

CLIMATE-RESPONSIVENESS EMBODIED IN MODERN MOSQUE DESIGN

Era Nopera Rauzi*, Izziah Hasan*, Laina Hilma Sari*

*Department of Architecture, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh, Indonesia,
era.rauzi@unsyiah.ac.id, izziah.hasan@unsyiah.ac.id, laina_hilma@unsyiah.ac.id

Email correspondent: era.rauzi@unsyiah.ac.id

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Abstract: A mosque is a place of worship for Muslims. Modernity concept to visualize the simple form in a mosque is relevant, which would help the worshippers to be more solemn. Office buildings, mainly located in Aceh, known as Serambi Mekkah, are required to provide a mosque in the office environment. Since its concept transforms from traditional style to modern style, the mosque in the office area is designed in modernity. The study purposes of enabling climate-responsive principles in mosque design for achieving indoor thermal comfort. Even though without available power support. The design method approached problem-solving by creating the building friendly to the environment and achieving indoor thermal comfort. This study used trial and error through modeling appropriate to climate-responsiveness mosque design in the office area. Furthermore, this study would be continued in complex buildings, namely schools and offices, promoting environmentally-friendly to be applied in building design.

Keywords: Mosque design; Modernity; Climate responsiveness; Environmentally-friendly building design.

Abstrak: Masjid adalah tempat ibadah bagi umat Islam. Konsep modernitas untuk memvisualisasikan bentuk sederhana di masjid adalah relevan, yang akan membantu jamaah untuk lebih khusyuk. Gedung perkantoran khususnya yang berada di Aceh yang dikenal dengan Serambi Mekkah wajib menyediakan mushola di lingkungan kantor. Karena konsepnya bertransformasi dari gaya tradisional ke gaya modern, masjid di area perkantoran juga didesain dengan gaya modern. Tujuan studi ini adalah untuk mengaktifkan prinsip responsif iklim dalam desain masjid untuk mencapai kenyamanan termal dalam ruangan meskipun tanpa dukungan daya yang tersedia. Metode desain pada studi ini menggunakan pendekatan pemecahan masalah untuk menciptakan bangunan ramah lingkungan dan mencapai kenyamanan termal dalam ruangan. Penelitian ini menggunakan metode *trial and error* melalui pemodelan yang sesuai dengan desain masjid yang responsif terhadap iklim di kawasan perkantoran. Selanjutnya studi ini akan dilanjutkan penerapannya pada bangunan kompleks seperti sekolah dan perkantoran untuk mempromosikan desain bangunan ramah lingkungan.

Kata kunci: Desain masjid; Modern; Responsivitas iklim; Desain bangunan ramah lingkungan.

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Introduction

A climate-responsive building utilizes the most effective climatic elements (air temperature, relative humidity, wind, irradiation, and rainfall) to diminish energy use for heating and cooling (Lamsal, Prativa; Bajracharya, Sushil; Rijal, Hom, 2021). Climate responsive building design is a way to have a naturally thermal-comfort living. This strategy is also practically proved to create a less energy-use building that is useful to the environment. In the tropics, the adaptive climate building works to maximize the building performance to invite the airflow to the buildings to reduce the high relative humidity and flow out the high air temperature from inside. This is challenging because the outside air temperature gradually rises due to climate change and the more built environment, which causes fewer greeneries. Therefore, it is common to have many modern buildings in the tropics constructed with an air conditioner to give a maximally cool indoor environment. The air-conditioned building has a very contrasting character to the natural ventilated building. The buildings are designed with fewer apertures to maximize the air conditioner works to cool down the buildings. A low-energy environmental solution often uses natural ventilation to improve indoor thermal comfort in buildings (Nguyen and Reiter, 2011), as shown in figure 1. A low ceiling is also recommended in an air-conditioned building to minimize the room volume for being cooled maximally by the AC. Vice versa, the naturally-ventilated building, is designed with a high ceiling and is rich in ventilations.

It is common for many offices or public buildings to have a small mosque in Muslim countries. The office mosques with limited space and land are frequently designed to be equipped with AC. This study investigates the possibility of applying the climatic building design to the modern mosque in an office environment. In this case, a small-mosque-in office environment located in Banda Aceh, Indonesia, is studied as a representative of the tropics.



Figure 1. Different ceiling configurations in buildings. Source: (Nguyen and Reiter, 2011)

Climatic Building Design In Tropics

A simple architectural type that is responsive to the context of microclimate is categorized as designers' inspiration towards the vernacular style (Asriningpuri, 2019). A design that regards climate is a passive design strategy (C Tjie, F Lianto, N W Priyomarsono, 2020). Climatic building design concerns the sun orientation.

The sun gives significant daylight and heat into the building interior during the day; in the tropics where the climate has high air temperature and relative humidity, the climatic building design would perform a technique that can deliver optimal daylight without excessive heat. Thermal comfort is a character of tropical architecture to prevent the sun's heat from the buildings (Harisdani, D.D., Kartika, F, 2018). Another environmental parameter regarding the climatic design is air movement, which reduces the high relative humidity. Tropical architecture strives for buildings to be passive, which can be changed automatically (by design) without the additional energy required, including reduced air conditioning and lighting during the day and reduced use of pumps when it rains. An essential element to adapt and modify is the roof element (tropical architecture is identical). This opening element offers the permeable concept to traditional tropical architecture, ornaments that use innate materials, and the most crucial sun shading to shield the exposed sun area (F Nadiar, A R Pattisinai, 2020).

Considering the above issue, tropical climatic architecture should have an optimal shading for minimizing the sun heat and avoiding the sun glare by installing appropriate shading as well as planting vegetation as a natural shading; optimizing the window design for natural ventilation; designing roof sloping; minimizing the surface toward the east and west; orientating the window toward north and south; layering the building surface in a light color, and constructing the building with lightweight materials.

In this study, the case of the tropics is presented by Banda Aceh city, which is located on 5°33'27.72"N, 95°19'19.92"E. The local climate is wet humid with an average temperature of 27 °C, relative humidity of 78%, wind speed of 2 m/s, and the dominant wind orientation faces southeast; the rain is 100.6 mm, mainly in December January (BMKG, 2008). The function of a building model depends on the shape and properties impacted by temperature, solar gain, wind, and humidity; thus, setting out a harmonious relationship between buildings and climate is a challenge for architects (Mohsenzadeh, M., Marzbali, M. H., Tilaki, M. J. M., Abdullah, A., 2021). The natural environment, climate, culture, religion, local materials and construction technologies influence a certain typical type of ceiling and roof (Nguyen and Reiter, 2011). The traditional house responded to those climatic data by the stilt floor, lightweight material, i.e., wood and thatch roof.

Islamic History to Modern Mosque Design

In this case, a modern mosque is studied. Throughout Islamic history, the mosque has been the centre of the community is; the mosque also becomes the centre of towns erected around this pivotal building (Ardhiati, 2013). Several dramatic changes and developing history have been thorough of Mosque architecture (Asfour, 2016). One of the most visual expressions of global Muslim

religious identity in a non-Muslim context is the mosque (Farrag, 2017). Modernity occurs with contrasting characteristics to the traditional one, emphasising that modern buildings will cost more than the traditional one due to the air conditioner utilized. Modern mosques are mostly rising with various styles, which bring less is more proposed by Ludwig Mies van der Rohe (Rowe, 2011). However, if we see back to Islamic history, fewer shapes and style is how the mosques were built in the early Islamic period. The Prophet Muhammad PBUH created the first Construction of Masjid an-Nabawi in 622 CE in the mosque's simple form (figure 2). There was a roofed area towards the front of the masjid, made from palm tree branches cemented together by beaten clay. It was slightly sloped to facilitate drainage during the rainy season. The roof was attached to the northern wall and stood about 3.6 meters high. The majority of the courtyard was left open. The living quarters of the Prophet Muhammad were adjacent to Masjid Nabawi's south-eastern corner. The Prophet's Mosque, An Nabawi, performs as a centre of community development (Aurobee Ahmed Dilkhosh, Norwina Mohd Nawawi, Nurul Hamiruddin Salleh, 2017).

We see that the essential meaning in a mosque is to provide spacious and comfortable space for giving solemnity for the worshipper in performing the worship. This principle is very close to the modernism in architecture principle, i.e., 'form follows function'. It asserts that forms should be simplified – architectural designs should bear no more ornament than is necessary to function. Modernists believe that decoration should follow the structure and purpose of the building (Rowe, 2011).

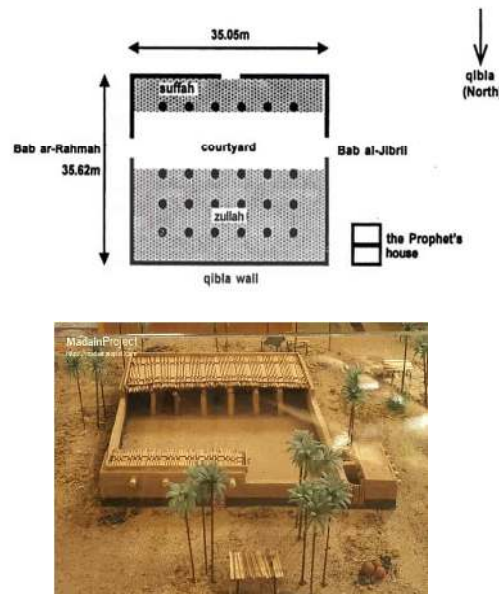


Figure 2. The initial mosque built by The Prophet Muhammad PBUH. Source: https://madainproject.com/masjid_al_nabawi_at_the_time_of_prophet_muhammad

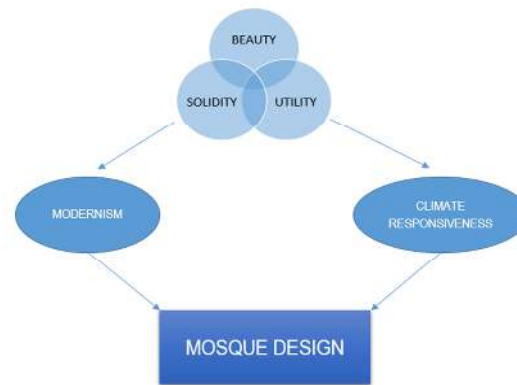


Figure 3. The flow chart of the mosque design concept

Methodology

The method utilized in this study is an experimental study that conducts a design by understanding the architectural design principles. Figure 3 shows how the writer developed a climate-responsive mosque design that brings the value of modernity and utility. Roman Architect Vitruvius has stated three fundamental principles of architecture design: strength, utility, and beauty (Gaurav Gangwar, 2017). According to Vitruvius, Architecture design has three main principles, i.e., Venustas, Utilitas, and Firmistas. Firmistas (solidity/strength) are a building's ability to remain durable after extended use and exposure to natural elements. Over time, architects have been able to calculate the expected life spans of their buildings with greater exactitude. Utilitas (usefulness) is a building's ability to appropriately predict and respond to its intended inhabitants' needs.

Vitruvius addresses the notion of integrity when dealing with the elements, but when it comes to the relationships between them, he proposes the idea of harmony (Manenti, 2019). Venustas (beauty) is a building's relationship to its context's standard of aesthetics. This element can be made apparent in the use of the attractive building or flooring materials. In this study, venustas is developed into the modernism style, which collaborates the utility obtained naturally through climate-responsive building design. Firmistas works as prominent supporters to withstand the building load. However, in this study, firmistas are not studied due to the only focus on collaborating on modernism and climate responsiveness in designing the mosque. The discussion of mosques on the physical and the social aspects is undoubtedly relevant to the study of space, especially regarding creating the space (Yuris Fahman Zaidan, Aquarini Priyatna, R. M. Mulyadi, 2020).

The mosque is designed in Banda Aceh City, located in the police office area. DMS latitude longitude coordinates for the location is 5.530161 N, 95.297930 E (figure 4). The design method is trial and error by making the model that implemented climate-responsiveness principles such as natural ventilation, shading, windows, and openings. However, the idea is developed by bringing the value of modernity and utility as secondary skin of the mosque design because the

indoor space should accommodate people to pray. Therefore, the façade and the roof should be designed to escalate indoor thermal comfort.

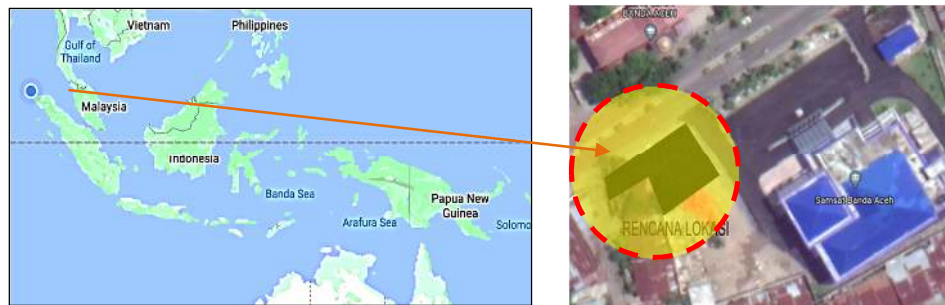


Figure 4. Mosque design location

Result and Discussion

Utilitas

The mosque was initially started using the Vitruvius principles, i.e., utility and venustas. Utilitas belong to the comfort provided by the building to the users. In this case, a mosque as a worshipping area is designed to accommodate up to 80 worshippers. As the average dimension of the worshipping room per user is 60 cm wide by 120 cm deep (Mokhtar, 2009), the total worship area is designed about 8,75 m by 12,50 m (figure 5). As a compulsory rule, the mosque is designed to orient the Ka'ba (qibla), from the location Ka'ba is obtained at about 2920 from the north on the clockwise (figure 5).

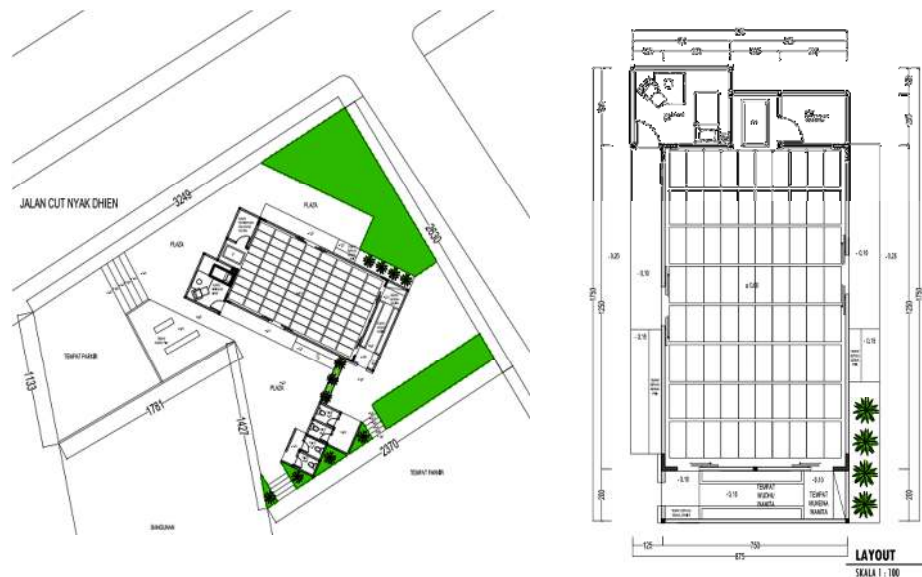


Figure 5. Mosque lay out and floor plan

There must be a separator Between males and females within the room where the males occupy the front and females at the backside. The mosque utilizes the common division, i.e., large fabrics as the curtain. There should be an

additional worship space for the prayer leader in the middle of the very front side. Besides prayer, a mosque needs the ablution space for purifying the worshippers before performing the prayer. The ablution space is built close to the female's entrance to comfortably direct access to the mosque. In contrast, the male ablution area is located outside, closed to the male door's access. A space for looking after the mosque and the storage is also designed (figure 5).

Climate responsive building considers the surrounding elements such as location, size, topography, zoning, traffic conditions, and climate. The climate includes airflow direction, Sun path to better sun orientation, sun radiation, relative humidity, and air temperature. In this mosque design study, these considerations run simultaneously with the modern building concept (figure 6), such as using the flat roof to show the simplicity and “less is more” idea. However, the flat roof is kept designed in pitch- angled in 150 to flow down the runoff. The roof surface is planted with grass to be the green roof for creating a cooling environment (figure 7). Despite being the roof terrace which is the principle of modern architecture, the green roof also performs the best approach to reduce the indoor environment due to heat absorbed by the grass and not transferred inside.



Figure 6. Mosque elevations



Figure 7. Green roof applied on the mosque

The mosque is equipped with a mechanical air conditioner (AC), yet the adaptivity to the environment is utilized. The reason for using AC is the location which is just next to the main road. Only relying on the open window to give the natural cooling would give the trouble on the presence of noise and dust from the road. However, the electricity condition in Aceh is not stable, which would also create problems if the fixed window is utilized. Therefore, the mosque is designed to have large openings using sliding glass windows (figure 8). The opening position is on the north-east and south-west sides for inducing the airflow through the cross-ventilation systems (figure 9). The airflow throughout the room is significant to decrease the high relative humidity (RH) for creating indoor thermal comfort. The vegetation is planted along the roadside within the location to reduce the noise and dust. Once the electricity is off, then all of that natural cooling equipment is run. Despite accessing the daylight from the glass window, the daylight is also achieved from the qibla corner using the glass block. The glass block can transmit the light without too much glare and heat. The ablution area is designed purely natural for running the natural air across the area to control indoor air quality by diluting and displacing indoor pollutants; it can also control indoor temperature, humidity, and air motion to benefit thermal comfort (figure 10).



Figure 8. The large sliding glass window



Figure 9. Climate responsiveness in mosque design

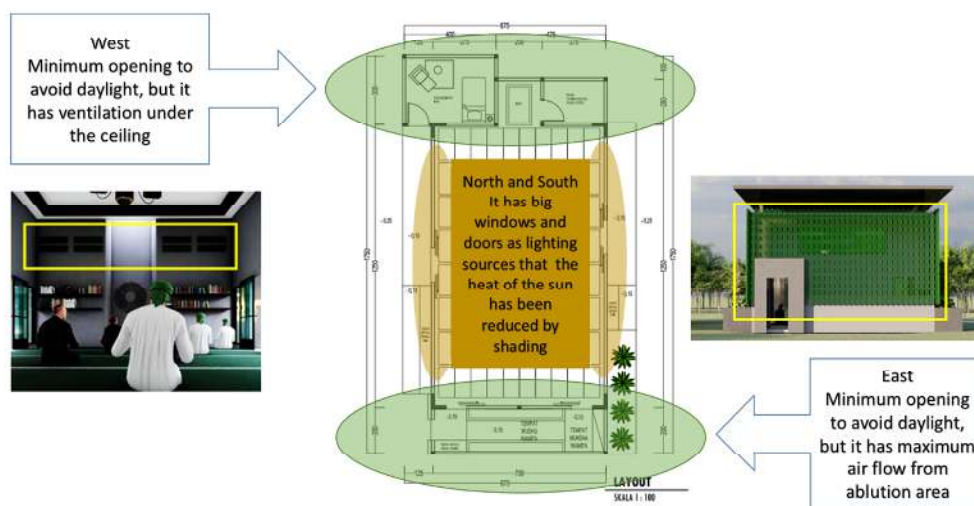


Figure 10. Environmental consideration (thermal, ventilation and lighting) for mosque interior design

Venustas

Aesthetic value in the history of Islamic art and architecture is depicted by its motifs and ornamentation, which are applied to the surfaces of Islamic building's walls (Othman, 2011). Venustas works on the modern façade, which performs an open concept essential in a mosque to accommodate more worshippers and avoid any barriers among the worshippers. In a mosque, the 'open concept works to perform 'form follows function,' i.e., worshipping God without disturbances. Rejection on the ornament is an apparent characteristic in modernity that is applied in the mosque design. However, the repetition concept is also a characteristic of modernity. This concept is also adopted in the mosque façade to have functioned as the second wall and the leaked shading for creating the lower air temperature surrounding the mosque (figure 11). This shading device is useful for minimizing the air conditioner's energy to cool the indoor thermal environment. The shading is also obtained from the roof cantilever, which also shades the terrace.



Figure 11. Shading on the terrace performing Venustas

Conclusion

The mosque is an essential worshipping space for Muslims. Modernity concept to visualize the simple form in a mosque is relevant, which would help the worshippers to be more solemn. Bringing this concept into the climate responsiveness principle in mosque design is appropriate to create the building to be friendly to the environment and create indoor thermal comfort. This study proposed a mosque design bringing those concepts. Vitruvius concepts, i.e., *Utilitas* and *Venustas*, are applied. *Utilitas* works on climate responsiveness embodied on the secondary wall to give shades on the mosque. Large openings designed on the wall aim to provide rich daylight to minimise electricity use

during the day. Venustas performs the beauty concept through modernity, i.e., the open layout and simple form. This study also recommends future works, i.e., simulating the indoor thermal comfort applying the design concept proposed by this study.

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