

# Chapter 18

## Passive Design Strategies of Colonial Mosques in Malaysia



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### Introduction

Malaysia is a multi-religion country but Muslims are the highest percentage among the population. Therefore, mosques are found in every rural and urban area, varying in sizes and architecture styles. It is a religious institutional building where Muslims perform their prayers and gather for social activities and religious education. Many mosques in Malaysia have significant aesthetic value in their design, and some had become an icon or a landmark to the respective city or state [1]. Despite having built for the same function and purpose, mosques design in Malaysia comes in different architectural styles. The most significant architecture styles are vernacular, colonial, and modern. Vernacular style mosques were influenced by their tradition and regional culture. Meanwhile, colonial style mosques were influenced by Moorish architecture with classical features. Some of them also portray Art-Deco influence. Modern style mosques were influenced by the modern and innovative structures and constructions [2].

Malaysia architecture styles developed over different eras (Table 18.1). However, although the building designs adopted the architectural styles of their eras, most were designed in response to its context and Malaysian climate.

Colonial architecture styles came in during the British occupancy, which influenced the building designs built between eighteenth and twentieth centuries. There are various building typologies, such as colonial schools, shop houses, and mosques. Sanusi et al. (2019) carried out a study on colonial style school buildings. It concluded that colonial style school buildings were designed and built with Malaysian climatic adaptation, which responded well with its context and microclimate [4]. Therefore, this study is intended to study the passive design strategies of three royal colonial mosques in Malaysia, namely, Ubudiah Royal Mosque, Perak

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**Table 18.1** Architecture styles in Malaysia over different eras [3]

Architectural styles	Eras
Indian Kingdoms	Seventeenth to fourteenth centuries
Traditional Malay Vernacular	Pre-fifteenth century until present
Straits Eclectics	Fifteenth to mid-twentieth centuries
Chinese Baroque	Nineteenth to early twentieth centuries
Colonial	Eighteenth to twentieth centuries
Modern	1950s until present

**Fig. 18.1** Ubudiah Royal Mosque, Perak**Fig. 18.2** Pasir Pelangi Royal Mosque, Johor

(Fig. 18.1), Pasir Pelangi Royal Mosque, Johor (Fig. 18.2), and Sultan Ibrahim Jamek Mosque, Johor (Fig. 18.3). Johor is in the Southern part and Perak is in the Northern part of Malaysia.

The study comprises two objectives. Firstly, to identify the passive design elements found in three case studies of royal colonial mosques in Malaysia. Secondly, the objective is to evaluate the significance and effectiveness of the passive design strategies adopted by colonial style mosques in Malaysia.

**Fig. 18.3** Sultan Ibrahim Jamek Mosque, Johor



## Royal Colonial Mosques in Malaysia

Among the colonial mosques, which were built between the eighteenth and twentieth centuries, there are some that were built as royal colonial mosques. Figure 18.4 shows the images of colonial mosques in Malaysia, built during the Colonial era.

Most of the colonial style mosques were designed and supervised by British architects who were working in the Public Works Department (JKR). Colonial style mosques differ from vernacular style in its form, scale and proportion and building materials. The designers intended to portray Islamic image onto the mosques by combining Moorish architecture with Classical architecture. Some of the common features found in colonial mosques are the onion or top-shaped domes, classical columns, pilasters, verandahs, and pointed arches. Towards the end of the era, Art-Deco design was implemented in Sultan Sulaiman Mosque (1932) and Jamek Mosque in Johor (1938). The square facades reflect its Art-Deco influence (Fig. 18.4) [2]. However, as stated earlier, this study limits its scope to three case studies: Ubudiah Royal Mosque, Perak, Pasir Pelangi Royal Mosque, Johor, and Sultan Ibrahim Jamek Mosque, Johor.

### *Ubudiah Royal Mosque, Kuala Kangsar, Perak*

Ubudiah Royal Mosque was built in 1912 within the proximity of the Perak state royal palace. Therefore, its physical appearance became a symbol of grandeur and sovereignty at the same time and reflects variety of influences to its design. It was influenced by an eclectic style of architecture, a style that incorporates at least two architectural styles in a single piece of work [5]. It may be a mixture from the previous historical styles which eventually creates an adaptive architectural style that is new and original. Throughout the years up to today, Ubudiah Royal Mosque has experienced renovation and expansion works, but the colonial character of the



Fig. 18.4 The timeline of Colonial Style Mosques era

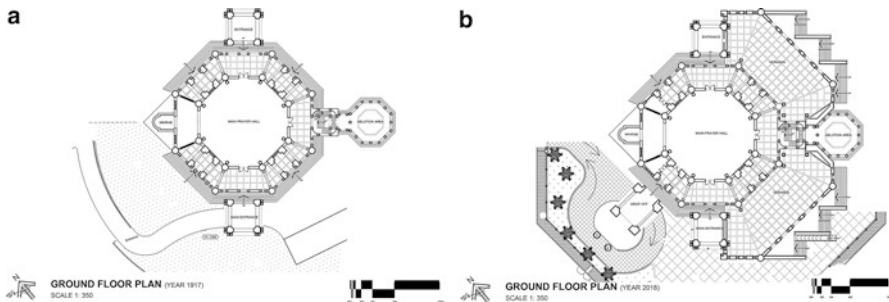


Fig. 18.5 Floor plans of Ubudiah Royal Mosque in 1917 and current [6]. (a) Ubudiah Royal Mosque floor plan in 1917. (b) Current condition of Ubudiah Royal Mosque

mosque remains intact. Some features had been added to increase the level of comfort and convenience of the people (Fig. 18.5) [6].

Æsthetically, Ubudiah Royal Mosque adopted Moorish and Mughal-Gothic designs as its primary architectural styles [2]. The architectural style that was implemented in the design of Ubudiah Royal Mosque can be seen in many of its elements. This includes the doors, windows, decoration, and ornamentation. Figure 18.6 shows the exterior view of the mosque, with the domes placed above the main prayer area, and Fig. 18.7 shows the interior view of the mosque.

**Fig. 18.6** Ubudiah Royal Mosque



**Fig. 18.7** Interior view of Ubudiah Royal Mosque main prayer hall



### *Pasir Pelangi Royal Mosque, Johor Bahru, Johor*

Pasir Pelangi Royal Mosque is one of the mosques that was built with prominent colonial style, yet adapting the vernacular passive design strategies for tropical climate. Located at Jalan Pasir Pelangi, Johor Bahru, Malaysia, Pasir Pelangi Royal Mosque was built in 1920, initially to serve the Muslim Chinese, Indian, and Javanese workers who worked for the Sultan of Johor. Currently, the mosque is still used by the royal families of Johor and the people living around the area. The masjid could accommodate about two thousand (2000) worshippers at a time [7].

Throughout more than a century of its life, Pasir Pelangi Royal Mosque has experienced numerous renovation and expansion works, but the colonial character of the mosque remains intact. The architecture of Pasir Pelangi Royal Mosque has unique features of colonial architecture, where there are apparent amalgamation of the neo-classical architecture and the Malay vernacular architecture. The Mosque is a single-story building and has a rectangular plan shape. The uniqueness of Pasir Pelangi Royal Mosque could be seen in the façade design, the arches design, the ornamentation, and the special colonial features of its single Minaret. Figure 18.8 shows the



**Fig. 18.8** Pasir Pelangi Royal Mosque



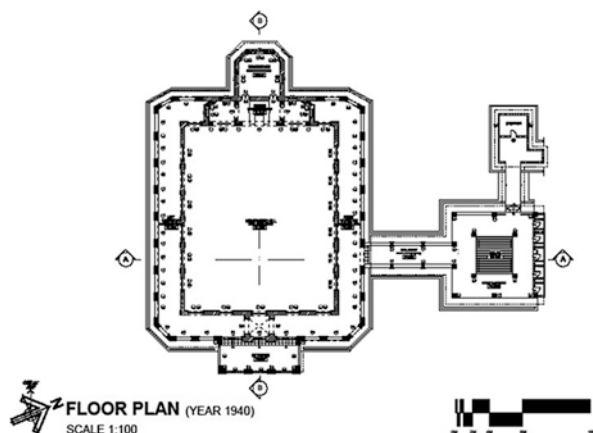
**Fig. 18.9** Pasir Pelangi Royal Mosque's interior view

exterior view of the mosque, with the single minaret placed at the frontage, and Fig. 18.9 shows the interior view of the mosque. The mosque has a simple floor plan that can hold a congregational prayer at any prayers time (Fig. 18.10).

### ***Sultan Ibrahim Jamek Mosque, Muar, Johor***

The construction of Sultan Ibrahim Jamek Mosque commenced in 1925 and completed in 1930. Sultan Ibrahim Jamek Mosque is a historical mosque in a small town named Muar in Johor, Southern state of Malaysia. The mosque is situated along the Muar River. Originally, it was a vernacular style timber mosque named Jamek

**Fig. 18.10** Floor plan of Pasir Pelangi Royal Mosque [7]



Mosque Muar. The timber Jamek Mosque completed its construction in 1884 and can hold up to a maximum of 50 people at one time. Through time, with the increase of number of visitors, it could no longer afford to hold such regular congregation. In the 1920s, a committee was formed to consider building a new Jamek Mosque for Muar, which is the Sultan Ibrahim Jamek Mosque [8].

Following a bid to raise funds from the public, the committee in charge of building the new mosque successfully raised RM10,000 for the said purpose. The committee then put forward the people's aspiration to the Sultan and obtained the royal consent. The cost to build this mosque had been sponsored by the state Government of Johor and the *Khairat* members of Johor Darul Takzim.

Sultan Ibrahim Jamek Mosque was first named as Jamek Mosque Muar, and also the oldest mosque located in Muar. The mosque was regularly visited by royal visitors and local people. Studying the mosque provides further understanding on the culture and environment of the royalty and locality during its period.

The uniqueness of this building is visibly seen from the minaret, which highlights the symmetrical architectural composition of the east and west. Classical Revival column with order are used on the interior and exterior of the mosque.

The significance of Sultan Ibrahim Jamek Mosque is that it was designed and built within the era of British rule. It is one of the major landmarks for the Royal Town of Muar, Johor. Its design was majorly influenced by the hybrid British Colonial and Malay architecture—a mixture of English Victorian style from the Classical Revival period, Malay and Moorish design features to suit the Malaysian climate. Its neo-classical design influence also includes Palladian and Byzantine elements. Figure 18.11 shows the exterior view of the mosque and Fig. 18.12 shows the interior view of the mosque. Similar to Pasir Pelangi Royal Mosque, Sultan Ibrahim Jamek Mosque has a rather simple floor plan that is also longitudinal shape (Fig. 18.13).



**Fig. 18.11** Sultan Ibrahim Jamek Mosque

**Fig. 18.12** Sultan Ibrahim Jamek Mosque's interior view



## **An Overview of Passive Design Strategies in Malaysia**

According to Malaysian Standard MS1525:2014, the fundamental approach towards good passive design is to shade the building from intense solar radiation, to insulate from solar heat gain, to ventilate indoor environment, and to provide adequate daylight into the buildings. Malaysian Standard MS1525:2014 is a Code of Practice on Energy Efficiency and use of Renewable Energy for Non-Residential Buildings.



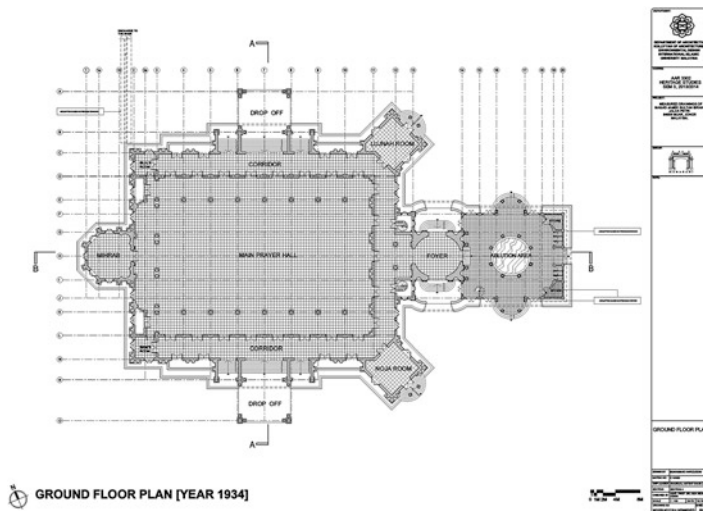


Fig. 18.13 Floor plan of Sultan Ibrahim Jamek Mosque, Muar, Johor [8]

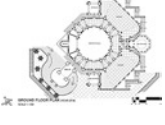
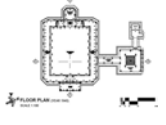
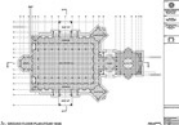





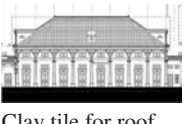
Table 18.2 Passive design strategies of MS1525:2014 and Carl Mahoney [11]

Passive design strategies	
MS1525:2014	Carl Mahoney
1. Site planning and orientation, preferably long axis facing North and South	1. Building layout and orientation
2. Daylighting	2. Spacial arrangement
3. Façade design	3. Air movement
4. Natural ventilation	4. Opeing size
5. Thermal insulation	5. Opeing position
6. Strategic landscaping	6. Protection of opening
7. Renewable energy	7. Wall and floor materials
	8. Roof design
	9. External building features

Therefore it is very much related to the case study buildings. MS1525:2014 stated seven significant factors to be considered in passive design, which are site planning and orientation, daylighting, façade design, natural ventilation, thermal insulation, strategic landscaping, and renewable energy [9].

Carl Mahoney has listed nine recommendations for passive design strategies for buildings in hot and humid climate [10]. They are in the aspects of layout, spacing, air movement, opening size, opening position, protection of opening, wall and floor materials, roofs, and external building features. In summary, both MS1525:2014 and Carl Mahoney passive design strategies are shown in Table 18.2. Table 18.2 was utilized to form Table 18.3 that indicates the passive design strategies adopted by the three case studies of colonial mosques in Malaysia.

**Table 18.3** The mosques' compliances of tropical passive design strategies

No.	Requirement of passive design strategies in tropical countries	Compliances		
		Ubudiah Royal Mosque	Pasir Pelangi Royal Mosque	Sultan Ibrahim Jamek Mosque
1	Layout • Orientation North and South (long axis east–west)	× 	✓ 	✓ 
2	Spacing • Open spacing for breezes	✓	✓	✓
3	Air movement • Single banked room for permanent air movement	✓	✓	✓
4	Opening sizes • Large opening, with 50–80% of facades	✓	✓	✓
5	Opening position • In North and South walls • At body height	✓ ✓	✓ ✓	✓ ✓
6	Protection of openings • Full permanent shading • Verandah	✓ 	✓ 	✓ 
7	Walls and floor • Light and low capacity materials	× Thick masonry walls	× Thick masonry walls	× Thick masonry walls
8	Roofs • Light and low capacity materials	×  Concrete roof dome	✓  Clay tile for roof	✓  Clay tile for roof

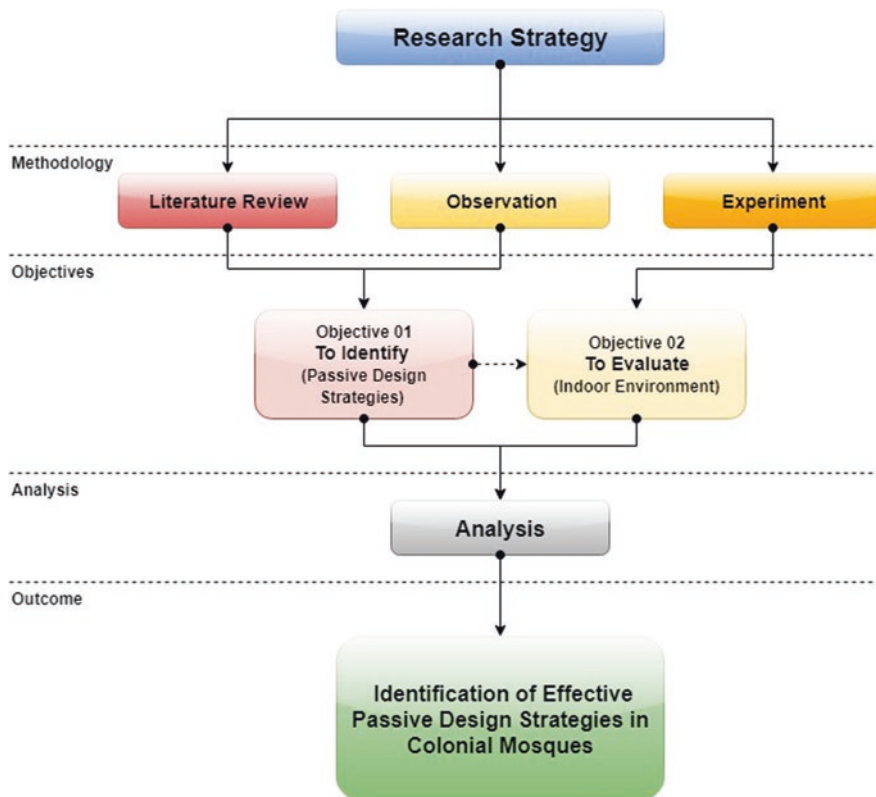


Fig. 18.14 Methodology chart

## Methodology

In order to achieve the two objectives, the study was carried out according to the following methodology structure (Fig. 18.14). The methodology comprises literature review of passive design strategies and colonial style mosques in Malaysia, observation of the three case studies of royal colonial mosques, and experiment on the airflow and indoor air temperature of the three case study mosques, Ubudiah Royal Mosque, Pasir Pelangi Royal Mosque, and Sultan Ibrahim Jamek Mosque.

## Identification of the Passive Design Elements

Tropical climate requires Malaysian buildings to have passive design strategies, including for those mosques that were built using the colonial style. This study identifies the passive design elements found in the three case studies. Table 18.3 shows the

mosques' compliance to the requirement of passive design strategies in tropical region, based on the summary of MS1525:2014 and Carl Mahoney's design recommendation for hot humid climate of Malaysia.

Based on observatory analysis, the design of Pasir Pelangi Royal Mosque and Sultan Ibrahim Jamek Mosque have complied seven out of eight of Mahoney's bioclimatic design and MS1525:2014 recommendation. For item number 7 in Table 18.3, the design of Pasir Pelangi Royal Mosque and Sultan Ibrahim Jamek Mosque do not have light and low capacity materials for walls simply because both mosques was designed with colonial style, that is characterized with the appearance of thick plaster brick walls. Nevertheless, this issue of noncompliance to the requirement has been well adjusted with the provision of large openings on three sides of the masjid's walls that provides continuous cross ventilation for cooling effect.

However, Ubudiah Royal Mosque has only complied five out of eight of Mahoney's bioclimatic design and MS1525:2014 recommendation. Similar to the other two case studies, Ubudiah Royal Mosque also does not have light and low capacity materials for walls due to colonial style design. Nevertheless, this issue of noncompliance has been also well adjusted with the provision of verandah and more than 50% openings to walls percentage. Apart from that, Ubudiah Royal Mosque does not have a façade on the North and South. This was resolved by having verandah all around the main prayer hall (Table 18.3, item no. 1).

## Evaluation of Indoor Environment

This study evaluates the indoor air temperature and air ventilation of the main prayer hall. The experiments were carried with intention to find the effective passive design strategies adopted in the design of the three royal colonial mosques, Ubudiah Royal Mosque, Pasir Pelangi Royal Mosque, and Sultan Ibrahim Jamek Mosque. The experiments were carried out using Autodesk Flow Design and Autodesk Ecotect computer software.

### *Indoor Air Temperature of the Mosques*

Indoor air temperature was obtained from computer modeling simulation. There are three measurements for each mosque: outdoor, main prayer hall, and verandah. The date was set to 23rd of March, one of the warmest day of the year. The outdoor DBT was obtained from the Meteorology Department [12]. The outdoor temperature on the 23rd of March ranges from 25.4 to 34.4 °C.

The average temperature of Ubudiah Mosque Verandah ranges from 27.4 to 34.0 °C. There is not much temperature reduction in the Ubudiah Mosque verandah. However, the indoor temperature of Ubudiah Mosque prayer hall ranges from 27.2 to 31.1 °C. There is a temperature reduction of up to 3.4 °C from the outdoor to its prayer hall (Fig. 18.15).

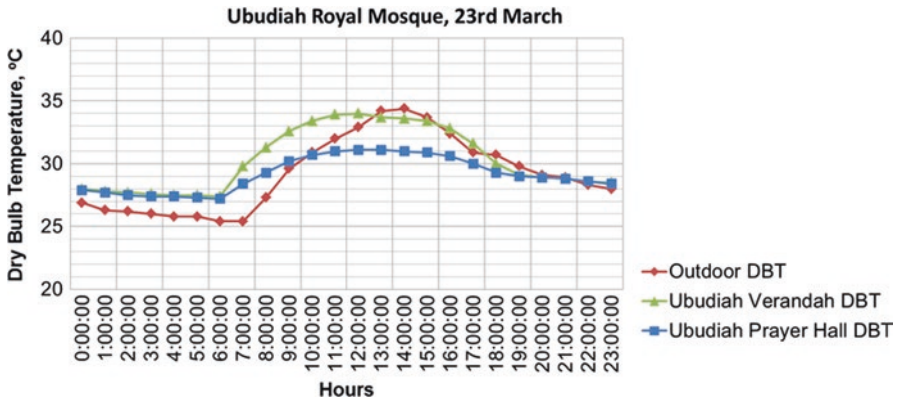


Fig. 18.15 Dry bulb temperature of Ubudiah Royal Mosque during the warm and dry season

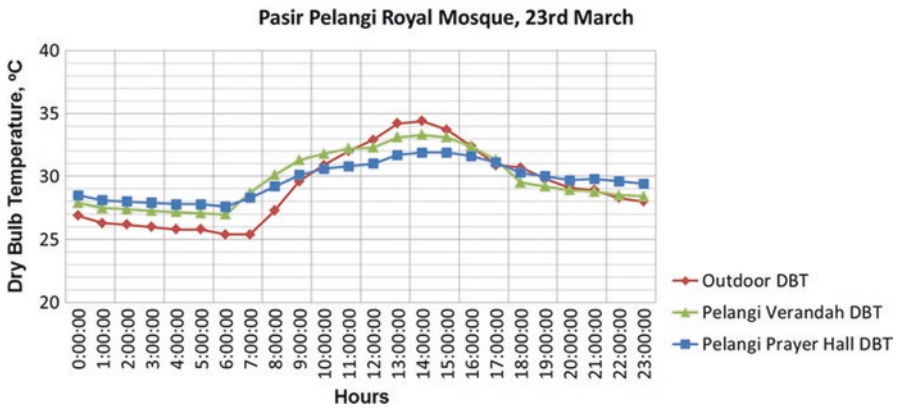


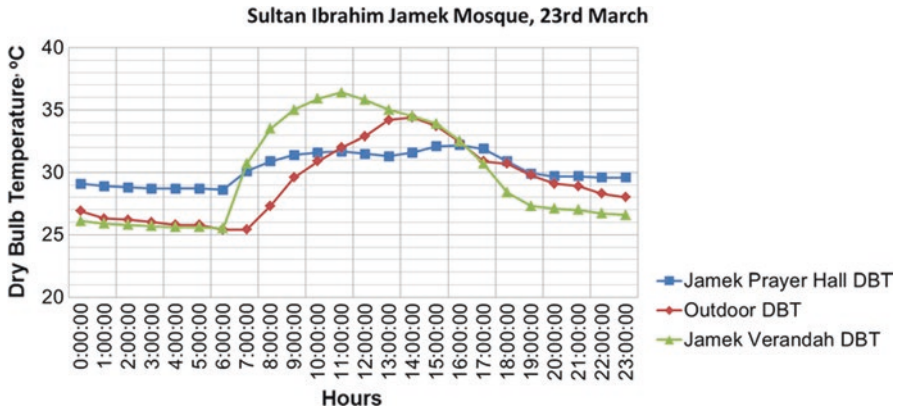
Fig. 18.16 Dry bulb temperature of Pasir Pelangi Royal Mosque during the warm and dry season

The average temperature at the verandah of Pasir Pelangi Mosque ranges from 27.0 to 33.3 °C. There is only up to 1.2 °C of temperature reduction at the verandah. Meanwhile, the indoor temperature of Pasir Pelangi Mosque prayer hall ranges from 27.6 to 31.9 °C. There is a temperature reduction of up to 2.5 °C from the outdoor to its prayer hall, which is slightly less than the prayer hall of Ubudiah Mosque (Fig. 18.16).

The average temperature at the verandah of Sultan Ibrahim Jamek Mosque ranges from 25.5 to 36.4 °C. There is an increment of temperature at the verandah. Meanwhile, the indoor temperature of Sultan Ibrahim Jamek Mosque prayer hall ranges from 28.6 to 32.5 °C. There is a temperature reduction of up to 2.9 °C from the outdoor to its prayer hall, which is quite significant (Fig. 18.17).

The result shows that the verandahs in all the three mosques are warmer than the indoor prayer halls. This shows that the verandah acted as protection to the indoor prayer hall from the outdoor air and solar radiation. Therefore, verandah is a significant and effective passive design strategy.





**Fig. 18.17** Dry bulb temperature of Sultan Ibrahim Jamek Mosque during the warm and dry season

The results show that the Ubudiah Royal Mosque prayer hall has the most temperature reduction from the outdoor air temperature, as compared to the other two mosques. Ubudiah Royal Mosque differs from Pasir Pelangi and Sultan Ibrahim Jamek Mosque in terms of the roof design. Ubudiah Royal Mosque has a dome, which provides a larger roof space above the prayer hall ceiling. The air gap gives insulation to the roof space and reduces solar radiation penetration into the prayer hall.

### *Airflow Through the Mosques*

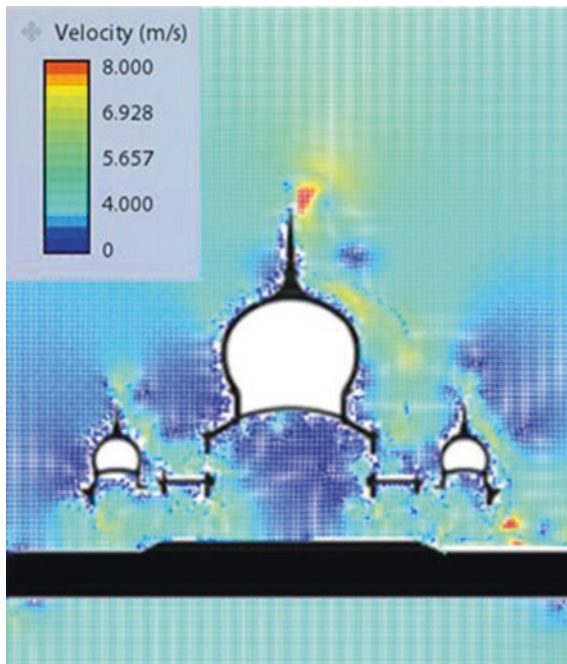
Figure 18.18 shows the simulation of airflow through the interior of Ubudiah Royal Mosque. A stacked effect occurred at the higher openings on the left and right of the prayer hall. Figure 18.18 shows that the prayer hall is adequately ventilated by cross ventilation and stack effect. However, the center part of the prayer hall has less airflow. The airflow could be increased with the help of a mechanical fan.

### **Conclusion**

The first objective is to identify passive design strategies of royal colonial mosques. There are five passive design strategies that were adopted by all three mosques. They are (1) open spatial layout, (2) permanent air movement through cross ventilation, (3) more than 50% of openings to walls area, (4) different positions of openings from the low level to the ceiling level, and (5) verandah for full protection of openings.

The second objective is to evaluate the significant and effectiveness of the passive design strategies adopted by all the three royal colonial mosques. From the findings,

**Fig. 18.18** Airflow through the interior of Ubudiah Royal Mosque















this study concluded that the most significant and effective passive design strategy of the royal colonial mosques is the verandah. The air temperature of the main prayer hall was reduced less than the air temperature in the verandah. The verandah became a permanent shading element for the main prayer hall of the mosques.

Secondly, the large openings are also significant and effective. In addition to the passive design strategies listed in Table 18.3, this study finds that the volume of roof space above the ceiling can also be a significant and effective passive design strategy adopted by the mosques. Despite noncompliance of the first passive design strategy, which is building orientation, Ubudiah Royal Mosque has the lowest maximum air temperature. This was because of the large roof space above the main prayer hall ceiling, which was created by the dome. The dome protects the main prayer hall from solar radiation transmission. Therefore, the introduction of dome or a large roof space is a significant and effective passive design strategy for cooling the indoor space of colonial mosques in Malaysia Table 18.4.

## Recommendation

Further study should be carried out in evaluating the passive design strategies in other colonial mosques in Malaysia to support the current findings.

**Table 18.4** Passive design strategies requirement

Passive Design Strategies Requirement by MS1525:2014	Passive Design Strategies in Ubudiah Mosque	Passive Design Strategies in Pasir Pelangi Royal Mosque	Passive Design Strategies in Sultan Ibrahim Jamek Mosque
1. Site planning and orientation, preferably long axis facing North and South	 Longer façade facing NS and prevailing wind	 Longer façade facing NS and prevailing wind	 Longer façade facing NS and prevailing wind
2. Daylighting	 Low and high level openings provide natural daylight	 Series of door openings provide natural daylight	 Low and high level openings provide natural daylight
3. Façade design – Verandah	 Verandah protects from solar heat gains	 Verandah protects from solar heat gains	 Verandah protects from solar heat gains
4. Natural ventilation	More than 50% openings to wall area	More than 50% openings to wall area	More than 50% openings to wall area
5. Thermal insulation	Thick masonry walls	Thick masonry walls	Thick masonry walls
6. Roof design	 The dome creates a large air gap above the ceiling	 Pitch roof creates an air gap above ceiling	 Pitch roof creates an air gap above ceiling

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