

# A Review on the Roofs' Design Influencing the Physical Environment in the Naturally Ventilated of Mosque Buildings

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Received: 08-05-2023

Revised: 22-05-2023

Accepted: 10-06-2023

## ABSTRACT

The modern pitch and domed roofs design of the Malaysian mosques was created as a symbolic of Muslim place of worship besides functioning as a filter to the outdoor climate. Malaysia is a country that is famous for the high air temperature and relative humidity and inconsistent air movement of local climate which can influence the indoor environment. The different roof designs of Malaysian mosques also give impact to the believers in conducting prayers and other activities inside the mosques. Therefore, this study is to investigate the difference of roof design that influenced the thermal comfort and believers' convenience in the mosque's building. It was found that the traditional roof design of mosques in Malaysia was the pitched roof with two and three-stacked mosques whereas most of the modern roof design was the domed roof. Both the pitched and domed roof of the mosque's design had the ability to control the indoor air distribution inside the mosque building. The pitch roof had the ability to control the circulation of the indoor air movement to achieve the equilibrium state whereas the domed roof could stratify the outdoor cool air to replace the hot indoor air inside the mosque building. Therefore, the future researcher could focus more strategies in order to improve the roof design of mosque for better indoor air inside the mosque building.

**Keywords**— Domed Roof, Indoor Air, Mosque, Pitch Roof

## I. INTRODUCTION

The external environment such as from the climate is the factor that influenced the internal load in the mosque's building (Azmi et al., 2021). Nowadays, most of the naturally ventilated mosques have been converted to the air-conditioned mosques (Hussin et al., 2018a) because the passive design strategies cannot be achieved alone in order to ensure better thermal comfort (Mushtaha and Helmy, 2017). Although this is the fastest action which could cool down the buildings, it could have a bad effect on the environment. Roof design is the major contribution of the energy consumption from the air-conditioned mosques building in Malaysia (Mohamed et al., 2022).

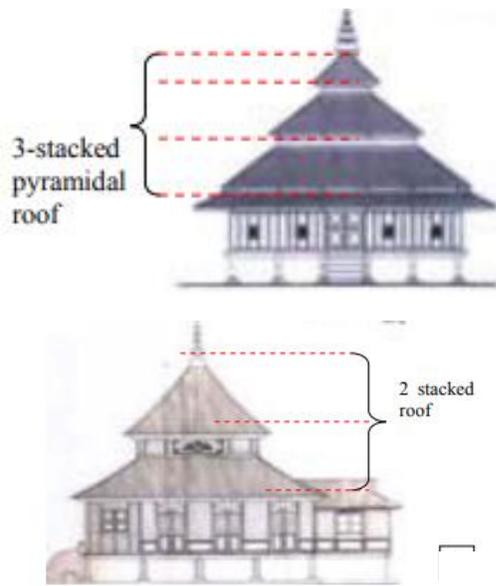
Mosque is one of the exclusive buildings because all the mosques orientated worldwide were designed facing the Qiblah (the Kaabah's direction in Mekkah). Meanwhile, the architecture of the mosque's building was different (Bakhlah & Hassan, 2012) and mostly influenced by the culture. According to Ahmad (1999), the Islamic revolution of mosque's architecture was categorized to the vernacular, colonial, and modern. The mosque's construction is one of the proofs of the admission of Islam in Islamic communities (Yan et al., 2015). The roof is one of the external buildings that is very important to focus because it would determine the thermal performance of the mosques. It included the design of the roof, the materials of the roof, the insulation of the roof, the shading and solar absorptance of the roof (Azmi, 2021).

## II. LITERATURE REVIEW

*The roofs design of mosques building in Malaysia.*

### a) *The traditional roof design of mosques in Malaysia*

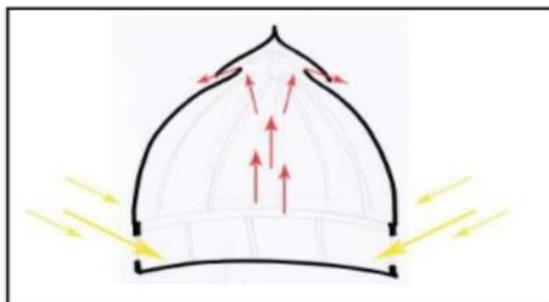
Previously, most of the roof design of old mosques in Malaysia had been influenced by traditional Malay architecture. The traditional mosque building was built typically following the pitched roof style or known as pyramidal roof mosque. It is also shown as symbolic of life and environment (Johar et al., 2011; Hassan & Nawawi, 2014). In between the 16th and 17th century, there was detected for three-stacked pyramidal roof design in the Kampung Laut (the oldest mosque in Malaysia) whereas in the between 18th and 19th century there was detected for two-stacked pyramidal roof design in Papan Mosque in Perak and Lenggeng Mosque in Negeri Sembilan (Johar et al., 2011). The three and two-stacked pyramidal roof designs of mosques have the same constructions but with different layers of roof. Figure 1 shows the example of mosques with three and two-stacked pyramidal mosques.



**Figure 1:** The traditional roof design of a mosque with three-stacked and two-stacked pyramidal roofs in Malaysia (Johar et al., 2011)

**b) The modern roof design of mosques in Malaysia**

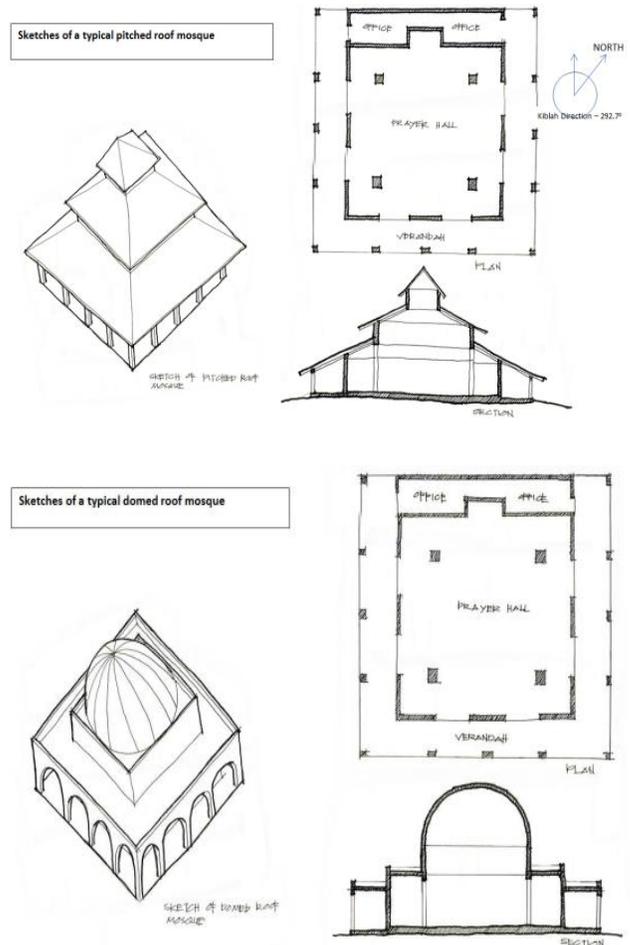
The domed roof style was popular in the modern mosques building over the time. The domed roof design was also popular in the mosques throughout the world. The domed roof style in Malaysia is suitable for tropical climate change as it has advantages to allow rainwater flow and to minimize the heat gain in the mosque's building (Asfour, 2009; Hameed, 2011; Hadavand et al, 2008; Baharudin and Ismail, 2014). The 3 meters high dome with the propeller fan and small openings on the top and sides is functioning to cool down the indoor air temperature inside the mosque's building. Figure 2 shows the example of the domed roof of a mosque with stack ventilation effect (Baharudin and Ismail, 2014). However, according to Maarof (2014), the process of development of the domed roof from the traditional pitched roof mosques had taken many levels.



**Figure 2:** The domed roof of mosque with stack ventilation effect (Baharudin and Ismail, 2014)

**c) The illustration of pyramidal and domed roof design style in Malaysia**

Figure 3 illustrates the typical sketch of pitched and domed roof design style with the position of the main prayer hall, office and verandah in Malaysia. The pitched roof design had been built in the 1990 in the past whereas the domed roof design in the 1999 and over the time. Table 1 shows the example of roof design categories of mosques that use pitched and domed style.



**Figure 3:** The typical sketch of pitched and domed roof design style in Malaysia (Maarof, 2014).

**Table 1:** The example of roofs design mosques that using pitched and domed style in Malaysia (Maarof, 2014)

No.	Name of the mosque	Description	The picture of the mosque
<b>The category of the roof: Pitched Roof</b>			
1.	Masjid Al-Azim, Melaka	- A state mosque of Melaka -Officially opened in 1990 -Can occupy up to 11,700 people	
<b>The category of the roof: Domed Roof</b>			
2.	Masjid Putra, Putrajaya	- A state mosque -Completed in 1999 -Can occupy up to 10,000 people	
3.	Masjid Tuanku Mizan, Putrajaya	- A state mosque -Completed in September 2009 -Can occupy up to 20,000 people	
4.	Masjid Kariah Panchur Jaya, Negeri Sembilan	- A community mosque -Completed in 2007 -Can occupy up to 1000 people	
5.	Masjid At Taqwa, Paroi, Negeri Sembilan	- A community mosque -Completed in 2011 -Can occupy up to 1000 people	

**The roofs design of mosques building in the Worldwide.**

Table 2 shows some of the examples of roof design mosques worldwide (i.e., Herzegovina, Jordan, Germany, Paris, and China). Most of the roof design style of the mosque was domed and others were pyramidal and influenced by Moorish architecture.

**Table 2:** The example of roofs design style of mosques worldwide

No.	Name of the mosque	The category of the roof /Picture	Authors
<b>Country: Mostar, Bosnia Herzegovina</b>			
1.	-Karadjoz Beg mosque - Was built in 1557	Single pendentive dome 	Hassan & Arab, (2013)
<b>Country: Mostar, Bosnia Herzegovina</b>			
2.	-Neziraga mosque - was built in 1550	Single pyramid roof 	Hassan & Arab, (2013)
<b>Country: Jordan</b>			
3.	Qasr Amra;	Domed 	Moustafa, (2018)
<b>Country: Germany</b>			
4.	- Imam Ali mosque, -built between 1960 and 1973	Domed 	Farrag, (2017)
<b>Country: Paris</b>			
5.	Grand mosque	Moorish architecture 	Farrag, (2017)

Country: China			
6.	Mosque of Gurun, Zhenjiang, Jiangsu	Domed	Ma, (2021)
			
Country: China			
7.	West Shanghai Mosque, Shanghai	Domed	Ma, (2021)
			

### III. REVIEW METHODOLOGY

An extensive literature search was carried out using Web of Science, Scopus, and Google Scholar databases in order to obtain literature pertaining to roof design of mosque building toward the indoor environment.

### IV. CONCLUSIONS

In conclusion, most of the traditional roof design was influenced by the origin of the place which was symbolic of life and environment. As in Malaysia the roof design was influenced by the traditional Malay architecture. The traditional pitched roof style of mosque or known as pyramidal roof mosque with three-stacked and two-stacked pyramidal roofs in Malaysia was detected since in between the 16th and 17th century and in the between 18th and 19th century, respectively. Meanwhile, most of the modern mosques in Malaysia and worldwide was influenced by the domed roof design which has the advantages which could allow the rainwater flow and minimize the heat gain in the mosque's building and suitable for the tropical climate.

### FUNDING

This study was funded by EACAR, USM.

### REFERENCES

[1] Yong Yan, Y. II., Utaberta, N., Mohd Yunus, M. Y., Ismail, N. A., Ismail, S. & Mohd Ariffin, N. F. (2015). An analysis of traditional mosques in relation to the contemporary practices of

Malaysia. *Research Journal of Fisheries and Hydrobiology*, 10(14), 42-46.

[2] Azmi, N. A. (2021). Establishing design parameters for thermal comfort in mosques of Malaysia (Unpublished Master's thesis). *Master of Engineering, Universiti Malaysia Sarawak*.

[3] Azmi, N. A., Arıcı, M. & Baharun, A. (2021). A review on the factors influencing energy efficiency of mosque buildings. *Journal of Cleaner Production*, 292, 1-52.

[4] Baharudin, N. A. & Ismail, A. S. (2014). Communal Mosques: Design functionality towards the development of sustainability for community. *Procedia-Social and Behavioral Sciences*, 153, 106-120.

[5] Bakhlah, M. S. & Hassan, A. S. (2012). The study of air temperature when the sun path direction to Ka'abah: with a case study of Al-Malik Khalid Mosque, Malaysia. *International Transaction Journal of Engineering, Management & Applied Sciences & Technologies*, 3(2), 185-202.

[6] Hassan, A. S. & Arab, Y. (2013). Analysis of lighting performance between single dome and pyramid roof mosque in Mostar, Bosnia Herzegovina. *Procedia-Social and Behavioral Sciences*, 91, 1-12.

[7] Hassan, A. S. & Nawawi, M. S. A. (2014). Malay architectural heritage on timber construction technique of the traditional Kampung Laut old mosque, Malaysia. *Asian Social Science*, 10(8), 230.

[8] Johar, S., Che-Ani, A. I., Tawil, N. M., Tahir, M. M., Abdullah, N. & Ahmad, A. G. (2011). Key conservation principles of old traditional mosque in Malaysia. *WSEAS Transactions on Environment and Development*, 7(4), 93-102.

[9] Maarof, S. (2014). Roof designs and affecting thermal comfort factors in a typical naturally ventilated Malaysian mosque. (*Doctoral dissertation, Cardiff University*).

[10] Moustafa, W. S., Hegazy, I. R. & Eldabousy, M. M. (2018). Roof geometry as a factor of thermal behavior: simulation-based study of using vaults and domes in the Middle East zone. *International Journal of Low-Carbon Technologies*, 13(3), 204-211.