

# Overview of The Application of Astronomical Science in The History of Islamic Civilization and The Relationship with Architecture

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## Article History

Received : January 08, 2024

Accepted : April 27, 2025

Published : May 27, 2025

## Abstract

The development of astronomy in the golden age era began with the discovery of astrolabes and predicting lunar and solar eclipses, the movement of stars, prayer times, determining the calendar system, and determining the direction of the Qibla. From these discoveries, knowledge about Qibla direction determination technology developed from time to time. The history of determining the direction of Qibla in Indonesia, especially in Yogyakarta, has its pros and cons in its implementation. The renewal figure was KH Ahmad Dahlan who was the pioneer of the Qibla direction based on astronomical calculations. This research was conducted at *Langgar Kidoel KH Ahmad Dahlan Yogyakarta*, which was the first Muslim place of worship to apply an astronomical system in determining the direction of the Qibla in Indonesia. This study aims to determine the application of astronomy in the history of Islamic civilization and its relation to architecture. The results of the study show that astronomy is very influential in the field of architecture, namely in determining the direction of the Qibla and the cardinal directions which have an impact on the design of the orientation of the building and the concept of Islamic architecture. In building orientation, the Qibla direction and the cardinal directions are closely related to building physics and building access; while in the concept of Islamic architecture, the direction of the Qiblah and the cardinal directions affect the spatial arrangement in accordance with the Sunnah of the Prophet.

**Keywords:** *Architecture; Astronomy; Islamic Architecture; Qibla Direction*

## Introduction

Astronomy or what is commonly called reckoning is very closely related to the worship of Muslims. One of them is in determining the Qibla direction. Qibla or direction of prayer is the place where Muslims around the world turn their faces while worshipping hoping for the blessings and pleasure

of Allah SWT. The command to face the Kaaba or the Grand Mosque (Masjidil Haram) during prayer can be found in Al-Baqarah verse 144, which means: "Turn your face towards the Grand Mosque. And wherever you are, turn your face towards it."

The development of astronomy in the golden age era began with the discovery of astrolabes and predicting lunar and solar eclipses, the movement of stars, prayer times, determining the calendar system, and determining the direction of the Qibla. From these discoveries, knowledge about Qibla direction determination technology

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developed from time to time (Sardar, 1984).

Although the science of astronomy has developed since the golden age era, its application in Indonesia has not been so widely developed. Especially in the application of the Qibla direction with astronomical calculations that had reaped the pros and cons. The renewal figure was KH Ahmad Dahlan who tried hard to purify the *akidah*<sup>1</sup> and worship of Muslims with the science of astronomy. With the science of astronomy that he mastered, KH Ahmad Dahlan became a pioneer who straightened the Qibla direction with the calculation of the science of astronomy which is still applied by Muslims.

In this study using previous research as a reference and development material. First, AN Rashid (2020) examines astronomy and cosmology in the perspective of the Qur'an. Namely the science of how nature was formed (cosmology) and changes in the phenomena of the universe and the stars (astronomy). This knowledge determines important events in life such as: (1) Discussion of the beginning of the month of *Qamariah* (especially Ramadan, Shawwal, and Zulhijah), (2) Discussion of prayer times, (3) Discussion of Qibla direction, (4) Discussion of when and where the eclipse occurs (solar eclipse and lunar eclipse) (Rasyid, 2020).

Second, Habibullah Ritonga et al (2016) in his research entitled "The Role of Astrology in the Problem of Qibla Direction, Prayer Times and the Beginning of the Month" discusses the role of astronomy for Muslims, including (1) determining prayer times, (2) determining the direction of Qibla, and (3) determine the beginning of the *qamariyah* month, especially in determining fasting and holidays (Ritonga & Butar-Butar, 2016).

Third, Iga Nur Ramdhani et al (2021) in their research entitled "The Effect of "Islamic Astronomy in the Golden Age on Architecture" discusses the relationship between astronomy in the golden age and architecture. Whereas there are aspects that

explain the implications of astronomy on architecture, namely the direction of the Qibla on the mosque and the influence of the cardinal directions on other public buildings (Ramdhani & Santosa, 2021).

From the first and second studies, it can be concluded that what has been studied related to astronomy is its role for Muslims related to the beginning of the month of *Qamariah* (especially the determination of fasting and holidays), prayer times, Qibla direction, and the occurrence of eclipses (sun and moon). While in the third study, namely the relationship between astronomy in the golden age and architecture. The research focuses on methods of determining the direction of the Qibla which then concludes that the relationship between astronomy and architecture is in determining the direction of Qibla and the influence of the cardinal directions on other public buildings.

Therefore, the researcher in this case chose to take a study on the review of the application of astronomy in the history of Islamic civilization and its relation to architecture with a case study of the Qibla direction shift in KH Ahmad Dahlan's *langgar kidoel* Yogyakarta.

## Methodology

This research is a literature study or literature that is supported by field observations. The main data is taken from books and journals written by Ziauddin Sardar in his book *The Touch of Midas* and supported by journals and articles related to the discussion. The results of this study were analyzed and concluded qualitatively.

The stages of writing and collecting data are as follows:

1. Search for and cite literature relevant to the research topic
2. Conduct a field visit to KH Ahmad Dahlan's *langgar kidoel* at the Kauman Yogyakarta complex
3. Collect documentation from the results of the field review
4. Analyze the found data, both data sourced from literature and data from field reviews

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<sup>1</sup> *Akidah*: basic trust; confidence. Source: KBBI

## 5. Summarize the research results

### Result And Discussion

#### History Of Astronomy Science

Based on the book *The Touch of Midas* by Ziauddin Sardar in chapter 5. Science and technology in Islam: the underlying value system (Alikettani, 1984), astronomy developed rapidly in the golden age era. At that time many Muslim scientists were studying and discovering new knowledge and technology which was the forerunner of renewal in Muslim civilization. The sciences that developed in the golden age era, including mathematics, physics, astronomy, chemistry, medical / medicine, geography. In this study, the author focuses on the science of astronomy which will then be associated with the field of architecture.

The translation of ancient astronomical works in Arabia began in the Umayyad period and continued under the first Abbasids. Ibrahim Ibn Habib Al-Fazari (d. 777) translated many Indian books, but he was the first Muslim scientist to do original work in the field of astronomy. He invented the astrolabe and predicted lunar and solar eclipses; he worked on the lunar year, movement of the stars, and prayer times. Books were translated from Greek, particularly Ptolemy's *Al-Majstati* (Almagest) by Al-Hajjaj Ibn Yusuf.

The mathematician Al-Khwarizmi, appointed court astronomer by Al-Mamun, was the first to compile astronomical tables; he calculated planetary motions, the tilt of the ecliptic and subtle geodesic measurements. The mathematician Al-Kindi, already mentioned, developed a spherical model of the universe and, using geometry, argued that his body was finite. (He also proved that the surface of the oceans, and consequently the earth is spherical.) He designed the skeletal spheres to represent the positions of the ecliptic and other celestial circles.

Another mathematician, Al-Battani (850-929), measured the increase in the sun's peak longitude since Ptolemy's time in 150 AD as  $6^{\circ}17'$  - finding in the process the apside motion of the sun resulting from slow variations in the equations of time. Abu

Al-'Abbas Ibn Muhammad Ibn Kathir, a ninth century astronomer from Farghana in Central Asia, devoted his energies to measuring the distance from the earth to the moon and the planets. He accurately measured the volume of the moon in relation to the earth, and found also the relative volumes of the sun, Mercury, Venus, Mars, Jupiter and Saturn - values used by scientists until the time of Copernicus. 'Abd-Al-Rahman Al-Sufi (903-86), who was born in Rayy near Tehran, made tables of fixed stars and drew maps of their celestial positions. Other Persians, Ibn Al-Haytham, used optics to determine the exact position of stars, taking into account the refraction of the atmosphere with altitude. He proved geometrically the law relating the latitude of a star to the time of its passage through the zenith (samt) and explained why spherical bodies appear as disks. Six hundred years before Galileo, Al-Baruni had claimed that the earth rotates on its axis. Using the astrolabe and the presence of high mountains near the sea or flat plains, he calculated the circumference of the terrestrial by solving very complicated geodesic equations. He also determined scientifically the direction of Mecca from any point in the world.

An Andalusian from Qadis (now Cadiz, Spain), Ibn Tufayl (d. 1118.5), wrote a philosophical book - *Hayy Ibn Yaqdhan*, which Dante Alighieri later imitated in his *Divine Comedy* - in which he theorized about the unity of law the universe and its immortality (he believed that the universe was finite). He refuted the Ptolemaic model, as did most Muslim scientists before him, and tried to examine it with facts.

One of the greatest achievements of the Syriac 'Ala' Al-Din 'Ali Ibn Ibrahim Ibn Al-Satir (1306 - 75) was his lunar theory, which was attributed to Copernicus more than 150 years later. He assumed an elliptical path of the sun, rather than a circular one as Ptolemy had, eliminating the excessive variance in lunar distances as proposed by Ptolemy. Ibn Al-Satir only uses movements that result from a combination of regular circular motions. His system consisted of vectors of constant length rotating at a constant angular velocity, and he abandoned the Ptolemaic equant, as Copernicus did many years later.

Among the last prominent Muslim astronomers was Shamduddin Muhammad Ibn Muhammad Al-Rudani (1627-83), who was from Tarudant (Morocco). He invented a spherical machine for measuring time, an instrument that worked inside a shell and could be used to measure time. operated at any longitude or latitude (Sardar, 1984) (King, World Maps for Finding the Direction and Distance of Mecca: Examples of Innovation and Tradition in Islamic Science, 1999) (King, n Synchrony with the Heavens: Studies in Astronomical Timekeeping and Instrumentation in Medieval Islamic Civilization, 2005).

### **History Of Calculation Of Qiblate Direction Using Astronomy In Indonesia**

In Indonesia, the determination of the direction of Qibla carried out by Muslims from time to time has always developed with advances in science and technology in human civilization, at the beginning of the entry of Islam, Muslims in the Walisongo period only relied on the west as the direction of Qibla because it was only based on Arabic. Saudi Arabia is located in the west. This is done only roughly without any prior calculations and measurements so it is not surprising that currently there is a deviation from the Qibla direction of mosques in Indonesia (Izzuddin, 2003).

The period of development with the new calculation and measurement model was during the time of KH Ahmad Dahlan who made major changes to the determination of the Qibla direction with astronomy obtained from the results of studying in Mecca and the world map capital owned. So from that time until now there has always been the development of various methods and tools used in measuring the Qibla direction.

Sakirman in his journal KH Ahmad Dahlan and the Qibla Direction Alignment Movement in Indonesia explained that KH Ahmad Dahlan, like a Muhammadiyah cleric, is of the view that facing the Qibla is a condition for valid prayer (Muhammadiyah M. T., 1430 H/2009 M) (Sakirman, tt). KH Ahmad Dahlan also holds the

view that, Muslims who cannot see the Kaaba directly when praying, just turn their faces towards the Kaaba. KH Ahmad Dahlan's view is in line with Kyai Syuja's notes, the term *jihat al Ka'bah*, used by KH Ahmad Dahlan to show that Muslims who are outside Mecca are considered valid when praying facing the Kaaba and not 'ain al-Ka'bah (Syuja', 2009).

KH Ahmad Dahlan tried hard to purify the *akidah* and worship of Muslims with the science of astronomy that was very controlled, KH Ahmad Dahlan became the first person in Indonesia, after Sheikh Arsyad al-Banjari who tried to straighten the direction of the Qibla of violators, prayer rooms and mosques in Indonesia which at that time it does not lead exactly to the Kaaba Baitullah in Makkah Mukarramah. The latter name has recently corrected the Qibla direction of the Betawi Lima Bridge mosque (Jakarta) 4 Shafar 1186 H/7 May 1772 AD. Armed with astronomy knowledge about the Qibla direction being controlled, KH Ahmad Dahlan turned the mosque's Qibla direction to the right by 25 degrees. Initially, the Qibla direction of the mosque was too tilted to the left (Daudi, tt).

This persuasive method was used by KH Ahmad Dahlan when trying to straighten the direction of the Qibla of the Yogyakarta Sultanate Mosque. Based on the science of *Hisab*<sup>2</sup>, at that time the Qibla direction of the great Kauman mosque did not lead to the Kaaba, but to Ethiopia (Hadi, 1993). By quoting Solichin Salam, describing the direction of the Qibla alignment movement begins with an intensive discussion conducted by KH Ahmad Dahlan with the ulama, especially with the head of the royal court (Alfian, 2010). Precisely one night in 1898, KH Ahmad Dahlan invited 17 scholars around the city of Yogyakarta to hold a discussion about the direction of Qibla at his family's surau in Kauman (Yulianto, 2020). This habit is actually a teaching of KH Ahmad Dahlan which is often conveyed to his students to always consult and exchange ideas with anyone related to the problems they face (Hadjid, 2006).

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<sup>2</sup> *Hisab*: count; calculation; estimation. Source: KBBI

The discussion between the scholars who had prepared themselves with various reference books lasted until dawn, without producing an agreement. Although the attention of the *ulama*<sup>3</sup> is focused on the controversial religious issue, the relationship between the *ulama* is actually relatively harmonious. New tensions arose when it was found that there were three lines of white chalk 15 cm thick on the front shaf of the *imam*<sup>4</sup> of the Yogyakarta Grand Mosque, which indicated that the line was facing the true Qibla. The Head of *Penghulu*<sup>5</sup> H. Muhammadi Khalil Kamaludiningrat deeply regretted the incident. An investigation was carried out to find the culprit. The results of the investigation showed that KH Ahmad Dahlan was not involved. The real perpetrators are three young men who have been diligently eavesdropping on debates about the direction of Qibla and are still relatives of the head of the head of the palace (Pasha & Darban, 2009).

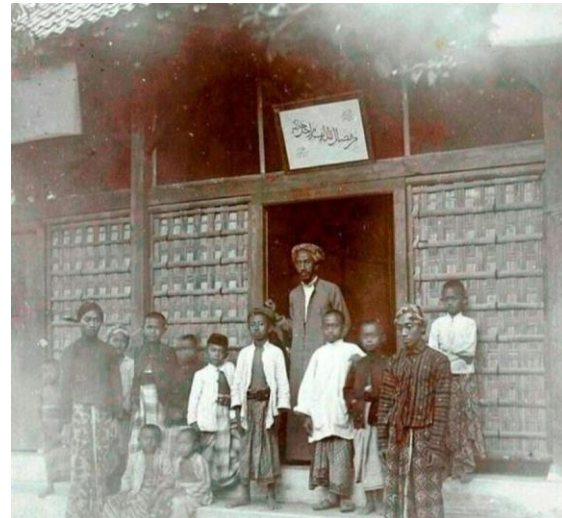
Figure 1. Illustration of *Langgar Kidoel* KHA Dahlan before it was torn down

Source: "Sang Pencerah" Film (Bramantyo, 2010)



As a realization of the idea of improving the Qibla direction, KH Ahmad Dahlan renovated his family's surau in 1899. Directing the surau towards the Qibla (which is in accordance with the science of astronomy) which is architecturally different from the direction of the *Gedhe Kauman* Mosque. Dominated by wood material and located near the residence of KH Ahmad Dahlan, the surau was then used for various worship activities such as praying, studying the Qur'an, etc.

Figure 2. KH Ahmad Dahlan with students at *Langgar Kidoel*  
Source: www.republika.co.id



After being used for a few days, Ahmad Dahlan received an order from the head of the palace to dismantle the surau. Moreover, the direction of Ahmad Dahlan's surau is different from the *Gedhe Kauman* Mosque. Because it was not demolished, one night several residents who rejected Ahmad Dahlan's surau forcibly demolished the building (Saputra, 2018). Even though he was feeling disappointed, Ahmad Dahlan rebuilt the surau in accordance with the direction of the *Gedhe Kauman* Mosque after being persuaded by his brother, while the actual direction of Qibla was marked by making a guide line on the inside of the mosque (Muhammadiyah M. D., tt).

Figure 3. *Langgar kidoel* KHA Dahlan after it was rebuilt  
Source: Diorama KHA Dahlan (1992)



<sup>3</sup> *Ulama*: a person who is an expert in matters or knowledge of the Islamic religion. Source: KBBI

<sup>4</sup> *Imam*: prayer leader (in prayers performed together such as Friday prayers);

<sup>5</sup> *Penghulu*: 1. head; chairman; 2 traditional heads; 3 heads of Islamic religious affairs in districts or municipalities; 4 advisors for Islamic religious affairs at the district court; caddy;

## Application Of Astronomy Science and Relationship with Architecture

### 1. Method of Determining Qibla Direction in Indonesia

In the history of astronomy in Indonesia, Sheikh Muhammad Arsyad al-Banjari (1772 AD) and Kyai Ahmad Dahlan (1897 AD) had inscribed gold ink. Both of them contributed greatly to the actualization of astronomy in Indonesia, especially in the problem of determining the direction of Qibla. In his lifetime, they tried to correct the direction of the mosque's Qibla which deviated from a precise direction. The event is long gone but will always be remembered. Presumably the fatwa issued by the *MUI*<sup>6</sup> regarding the Qibla above is considered to underestimate the struggle of Sheikh Muhammad Arsyad al-Banjari and Kyai Ahmad Dahlan who straightened the direction of Qibla when science and technology was not as advanced as it is now.

Methods for determining the direction of Qibla in Indonesia include the following: using special sticks, compasses, global *rashd al-qiblah*, local *rashd al-qiblah*, theodolites, referring roughly to the Qibla direction of existing mosques, determined by someone who is prominent in the community, the belief that the Qibla direction is west, and the habit of aligning the Qibla direction of a mosque with the road nearby (Jayusman, 2014).

Table 1. Qibla Direction Determination Method

No.	Method	Accuracy
1.	Special Stick	Accurate for determination of true east and west. When used for determining the direction of Qibla, of course, Rubu' Mujayyab or Kompas must assist.
2.	Compass	Use a compass that has high accuracy, keep it away from metal because it can affect the magnetic field of the compass, and correct the magnetic declination, then the results are accurate.

<sup>6</sup> MUI: The Indonesian Ulema Council (MUI) was formed in 1975 with the aim of being a supporting instrument for state policy in the religious affairs of Muslims

3.	Razor or sewing needle	The direction indicated by the razor and sewing needle is magnetic north and south, not north and south of the earth. So based on that direction is not accurate.
4.	Rashd al-qiblah global	Accurate
5.	Rashd al-qiblah local	Accurate. It is better to use the local rashd al-qiblah time in the morning or evening (not when the sun is near the sky meridian because at that time the movement of the sun is "faster". This condition is vulnerable to determining the direction of the Qibla).
6.	Theodolite	Accurate
7.	Refers roughly to the Qibla direction of the existing mosque	Not accurate
8.	Determined by someone who is prominent in society	If the person is not an expert in astronomy, it will result in the wrong Qibla direction; not accurate.
9.	Qibla direction is west direction	Wrong assumptions so that the calculation results are not accurate.
10.	Aligning the Qibla direction of a mosque with the road nearby	Wrong assumptions so that the calculation results are not accurate.

Source: Author

Thus, some of these methods can still be used in determining the Qibla direction, of course an accurate method. The use of several methods at once can also correct each other to obtain precise Qibla direction results.



## 2. History of the Development of Building Orientation in *Langgar Kidoel* Yogyakarta

Figure 4. *Langgar Kidoel* KHA Dahlan who has stood strong until now

Source: Azzah Juharida (2022)



KH Ahmad Dahlan directed the *surau*<sup>7</sup> to the direction of the Qibla astronomically, which of course was architecturally different from the direction of the *Gedhe Kauman* Mosque. The Qibla direction reaped the pros and cons among the scholars who in 1898 had not yet found a bright spot. Until then, on orders from the head of the Keraton, the *surau* was forcibly dismantled by the opposing community. Although the *surau* was demolished, KH Ahmad Dahlan rebuilt the *surau* in 1899 in accordance with the direction of the *Gedhe Kauman* Mosque with the Qibla direction marked using a guide line on the inside of the mosque.

Figure 5. White square detail where Kiai Dahlan corrected the Qibla direction in *Langgar Kidoel* KH Ahmad Dahlan Yogyakarta

Source: Azzah Juharida (2022)



*Surau* KH Ahmad Dahlan which was rebuilt in 1899 is directed towards the *Gedhe Kauman* Mosque but with the Qibla direction marked with a

guide line on the inside of the mosque. The method used by KHA Dahlan is astronomical calculations using a compass and world map. As seen in the detailed white square image in Figure 5 above, the blue arrow represents latitude, while the yellow arrow represents the Qibla direction. So, even though the building does not face the Qibla, the direction of prayer is still facing the Qibla with the help of the Qibla guideline applied to the floor of the mosque. The Qibla alignment technique with the guide line method is still being applied to mosques in Indonesia.

Figure 6. Qibla direction marking with white line at *Langgar Kidoel* KH Ahmad Dahlan Yogyakarta

Source: Azzah Juharida (2022)



Therefore, astronomy, which is the basis for determining the direction of the Qibla, has a huge impact on the orientation of the mosque building. Which until now, the planning of mosques in Indonesia and even the world, has made the Qibla direction the main reference in the design.

## 3. Relationship between Astronomy and Architecture

Based on discussion on the points above, then the relationship between astronomy and architecture are as follows:

### a. Determination of Building Orientation

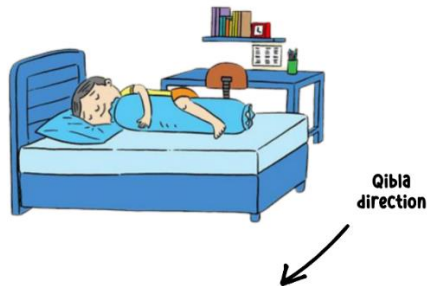
The orientation of the building really needs the cardinal directions as the basis for its determination. So before designing a building, an important point that an architect must know is the direction of the wind. Determination of the cardinal directions of the building is based on the following factors: the direction of sunrise and sunset which affects the lighting and heat effects on the building

<sup>7</sup> Surau: the place (home) for Muslims to carry out their worship (performing prayers, reading the holy Quran, and so on); source: KBBI.

(building physics), the relationship with the surrounding environment (roads/access to the building), and others.

## b. Islamic Architecture

Figure 7. Sleeping position with the face facing towards the Qibla (Sunnah of the Prophet)  
Source: Researcher sketch (2022)



The science of astronomy is clearly connected with Islamic architecture, namely its relation to the Qibla direction (as has been discussed in the research above). In buildings with Islamic architectural concepts, the Qibla direction is an important factor in designing the building. The direction of the Qiblah and the cardinal directions affect the spatial layout in accordance with the Sunnah of the Prophet, including: the direction of the toilet that must not be facing or opposite to the direction of the Qibla (HR. Muslim: "If you squat down to perform your purpose, then do not face and turn your back to the Qibla direction"), as well as the recommendation to face the Qibla when sleeping (the etiquette of sleeping with your head on the north side, and your face facing the Qibla is the Prophet's guidance and means that Muslims must prepare for everything that will happen before going to bed).

## Conclusion

The development of astronomy in the golden age era began with the discovery of astrolabes and predicting lunar and solar eclipses, the movement of stars, prayer times, determining the calendar system, and determining the direction of the Qibla. From these discoveries, knowledge about Qibla direction determination technology developed from time to time.

Although the science of astronomy has developed since the golden age era, its application in

Indonesia has not been so widely developed. Especially in the application of the Qibla direction with astronomical calculations that had reaped the pros and cons. This is because Indonesia is far from the city of Mecca and does not see the Kaaba directly, so the best effort to get an accurate Qibla direction is to use astronomical calculations. The renewal figure was KH Ahmad Dahlan who tried hard to purify the aqidah and worship of Muslims with the science of astronomy. With the science of astronomy he mastered, KH Ahmad Dahlan became a pioneer who straightened the Qibla direction with the calculation of the science of astronomy which is still applied by Muslims.

The method used by KHA Dahlan is astronomical calculations using a compass and a world map by analyzing latitude to produce an accurate Qibla direction. At first, the orientation of the *Kidoel* was a qibla based on astronomical calculations. However, because there are pros and cons to the demolition of the *langgar*, the construction of the new *langgar* is then faced with following the *Gedhe Kauman Mosque*. Although the orientation of the *Langgar Kidoel* follows the *Gedhe Kauman Mosque*, the direction of prayer is still facing the Qibla astronomy with the strategy of marking the direction of the Qibla on the floor.

The results of the study show that astronomy is very influential in the field of architecture, namely in determining the direction of the Qibla and the cardinal points which have an impact on the design of the orientation of the building and the concept of Islamic architecture. In building orientation, the Qibla direction and the cardinal directions are closely related to building physics and building access; while in the concept of Islamic architecture, the direction of the Qiblah and the cardinal directions affect the spatial arrangement in accordance with the Sunnah of the Prophet. So with this research, the author hopes that it can be the basis and reference for further research that discusses the relationship between astronomy and architecture in more depth and specificity.



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