Malaysia Architectural Journal

Sustainability of Green Design Mosque in Cyberjaya

Muhammad Danish[1*], Sharyzee Mohmad Shukri[2], Idris Taib[3]

[1,3] *Faculty of Architecture and Built Environment, Infrastructure University Kuala Lumpur, Malaysia*
[2] *Faculty of Built Environment, Universiti Malaya, Malaysia*

* danish5432168@gmail.com

Received: 1st October 2023 *Final version received: 10st Dec 2023*

The sustainable design aims to improve the building's overall performance in regard to the surrounding natural elements by reducing negative impacts on the environment as well as the health and comfort of the users of the building. The primary goals of sustainability are to limit non-renewable resource use, eliminate waste, and promote healthy, productive ecosystems. The intention of this paper is to evaluate the approaches of Raja Haji Fi-Sabillilah Mosque to achieve a Platinum Award in Green Building Index. The method of this paper is the study of the elements of sustainability by an in-depth literature review, sources from interviewing the Project Designer, and Site Observation. This paper discusses on how the mosque adapt to the environmental issue, elements of design that works to correlate with nature and lessen its impact towards it. The implementation of sustainable design the building incorporates are sustainable material of construction, cross ventilated, green rooftop, Low-E Glass, Water Body, Solar Energy, Screening Façade, Structural Canopy, Passive Dome Design, and a green Landscape. Findings collected help conclude that the sustainable application implement onto the Mosque not only reduces the heat gain by the Mosque by means of the Overall Thermal Transfer Value (OTTV), it also works with the environmental factor to benefit the Mosque, using it to its advantage achieving peak Sustainability, achieving a Platinum rating Green Building Index.

Keywords: Sustainability, Green Building, Mosque

1. INTRODUCTION

Raja Haji Fi Sabilillah Mosque projects the pinnacle of Sustainability into its design. Improving the environment or reducing its damage to the environment is the motive behind a sustainable approach. Not only will it be beneficial to the environment, but to the building, as well as all users. A sustainable build however will always be referred back to its environmental factor, as it poses as the only issue to achieving an environmentally friendly design. Upon the evaluation of the site, issues were determined (Altomonte, S., 2009).

Summary of Tropical Climate

Malaysia's climate is inextricably tied to its equatorial location. Because of the symmetry of the sun’s path, throughout the scope of every month of a year, inconsistent weather can be observed.

Aspect of Construction

Buildings account for over half of all global energy use, greatly contributing to global warming and ecological disruption (Altomonte, S., 2009).

Rainfall in abundance

Rainfall is abundant, with measurable rain falling on about half of the days of the year. Malaysia's typical winds are inconsistent with other areas in the equatorial mixing zones, or doldrums, due to its proximity to the equator.

Haze Season

The yearly haze that emerges from nearby flashes and burns farming techniques. Year by year its concentration increases drastically which impacts negatively a building and to the people.

Extremely hot temperatures

The average daily maximum temperature ranges from 31 to 33 degrees Celsius, with the warmest months occurring between March and May. The site has no vegetation for natural cooling and direct sunlight hit. Environmental issue

The aim of this study is to examine the scope of sustainable elements the mosque implements into its design in order to understand how the Mosque adapts to the environmental issues presented in order to attain its Platinum award, making it the most Sustainable Mosque. The coming criteria to be mentioned are examined for attaining information to carry case study. These criteria are set in regard to the Green Building Index criteria which are Energy Efficiency (EE), Materials and Resources (MR), Water Efficiency (WE), Indoor Environment Quality (EQ), Sustainable Site Planning and Management (SM), Innovation (IN). The objective is to study the Mosque design by analyzing researched papers, articles, site observation, and the informative guide by the Project Director.

2. LITERATURE

Green Building, often known as green design, and green architecture, is a building method that reduces the negative and disruptive impact of construction projects on human and environmental health. The "green" architect or designer seeks to safeguard air, water, and the environment by employing ecologically friendly building materials and construction procedures in other words, the environmental elements. (Olubunmi, O. A., Xia, P. B., & Skitmore, M., 2016).

A building may be 'green' in several ways. These include energy efficiency in buildings, efficiency in its water usage and innovative approach to it, as well as other resources, utilization of renewable energy sources like solar energy, waste, and emissions minimization, and the facilitation of re-use and recycling, enhanced air quality of the interior, use of non-toxic, ethical, and sustainable materials, and forethought of the environment in every scope of the construction phases such as design, development, construction, and operation.

A design that allows for changes in the environment to be accommodated. Any structure, regardless of its function, or its form of construction, can be classified as a green building if it has the criteria and characteristics stated above. It is important to acknowledge, though, that each green building does not have to reflect its similarities to the other. Various nations and areas have different climatic conditions, customs and traditions, specific sorts and ages of buildings, and diverse environmental, economic, and social concerns, all of which influence their approach to green construction (Berardi, U., 2013). The idea of a green design is the adaptation of its Building to its environment, not to specified setting standards. As we are approaching a new era in the Built environment where Sustainable will soon take the lead, there are numerous great Green Buildings in Malaysia, as such, KAIA Heights located in Taman Equine, Seri Kembangan. PJ Midtown in Petaling Jaya, Leisure Farm Resort in Iskandar Malaysia, Raja Haji Fi Sabillilah Mosque in Cyberjaya, and more.

Figure 1: KAIA Heights located in Taman Equine

Figure 2: PJ Midtown in Petaling Jaya

Figure 3: Leisure Farm Resort in Iskandar Malaysia

Figure 4: Raja Haji Mosque in Cyberjaya

3. METHODOLOGY

The goal of this research paper is to evaluate and understand the adaptation in the element of sustainability the mosque adopts in order to adapt to the environmental issues such as the often rain and strong concentrated heat waves. The process of accumulating the information and data requires the reach of multiple sources. This paper is the result of the study of a total of 12 researched article papers which covers the scope of environmental sustainability, study on the mosque, general technical knowledge, and Mechanical and Engineering. An interview with the Project Director of the Mosque, Mr. Vejayarajah is carried out to understand the mosque design features from the perspective of the Director himself. A site observation is also done to further understand and analyze the Mosque firsthand. The sensory of touch, smell, and sight help with further understanding of the elements implemented in the Mosque. From sources of an Article, Interview, and Site Observation, this study is able to be carried out effectively with a positive outcome.

4. FINDING: Green Platinum Award Mosque

The fundamental goal in designing this mosque, while adhering to GBI Gold criteria, is to guarantee that it meets the standards that will make it a truly sustainable mosque and a true model for future mosque construction in Malaysia. The mosque's goal or original design intent was to make the main 'Prayer Hall' air-conditioned for two hours on Fridays and during prayers for special events according to the Islamic calendar. During the rest of the day and night, fans and ventilators are likely to suffice. It is designed and planned to be 26 degrees Celsius on average during the day. (Aziz, A. A., 2016)

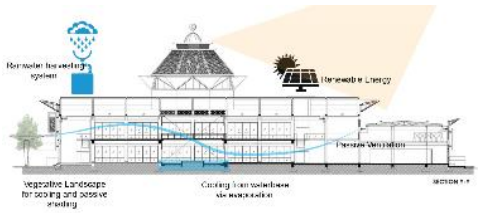


Figure 5: Features of the Mosque

GBI Green Platinum Building

Figure 6: Certified Platinum Award

The architectural philosophy behind the mosque aims to make it a truly sustainable structure that would eventually serve as a model, setting standards, a benchmark for future mosque construction in Malaysia. As a result, the design meets the highest Green Building Index (GB) certification level, Platinum, by using recyclable materials and energy-efficient technology to decrease energy use and operating expenses. It will be one of the world's first mosques to employ solar panels to generate power and to participate in the feed-in tariff (FIT) system. The energy created and fed into the natural grid will help the country's renewable energy supply. The mosque's design adheres to the Malaysia Standards (MS) 1525 criteria, which focus on the building's energy usage. The points required for a GBI Platinum grade are less than 90. The building is designed to meet six GBI criteria, which are listed below. They're as follows:

1. Energy Efficiency (EE)

2. Materials and Resources (MR)

3. Water Efficiency (WE)

4. Indoor Environment Quality (EQ)

5. Sustainable Site Planning and Management (SM)

6. Innovation (IN)

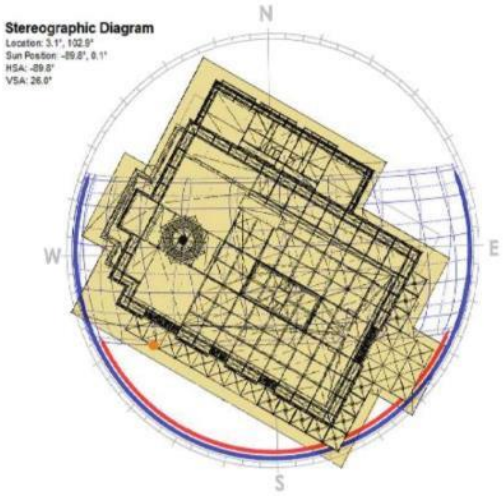
PART	ITEM	MAX POINTS	TARGET POINTS
1	Energy Efficiency (EE)	35	34
2	Indoor Environment Quality (EQ)	21	20
3	Sustainable Site Planning & Management (SM)	16	15
4	Material & Resources (MR)	11	10
5	Water Efficiency (WE)	10	8
6	Innovation (IN)	7	7
	Achievable Point-pre-certification estimates	100	94

GREEN BUILDING INDEX CLASSIFICATION

POINTS	GBI RATING
86+ points	Platinum
76 to 85 points	Gold
65 to 75 points	Silver
50 to 65 points	Certified

Table 1: Green Building Index Rating

Orientation of the Building



To enhance the building shape and location by means of its orientation as well as form, the fundamentals of the climatic building design are addressed. This was the project's beginning point, and it has shown to be successful in decreasing the building's load. The architectural elements of its design can also gain from the symmetry of the sun's path at the equator. It only makes sense to

make use of the sun's free light, energy, and, in many situations, heat to maintain a comfortable inside atmosphere. A high percentage of openable areas that enables sunlight to enter the structure at sunrise and sunset should be prevented (Western and Eastern Facades). (Aziz, A. A., 2016)

Sustainable Material of Construction

Figure 7: Construction using Fly-Ash

The mosque contains many environmentally friendly features and materials, including Lafarge fly-ash concrete, which contains recyclable materials, Pantene insulation to help reduce heat gain from the roof, ionized ceiling material in the main prayer hall to help provide good air quality and dirt-free, and double-glazed glass for the dome to omit light and reduce heat in the main prayer hall whilst instilling passive cooling. A wide landscape, water collecting, and solar panels also help to keep the area cool.

Figure 8: Cement and Fly-Ash

Fly ash is a pozzolan, which is a substance combining aluminous and siliceous material that, when mixed with water, makes cement. Fly ash, when combined with lime and water, produces a chemical that is comparable to Portland cement. Fly ash can thus be used as a primary component in blended cement, mosaic tiles, and hollow blocks, among other construction materials (Olubunmi, O. A., Xia, P. B., & Skitmore, M., 2016).

Fly ash is a very environmentally friendly material in usage. It has several advantages. Produces a number of preset timings that will save time, Resistance to the cold, and High improvements in strength, depending on usage As an admixture, it can be employed. It is a non-shrinkable material. Produces solid concrete with a smooth finish and fine detail. Excellent adaptability Crack issues, permeability, and bleeding are reduced. Reduces hydration heat, when compared to no-fly-ash mixtures, allowing for a lower water-cement ratio with equivalent slumps. CO2 emissions are reduced which ultimately benefits the environment (Thomas, M. D. A., 2007).

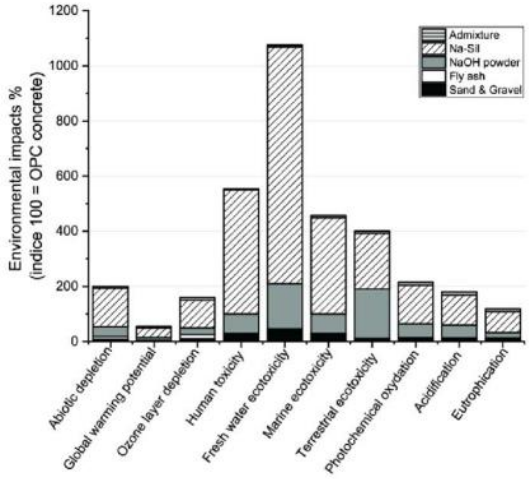


Figure 9: Environmental impact of Fly-Ash

Cross Ventilated

Figure 10: Cross Ventilation design of the Mosque

A high openable area promotes natural ventilation towards the building interior and as it travels through the leading space into the prayer's hall (a semi-enclosed space), the air will then flow outwards either from the opposite end of an opening area or upwards towards the ventilator fan located at the dome's interior peak. This event if called Cross Ventilation. (Aziz, A. A., 2016)

Cross ventilation or in other callings, Wind Effect Ventilation is a natural cooling mechanism. Through an inlet (such as a wall louver, a gable, or an open window), in the case of this mosque, an open space design, the wind drives cold outer air into the structure, while an outlet force heated inside air outside (through a roof vent or higher window opening) (Pabiou, H., Salort, J., Ménézo, C., & Chillà, F., 2015).

Cross ventilation is a type of passive cooling that takes advantage of the natural surroundings. Assisting in the regulation of interior temperatures (andMahyuddin Ramli, A. S. H., 2010). Moisture smells, and other gases that might accumulate during occupied times are reduced. It flushes out the present flow of air, bringing in the new fresh air. It does so in a constant manner, acting as a cooling agent. Despite not having a set time to switch on the air conditioner, the Raja Haji Fi Sabilillah Mosque is able to maintain a comfortable temperature in its interior. This is due solely to cross ventilation and the components that aid in its integration, such as the water body feature strategically positioned at the entrance of the prayer hall.

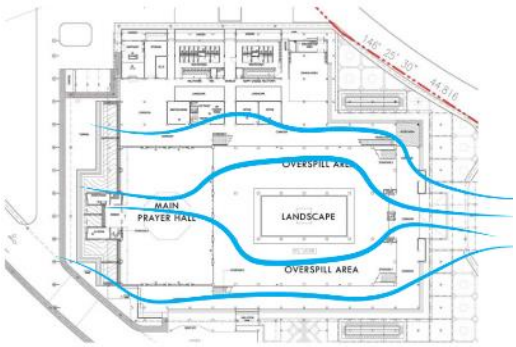


Figure 11: Air flow from Cross Ventilation

Green Rooftop – Synthetic Grass

The rooftop area features synthetic grass. This is significantly more efficient to implement since it is easier to maintain the grass clean when people go barefoot. It also acts as real grass as its responds to heat. With exposure to direct sun, the synthetic grass will rise upwards and lowers back down as the sun begins to set. Collecting and storing water for the mosque's rainwater harvesting system is also quite efficient. The synthetic layers are also effective in keeping heat out. This will lower the building's overall thermal transfer value, resulting in peak cooling and long-term sustainability. (Aziz, A. A., 2016). Syfon Technology is used to collect rainwater. Syfon Systems are roof drainage specialists with a wealth of expertise, particularly in areas with frequent rainfall. This will be considerably more effective in collecting rainwater.

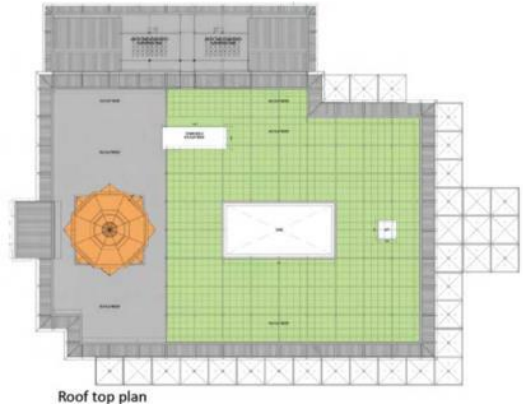


Figure 12: Rooftop Plan

Many beneficial outputs arise from implementing a synthetic rooftop to its design. It is easy to maintain and due to its light built, it reduces the total weight pressure towards the ground. Reduce Heat Gain of Building from the layering of the synthetic grass acting as a buffer. Easy Instalment. Collects water for the rain harvesting system more efficiently with the complimentary Syfon technology. Collect more volume of rainwater due to the large covering area. Syfon technology works fast as they implement pressure pull for the liquid transfer. It opens to more praying spaces.

Figure 13: Synthetic Grass of Rooftop area

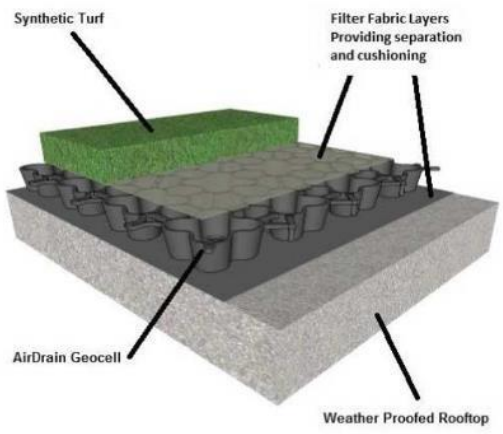


Figure 14: Layers of Synthetic Grass rooftop

Figure 15: Exposed layer of Synthetic Grass

Low-E Glass

This mosque's wall system consists of low emissivity glass set below its façade screening, covering the entire parameters, especially in the enclosed area of the Main Prayer Hall. The Mosque does not use walls for its coverage for sustainability purposes. The very little use of walls is constructed with cement cavity blocks of fly ask concrete.

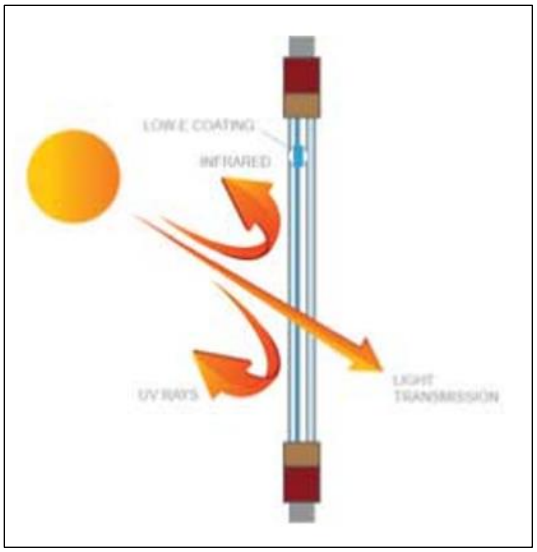


Figure 16: Filtering effect of Low-E Glass

The sun's control Because it reduces the amount of heat absorbed into the area, Low-E glass is suitable for mild to warm conditions. Low E glass has the principal benefit of improving the insulating effectiveness of building openings. Better insulation creates a more pleasant environment. The double-glazed glass prevents up to 70% of solar heat input, decreasing the solar heat gain coefficient substantially (SHGC). The bulk of UV rays will be blocked as well (Finley, J. J., 1999).

Figure 17: Main Prayer Hall enclosed by Low-E glass

The intention behind the building's approach is green and sustainable building. Hence, an openable is ideal. Raja Haji Fi Sabilillah Mosque is an open building with a high openable area, and the enclosed space is simply concrete cavity blocks walls that project towards ecofriendly. The remainder is made up of open spaces by means of

high openable areas and places with Low-Emissivity glass for weathering protection and to maximize the eco-friendly practices. By implementing Low-Emissivity glass, passive cooling, passive lighting, and other aspects of sustainable are reached.

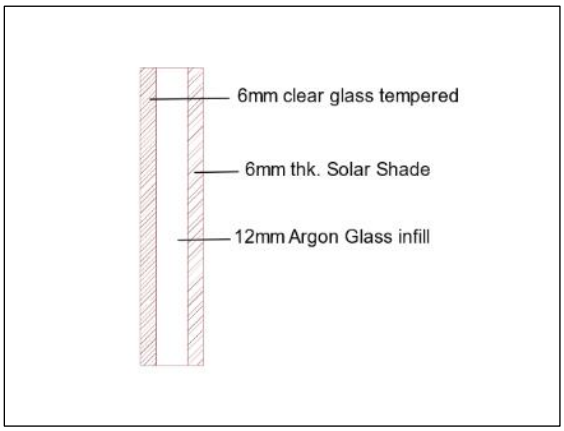


Figure 18: Detailed layer of Low-E glass

A. Low-E Glass Saves Money on Energy

An undetectable coating on Low-E glass reflects long-wave infrared radiation into the building's interior. They sustain a cooler interior temperature in the warmer months and a comfortable interior temperature in the cold season, lowering energy consumption by controlling the internal climate.

B. The use of Low E glass reduces UV radiation

By inhibiting UV radiation, Low-E glass prevents sunlight from harming carpets, draperies, sofas, and other furniture. Furthermore, low-E glass reduces glare in a room. The sun's heat is reflected away from the building, reducing glare.

C. Low-E glass does not totally filter out all light

Infrared and ultraviolet light are blocked by low E windows, yet visible light is a significant component of the sun's spectrum. They will, of course, diminish visible light slightly when compared to a clear glass window. Regardless, the quantity of natural light will brighten your space. Low-E Glass Provides Energy Savings By maintaining the ideal room temperature, they help to reduce electricity consumption.

Screening Façade

The main shading device diffuses daylight while enabling the wind to travel through the building's openable area space, resulting in passive cooling. This patterned facade runs the parameters of the building's whole exterior facade. The Islamic pattern also helps in projecting aesthetic shadow cast features toward the interior of the Mosque.

Figure 19: Screening Facade of the Mosque

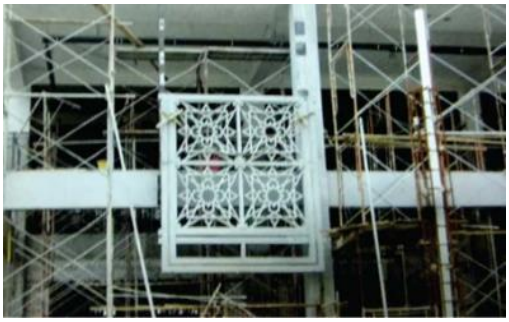


Figure 20: Attachment of Screening Facade

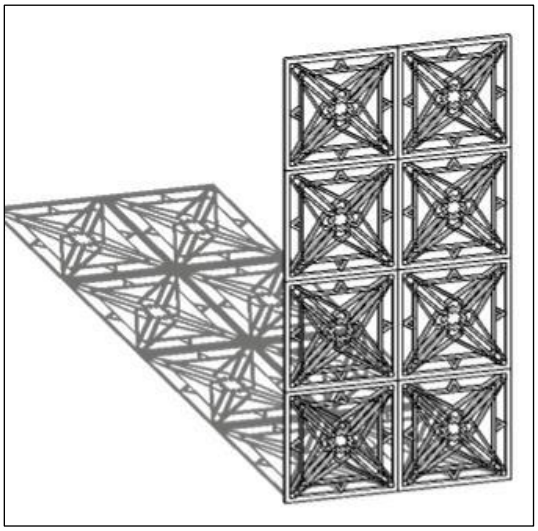


Figure 21: 3D Model of Screening Facade

This screening façade will benefit not only the users but the building's conditioning overall. It provides passive Shading, hence reducing concentrated light and heat from the sun, which ultimately reduce the heat gain of the building. It is easy to install and acts as a beautiful architectural façade design that adds to the beauty and uniqueness of the Mosque.

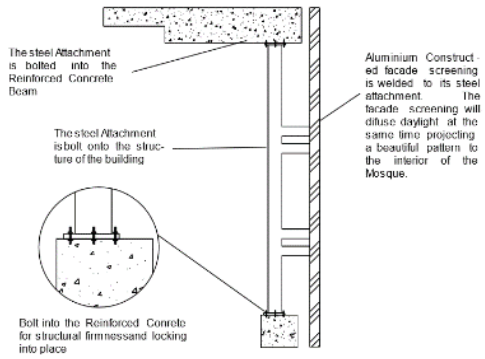


Figure 22: Detail of the attachment of Screening Facade

Solar Panels

By incorporating integrated PV at the roof top area, this space may be used as an additional prayer space with a capacity of 1,875 jemaah places at a same time. Hence, a much efficient use and a conserved of space. Using a 740 pv panel as the covering, this BIPV will be able to supply a minimum of 0.18 MW. With TNB's present Feed In Tariff, 0.18 MW will create close to RM7.2 million in profit after 21 years. (Aziz, A. A., 2016)

Solar panels will ultimately cover much of the rooftop space, generating renewable energy while also providing shade during times when the rooftop area is used for prayers. This implementation makes it Malaysia's first mosque to include a covered rooftop prayer space. In addition to producing power, the energy generated by the solar panels is expected to be lucrative to the mosque, allowing it to maintain its operating costs.

The energy produced by the over 800 solar panels is able to light the 41-hectare facility and is sold to Tenaga Nasional Berhad, which ultimately generates up to RM5,000 per month. As a result, monthly costs have been reduced by RM5,000. A solar panel with a surface area of 350 square meters may generate power with a peak capacity of 48 kilowatts.

Confreth (M) Sdn Bhd is the project's green building consultant. Saga Jurutera Perunding Sdn Bhd is the Mechanical & Electrical Engineer. These parties are in charge of the Solar Panel's design scope and construction.

Figure 23: Solar Panels of the Mosque

The Mosque's adoption of solar panels has several advantages. The mosque's monthly electricity expenditure is reduced thanks to solar energy. Solar energy has enticing tax advantages. Solar energy is pollution-free and does not generate greenhouse gases after installation. The building is sustainable thanks to solar energy. Solar panels endure over 30 years and require almost little maintenance. In the mosque, the panels also serve as a roof. Reduces the building's total maintenance costs. These solar panels take advantage of the projected heat waves from the sun into the wide landscape for its benefit, powering the mosque.

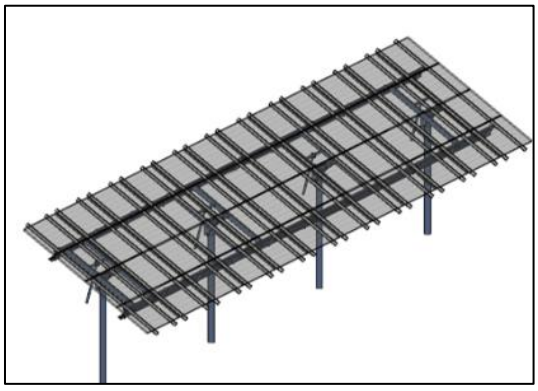


Figure 24: 3D Model of Solar Panel

Figure 25: Solar Panels Generated Energy

Structural Canopy

The attendees sat below were shaded by the freestanding canopies that were put at the front and sides of the mosque. The canopies additionally give shade to those performing ablution prior to prayers. Before and after services, the sitting areas were designed to promote socialization. It's a welcoming addition to the mosque that allows visitors to relax, interact, speak, or just take a rest prior moving on to their next activity or location. (Aziz, A. A., 2016).

The placement of this concrete structural Canopy is surrounding the parameters of the Mosque's main face. It provides shading and ultimately comforts the users. As it surrounds the Mosque, it reduces the total heat gain by the building, reducing the temperature from within.

Figure 26: Structural Canopy from eye view

Figure 27: Structural Canopy Eye view

Figure 28: Positioning of Structural Canopy

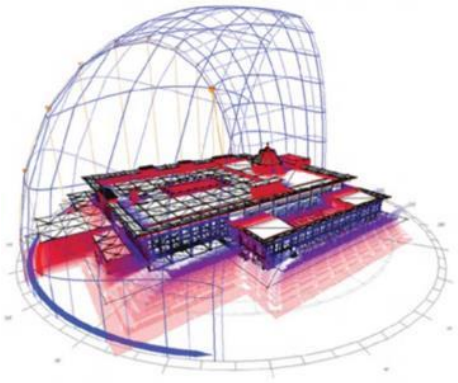


Figure 29: Shading performance of the Mosque

The structural Canopy provides Shading from direct Sunlight which will promote coolness and comfortability for the building and users. Creates a comforting resting spot. Reduce Heat Gain of Building by buffering out direct sun light. Made from sustainable Concrete material (fly-ash). It acts as a beautiful Facade Finishing and it stand strong and firm as it uses pile foundation for the structural Canopy.

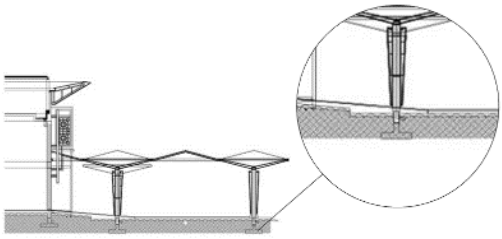


Figure 30: Sectional Drawing of Structural Canopy

Figure 31: Pile Foundation

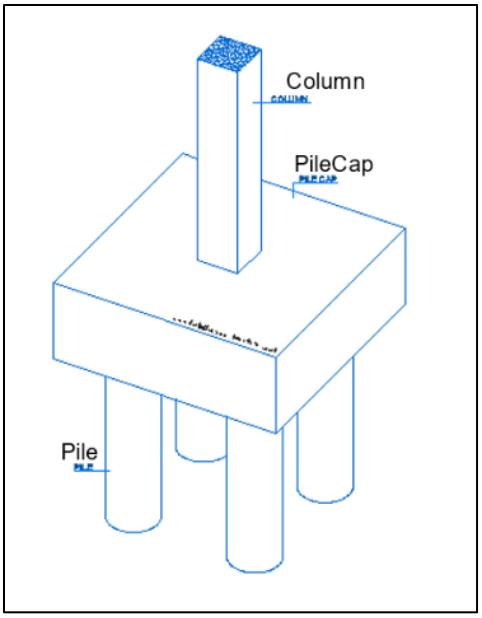


Figure 32: Detail of Pile Foundation

As the structural foundation of the Mosque uses RC pile, so does the canopy. This to boost bearing capacity and decrease settlements at sites with poor compressible soil that are often unsuitable for construction.

Water Harvesting System

As part of a full landscape irrigation system and for greywater use, the mosque has a water collecting/harvesting system. The mosque's design includes efforts to collect water from rain and used ablution water. Greywater is used for toilet flushing and landscape irrigation with some of the collected water. To reduce use and overall mosque water consumption, G.I. steel tanks were utilized on the rooftop above the toilet construction to collect rainfall, and subsurface concrete reinforced tanks were used to collect water recovered largely from discarded ablution water and precipitation. It projects the pinnacle of Sustainable development (Rahman, A., 2017). It's also an endeavor to think of water as a life-sustaining resource. Rainwater harvesting is a cost-effective water use that alternate with domestic water consumption (Che-Ani, A. I., Shaari, N., Sairi, A., Zain, M. F. M., & Tahir, M. M., 2009).

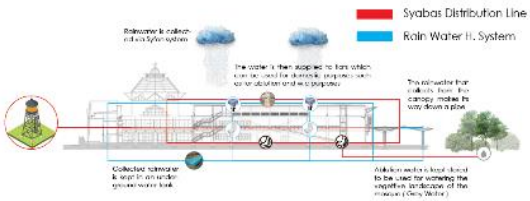


Figure 33: Distribution flow of Water in the Mosque

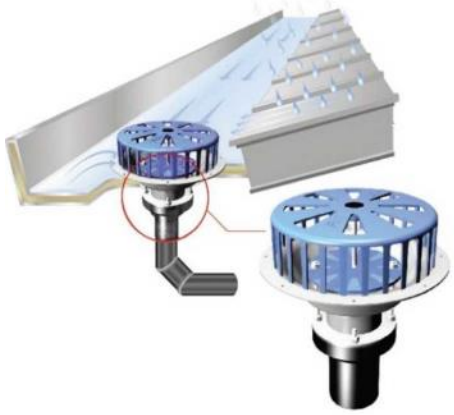


Figure 34: Syfon technology of the Mosque

Roof drainage specialists Syfon Systems have a plethora of experience, especially in areas where there is significant rainfall. Reduced roof outlets and downpipes, as well as narrower pipe diameters and shorter pipe lengths, save space and save installation costs. Without air, pipes run-flat and full; greater flow rates boost efficiency. The usage of the building height is maximized with lateral pipes since they do not require a gradient. Pipe elongation caused by temperature changes has no effect on the bracketing system. Ventilation and overflow are possible in special inspection chambers.

i. Simple to keep up with

The community benefits from the usage of a rainwater collection system in several ways. Rainwater collection, first of all and foremost, allows us to make optimum and effective use of an energy resource. It is vital to do so since drinking water is scarce, and waste is reduced.

ii. Water supply that is self-sufficient

In locations where clean water is expensive or limited, rainwater collecting provides a self-contained water supply. Rainwater collecting is a valuable source of clean water, increasing the amount of drinking water available.

iii. Saving Money on Water

Rainwater collected in a rainwater harvesting system may be utilized for a variety of reasons other than drinking. As a result, most households and small companies conserve money on their energy bills.

iv. Reduces groundwater demand

As the world's population expands, so does the need for water. As a result, many residential areas and businesses rely on groundwater for their daily requirements. Groundwater depletion has ensued, with some areas experiencing acute water shortages reaching dangerously low levels.

v. Water Feature

On the mosque's western side, which is also the direction of the qibla wall, there is a water feature which is a pool of water based and also a built in water fall and a wall. The water features operate as a coolant agent when the main prayer hall's glass doors are opened to allow natural air in, helping in the cooling of the main prayer hall, providing comfort during prayers or simply leisure. The trickling flow of water from the slanting cascade wall creates a soothing sound. The wall acts as a barrier, obscuring the mosque's unfavorable perspective from the west. The top of the wall has planter boxes constructed into it. The calatia plants, which may reach a height of 10 feet, are utilized as a buffer zone and screen. It is also intended to block out or filter the western sun to an extent in the afternoons until the evening sunsets. Hence also providing passive shading to the Mosque. (Aziz, A. A., 2016)

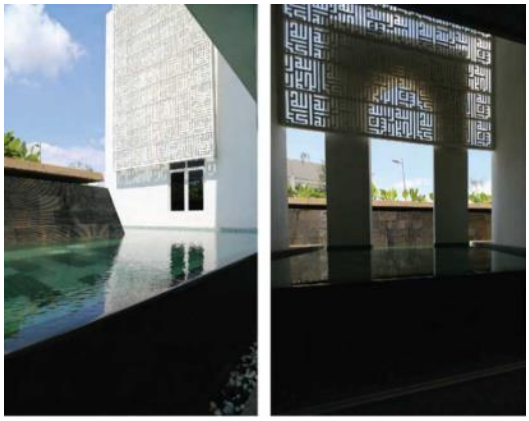


Figure 35: Water Body Feature of the Mosque

In hot, dry locations, courtyard water features use evaporative cooling to help regulate outdoor temperatures. because the water and air have a broad contact area, which encourages evaporation Water spray may chill the skin when it comes into touch with it, and when water surfaces meet a wind, it acts as a cooling agent for the environment.

Figure 36: Water Body cooling effects

Water feature of the mosque helps in Passive Cooling, promoting comfort to the users without the use of any mechanical element such as fan or the AC. Physiological impact of calmness and reduces Heat Gain of Building. Beautiful Design Display that non other Mosque will innovate to this idea in today's day.

LED Lights

Figure 37: LED Feature of the Mosque

Figure 38: LED Feature of the Mosque

Figure 39: LED Features of the Mosque

LED light fittings and low-energy lighting will be used to supplement the mosque's natural illumination in the evenings and at night. Light sensors will be installed throughout the facility to automatically modulate artificial lighting when it is not in use. LED is a very sustainable strategy since it saves a significant amount of money on

electricity while still providing a wide range of functionality and benefits.

At the moment, LEDs can produce 135 lumens per watt of electricity. Long service life – 50,000 hours or more if built properly. Because LEDs are made of solid material and do not have a filament, tube, or bulb to break, they are also known as "Solid State Lighting (SSL)." (Byun, J., Hong, I., Lee, B., & Park, S., 2013). LEDs do not require any warming up time before turning on; they turn on in nanoseconds. Low temperatures are "enjoyed" by LEDs, and they will turn on even at subzero temperatures. LEDs are directional, which means you can direct the light precisely where you want it without wasting any. Excellent Color Representation — LEDs do not bleach out colors like other light sources like fluorescents, making them excellent for displays and retail applications. Mercury or any other harmful substance is not present in LED. Hence, it is very environmentally friendly

Dome Passive Cooling Feature

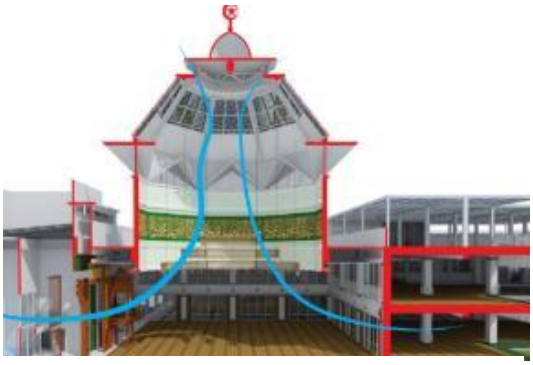


Figure 40: Stack Effect at the Mosque dome

The dome is one of the Mosque's most distinctive features. The single dome, composed of double-glazed Low-Emissivity glass, sits atop the enclosed main prayer hall and providing both passive shading, and natural lighting. The ventilators by the brand of 'Big Ass Fana' at the pinnacle and at the top of the dome's underbelly remove and discharge rising hot air, releasing trapped hot air and decreasing the temperature in the prayer hall. Retractable blinds will provide additional shade as needed to keep harsh sunshine out of the main prayer hall. The dome's structural design provides a stack effect, in which heated air rises and exits through the ventilators.

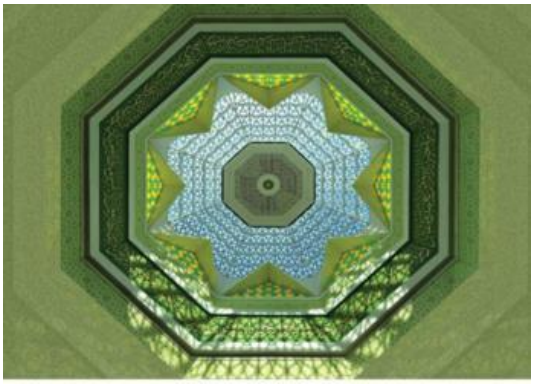


Figure 41: View of the Dome from the Interior

Figure 42: Exterior View of the Dome

With the implementation of BMS System to control the Air-Conditioning with specified schedule, stack effect to discharge hot air, ventilation fan to help ventilate, and water-cooling feature, the enclosed area is able to keep at 26 C even when the air conditioning is not switched on often (Wong, N. H., & Heryanto, S., 2004). This innovative design of the dome gives Natural Lighting whilst eliminating discomfort heat from the Low-E glass placed at the dome. Passive Cooling by Stack Effect whereby hot air will be dispersed out and cool air will be pulled in from the ventilator fan within the dome. Reduces the overall heat gain of the building. Ultimately reducing the Overall Thermal Transfer Value of the building. Increases and integrates the comfortability of users of the Mosque (andMahyuddin Ramli, A. S. H., 2010).

Green Landscape

Figure 43: Vegetative Landscape of the Mosque

Raja Haji Fi Sabilillah Mosque and its accompanying structures were planned to fit into the master plan for University Islam Malysia (UIM), which will be developed upon that remaining 90 acres of land. The mosque will be bordered by a vegetative landscape of both fragrant plants and plants that represent the notion of a mosque within a garden, thanks to the landscape allocation. Flora trees are blended with botanical structural forms. Shrubs are grown to provide a visually appealing environment that complements the tropical surroundings. The parking spots have been built using grass crete. Grass Crete helps to minimise the amount of hard surface area. Grass will grow and eventually cover much of the concrete pavers. Plants such as frangipani, tecoma, and red flame trees are also used to provide colour to the mosque's environment. (Aziz, A. A., 2016)

Figure 44: Vegetative Species Surround the Mosque

5. DISCUSSION

Raja Haji Fi Sabilillah Mosque is the most sustainable Mosque. Its Methods for an environmental adaptation to achieve sustainability cover every scope of the environmental factors such as heat, sun path, orientation, wind pattern, etc. This Mosque is able to maintain its Platinum due to measures it took in terms of Energy Efficiency (EE), Materials and

Resources (MR), Water Efficiency (WE), Indoor Environment Quality (EQ), Sustainable Site Planning and Management (SM), and Innovation (IN)(Aziz, A. A., 2016). The issue on-site has been established however, the main challenge is to achieve a truly peak sustainable Mosque that will be a set benchmark for all future Mosque and construction. What makes the Mosque truly sustainable is its manipulation methods to take advantage of the environmental factor, and their methods of preservation.

The mosque typological orientation is positioned in a systematic way whereby it helps with building load reduction and in the Overall Thermal Transfer Value of the mosque projecting peak Sustainable Site planning and Management (SM). LED Lighting and solar energy sides with the Energy Efficiency (EE) of the Mosque. Material and Resources (MR) the mosque uses fly-ash concrete and cement cavity block are used for its walls, both sustainable approaches. Water Efficiency (WE), the mosque implements a rain harvesting system and recyclable grey water from toiletry use to water the vegetative landscape of the mosque. For the indoor Environmental Quality (EQ), comfortability of users is kept optimal as the structural built of this mosque helps in cross ventilation which ultimately cools the temperature of the mosque.

Water Body are also presented which acts as a cooling agent. The mosque is design as a high openable space and only the main prayer hall is enclosed. However, the enclose space is covered with Low-e glass which help in reducing the internal heat gain. The remarkable architecture of the dome of the mosque also contributes to its element of sustainability. The dome promotes stack effect whereby the cycle of hot air will be dispersed out from above, and the ventilated fan located on top of the dome interior peak helps to pull cool air in. The dome promotes passive shading, passive lighting, and natural cooling which will not be seen from any Mosque around the world, having the innovation (IN) approach in checked.

6. CONCLUSION

The findings of this study based on literature references, interview with the director, and site observation concludes that the mosque took very specific and precise measures in order to adapt with the environment to achieve peak sustainability, and it was successful. These approach are the adaptation of design elements in order to counter the environmental issues of haze, concentrated heat waves, and heavy rainfall. Placing the Mosque Green Building Index at a score of 94 points, earning its Platinum Award, the most sustainable Mosque in the world. The engineering and Architecture of the Mosque has enabled the mosque to make use of the environmental issues into the Mosque advantage.

Scorching heat and direct sun help runs the building by solar, and natural lighting. Typological Built flushes and cycles out toxifies air by means of stack effect which also promotes cooling. Heavy Rainfall ensures the building to have sufficient storing in their water tank. In other words, what makes the Mosque achieve peak sustainable design is not precisely adapting to the environment, rather working with it. As the world is marching to an unhealthy and an unfriendly environmental state due to haeby unmonitored human activity, this very project such as Raja Haji Fi Sabilillah is a great example and can be the setting stone for future built, as after all, Sustainability is the future.

7. REFERENCES

Azim, A. Aziz. (2016). Masjid Raja Haji Fi Sabilillah, Cyberjaya, Selangor Darul Ehsan, Malaysia (1st ed.). ATSA Architects Sdn. Bhd.

Altomonte, S. (2009). Environmental education for sustainable architecture. *Rev. Eur. Stud.*, *1*, 12.

Mahyuddin Ramli, A. S. H. (2010). Natural ventilation of indoor air temperature: A case study of the traditional Malay house in Penang. *Am. J. Engg. & Applied Sci*, *3*(3), 521-528.

Byun, J., Hong, I., Lee, B., & Park, S. (2013). Intelligent household LED lighting system considering energy efficiency and user

satisfaction. *IEEE Transactions on Consumer Electronics*, *59*(1), 70-76.

Berardi, U. (2013). Clarifying the new interpretations of the concept of sustainable building. *Sustainable cities and society*, *8*, 72-78.

Che-Ani, A. I., Shaari, N., Sairi, A., Zain, M. F. M., & Tahir, M. M. (2009). Rainwater harvesting as an alternative water supply in the future. *European journal of scientific research*, *34*(1), 132-140.

Finley, J. J. (1999). Heat treatment andbending of low-E glass. *Thin Solid Films*, *351*(1-2), 264-273.

Olubunmi, O. A., Xia, P. B., & Skitmore, M.(2016). Green building incentives: A review. *Renewable and Sustainable Energy Reviews*, *59*, 1611-1621.

Pabiou, H., Salort, J., Ménézo, C., & Chillà, F. (2015). Natural cross-ventilation of buildings, an experimental study. *Energy Procedia*, *78*, 2911-2916.

Rahman, A. (2017). Recent advances in modelling and implementation of rainwater harvesting systems towards sustainable development. *Water*, *9*(12), 959.

Thomas, M. D. A. (2007). *Optimizing the use of fly ash in concrete* (Vol. 5420). Skokie, IL, USA: Portland Cement Association.

Wong, N. H., & Heryanto, S. (2004). The study of active stack effect to enhance natural ventilation using wind tunnel and computational fluid dynamics (CFD) simulations. *Energy and Buildings*, *36*(7), 668-678.