to the wall surfaces and provide thermal insulation when the exterior air temperature is greater than that of the walls. Also, the average temperature of buildings walls which are shaded by plants can be 5-15°C less than that of unshaded ones, depending on the local climates and planting details (Parker, 1989). Other than that, the colour and texture are important for the building envelopes and their surrounding surfaces.Light colour and smooth surface able to reduce the temperature of the surfaces while the darker and denser building materials increase the thermal productivity. "Dark colored materials such as asphalt used for building roads and for roofing tiles absorb more heat from the sun than materials with lighter colors such as white roofing shingles or cement. Lighter colors reflect the rays of the sun back into the atmosphere, and less heat is built up" (Environmental Literacy and Inquiry, 2010).

3.0 METHODOLOGY

In studying the effect of the landscape design material and mosque design in influencing the thermal comfort at the internal area, the main prayer hall of Tuanku Mizan Zainal Abidin Mosque was selected. Applying the concept of passive design, the mosque was designed by the architect Nik Arshad Nik Mohammed based on the three design principles which are simplicity, airiness, and transparency. The design philosophies of simplicity and transparency are expressed through the design of the meandering structures with rectangular openings and the use of hook bolts on its structures. The airiness principle is achieved through the design of openings that stretch across the entire height of the wall, and the use of glass windows and mesh skin as a protection against the rain and sun while at the same time allowing the breezes to flow through (Archello, 2010). Figure 3- 5 illustrate several images at Tuanku Mizan Zainal Abidin Mosque.

Figure 3: Tuanku Mizan Zainal Abidin Mosque Applies an approach of passive building design.

Figure 4: Large openings at the Northeast and Southwest of the mosque allow breeze flows through.

Figure 5: The landscape elements surrounding the mosque are mostly covered by the pavement materials.

During the fieldwork, several techniques have been employed. The landscape design elements surrounding the mosque have been studied, focusing on the types and width of the pavement materials. In addition, the design of the mosque building in terms of building orientation, size of the openings and doors, building and floor finishing materials, and shading were also studied. The sky condition was observed and, environmental parameters such as solar radiation, wind speed, light intensity, and surface temperature were recorded. The process of data collection is demonstrated in the Figure 6 below which it is divided into four stages.

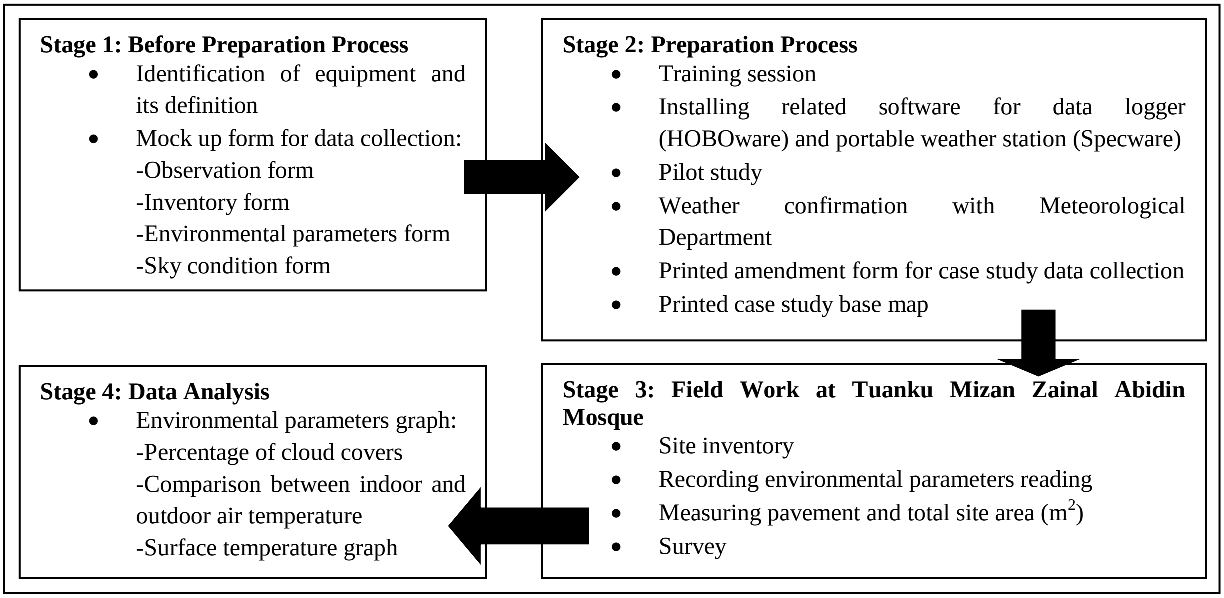


Figure 6: Stages of data collection process

Preparation Process

A pilot study was conducted in order to apply the basic training of using the equipment. Sultan Haji Ahmad Shah Mosque of IIUM was selected for conducting the pilot study since it has almost the same characteristic as the actual field work. The pilot study was done from 2pm to 5pm which serves as a basic preparation for the researchers before conducting the actual field work at Tuanku Mizan Zainal Abidin Mosque in Putrajaya. Among the objectives of the pilot study are to get the idea on collecting data before going to the case study area, to test the smoothness of using the data collection form, and to determine the appropriate time interval for each collection of data reading. As a result, a new form of data collection has been designed and improved, and the time interval for manually data collection has been changed to 30 minutes interval due to the research limitation.

Field Work at Tuanku Mizan Zainal Abidin Mosque

Initially, the researchers planned to collect the data on the 2^{nd}, 3rd, 4th, and 5^{th} March 2012 and 9^{th}, 10th, 11th, and 12^{th} March 2012. The data collection is expected to be collected from 09:00a.m. until 17:00p.m. However, due to crosscheck of weather forecast with the Meteorological Department, and the availability of the researchers to visit and conduct the study at the study area during Friday, Saturday, Sunday, Monday, and mid-term break only, the dates of collecting data have been changed. Table 1 shows the new dates that have been chosen for data collection. The time for data collection to be stated in the graphs has been centralized starting at 10:00a.m. and ends at 14:00p.m. due to weather condition where there were rainy time during the evening, and foreseen limitations. In Malaysia, March is known as one of the hottest months. However, during the field work, the presence of precipitation at most of the days did affect the readings taken since it cannot be completed until 17:00p.m. as planned before. Besides that, several equipments had been used during the fieldwork was conducted. The following Table 2 shows the types of equipment used by the researchers at different locations and time intervals. The differences happened because of the different scope of study, and the limitations of collecting data at the intended time interval which is every 15 minutes due to the far distance in between one location to another location.

Day		Date	Start	End
1	Friday	2.3.12	1000	1400
2	Friday	9.3.12	1000	1400
3	Saturday	10.3.12	1000	1400
4	Sunday	11.3.12	1000	1400
5	Monday	26.3.12	1000	1400
6	Wednesday	11.4.12	1000	1400

Table 1: Schedule of data collection for 6 days

No.	Reading Taken	SI unit	Equipment	Quantity	Images	Time Interval/ min		Location of Reading Taken	
						Indoor	Outdoor	Indoor	Outdoor
1	Air temperature Relative humidity	**(°C)** **(%)**	HOBO Data Logger	3		5	5	-Northeast -Southwest	-Northeast
2.	Air temperature Relative humidity Solar radiation Wind speed Wind direction	**(°C)** (%) (w/m^2) (m/s) (°)	Portable Weather Station	1		5	5	-None	-At the courtyard of Putra Mosque
3.	Light	(lx)	Heavy Duty Lux Meter	1		15	30	-None	-Southeast -Southwest -Northwest -East
4.	Surface temperature	(°C)	Infrared Thermometer	11		15	30	-Northeast -Northwest -Southwest	-Southeast -Southwest -Northwest -East
5.	Wind speed	(m/s)	Wind Speed Anemometer	1		15	30	-Southwest -East -Northwest -Southeast	-Southeast -Southwest -Northwest -East

Table 2: Types of equipment used at different locations and time intervals

As shown in Figure 7, the yellow and blue circle in the map is the location of data logger from day 1 to day 6. The HOBO 1 is located at the Sahn A which is located beside the mosque's courtyard, while HOBO 2 is located at the main prayer hall and HOBO 3 is located at the building's column close to the pool area.

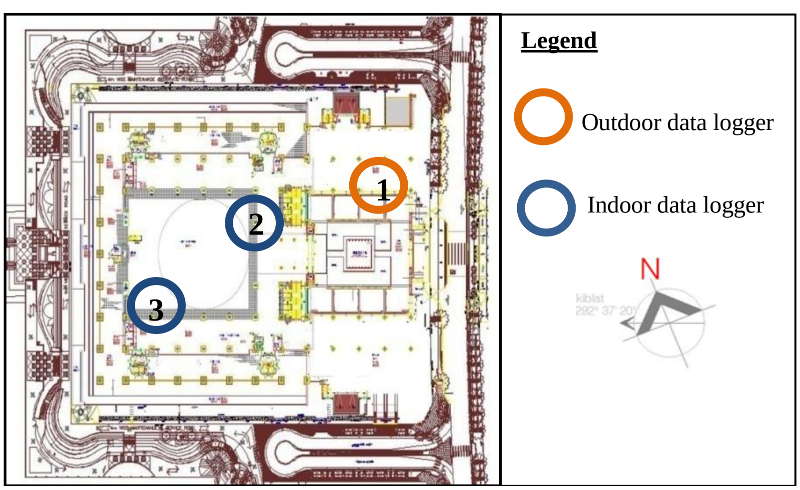


Figure 7: Location of data logger at the indoor and outdoor area at Tuanku Mizan Zainal Abidin Mosque

4.0 RESULT AND ANALYSIS

Sky Condition

Table 3 below shows the summarization of weather condition during field work and the time period of collecting the data.The analysis on the reading taken were categorized in two different times which are from 10:00 a.m. until 11:00a.m., and from 11:00 a.m. until 14:00 p.m. This is due to the weather condition at this time was slightly difference, which can affect the reading taken.

Day	Weather Condition	
	10:00-11:00am	11:00-14:00pm
1	Sunny	Partially Sunny/ Cloudy
2	Partially Sunny/ Sunny	Partially Sunny/ Cloudy
3	Partially Cloudy	Cloudy
4	Partially Sunny/ Sunny	Partially Sunny
5	Sunny	Partially Sunny
6	Cloudy/Partially Sunny	Sunny

Table 3: Summarized Weather Condition

Cloud Covers

Day 4 is classified as the hottest heat productivity, this happened as it received more light radiation from the sun as the highest reading reach to 120000 lux, the sky was quite clear throughout the day as shown in the Figure 8 below. This occurred during 11:30a.m.when the percentage of the cloud covers during that particular time is 10% only. On the other hands, Figure 9 shows the data of light intensity for five days only since there is not enough equipment available to collect the data during day 6. The highest average data is during 14:00pm which is at the average of more than 80% while the reading of light radiation during that particular time is at 20000lux.

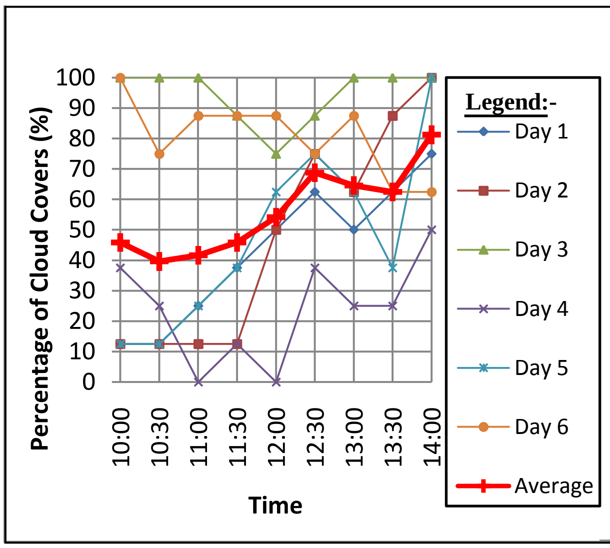


Figure 8: Graph of cloud covers for 6 days

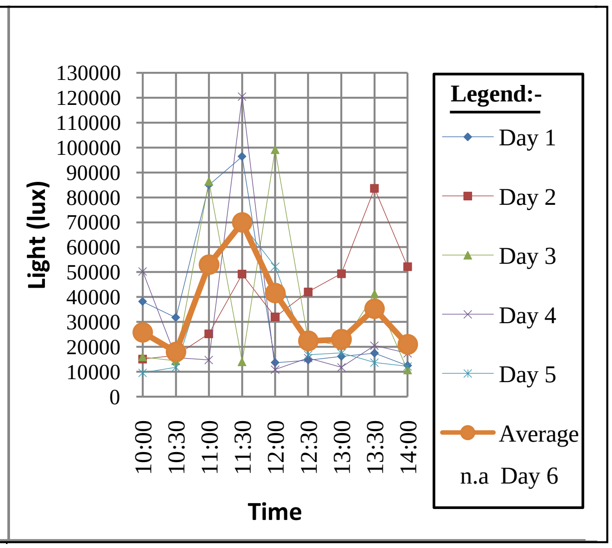


Figure 9: Graph of light intensity for 6 days

Air Temperature

Figure 10 shows the highest air temperature recorded from the data logger which is located at the outdoor area is during Day 1 on 1200 with the degree of 40°C and above. On the other hands, the lowest air temperature recorded is during Day 2 on 1000 with the rate of 27°C and above. However, the reading for Day 1 is haywire as the data logger should not be placed at the exposed area where the casing of the data logger is easily affected by heat which caused the air temperature rises as mentioned earlier. Thus, the reading for Day 1 is not reliable as shown in Figure 10. So, the highest air temperature for outdoor should be 39°C which happened to be on Day 4. On the other hands, Figure 11 illustrates the average of the outdoor air temperature for five days only since the reading for Day 1 is not reliable as mentioned earlier. As shows in the Figure 11, the reading gradually increases as the day passes to noon. The highest average reading for outdoor air temperature is 35°C and the lowest is 29°C.

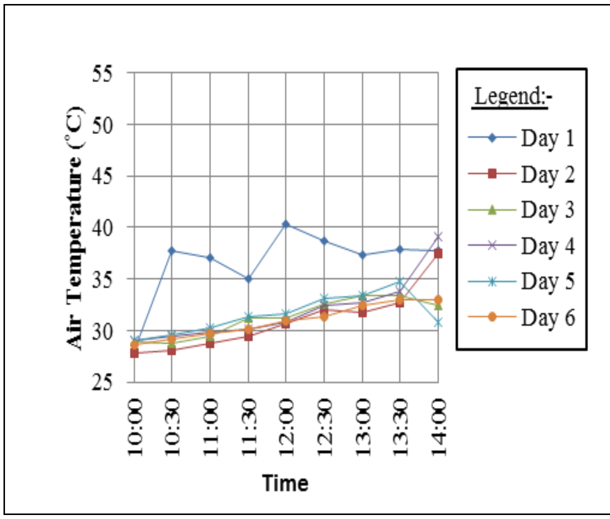


Figure 10: Graph of outdoor air temperature for 6 days

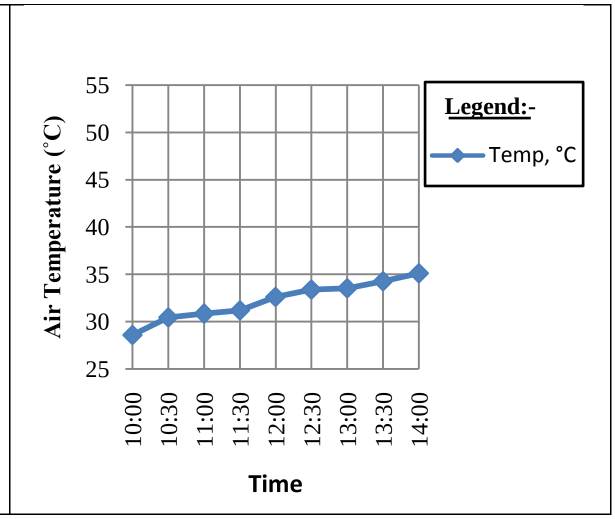


Figure 11: Graph of average outdoor air temperature for 5 days

Figure 12 shows the graph of indoor air temperature whereby the alphabet a and b mean the location of the data logger placed inside the mosque. The data logger a is located at the location 2 which is at the Southwest of the main prayer hall, while the data logger b is located at the location 3 that is at the Northeast area as shown in Figure 7. As seen in the Figure 12, the reading for day 5 b is slightly lower from day 1, day 2, day 3 and day 6 as the reading from 10:00 to 12:00p.m. is within 26°C to 27°C. The reading of the mentioned day is lower compared to the other day may due to the presence of cloudy cloud which is slowly increasing from 10% to 60% while in the Figure 13 shows that the average air temperature for location a is slightly different by 1°C from location b during 11:00 to 12:00 noon.

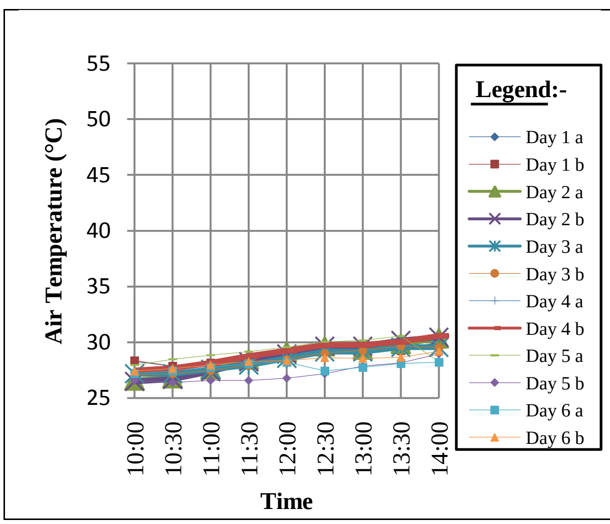


Figure 12: Graph of indoor air temperature for six days based on 2 different locations

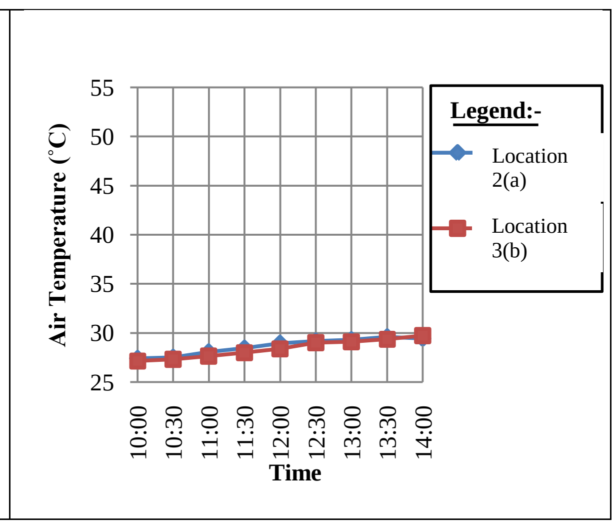


Figure 13: Graph of average indoor air temperature for six days based on 2 different locations

Surface Temperature

In accordance to Figure 14, it shows the comparison data on surface temperature for four types of indoor pavement material which are located close to the pool area. Marble B2 records the lowest temperature with the rate of 27.2°C. Thus, it proves that water elements do help to lower down the temperature of the surface material that located near to it.

On the other hands, Figure 15 shows the average indoor surface temperature for four different pavement materials located at the main prayer hall area. Granite A in Figure 16 shows the average surface temperature for outdoor area which focusing on the concrete slab, pebbles and granite materials. Located at the same orientations which are at the Northeast area, the graph consist only four days data which as the selected four days data are more consistent. The data for Day 6 is not available because of lack of equipment on that particular day which Day 1. On the other hands, the data from Day 6 is not available as the set data collection obtained is not consistent. The highest reading is concrete slab B2 which is at the average of 51°C and the lowest reading of the surface materials are granite A1 which is at the average of 27°C. While the pebbles material average reading is in between the average reading for material concrete slab and granite.

Table 4 below shows the types of materials exist in the internal building of the mosque of Tuanku Mizan Zainal Abidin. This table can be as a reference for the indoor surface materials graph whereby certain reading may be affected due to the color of the materials and the criteria of the texture materials.

Types of Material	Images	Colour	Texture	Area (m^2)	Percentages of Materials (%)
Marble A1		White	Fine	1163.27	18.4
Marble A2		Beige	Fine	776.41	12.3
Granite A		Dark Grey	Slightly Fine	724.60	11.4
Granite B		Light Grey	Slightly Fine	46.76	0.7
Mosaic A		Red, black, and green	Slightly fine	3625.94	57.2
				Total:	100

Table 4: Inventory on indoor surface materials

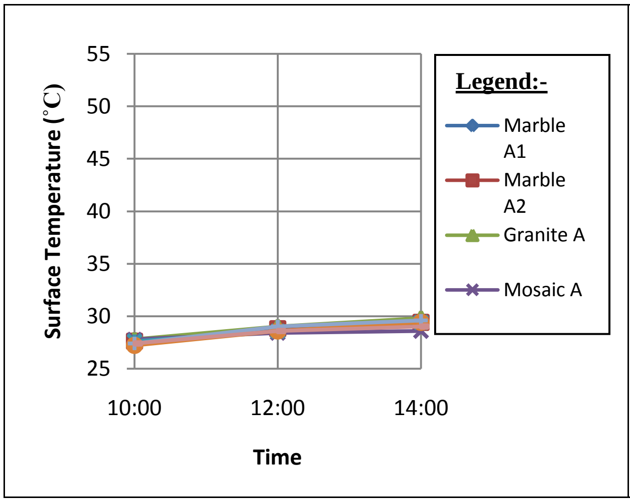


Figure 14: Graph of the average indoor surface temperature for 6 days which is located at the pool area.

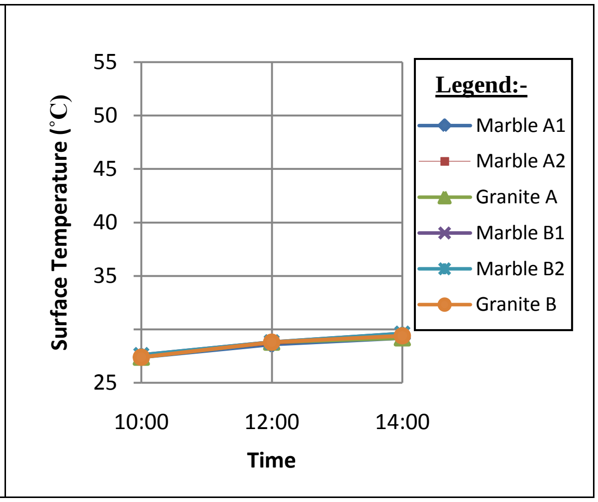


Figure 15: Graph of the average indoor surface temperature for 6 days which is located at the main prayer hall.

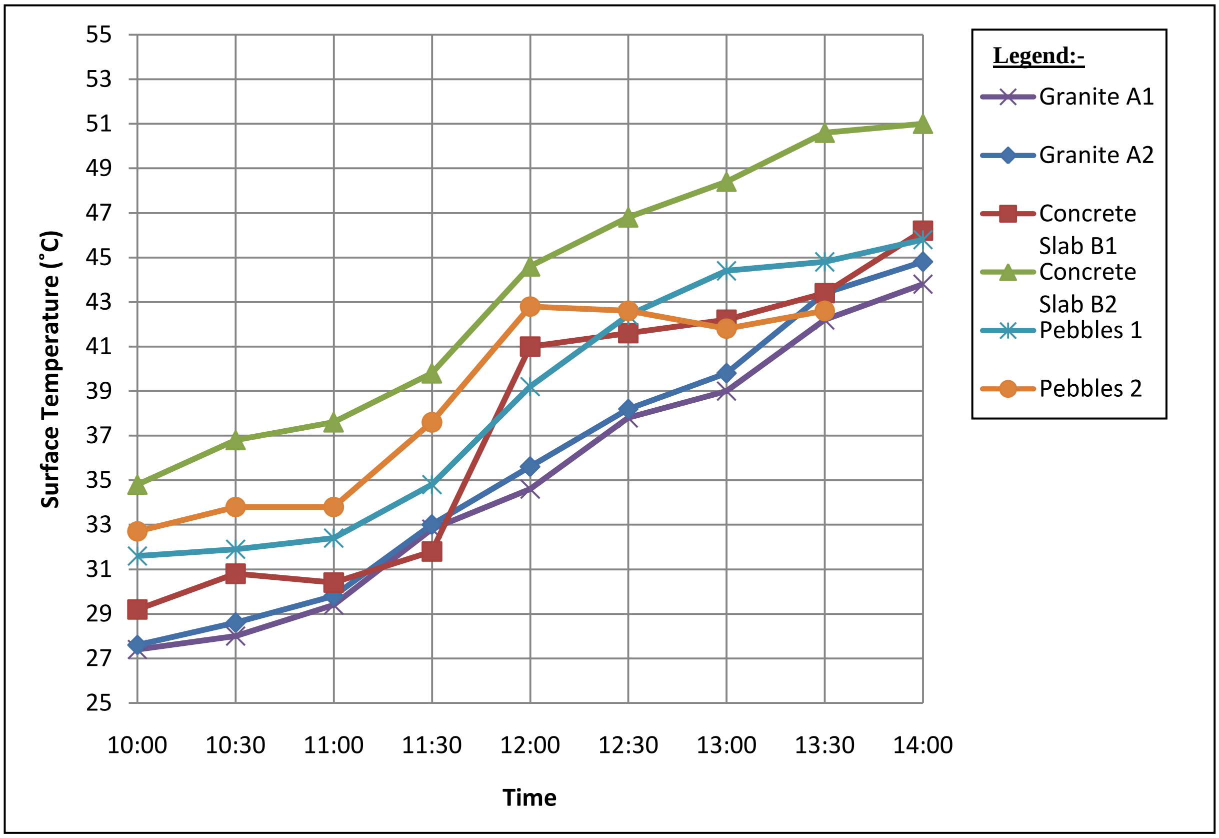


Figure 16: Graph of average surface materials at outdoor area for 4 days.

Survey Data Collection

Apart from doing manual data collection, a survey had been conducted in the main prayer hall in order to know the users comfort levels. 100 surveys have been given out and a total of 100% of survey have been achieved. The data obtained have been inserted the SPSS software for analysis. The age of the respondents has been classified into three groups which are the group of young people from 10 to 24 years old, adult from 25 to 59 and elderly from 60 years old and above. These ranges of age group are selected because different age level has different preference and reaction to the level of comfort and current temperature of the surrounding environment.

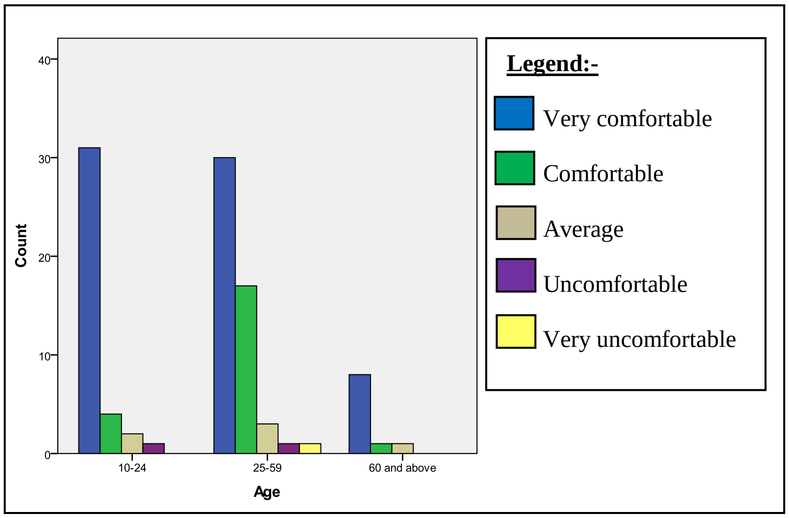


Figure 17: Survey of comfort level at the main prayer hall of Tuanku Mizan Zainal Abidin Mosque

Figure 17 above shows the result of survey conducted at the main prayer hall on Day 2, Day 3, and Day 4 during Zuhr and Asr' prayer time. Most of the respondent are from the adult categories (51%), followed by the young people (39%), and elderly (10%). In accordance to the graph, 69% of the respondents voted the comfort level at the main prayer hall as very comfortable, followed by comfortable (22%), average (6%), uncomfortable (2%), and very uncomfortable (1%). Thus, it can be analyzed that basically the comfort level at the main prayer hall are quite satisfying.

5.0 CONCLUSION

In conclusion, the environmental parameter readings gradually increase at noon as such can be seen in the analysis before where the reading increased mostly between 11:00 to 14:00. Based on the inventory and analysis that have been done previously, it is proven that light radiation is affected by the cloud covers as the more percentage of cloud covers occur, the less light radiation will penetrate to the ground or surface materials. This factor can affect the reading of the surface materials. To be highlighted in the recommendation later on is the readings shown in the Figures 16 as the surface materials absorb more heat with the factors of color and texture. The darker the color of the materials, the more heat will be absorbed by the materials. As mentioned earlier, the dark grey concrete slab absorbs more heat which the highest average is at 51°C and with a slightly fine texture.

6.0 FINDINGS AND RECOMMENDATIONS

Table 5 and Table 6 below show the findings and recommendations for Tuanku Mizan Zainal Abidin Mosque. Based on the site inventory, observation and data gathered and analysis, we found that there are a few alterations need to be done on the research study area. The recommendations are highlighted in the layout plan.

Findings	Recommendations
Surface materials	
• The reading of the surface temperature may be affected by several reasons such as texture and colour. Both have the highest influence in the surface temperature as they easily absorbed direct heat from the light. • The darker the material, the higher the surface temperature reading. In this matter, the dark grey concrete slab has the highest surface temperature which reached about 52°C during noon.	• The pavement materials mostly outdoor environment should use light color as it helps in reducing the surface temperature. • As for types of pavement materials change the concrete slab material into lower surface temperature materials such as granite and grass as highlighted in patch green design for Northwest area. This should applied to Southwest area of the mosque too as it have the same elements of design as the Northwest area. This recommendation is applied in Figure 18.

Table 5: Findings and recommendation for surface materials

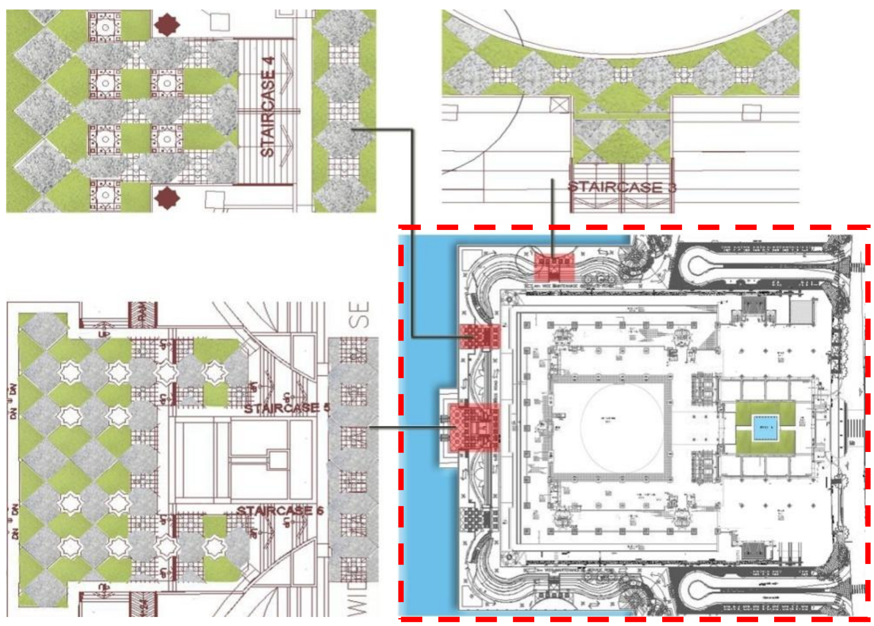
Current design	Proposed design
 Current pavement material at the site area: the surface material-concrete slab that been replaced in the proposed design grass and granite materials.  Recommended materials for selected area: granite and grass  	

Figure 18: Current and proposed design

Findings	**Recommendations**
Landscape design	
• The landscape design surrounding mosque has plenty of softscape elements. In fact the softscape designs at northwest and southwest have the same characteristics of landscape elements. • However, due to the chosen of hardscape materials in the landscape design are high in surface temperature which is the dark grey concrete slab. The existing softscape design in that particular area does not really help in reducing the temperature. • This is slightly different at the area of outdoor qiblah point whereby the temperature there is lower compared the other two parts which are mentioned earlier. In addition there is a water facades design which helps in soothing the thermal comfort for the users in the area.	• Insert more crown trees and taller trees as it produces larger shades • Add greener element such as grass and water elements at northwest and southwest area as green and water helps in reducing the air temperature of the area. • As proposed in Figure 19, the concrete slab at the highlighted area are designed with water fountain and pebbles wash as drainage, and with adds of grass and granite material for pavement design.
Mosque design	
From the field measurement done, it shows that the air temperature close to the pond is lower compared to air temperature at the main prayer hall. It can be analyzed that the air temperature can be at a lower temperature within the main prayer hall by using air and water as medium transfer in cooling the internal spaces as referred in articles by Sandifer.	• In order to increase the level of cooling environment at the main prayer hall area, the application of fountain sprays at the pond is recommended in order to increase the air speed at the water surface. This too should be applied at the Northwest and Northeast area.

Table 6: Findings and recommendations for landscape design and mosque design

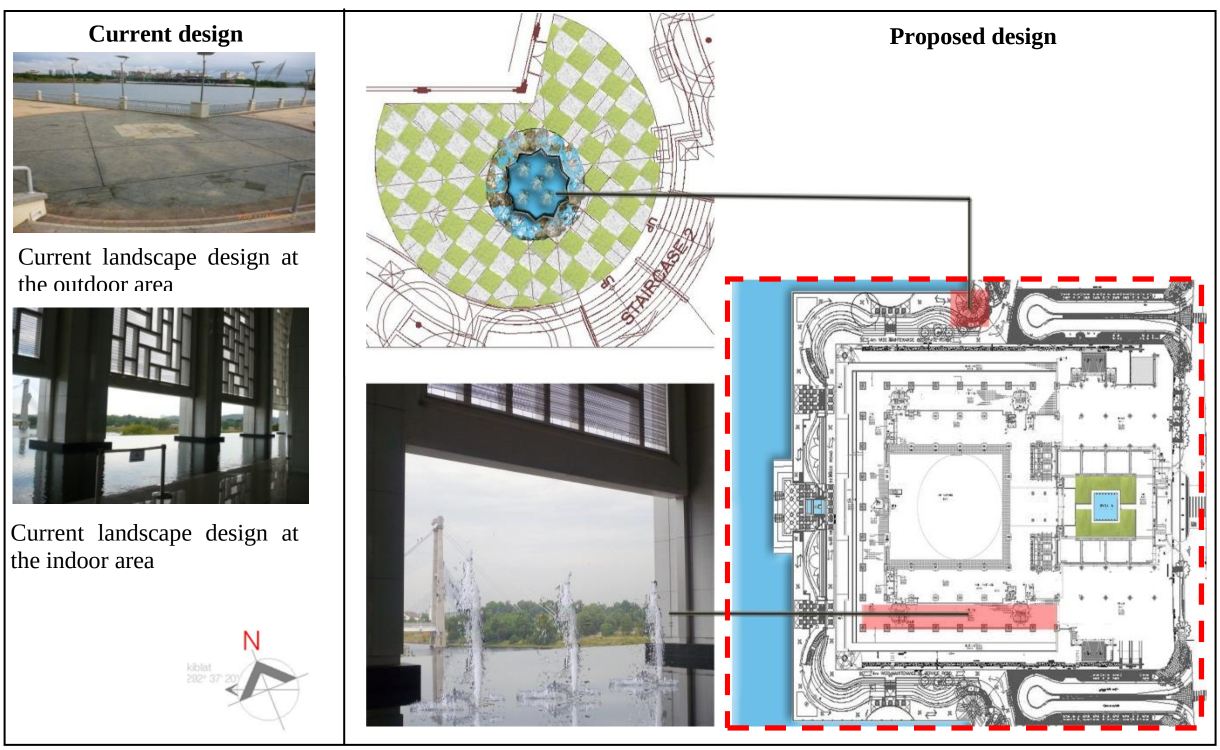


Figure 19: Current and proposed design

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