



## **An Assessment of the Spatial Comfort at the Open Piazza of Baiturrahman Mosque, Banda Aceh, Indonesia**

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**Abstract** –The Baiturrahman Grand Mosque is well-known as the identity of Banda Aceh town, Indonesia. The extensive renovation was carried out in 2015 to the Mosque, presenting an open piazza coated with glossy white marble replacing the previous greeneries and grass. This change creates a much different thermal sensation of the prior environment. This condition also invites the contrast to respond and define spatial comfort, including thermal and visual comfort. Therefore, this study conducts an assessment of thermal and visual comfort at the open piazza, which was done through field measurements. The outdoor thermal comfort was calculated using the equations proposed by Sangkertadi that are appropriate for the tropics. The visual comfort was examined using the De Boer glare scale. The result shows the discomfort appearance for both thermal and visual comfort. The study gives recommendations, such as planting greeneries, providing more shades for achieving lower outdoor air temperature. Replacing the glossy marble with the diffusing and rough surface will reduce the glare for getting the more acceptable visual comfort against the marbles.

**Keywords:** Mosque; Open Piazza; Thermal Comfort; Glare

### **Introduction**

The Baiturrahman, the Grand Mosque in Banda Aceh, is well-known for the history, performance, and function, such as a Muslim worshipping place, a sacred place, and a tourism destination for locals and internationals. The Mosque is a symbol of religion, culture, spirit, strength, struggle, and nationalism of the Acehnese people. Sultan Iskandar Muda built this Mosque during his reign (1607-1636). In Sultan Nurul Alam's reign (1675-1678), the Mosque was burned and replaced with the new one (Melayuonline, 2016). Later, in 1873 the Dutch colonialism burned the Mosque. To get the sympathy of the Acehnese people, in 1879, the Dutch rebuilt the Grand Mosque with the heavy-weight construction installed with a dome roof, replacing the initial design, namely lightweight construction with the four-tiered roof made from the leaf (Setyadi, 2018). In 2015, the Acehnese government conducted a massive reconstruction of the Mosque outdoors, funded by the government for 458 billion by building the open piazza installed with 12 giant electrical umbrellas (Bappeda, 2017).



**Figure 1.** The new facade of Baiturrahman Grand Mosque

Based on the specifications of the Giant electrical Umbrellas installed in the Baiturrahman Mosque (see Table 1), the total area that the umbrellas could shade is 4.806 m<sup>2</sup>. It reaches almost 80% of the floor. However, the umbrellas are not frequently open due to various reasons, such as maintenance or windy weather. Another renovation includes the extension of the yard, ablution space, and underground car park.

**Table 1.** The specifications of electrical umbrellas installed at the open piazza of Baiturrahman grand mosque

Type	Height (m)	The surface area of the umbrella (m <sup>2</sup> )	Weight (kg)	Numbers
A	20	24 x 24	400	6
B	14	15 x 15	250	6

*Source: Serambi Indonesia (2017).*

The twelve umbrellas were designed like the ones installed in the Nabawi mosque in Medina, built to shelter the 24.400 worshippers who are not able to be accommodated inside the Mosque. However, the positions do not cover all the open piazza accommodating the worshippers (Figure 2). Additionally, the twelve umbrellas are not frequently available, creating the absence of shadow. It caused the large space to separate the worshippers conducting the prayers, which are in Islam. The separations between the worshippers must be avoided (Figure 2).



**Figure 2.** The positions of the umbrellas once all are open, and the large separations due to the limited shadings among the worshippers while conducting the prayer if the umbrellas are close

Despite the above condition, the open piazzas coated with glossy white marble replacing the green surface also invites the contrast response of the visitors in sensing the spatial comfort such as thermal and visual comfort (Mardhatillah, 2017). Mostly, the visitors of the Mosque stand or sit under the umbrella or on the shaded surrounding area. Based on some interviews and personal experience, walking across the unshaded marble from the underground car park into the Mosque is thermally disturbing due to the hot thermal sensation and the glare of the marble surface. This condition may quickly occur since Banda Aceh has high solar radiation, which is up to  $1042 \text{ W/m}^2$  (Thaib et al., 2018). There has not been any research conducted concerning this matter because the marble construction and the electrical giant umbrellas installation on the open piazza are relatively new. Therefore, this study aims at assessing the spatial comfort of the Baiturrahman Grand Mosque, i.e., the outdoor thermal comfort and the glaring surface.

## Materials and Methods

### Outdoor Thermal Comfort

Some studies concerning the investigation of human thermal comfort in outdoor space indicate that the discomfort at the outdoor area is generally sensed smaller compared to the situation when people are in the closed room for the same climatic condition (Nikolopoulou, 2011; Ahmed, 2003). There is a tendency for people, will be more tolerant in response to climatic conditions outside than in a closed space (Sangkertadi and Syafriny, 2014). Some researchers proposed a temperature index to measure the level of comfort for people outdoors such as Out\_SET (Outdoor Standard Effective Temperature), and TEP (Temperature Effective Psychologically); (Monteiro and Alucci, 2009) and PET (Physiologically Effective Temperature), a physiological index that was derived from the human energy balance for the assessment of the thermal complex. (Mayer, and Höpfe, 1987). There are also the regression equations developed by Sangkertadi and Syafriny, which determines the outdoor comfort level perception referred to PMV scale for the tropics (Table 1).

**Table 2.** Comfort level perception refereed to PMV scale

Value of 'Y'	Comfort level perception (refereed to PMV scale)
-2	Cold
-1	Cool
0	Comfort (neutral)
1	Warm/ Slightly hot
2	Hot
3	Very hot
4	Very- very hot and feel pain
5	Very not tolerable

*Source: Sangkertadi and Syariny (2014)*

The regression of Sangkertadi include normal walking (YJS), brisk walking (YJC) and seated people with moderate activity (YDS)

$$YJS = -3.4 - 0.36v + 0.04Ta + 0.08Tg - 0.01RH + 0.96Adu \text{ (Multiple R = 0.70)} \dots\dots\dots(1)$$

$$YJC = 2.53 - 0.29v + 0.11Ta + 0.05Tg - 0.0009RH + 0.35Adu \text{ (Multiple R = 0.5)} \dots\dots\dots(2)$$

$$YDS = -7.91 - 0.52v + 0.05Ta + 0.17Tg - 0.0007RH + 1.43Adu \text{ (Multiple R = 0.75)} \dots\dots\dots(3)$$

where :

v : Air velocity (m/s)

Ta: Air temperature (°C)

Tg: Globe Temperature (°C)

RH: Relative Humidity (%)

Adu: Area of body skin (surface of du Bois, m<sup>2</sup>)

This study applies Sangkertadi's equations due to the appropriateness of the tropics.

**Discomfort Glare**

Discomfort glare is caused by a high or non-uniform luminance distribution within the visual field or by high contrasts of Luminance between the glare source such as window or sky and its surroundings (Kim, and Kim, 2010). There are some approaches for calculating discomfort glare, such as (DGI) Discomfort Glare Index (Chauvel *et al.*, 1982) and (DGIN ) New Discomfort Glare (Nazzal, 2005). DGI mostly refers only to uniform light sources that exclude direct sunlight and does not consider that non-uniform sources can cause more glare when positioned perpendicularly to the line of view and less glare when located between 10° and 20° from the hemisphere. Meanwhile, DGIN could evaluate discomfort glare for direct sunlight. However, these two indexes do not provide results consistent with the real perceptions of situations of daylight discomfort glare (Bellia, 2005). Regarding the limitations of the two indexes, therefore, this study utilizes the glare index proposed by Bullough *et al.* (2011).

The alliance for solid-state illumination systems and technologies ASSIST recommended a different index to quantify the glare of a light-emitting source (Bullough *et al.*, 2011). This discomfort glare index is more suitable for the classification of glare caused by solar installations. This index accounts for the distribution of the source illuminance by including both the total illuminance (lux) of the source as well as the maximum Luminance (cd/m<sup>2</sup>) received.

$$DG = \log (EL+ES) + 0,6 \log (EL/ES) - 0,5 \log (EA) \dots\dots\dots(4)$$

Where:

EL = illuminance from the source (lux)

ES = illuminance from the area surrounding the source (lux)

EA = Ambient illuminance (lux)

From this quantity, it is possible to determine the corresponding De Boer rating scale value (DB) (Ruescha *et al.*, 2016):



$$DB = 6.6 - 6.4 \log DG + 1.4 \log (50.000/LL) \dots \dots \dots (5)$$

Where,

LL = Luminance of the source

The De Boer scale uses a nine-point scale with odd-numbered values having the equivalencies explained in Table 3. The even number in the table shows the average glare values between the specified odd numbers.

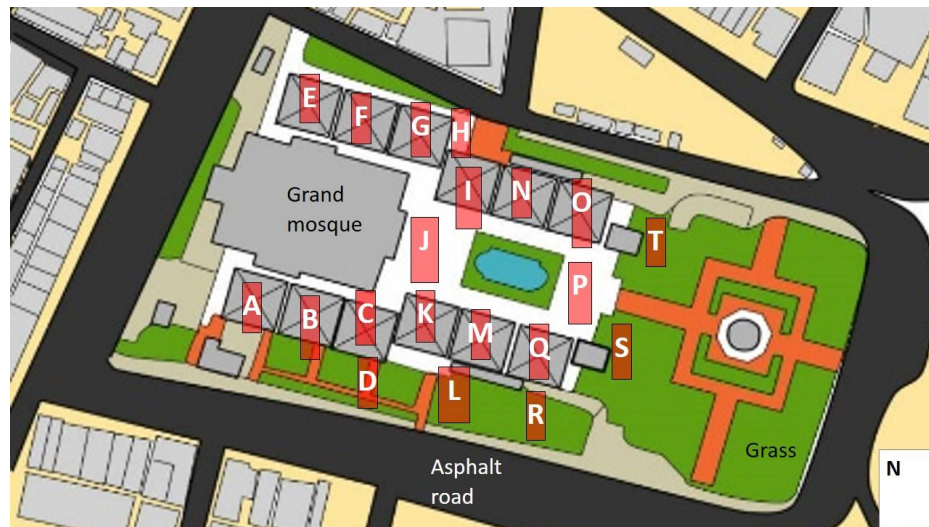
Table 3. Glare values

Scale	Glare values
1	Unbearable
2	
3	Disturbing
4	
5	Just permissible
6	
7	Satisfactory
8	
9	Just noticeable

*Source: Bullough et al. (2011)*

**Methodology**

This study uses the data collected through field measurements. The measurement includes recording the thermal parameters for predicting the outdoor comfort level perception such as Air velocity (v), Air temperature (Ta), Globe Temperature (Tg), Relative Humidity (RH). While for predicting the glare index, illuminance from the source (EL), illuminance from the area surrounding the source (ES), and ambient Illuminance (EA) were measured. The thermal comfort parameters were collected at the outdoor yard surface surrounding the Mosque (figure 3). The positions of the measurement were decided to represent the marble, paving block, and grass surface either with or without shade.



**Figure 3.** The positions of field measurement

The measurement was carried out on February 28th; March, 1st, and 2nd; from 10.00 am to 4.00 pm, where people mostly spend their time out of the Mosque. The measurement on March was conducted because March is apparent on equinox days where the sun appears to rise at due east and set at due west (at exactly 6:00 and 18:00 h, respectively). While February is the nearby month of the equinox, where the altitude of the sun is around 70° toward the South, which can be the representative of glare altitude against the eyes. Due to the limited

number of tools, the measurement only took place every hour. The measurement positions are specified as follows:

- Zone 1: Marble surface surrounding the electrical umbrella which is frequently open (A, B, E, F, I, O, Q, K)
- Zone 2: Marble surface surrounding the electrical umbrella which is frequently closed (C, M, G, H, N)
- Zone 3: Marble surface without any shades (J, P)
- Zone 4: Dry grass surface without any shades (L, R, S, T)
- Zone 5: Red paving block without any shadows (D)

## Results

### *Thermal performance*

Banda Aceh is the capital city of Aceh province situated at 5°33'0"N 95°19'0"E, which is about 8 meters above the sea level. The coast and sea mostly surround this town. The local climate is wet humid with average temperature 27°C, relative humidity 78%, wind speed 2m/s, and the dominant of wind orientation face southeast; the amount of rain is 100.6 mm, which mostly falls in December and January( Sari *et al.*, 2017).

The thermal performances of the Mosque outdoor collected for three days in Table 5 show the average, minimum, and maximum value of air temperature, globe temperature, relative humidity, and air velocity. The performances are higher than the climatic data collected by the meteorology and climatology office in Blang Bintang, Aceh Besar, for the three measurement days (Table 4). The high value is probably due to the location of the Baiturrahman Grand Mosque, which is in the central business district area of Banda Aceh. The outdoor globe temperatures recorded in this study are relatively higher compared with the air temperature. This character is due to the influence of air velocity, mean radiant heat, and air temperature in the globe temperature (Kazkaz and Pavelek, 2013). The globe temperature also resembles the thermal conditions felt by the human body (design building, 2016). Therefore, in predicting the thermal sensations, many formulas apply the globe temperature, including the Sangkertadi procedure which is employed in this study.

**Table 4.** Banda Aceh climatic data

No	Parameters	28/02/2018	1/3/ 2018	2/3/2018
1	Minimum temperature (°c)	22,6	22,4	22,2
2	Maximum temperature (°c)	32,6	32,0	32,5
3	Average temperature (°c)	26,4	25,4	26,7
4	Average Relative Humidity (%)	84	89	86
5	Precipitation (mm)	12,4	1,5	1,2
6	Sun hours (hours)	2,6	5,6	5,1
7	Average air speed (m/s)	1,02	1,02	1,02
8	Wind direction (deg)	SE	SE	SE
9	Maximum air speed (m/s)	3	4	4
10	Wind direction during the maximum speed (deg)	120	10	50

*Source: BMKG (2018)*

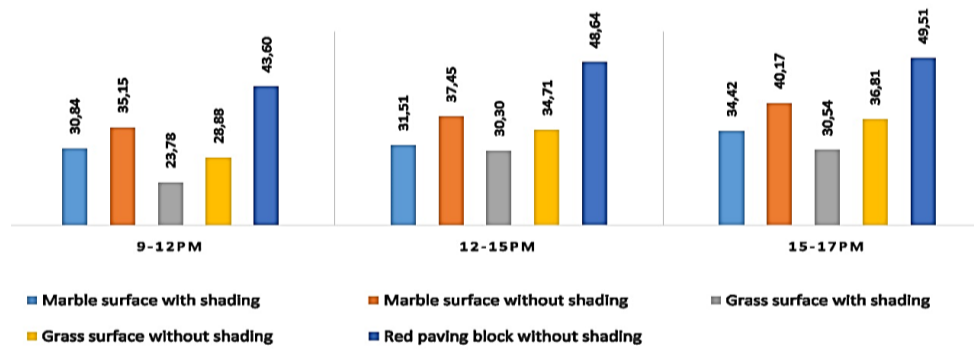
Table 5 shows that in general, the air temperature in the five zones is nearly similar. The average air velocity is about 1,5m/s, yet in some hours can be up to 5,66 m/s, which is quite right to provide comfort. However, the global temperature in zone 2, 3, 4 is relatively high. Zone 3 suffers the highest value of maximum Tg that is 46,45°C, which can be understood due to the absence of shading causing the substantial sun irradiance heating the marble floor surface throughout the day except at 3.30 pm to the evening. The lack of shading also creates a high average of globe temperature value in zone 2 and 4, which has the same maximum temperature of 45,58°C. Zone 2 is supposed to be excellent due to the electrical umbrella installed around the zones. However, the umbrella is frequently closed; therefore, the lack of shading causes the high global temperature. Zone 4 is grass, which has the lowest surface temperature compared with the other surfaces (Figure 4). However, the air and globe temperatures are high since it is not fully grown and slightly dry, which has a high absorptance value

which is up to 80% (Table 6). Another reason is also the asphalt road, which has around 90% of absorptance value surrounding the Mosque, which is just very close to the grass surface causing the globe temperature remains high.

**Table 5.** The outdoor thermal performance of Baiturrahman mosque during three days measurement from 10 am to 4 pm

	TA (°C)			TG (°C)			RH (%)			V (m/s)		
	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN
<b>ZONE 1</b>	29,47	33,88	28,13	35,59	44,30	28,90	67,41	85,80	50,99	1,47	5,66	0,14
<b>ZONE 2</b>	31,41	33,94	28,30	36,73	45,58	29,25	67,30	85,53	52,70	1,57	5,25	0,25
<b>ZONE 3</b>	31,35	34,70	28,05	36,68	46,45	29,05	67,64	85,33	51,21	1,70	5,13	0,80
<b>ZONE 4</b>	31,49	34,40	28,15	37,05	45,58	28,30	67,28	84,05	51,38	1,18	3,89	0,15
<b>ZONE 5</b>	31,59	34,33	28,45	36,35	43,95	29,25	67,22	81,58	50,99	1,25	4,87	0,03

Figure 4 shows the temperature of the surface outside the Mosque. The red paving block connecting the marble surface to some entrance toward the asphalt road suffers the highest surface temperature, which is up to 49,51°C. The increased solar radiation due to the absence of the shades and its absorption is up to 95% may support this lousy performance. It is then followed by the unshaded marble surface where the temperature is up to 40,17°C. The marble surface with shading can be more cooling around 5° C difference compared with the unshaded one. The lowest surface temperature is on the shaded grass, which is about 30°C during the sunny day.



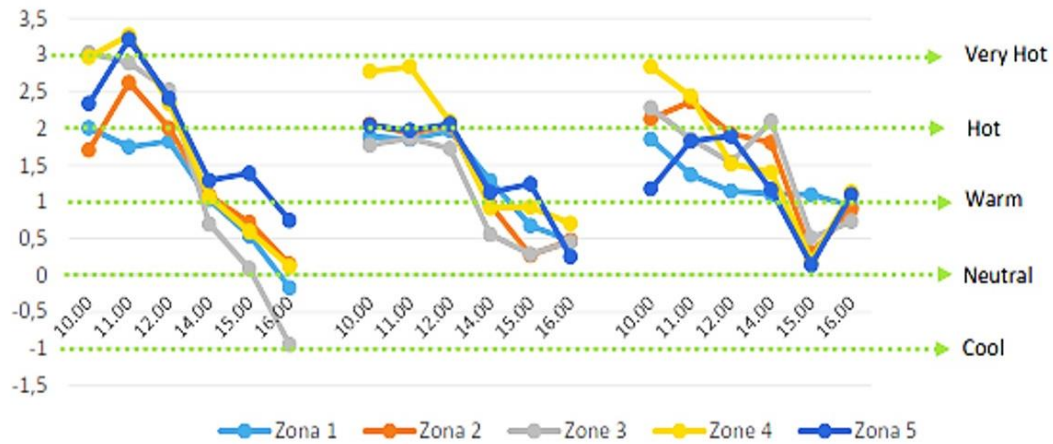
**Figure 4.** The average surface temperature of the measured surface representing three groups of measured time

**Table 6.** The absorptance and reflectance value of some surface types

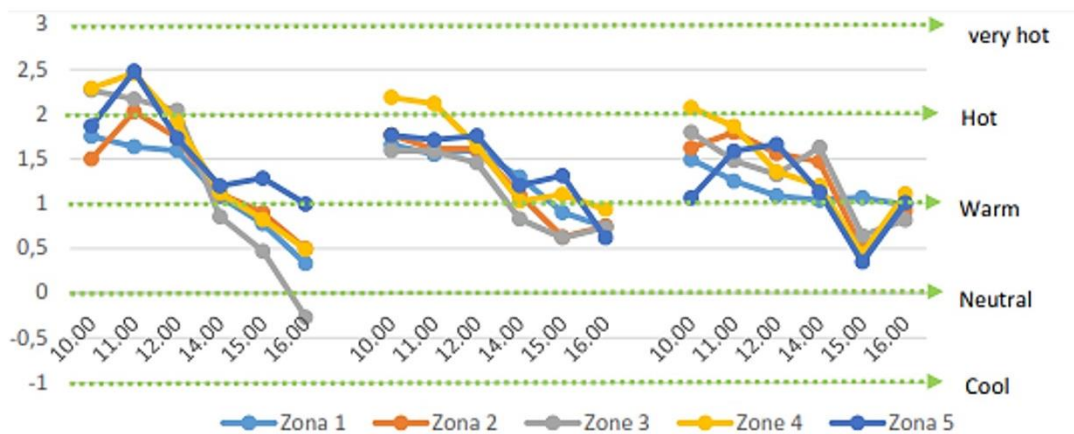
No.	Materials	absorptance (%)	reflectance (%)
1	Smooth surface concrete	76	24
2	Water	93	7
3	Dry soil	80	20
4	Green grass	64	26
5	Dry grass	70 – 80	20 – 30
6	Marble surface	40 – 50	50 – 60
7	Paving block	85 – 95	5 – 15

Source: *Engineering ToolBox*, (2009)

The thermal sensations are objectively calculated through the Sangkertadi formula, which is explained in equations 1, 2, and 3. The influence of airspeed and globe temperature besides air temperature and relative humidity strengthens the reason for adopting it. Since the everyday outdoor activities are regular walking and sitting, therefore regressions a and c (YJS and YDS respectively) are utilized.



**Figure 5.** Thermal sensations calculated based on Sangkertadi formula during sitting



**Figure 6.** Thermal sensations calculated based on Sangkertadi formula during walking

Figures 5 and 6 show that thermal sensations during sitting are higher than the usual walking. Sangkertadi formula shows that despite the globe temperature, the air movement also influences the outdoor thermal sense. Sangkertadi indicated in his equation that the increase of air velocity of 1 m/s might improve the scale of the comfort level of around 0.5 to 1.5 on average for three types of activities. It is also shown that  $T_g$ , as a representation of mean radiant temperature, plays a significant role in the perception of comfort. Therefore during walking, where the flow would increase the airspeed, the thermal sensations are slightly lower compared with during sitting. However, the thermal trends, in general, are above the warm feeling. The worst phenomena mostly occur from 10.00 to 15.00, which reaches hot up to a very hot sensation (Figure 5). Zone 4, which is the unshaded grass surface, suffers a large scale of thermal phenomena. It can be due to the lack of shade and the influence of the surrounding asphalt road. Zone 2, 3, 5 also suffer the massive scale of thermal sensations, which is caused by the absence of the shades.

### Glare

The installation of the white and glossy marble is an excellent choice due to its reflectance ability, which is up to 60% (see Table 6), which means to reduce the surface marble temperature. However, the reflectance causes



the glare, which reduces the spatial comfort of the visitors in enjoying the outdoor Mosque. In assessing the glare, this study considers the value of illuminance from the source (EL), illuminance from the area surrounding the source (ES), ambient Illuminance (EA), and Luminance of the source (LL) (see Table 6). EL was obtained from the measured illuminance during the survey. ES is the diffuse illuminance from the surrounding which was derived from the daylight measurement in Indonesia conducted by Koga *et al.* (1993), who specified the sun altitude as defined in Table 7. At the same time, EA is the sunrise illuminance, namely 1,555 lx (Koga *et al.*, 993).

**Table 7.** Diffuse Illuminance (ES)

Sun altitude	Hours	$E_s$ (lx)
48-54	10.00	23,463
60-66	11.00	30,653
66-72	12.00	38,908
72-66	14.00	38,677
60-54	15.00	32,145
42-36	16.00	23,138

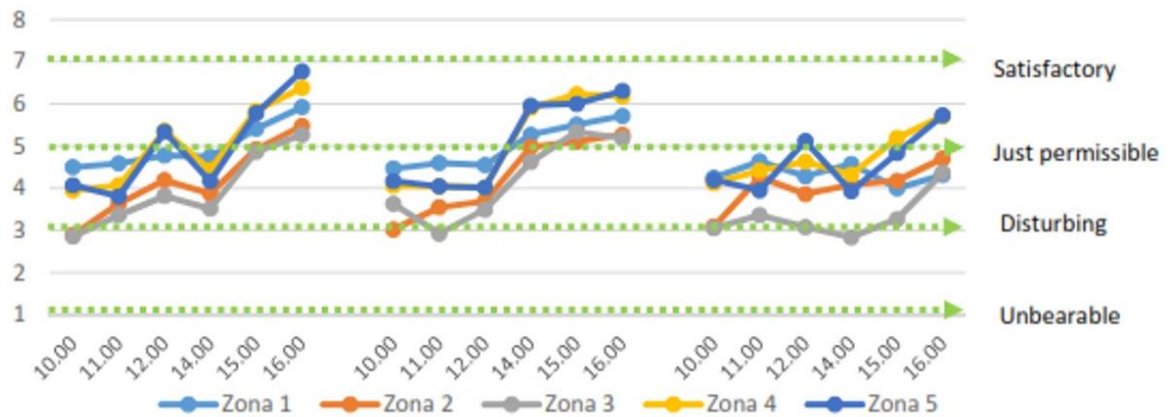
*Source: Koga et al. (1993).*

**Table 8.** Illuminance (EL) and Luminance from the source (LL)

Zone	Illuminance ( $E_L$ )- lx			Luminance( $L_L$ )-Cd/m <sup>2</sup>		
	Average	max	Min	Average	max	Min
Zone 1	13,327	86,300	2,800	13,876	180,000	2,100
Zone 2	36,663	106,600	8,300	28,168	88,275	4,200
Zone 3	43,725	101,700	8,100	36,952	87,900	4,500
Zone 4	46,088	106,000	7,700	12,574	29,614	2,002
Zone 5	49,133	103,300	5,300	12,887	26,858	1,378

Figure 7 shows that the glare value of the five zones calculated based on the amount of EL and LL in Table 8 in this study is dominantly within range 3 to 5, which respectively mean disturbing and just permissible criteria. From 10.00 to 14.00, zone 2 and 3 are very close to problematic standards. There are no buildings nor trees at the eastern part that can give the shades. In the De Boer scale of glare value, the higher the value, the less glare and vice versa. In this study, zone 3, which is the marble surface unshaded by the umbrella, is the largest area that is categorized in to disturbing. It is followed by zone 2, which is the area under the umbrella; however, the umbrella is frequently closed.

When the sun is running down to the west where the grand Mosque stands, the glare is minimized shown by the glare value throughout the zones rising close to the permissible scale. Even more, zone 1 and 4, which are the shaded marble surface and the grass surface, approach the satisfactory scale. This condition is also caused by the grand Mosque standing at the western side that gives the shades to the surrounding environment.



**Figure 7.** The glare average of the outdoor surface of Baiturrahman mosque calculated based on De Boer scale

### Discussion

The study shows the discomfort appearance for both thermal and visual comfort. The thermal sensations during sitting are higher than the usual walking. Based on the data collected in this study, the most problems causing low thermal feelings and glare are the absence of shading. Thus, the additional shades are essential to improve outdoor spatial comfort. Installing more electrical umbrellas would cost more since the need for electricity utilized to open and close the umbrella is exceptionally high. The high airspeed around Banda Aceh town also causes a risk for breaking the umbrella. Based on the case on July 9th, 2018, one of the umbrella cloth was torn, which create the closeness of all of the umbrellas for some particular times (Detik, 2018; Acehkita, 2018). Besides this condition, the high cost of each electrical umbrella installation, which is up to 10 million IDR also a reason to neglect the suggestion of increasing the number of umbrella installations.



**Figure 8.** The torn umbrella due to the stiff wind

It is not worthed to compare the electrical umbrella installations with the ones installed in the Nabawi mosque in Al-Madinah. In the Nabawi mosque, the umbrellas are massively installed and frequently open. The availability of substantial electrical power is ready to run and maintain the umbrella for giving the shades in the desert area where the trees and greeneries do not as easily grow as in the tropics. Meanwhile, in the tropics, the greeneries with thick leaves grow easily. Therefore the choice for planting more thick trees can be an alternative. However, the outdoor, where the front bottom surface has been designed as the car park and ablution areas, creates the limited possibilities to plant the tall tree with thick leaves, which needs the good supporting ground for the root

trees. The maintenance is also a challenge for planting the trees since the wind could blow the leaves across the marble surface. However, this becomes the simple choice since no electric bill runs for maintaining the trees.



**Figure 9.** The proposal of planting thick trees surrounding the piazza of Baiturrahman grand mosque for creating more shadings



**Figure 10.** Aerial view of Punggol Breeze Garage – Sky Park.  
Photo Source: <http://www.nparks.gov.sg>.

In this case, the intensive system of the green roof where the thick and tall trees can grow can be adopted. The intensive course which is built on the flat roof applies the waterproofing that should be taken up at least 150 mm above the finished surface, be it soil, paving, gravel, etc. It is advisable to have a plant-free area immediately adjacent to upstands; this can be achieved by infilling with gravel instead (Axter, 2008). This system needs regular maintenance. The green surface supports environmental sustainability. Many cases show the success of the green roof with thick vegetation built on dense buildings such as a car park. Singapore is an example of a dense country which can efficiently grow the Skypark. Car parks with their robust structures, necessary to support the weight of vehicles, inherently have a built-in propensity to sustain a living roof and living wall system (Falkerson and Cole, 2015). As the Baiturrahman Grand Mosque is located in the center of Banda Aceh town, the high activities run surrounding it. Therefore, the greeneries is extremely important to reduce the urban heat island.

Another recommendation for achieving the thermal and visual comfort is installing the diffusing surface on the open piazza. The installation should be taken into account as a primary parameter in reducing the discomfort

glare. White and Glossy color properties may cause discomfort glare yet, at the same time, beneficially have low surface temperature due to its considerable reflectivity. Therefore, to get both low surface temperature and no risk of glare, the diffusing light color marble surface should be installed. Since the glossy marble is also slippery, which is dangerous for walking during the rain or wet condition, the marble should also have a slightly rough surface, which is quite helpful to diffuse the light.

## Conclusion

This study evaluates the thermal and visual performance of the open piazzas of the Baiturraman grand mosque. By zoning some areas into some criteria, this study found that the zone of marble surface surrounding the electrical umbrella, which is frequently closed, and the area without shades suffer the highest Earth temperature, which reaches up to and disturbing glare. Using the Sangkertadi equation, the thermal sensations during sitting are higher than the usual walking. The study shows that despite the Earth temperature, the air movement also influences the outdoor thermal sensation. The Sangkertadi equation also indicates in his equation that the increase of air velocity of 1 m/s may improve the scale of the comfort level of around 0.5 to 1.5 on average for three types of activities.

The glare value of the measured zones is dominantly within ranges 3 to 5, which respectively mean disturbing and just permissible criteria. The glaring period happens from 10.00 to 14.00. For sorting the thermal and glaring problem out, the study highlights that in the tropics, the shade is very crucial in providing the cooling environment. Therefore the conclusion recommends the surrounding open piazza to be planted with more trees for delivering more coverings to reduce the earth's temperature. Installing the outdoor surface with the slightly rough white marbles instead of the glossy white marble is an alternative for reducing the glare across the piazza.

## References

- Ahmed, K. S., 2003. Comfort in Urban Spaces: Defining the Boundaries of Outdoor Thermal Comfort for the Tropical Urban Environments'. *Energy and Buildings*. 35, 103-110.
- Bappeda, Mesjid Beuracan. 2017  
<http://bappeda.pidiejayakab.go.id/index.php/jelajah/read/2015/08/05/3/mesjid-beuracan.html>
- Bellia, L., Cesarano, A., Spada, A. 2005. Application of videophotometer in the evaluation of DGI in scholastic environment, *International Journal on Architectural Science*, 6(2), pp.82-88
- BMKG (Meteorology, Climatology, and Geophysics – weather station of Blang Bintang, Aceh)
- Bullough, J. D., Hickcox, K. S., Narendran, N. 2011. A Method for Estimating Discomfort Glare from Exterior Lighting Systems, *ASSIST recommends*, 9(1), pp. 1-7
- Chauvel, P., Collins, J.B., Dogniaux, R., Longmore, J. 1982. Glare from windows: current views of problem, *Lighting Research and Technology*, 14(1), pp. 31 – 46.
- Falkerson, K., Cole, K. L. 2015. *The Living Architecture of Parking, Part 1*
- Kim, W and Kim, J. T . 2010. The Scope of the glare light source of the window with non-uniform luminance distribution, in *SHB2010 – 3rd International Symposium on Sustainable Healthy Buildings: Seoul (KR)*.
- Kazkaz, M., Pavelek, M. 2013. Operative Temperature and Globe Temperature, *Engineering Mechanics*, 20(3/4), pp. 319–325
- Koga, Y., H. Nakamura, M. Ramli Rahim, K. Goto. 1993. Daylight Measurement In Indonesia Part 2. Summary of The Data, In *Journal Of The Illuminating Engineering Institute of Japan*.
- Melayuonline. 2016. Masjid Raya Baiturrahman,  
<http://melayuonline.com/ind/history/dig/290/masjid-roya-baiturrahman>
- Mardhatillah, F. 2017. Masjid Raya Baiturrahman Tak Teduh Lagi  
<http://www.pikiranmerdeka.co/2017/04/07/masjid-roya-baiturrahman-tak-teduh/>
- Monteiro, L. M., Alucci, M, P. 2009. Thermal Comfort Index for the Assessment of Outdoor Urban Spaces in Subtropical Climates, *The seventh Intenational Conference on urban Climate*, 29 June-3 July 2009, Yokohama, Japan)
- Mayer, H., Höppe, P. 1987. Thermal comfort of man in different urban environments. *Theor. Appl. Climatol*, 38, pp. 43-49.
- Nikolopoulou, M. 2011. Outdoor comfort, *Frontiers in Bioscience S3*, pp.1552-1568



- Nazzal, A. 2005. A new evaluation method for daylight discomfort glare, *International Journal of Industrial Ergonomics*. 35, pp. 295 – 306
- Ruescha, F., Bohrena, A., Battaglia M., Brunolda, S. 2016. Quantification of glare from reflected sunlight of solar installations, *Energy Procedia* 91, pp. 997 – 1004 , *International Conference on Solar Heating and Cooling for Buildings and Industry*
- Sari, L.H., Irwansyah, M., Izziah, Meutia, E. 2017. An Environmental Assessment of Vernacular Housing In Banda Aceh, Indonesia, *TESA ARSITEKTUR*, 15(1), pp. 2460-6367 .
- Setyadi, A. 2018. Masjid Baiturrahman: Berdiri 1612, Dibakar Belanda, Jadi Ikon Aceh', *DetikNews*, <https://news.detik.com/berita/d-4036165/masjid-baiturrahman-berdiri-1612-dibakar-belanda-jadi-ikon-aceh>
- Serambi Indonesia . 2017. Banda Aceh
- Sangkertadi, S., Syafriny, R. 2014. New Equation for Estimating Outdoor Thermal Comfort in Humid-Tropical Environment. *European Journal of Sustainable Development*, 3(4), pp. 43-52.
- Thaib, R., Rizal, S., Hamdani, H., Mahlia, T. M. I., Pambudi, N.A. 2018. Experimental analysis of using beeswax as phase change materials for limiting temperature rise in building integrated photovoltaics, *Case Studies in Thermal Engineering*, 12, pp. 223-227
- <https://travel.detik.com/travel-news/d-4105800/akibat-cuaca-payung-masjid-baiturrahman-aceh-sobek>
- <http://www.acehkita.com/payung-masjid-roya-baiturrahman-sobek/>
- <https://www.axter.co.uk/brochures/GreenRoofsOct08.pdf>
- <http://www.greenroofs.com/content/articles/141-Park-Here-Part1.htm#.W3ydMugzbIU>
- [https://en.wikipedia.org/wiki/Diffuse\\_reflection](https://en.wikipedia.org/wiki/Diffuse_reflection)
- [https://www.designingbuildings.co.uk/wiki/Globe\\_temperature](https://www.designingbuildings.co.uk/wiki/Globe_temperature), November 23rd 2016
- [https://www.engineeringtoolbox.com/solar-radiation-absorbed-materials-d\\_1568.html](https://www.engineeringtoolbox.com/solar-radiation-absorbed-materials-d_1568.html)