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THE MOSQUE'S PRIMARY SPACES AND THE REQUIRED DIRECTION OF THE MOSQUE BUILDING

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ABSTRACT

This study investigates the primary spaces and required orientation of mosques. Similar to other architectural styles, mosques have specific primary spaces that must be featured in every typical mosque, while each region's cultural and traditional needs determine secondary spaces. Orienting the mosque toward the Qibla direction is also crucial. The study sheds light on the correct orientation of typical mosques and the origin of Islamic directives regarding their orientation. Several common ancient mathematical procedures for calculating Qibla have been described. In addition to architectural plans for five mosques in Pakistan, artistic depictions of aerial views of existing mosques in other parts of the globe are also included.

KEYWORDS:
Mosque architecture, Spaces of mosque, Orientation of mosque, Qibla direction.

INTRODUCTION

Muslims have been constructing mosques for centuries to win Allah's favor, drawing inspiration from the Prophet Muhammad's (PBUH) sayings recorded in Hadith Numbers 1084–1085 in Sahih Muslim, book 4 [1].

The Prophet Muhammad (PBUH) founded the first mosque in Islamic history, the Prophet's Mosque, upon his migration to Medina, lending these sacrosanct structures a profound historical significance. Mosques have nurtured spiritual unity, camaraderie, and social cohesion among believers worldwide [2]. The mosque stands out for its intricate architectural design and transcends the realm of simple structures. It is a flexible space for religious, educational, communal, and occasionally political endeavors. Specific areas within the mosque's blueprint are of the utmost importance, serving as integral components of its operational substance. These pivotal zones are universally present in mosques worldwide regardless of geographical, cultural, social, or contemporary influences [3]. However, Islamic society exists in different parts of the world and mostly in every region, where a mosque differs from another. This variation is mostly due to the climatic conditions or inspired by regional, traditional, cultural, and contemporary architecture.

Moreover, the design and style of mosques may vary, but some spaces inside every mosque are the same purpose-wise [3]. Unique in its architectural design, the mosque transcends the domain of mere structures. It is a multipurpose space for religious, educational, social, and political activities. Certain spaces within the mosque's design are of utmost importance, functioning as essential to its functionality. These essential spaces are common in mosques worldwide regardless of regional, traditional, cultural, or modern influences [4], [5].

The orientation of a mosque is crucially significant, as it must face the Qibla direction, which corresponds to the Kaaba in Mecca. This architectural requirement is based on the fundamental practice of Muslims praying while facing the Qibla. The Prophet Muhammad (PBUH) commanded a change in the prayer direction from Jerusalem to Mecca in the early days of Islam, a historical event that formed the basis of the Qibla's significance in Islamic architecture [6], [7].

This research paper intends to investigate the primary spaces inherent in a typical mosque structure and the required orientation of the mosque toward the Qibla direction. It explains the historical context of Qibla's direction, its profound significance in Islam, and its enduring impact on mosque architecture. In addition, the paper will present a variety of common methods for accurately calculating the Qibla direction. To demonstrate these principles in practice, the author will present the architectural plans of five mosques in Pakistan, highlighting their alignment with the Qibla orientation while deviating from the city/town/Road/ Street grid[8], [9].

Existing research on the same topic either explains the architecture of a mosque by concentrating on its design and construction or explains the qibla direction or correction of a particular mosque by resolving the qibla problem of a mosque[6, 10]. This study focuses on spaces that are mandatory for every mosque, the purposes they serve, the flow of spaces, and the effect of orientation in mosque buildings attributed to the Qibla, which may cause them to deviate from the city grid line, street line, road line, or a particular linear form of plotting.

This study aims to provide a holistic comprehension of these sacred structures by exhaustively examining the fundamental components of a mosque and explaining their interdependence. In addition, it emphasizes the significance of adhering to Islamic design principles for mosques, ensuring their correct orientation by the topography. Ultimately, this research aims to contribute to the ongoing discourse surrounding mosque architecture by fostering a greater appreciation for these revered religious structures' inherent spirituality and practical significance.

METHODS

The methodology of this research study is primarily based on an empirical survey; consequently, the research method depends upon qualitative data through observation documentation. The research progresses according to the following sequential stages:

1. LITERATURE SURVEY

- Expand the literature review to include relevant academic sources on mosque architecture, Islamic traditions and rituals, and the historical evolution of mosque design.
- Consider a comparative analysis of mosque buildings across different regions and periods to identify commonalities and differences in design and primary spaces.
- Include a discussion of the theoretical and conceptual frameworks that underpin mosque architecture, such as the concept of tawhid (unity) and its expression in the design of mosques.
- Consider a deeper analysis of the Islamic orders related to mosque orientation, including their origins, interpretation, and historical context.

2. FIELD STUDY

- Include a larger sample size of mosques to observe, both recently designed by the author and pre-existing ones.
- Consider using structured observation techniques and documentation tools such as photography, sketches, and notes to gather data and architectural details.
- Expand the observation of primary spaces to include their dimensions, layout, and relationship to each other, as well as their symbolism and significance in Islamic rituals and traditions.
- Conduct interviews or surveys with mosque users and staff to gain a deeper understanding of their needs and preferences, and to identify any challenges or opportunities for mosque design and orientation.

3. EXPLORING ACTIVITY

- Conduct a needs assessment or user requirements analysis to identify the specific needs and preferences of the local community in terms of mosque design and orientation.
- Consider involving local architects, designers, and community leaders in the exploration activity to gain a more diverse and inclusive perspective on mosque design.
- Incorporate feedback and insights from the exploring activity into the design of the author's mosques and broader recommendations for mosque design and orientation.

4. MATHEMATICAL CALCULATION

- Exploring earliest mathematical methods used for Qibla direction determination.

Historical background of the mosque

The Arabic term "Masjid" derives from the prehistoric Nabatean term "*masgheda*." It refers to the "place of prostration." The mosque is the most obligatory structure in Islamic culture; it is designed for public worship and political, social, and educational functions. The mosque symbolizes Islamic culture and civilization, and as such, it contributes to the Islamic identity of localities. Prophet Mohammed (S.A.W) constructed the first mosque in Medina, formerly known as Yathrib City, before his arrival. This mosque was constructed from locally accessible materials. It was a simple quadrate with a square plan, which appears to have been influenced by the cube-shaped Kaaba. The mosque was separated into a few distinct sections: the Qibla facing Mecca, the Holy City, the prayer space (*Musalla*) with an accompanying porch or portico shielding the congregation from the sun, the pulpit (*Minbar*), and the courtyard (*Lawn/Sahn*)[11].

The first mosques were erected in the first century after the Prophet's arrival, and numerous mosques were built after that by replicating the basic form and areas of the Prophet's Mosque in Medina. In its original concept, the mosque reflects Islamic architecture in its basic form: an enclosure for community assembly and prayer, reading the Qur'an and Hadith, and other religious purposes [12].

The geographic location of mosques was extremely important in the early history of Islam. Friday or Jumma mosques were constructed near the marketplace to enable early entry and to gather more individuals who might otherwise be engaged in business activities. In addition to being a place of worship, the mosque acted as a social center and an administrative structure. Unfortunately, the mosque is only used for practices such as namaz, i'tikaf, and Holy

Quran recital. The following are some additional responsibilities that were often performed in mosques in the past:

- The mosque is for resolving communal difficulties and soliciting public input on urgent matters.
- Mosque as an educational institution from basic to higher education, as well as a research center.
- Mosque is for providing primary education to young children.
- Mosque as a venue for encouraging and hosting literary conversations and debates.
- Giving lectures, holding seminars, and inviting questions and criticism.
- Served as a venue for imparting justice through Qazi in various circumstances.
- Mosque as a state guest home for delegates/ visitors from other locations.
- As a clinic, providing care and medications to the sick.
- Nikah/marriage ceremonies are held.
- The mosque is for weapon storage.
- A place to stay for the homeless and travelers.
- A location where food is distributed to the needy or hungry.
- Mosque as a *bait-ul-maal* for the payment of employee salary.
- Mosque as a venue for the deposit and redistribution of *maal-e-ghaneemat* (war booty).

RESULT & DISCUSSION

MANDATORY SPACES FOR A TYPICAL MOSQUE

1. ANTEROOM (ENTRANCE, FOYER)

Mosques are considered extremely tidy and clean, so it is considered spiritual for worshipers to remove their shoes and enter the mosque barefoot to respect its dignity and keep it clean.

Figure 1 (a and b) Shoe racks in Sheikh Shakhboot bin sultan mosque at Abu Dhabi. [Architect Rizwan Khan] (c) Image describing shoe rack at Sultana Mosque, Riyadh, Saudi Arabia. [Architect Aman Ullah]

Consequently, every mosque has a place to put your shoes (Fig. 1, a and b). This area needs to be covered and shielded from the sun and rain. It serves as a corridor between the exterior and interior of the mosque while coming and leaving and a place to store shoes and other personal items. To give the impression that the worshiper's belongings are sacred, lockers or "cupboards" are typically found in large mosques with thoughtful floor plans[13].

2. COURTYARD

Most mosques have a courtyard in the middle. It is a crucial component of traditional architecture; most large mosques have courtyards. The courtyard served various functions during the Prophet Muhammad's (PBUH) lifetime, including educational, political, and social gatherings. A courtyard can further articulate and connect internal and external spaces in a design. It must be a bridge leading from the mosque's interior to the outside. Most worshipers use the courtyard for congregating, holding meetings, and relaxing before and after prayers (Fig. 2). Since secular speech is strictly prohibited inside the mosque, greeting and conversation should occur in the courtyard[14].

Figure 2. Courtyard of Sheikh Zayid Mosque. [Author]

3. THE PRAYER HALL

The location where a group or solitary primary prayer is offered is known as a prayer hall (Fig. 3). Usually, it is surrounded or given the appearance of being surrounded by a succession of columns. All Muslims must face a specific wall while praying, which is always directed to the side facing the "Kaaba." The "Qibla/Mecca" refers to the direction of the "Kaaba." Inside the Prayer Hall, the direction of rows must be towards Qibla direction. Prayer Hall is the most compulsory and main space of every mosque. The main purpose of worshipers is to come to this space and do worship in a completely comfortable environment. It is strictly forbidden to talk with even a little loud sound inside the prayer hall of every mosque[15]. Men and women must adhere to the mosque's rigorous dress code and segregation policy. Only the mosques have enough space to accommodate women, and then there is a separate place kept inside a prayer hall covered by curtains for women. The entire prayer hall is set up to promote the ideal environment for prayer and meditation, free from outside distractions.

Muslims should treat the mosque respectfully and ensure it is kept tidy and odor-free. Before praying in the mosque, a Muslim should ensure that he does not carry unpleasant odors or eat anything that gives him unpleasant odors, such as garlic and onions. Shoes are not allowed inside the prayer hall to keep the prayer hall clean [16].

Figure 3. Prayer Hall of Umar Mosque at Sialkot, recently designed by the author. [Author]

4. I'TIKAAF AREA IN PRAYER HALL

I'tikaaf (Arabic word) is an Islamic practice that involves spending a certain amount of time in a mosque, focusing on ibadah during that time, and avoiding worldly affairs.

The word's literal meaning denotes consistently sticking to something, adhering to it, or doing it. Devout Muslims particularly enjoy it during the final 10 days of Ramadan, when they isolate themselves in a room or area of the mosque and devote their entire time to praying, supplicating, or reading the Qur'an or hadith. What are images that you pay devotion to them, asks Allah in the Qur'an? (Al Anbia': 52) i.e., what they focused on during worship. Here, seclusion and staying in the mosque to get closer to Allah are meant. All academics concur that it is legitimate. Every Ramadan, the Prophet would observe I'tikaaf for ten days. He did it for twenty days in the year before he passed away. Al-Bukhari, Abu Dawud, and Ibn-Majah all mention this. I'tikaaf was performed with and after the Prophet's death by his companions and wives. I'tikaaf enables worshipers to communicate with their Creator through prayer, Holy Quran recitation, and reading religious texts, enabling them to comprehend worship broadly [17].

There is a dispute among jurists over which mosques suit the I'tikaaf. I'tikaaf is permissible in any mosque with a congregation where the five prayers are offered, according to Abu Hanifah, Ahmad, Ishaq, and Abu Thaur. This is consistent with the Prophet's Hadith, which indicates that "any mosque with a call to prayer and an imam is suitable for I'tikaf" (Related by Ad-Daraqutni)[18]. For Muslims who wish to practice "i'tikaf" (meditative seclusion) starting the 20th Ramazan during the last ten days of the holy month of Ramazan, many mosques worldwide make extensive arrangements. Mostly it is Performed inside the main Prayer hall. The worshipers put their portable beddings and some daily life things (Fig. 4, a and b) with them and stay at the Prayer hall (day &night). The specific area is mostly bounded by some curtains, railings, or any other moveable obstacle for these 10 days[18].

Figure 4. (a) I'tikaaf space at Faisal Mosque in Islamabad. (b) I'tikaaf space inside a mosque in Karachi. [Geo News Pakistan]

5. MIHRAB

The mihrab is typically a centralized element in the prayer Hall wall facing towards Qibla (Fig. 5). The Mihrab is the alcove in the Qibla wall that indicates the required position for ritual prayer. It is mostly denoted by a concave niche in the Qibla facing wall and points worshippers towards the direction of the Kaaba, the holiest site for Muslims. In addition to the Haram al-Sharif in Mecca, the mihrab and the Qibla wall are essential architectural components of every mosque. In Mecca's Haram al-Sharif, worshippers form circles around the Kaaba[19]. The mosque's Imam stands inside the mihrab, and all the other worshipers follow him during prayer. Many mosques employ Muslims who direct their prayers in a particular direction and are reminded that their life should center on worshipping a single God. They also believe they are part of a sizable global society praying in this direction for more than 1,400 years—and possibly even earlier, according to Quranic experts. Some Mihrab style and minbar placement types are shown in Figure 6 through the architectural plan.

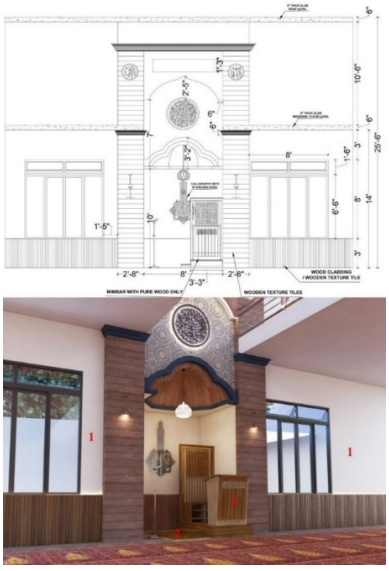


Figure 5. Visual representation of mihrab, minbar and Qibla wall. [Author]

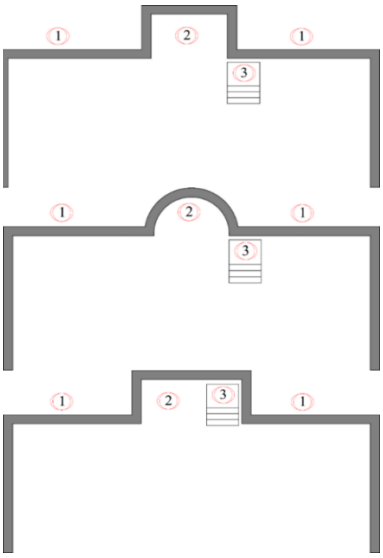


Figure 6. Describing different shapes of mihrab. [Author]
1= Qibla Wall, 2= Mihrab, 3= Minbar

6.ABLUTION AREA

The mosque's "ablution area" is essentially a place where worshipers get ready and wash some body parts with clean water. Fundamentally, ablution is a state in which Muslims remain until the start of prayer for one, two, or even more prayers. Some acts change their status (going to the restroom, passing gas, sleeping, being unconscious, vomiting, giggling uncontrollably during any prayer, and losing a single drop of blood as a result of an injury). Cleaning specific body parts in a specific order with fresh water is part of the ablution function. The main processes consist of beginning with the palms, then washing the mouth, nose, face, each arm up to the elbow, wiping the hair with wet hands, rubbing the ears with wet hands, and finally washing the feet up to the ankle. It is not always sufficient to carry out the procedure mentioned above to reach the ablution state (after sexual activity or unintentional semen discharge). Additionally, a showering procedure must be carried out[20].

The ablution area mostly consists of some toilets to the side for washing the body parts of excretion. Additionally, the primary area for ablution is a location with water taps (Fig. 7), a wash basin, or a pool of water. In this area, the primary ablution procedures happen. Some mosques have a water pool where visitors can ablute, whereas others only have water taps. It depends on the mosque's architectural design, style, and traditions. If a person has ablution already, they can go directly to the prayer hall without going through the process. On the other hand, if someone needs to do ablution, then they will need to pass through the ablution area to have ablution. Ablution areas mostly connect with Toilets and shower areas for users who need to shower or defecation/Urination (Fig. 8).

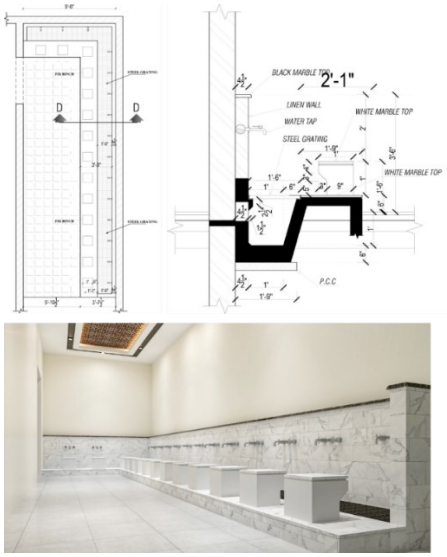


Figure 7. Ablution area of Umar Mosque Sialkot. [Author]

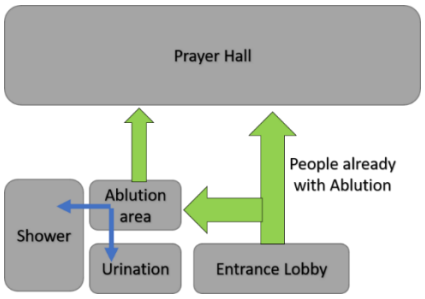


Figure 8. General flow diagram for mosque while passing through ablution area. [Author]

Limitations of toilet orientation in Islam (Hanafi Jurist Ideology)

In a sahih report, it is related that the Prophet (peace and blessings of Allah be upon him) prohibited facing the Qibla or turning one's back on it when going to the bathroom (Fig. 9).

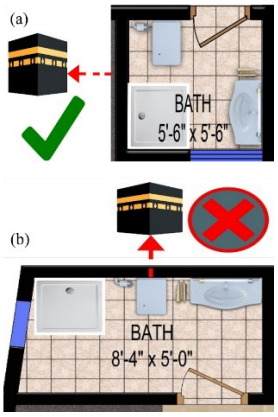


Figure 9. Right and wrong placement of toilet w.r.t qibla direction. [Author]

In all circumstances, whether outside in the open or inside a structure, Islamic scholars (such as Abu Haneefah and Shaykh al-Islam Ibn Taymiyah, may Allah have mercy on them) hold that it is prohibited to face the Qibla or turn one's back towards it when urinating [21].

Praise Allah, the Lord of the Worlds, and may He grant our Prophet Muhammad (S.A.W), his family, and his companions His blessings and peace. The Kaaba direction is, without a doubt, the most sacred. Therefore, one must revere it by refraining from doing anything that might be seen as minimizing this glory and honor or as a form of disrespect. This is why the Prophet (S.A.W) ordered Muslims, the Prophet (S.A.W) said: Do not face the Qibla or turn their back to it while urinating or passing stool. [Reported by Imams al-Bukhari and Muslim] Abu Ayyub says that when we first arrived in Syria, we noticed that the bathrooms were oriented toward prayer. As a result, we occasionally strayed while using them and begged Allah's forgiveness. Allah does not force people to do things beyond their capacity if they cannot stray. Allah is the wisest[22].

Suppose the plans for the building have not yet been implemented, and the toilets in the plan are facing towards the Qibla or have their backs towards it. In that case, it is safer to alter them so that one is not facing the Qibla or turning one's back towards it when relieving oneself. It is explained graphically how we can place our toilet seat w.r.t to qibla direction (Fig. 10). The green color shows us the range of angles in which we can place the toilet seat, while the red color declares its wrong placement which is prohibited in Islam.

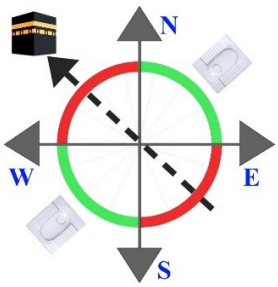


Figure 10. Graphical representation of toilet orientation w.r.t qibla direction. [Author]

7. MINBAR

The minbar is a stair-shaped pulpit from which the Imam (who leads Friday prayers) delivers sermons. Normally crafted from stone or wood with exquisite carvings, the pulpit is typically positioned to the right of the Mihrab [23].

The Imam conducts preaching from the minbar (Fig. 11), which is considered a visual representation of his position. This seat was originally reserved for the Islamic Prophet Muhammad (S.A.W) and later for the caliphs who followed him, each serving as the Imam of the entire Muslim community. It eventually became the standard practice for all Friday mosques, and the local Imam would employ it[23].

Muhammad's (S.A.W) minbar in Medina was the earliest known minbar in the Islamic world, built around 629 CE (possibly between 628 and 631 CE). It was only two steps and a throne-like seat. After Muhammad's (S.A.W) death, the caliphs continued to utilize the minbar as a symbol of their sovereignty. Muhammad's (S.A.W) original minbar was upgraded by the Umayyad caliph Muawiya (reigned 661-680) by raising the number of steps from three to six, thus increasing its prominence[4], [24], [25].

Figure 11. Minbar (pulpit) in the sanctuary at the Sultan Hassan Mosque and Madrasa, Cairo [https://www.mypicksmag.com/sultan-hassan-mosque-and-madrassa-a-beautiful-place-with-a-mystery/]

8. THE GENERAL PLAN OF A MOSQUE (DISCUSSING THE PLAN OF BILAL MASJID AT SALA VILLAGE SWABI, PAKISTAN)

From the above discussion, it is clear that every mosque has some common spaces, which are called primary spaces, and thus, these spaces should be in every mosque will meet the basic needs of worshipers (Fig. 12). Moreover, secondary and tertiary spaces depend upon the needs of the Muslim society of a region, their culture, tradition and regional aspect as like climatic conditions.

MANDATORY ORIENTATION IS NEEDED FOR EVERY MOSQUE

THE ORIENTATION OF THE MOSQUE TOWARDS MECCA (QIBLA)

The mosque must face Mecca to be in the right direction. Muslims worldwide must face the Qibla, the House of Allah (Mosque Located in Mecca, Saudi Arabia). Muslims use the Qibla, an Arabic word Romanized, to point toward the Kaaba, the Sacred Mosque in Mecca. This is especially true when they are praying the salah. Islam holds that the Kaaba is a Holy site created by the prophets Abraham and Ishmael. God designated it as the Qibla in several verses of the Quran that was revealed to Muhammad in the second Hijri year[26].

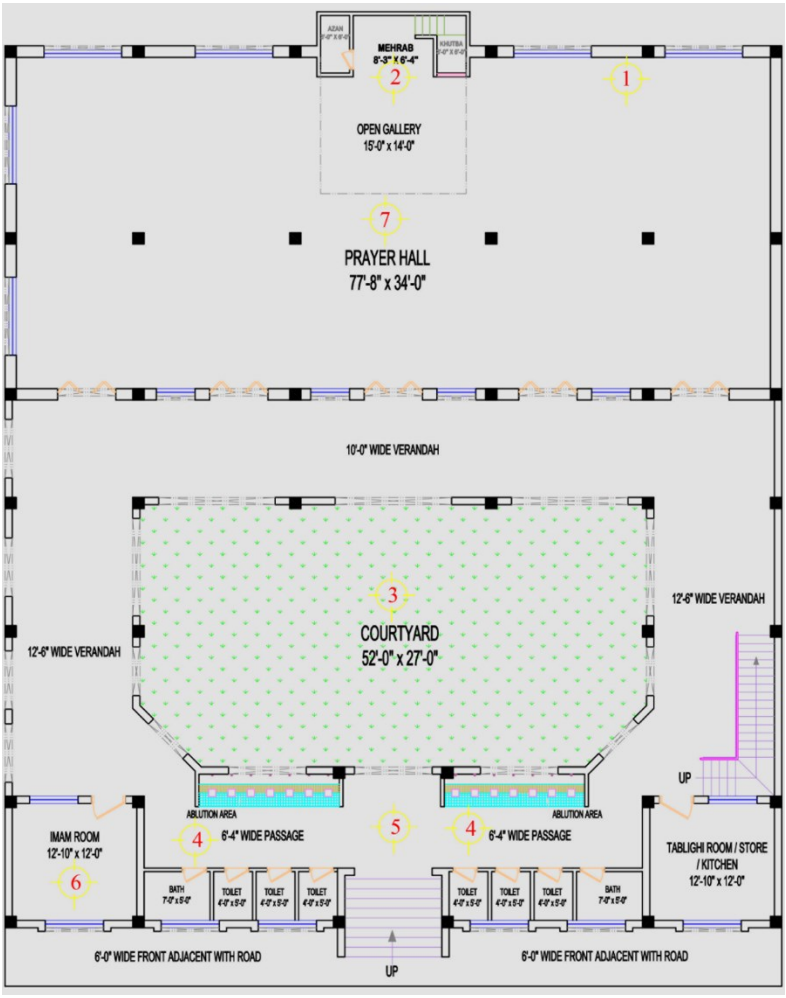


Figure 12. Spaces of mosque shown through a Mosque's plan.[Author]
Legends 1=Qibla wall (The wall to which worshipers face while praying), 2=Mihrab (The Place where the Imam, "The person who leads the worshipers while praying" stands) 3=Courtyard, 4=Ablution area, 5=Entrance foyer, 6=Imam room, 7=Prayer Hall

Muhammad (S.A.W) and his companions in Medina faced Jerusalem for prayer before this revelation. Mosques stand out from other buildings in design and orientation primarily because of this. In a well-established urban society, other structures are planned following the planning and context, whereas mosques always face the Qibla[27]. Most mosques contain a mihrab (a wall niche) that indicates the direction of the Qibla. The most common technical definition of a location used by Muslim astronomers is the direction of the great circle in the sphere of the earth, going via the location and the Kaaba. This enables precise computation of the Qibla using a spherical trigonometric formula that takes as inputs the coordinates of a site and the Kaaba. It is the direction of the shortest route from a place to the Kaaba; the technique is used to create websites and mobile applications for Muslims as well as to compile the qibla tables found in tools like the qibla compass. The Qibla can also be ascertained at a place by viewing the shadow of a vertical rod on the two occasions each year when the sun is directly overhead in Mecca—on the 27th and 28th of May at 12:18 Saudi Arabia Standard Time (09:18 UTC) and on the 15th and 16th of July at 12:27 SAST (09:27 UTC)[24].

Before the development of astronomy in the Islamic world, Muslims employed traditional procedures to determine the Qibla. These approaches included facing the direction Muhammad's companions had faced when they were in the same area, using celestial objects' rising and setting points, following the wind, or facing directly south, which was Muhammad's Qibla in Medina. Early Islamic astronomy was based on Indian and Greek texts, particularly those of Ptolemy, and by the mid-ninth century, Muslim astronomers had established procedures for approximating the qibla directions. In the late ninth and early tenth centuries, Muslim astronomers

developed techniques equal to the contemporary formula for determining the precise direction of the Qibla. This "qibla of the astronomers" was initially utilized with other historically established qiblas, resulting in considerable variation in medieval Muslim communities. Furthermore, before the 18th and 19th centuries, the precise geographic information essential for astronomical procedures to achieve an accurate result was unavailable, resulting in additional qibla fluctuation[28].

1. ORIGINATION OF ISLAMIC ORDERS FOR PRAYING TOWARDS QIBLA

The Qur'an's verse 144, known as the Al-Qibla Verse, is found in Sura al-Baqarah of Chapter #2 and instructs Muslims to change their direction of Qibla from Jerusalem to Masjid al-Haram. Following the arrival of Muslims in Medina, local Jews interpreted the Muslims' direction toward Jerusalem as proof that Islam was not a true religion. This made the Prophet Muhammad (s) wish that the Ka'ba was the Muslims' direction of travel (Qibla). Qur'anic chapter number two, verses 142, 143, and 150, have also been referred to as verses of Qibla. Verses 142 through 144 of Qur'an chapter 2 are regarded as Qibla Verses by some Qur'an exegetes.

Muslims have agreed that a valid prerequisite for prayer is facing the Qibla with all their might and effort.[29] Prophet Muhammad (S.A.W) served as an example of this and is said to have instructed a man who wanted to pray to face the Qibla after finishing his ablution in a hadith narrated by Bukhari. Muslim scholars concur that turning toward the Qibla should be done carefully and to the best of one's ability, not just randomly. According to the scholars of Syafi'iyah and Hanabilah, facing the Qibla is obligatory, but only if one is facing the Kaaba building. It means that this duty must be performed right up to the Ka'ba.[30] It is crucial to face the Qibla when offering prayers. In a hadith, the Prophet urged all followers to perfect their ablution and face the Qibla when offering prayer[31]. Except in two cases, the *khauf* prayer (done in a condition of danger or terror) and the supplementary prayer performed on the vehicle, anyone not facing the Qibla during the prayer is illegally punished[32]. As a result, choosing the correct Qibla direction becomes crucial, especially when getting ready to build a mosque. Additionally, figuring out the Qibla's direction is necessary in other locations like workplaces, retail establishments, and homes[33].

2. OCCASION OF THE REVELATION

Exegetical sources claim that the Qibla Verse was revealed to shift Muslims' Qibla from the al-Aqsa mosque to the Ka'ba. Jews in Medina took the Muslims' direction toward the al-Aqsa mosque as evidence that Islam was not a true religion after the Muslims moved there. Moreover, the reality is that Islam was not a new religion. In fact, Muhammad (S.A.W) was the last Prophet of Allah, like Moses, Jesus, David and Ibrahim (A.S). Islam was blessed by Allah to explain the past principles given to the previous Prophets and to give a complete way of passing life in the world till the end of this world. They questioned why Muhammad (s) prayed toward our Qibla if he had introduced a new religion. Some hadiths claim that the Prophet (s) wished that the Ka'ba was the Muslims' direction of prayer, but he never asked God for this. The verse refers to the Prophet's (s) anticipation of the shifting of the Qibla[34].

3. CHANGE IN THE ARCHITECTURAL MASS OF PROPHET'S MOSQUE DUE TO QIBLA REVELATION.

In the context of mosque architecture, the Prophet's Mosque in Medina, the predecessor of subsequent mosque constructions, represents a significant historical turning point regarding the design principles from which it originated. This landmark structure, distinguished by its north-south architectural axis, paved the way for the spatial arrangement of subsequent mosque structures.
A notable architectural element emerged during a distinct period in which the Qibla was directed toward the Al-Aqsa Mosque in Palestine (Figures 13 and 14). A northern bay, designated for prayer and aligned with the dominant Qibla, was meticulously incorporated into the mosque's design (Figure 14). This architectural arrangement reflected the inherent connection between religious orientation and spatial organization.

Nonetheless, the relocation of the Qibla towards the Kaaba in Mecca signified a significant evolution in mosque design, as it marked a turning point in the evolution of mosque architecture. As a result, the original northern bay retained its architectural prominence and was a physical link to the historical qibla orientation. Simultaneously, a southern bay was introduced to accommodate the redirected Qibla toward the Kaaba (Figure 15).
This dual-bay configuration resulted in a distinct spatial interstitial—the courtyard—between the two bays. The courtyard, now emblematic of mosque architecture, has taken on multiple meanings. It offered a communal gathering area, facilitated congregational activities, and harmonized the juxtaposition of historical and modern qibla orientations.

This architectural response to shifting qibla orientations highlights the intricate relationship between religious principles and spatial design within mosque architecture. The way the mosque went from having a bay facing north to having a bay facing south, with an atrium in the middle connecting the different parts of the building, shows how religious doctrine and spatial innovation work together in mosques.

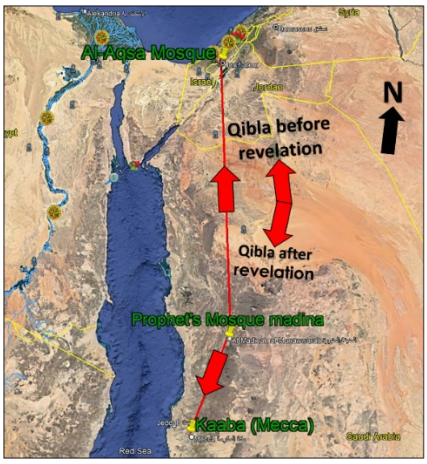


Figure 13. Qibla revelation before and after w.r.t Prophet's mosque. [Google Earth, edited by author]

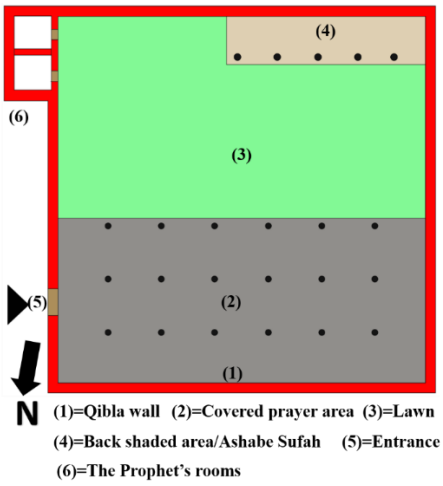


Figure 14 Conceptual plan of Prophet's mosque before Qibla revelation. [Oldham and Elkhateeb, 2008, drawn by author]

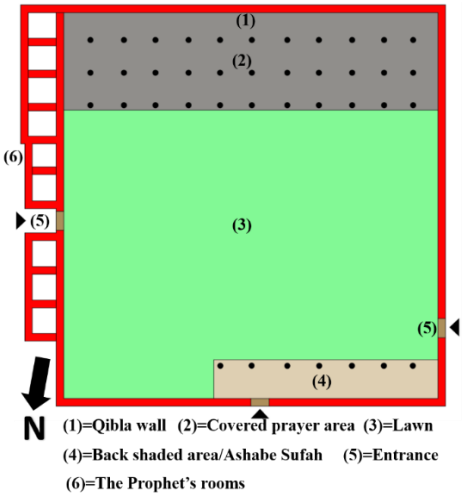


Figure 15 Conceptual plan of Prophet's mosque after Qibla revelation. [Grabar, 1987, Drawn by Author]

4. METHODS USED FOR QIBLA DIRECTION CALCULATION

In addition to observational methods, Muslim scholars and astronomers developed mathematical techniques for calculating the qibla direction, which was more accurate and could be used worldwide. Here are some of the earliest calculation methods used for qibla direction.

i. Spherical Trigonometry

Muslim mathematicians developed the field of spherical trigonometry, which is the study of triangles on the surface of a sphere. They used this mathematical tool to calculate the qibla direction by determining the shortest path, or great circle, between two points on the earth's surface. The qibla direction was then determined by finding the angle between the great circle and the direction of the North Pole[35].

Muslim astronomers created almanacs, tables of astronomical data, including the positions of stars and planets. They used these tables to calculate the qibla direction for different locations and times. Almanacs were updated regularly to ensure accuracy.

Astrolabes were sophisticated astronomical instruments used for various purposes, including determining the qibla direction. Muslim astronomers developed different types of astrolabes for different locations worldwide, which could be used to calculate the qibla direction based on the latitude and longitude of a given location[36].

ii. Mathematical Projections

Muslim mathematicians also developed mathematical projections that could be used to create world maps. These maps were used to determine the qibla direction for different locations. One example is the stereographic projection used to create maps of the Islamic world in the 10th century[37]. These early calculation methods were based on mathematical principles and provided a more accurate way of determining the qibla direction than observational methods. Muslim scholars and navigators used them for centuries, and they were essential in determining the qibla direction for different locations worldwide. Today, these calculation methods have been refined and improved upon and are used in modern technologies like GPS and online qibla direction apps.

iii. Khwarizmi's Method

Let P be the point on the earth's surface where we want to find the qibla direction. Let Q be the location of the Kaaba in Mecca. Then, the qibla direction from P is given by the great circle passing through P and Q[38]. The formula for the great circle passing through two points on a sphere is:

$$\cos(c) = \sin(a)\sin(b) + \cos(a)\cos(b)\cos(\theta)$$

where a and b are the latitudes of the two points, c is the angular distance between them, and θ is the longitude difference. In the case of the qibla direction, we can take Q to be located at latitude 21.4233°N and longitude 39.8262°E (the coordinates of the Kaaba in Mecca). We can then calculate the latitude and longitude of the point P for which we want to find the qibla direction.

Once we have the latitude and longitude of P, we can calculate the angle θ using the formula:

$$\theta = \lambda Q - \lambda P$$

Where λQ and λP are the longitudes of Q and P, respectively, note that we must convert the longitudes to radians before using this formula. Then, we can plug in the values of a, b, and θ into the formula for the great circle to get the cosine of the angular distance between P and Q. The qibla direction is the direction perpendicular to this great circle [38].

iv. Al-Battani's Improvement

Al-Battani noticed that Khwarizmi's technique did not account for the earth's curvature. He expanded on Khwarizmi's method by employing a new formula considering the earth's curvature [39].

Let r be the earth's radius, and d be the distance between P and Q along the earth's surface. Then, the qibla direction from P is given by:

$$\sin(\theta) = \sin(\alpha)/\sin(d) \ldots\ldots\ldots (a)$$

Where α is the angular distance between the meridian of Q and the meridian of P. This can be calculated using the formula:

$$\alpha = \arctan[\cos(\varphi Q) \tan(\lambda Q - \lambda P)/\sin(\varphi P)] \ldots\ldots\ldots (b)$$

Where φQ and φP are the latitudes of Q and P, respectively, note that we must convert the latitudes and longitudes to radians before using these formulas.

Once we have calculated the values of α and d, we can use the formula for sin(θ) to find the qibla direction from P.

v. Projecting the Circle on Map

In this method, the circle's characteristics using longitude and latitude lines are determined as a reference (Fig. 16a), and the red circle represents the following circle. It is situated at the center of the globe. It has the same diameter as the earth. The intersection of the points (λ, 0°) and (+180°, 0°) on the circle with the equator line. The point (+90°, A) is at maximum latitude. In contrast, the point (+270°, -A) is located at the minimum latitude (Fig. 16b). After connecting these sites, a sinusoidal curve is discovered on the map [40].

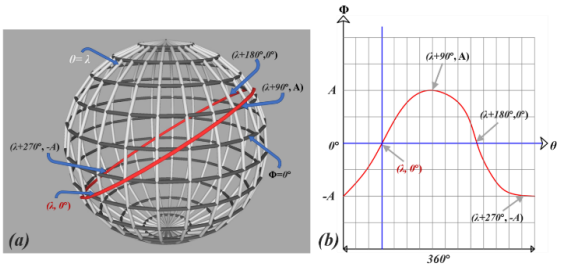


Figure 16. (a) Projecting circle on map w.r.t latitude and longitude. (b) Describing the highest and lowest latitude on the map. [Author]

Let, Latitude = Φ

Longitude = θ

Offset Longitude= λ

A is the highest magnitude of the wave.

360° is the wavelength of the sinusoid.

Therefore, the equation of the following sinusoid,

$$\Phi = A \times \sin(\theta - \lambda) \ldots\ldots\ldots (1)$$

Where θ and Φ are variable, and λ and A are constant. Therefore, to specify a sinusoid over the map, we must determine the values of λ and A.

Finding the path to Kaaba

By determining the constants of the sinusoid that intersects your and Kaaba's location, we will find the straight path on the earth's surface that leads to Kaaba.

Let the geographical location of the proposed site, $(\theta, \Phi) = (\theta_0, \Phi_0)$

Kaaba's geographical location, (θ, Φ) = (39.8262°, 21.4225°)

Therefore, from equation (1),

$$21.4225^\circ = A \times \sin(39.8262^\circ - \lambda) \ldots\ldots\ldots (2)$$

$$\Phi_0 = A \times \sin(\theta_0 - \lambda) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Here, we have two equations and two variables (λ and A). So, solving this is possible.

Finding the Qibla direction

The sinusoid equation or Path to Kaaba is found. Now, to determine the direction, we use a simple formula,

$$\alpha = \tan^{-1} \quad (d\emptyset/d\theta$$

, $\alpha = \theta = \theta_0$; $90^\circ \geq \alpha \geq -90^\circ$

If

$\alpha \geq 0^\circ$

The direction is α NE or SW.

Else if

$\alpha < 0^\circ$

The direction is |α| NW or |α| SE.

ARCHITECTURAL INFLUENCE OF MOSQUES ON THE LAYOUT OF ISLAMIC CITIES

The historical and cultural significance of the mosques' influence on the urban fabric of Islamic cities is immense. This section attempts to clarify the crucial relationship between mosque architecture and the urban development of Islamic cities, with an emphasis on the Kaaba-facing orientation. By analyzing the cities of Kufa in Iraq, Fustat in Egypt, and Kairouan in the Islamic Maghreb, we demonstrate how the establishment of mosques as central landmarks influenced the spatial layout of these cities.

1. KUFA, IRAQ

In the case of Kufa, the mosque's orientation towards the Kaaba profoundly affected the city's spatial configuration. Figure 17 depicts how the axis of the mosque affected the configuration of streets and pathways. A well-organized urban layout resulted from the central mosque serving as the nucleus from which streets emanated. This design strategy nurtured a sense of community and facilitated efficient citywide movement.

Figure 17 Image depicting mosque orientation and street layout in Kufa. [Google Earth, edited by author]

2. FUSTAT, EGYPT

Similar to Kufa, the orientation of the mosque towards the Kaaba in Fustat was crucial to urban development. Figure 18 illustrates how the mosque's orientation determined the layout of markets and residential areas. The central location of the mosque made it easier for people to congregate, while adjacent markets and residential areas created a cohesive urban ensemble.

Figure 18. Image illustrating mosque alignment and urban zones in Fustat. [Google Earth, edited by author]

3. KAIROUAN, ISLAMIC MAGHREB

In the case of Kairouan, the influence of mosque orientation on urban planning is evident. Figure 19 depicts the mosque's orientation concerning the Kaaba and its relationship to the city's layout. The radial pattern of streets and buildings surrounding the mosque is evidence of the organized urban growth that this architectural orientation fostered.

Figure 19. Image illustrating mosque alignment and urban layout in Kairouan. [Google Earth, edited by author]

4. VISUAL VIEW OF MOSQUE ORIENTATION IN A CONTEXT OF TOWN

Normally, when an architect designs a building, he considers the wind direction, sunlight, noise pollution, and accessibility from the main road. In contrast, in the case of mosque design, it is different. In this instance, an architect must prioritize the orientation of the mosque prayer hall towards the qibla direction before addressing the other variables.

In our daily lives, we see worldwide that the building of a mosque never follows the linear grid of a town, society or city. (Fig. 20 a and b) determines the application of this theory at two major sites (Isfahan in Turkey and Abuja in Nigeria), where mosques are diverted from the continuous grid of the Town. It always follows the direction towards the Kaaba (Fig. 21), even if the building coverage is unsuitable according to plot size.

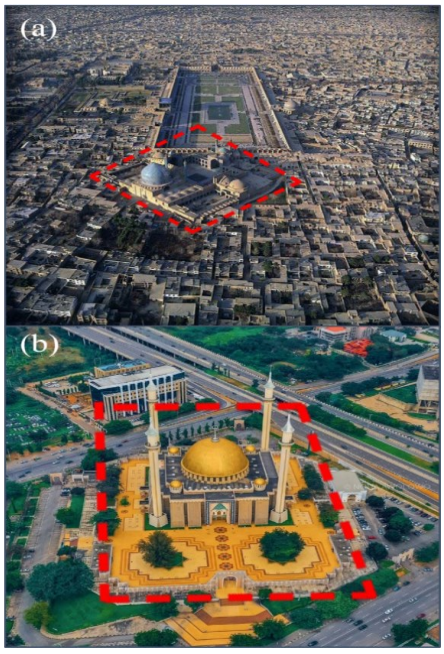


Figure 20. (a) Orientation of Blue Mosque at Isfahan in contrast with city grid, [https://www.intechopen.com/chapters/80778] (b) Orientation of Nigerian National Mosque in Abuja. [Source: Courtesy of Nora Awolowo]

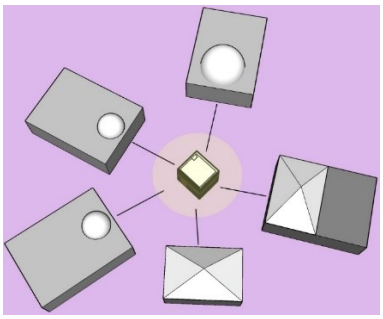


Figure 21. Graphical conceptual view of mosques directed towards Qibla. [Author]

5. HOW DO ARCHITECTS BENEFIT AND EXPLOIT THE SPACE LEFT BY THIS ORIENTATION?

Architects can educate practitioners and the general public on the significance of orientation and its effect on architectural design. This promotes a greater appreciation for buildings' cultural and religious significance in urban planning and design. The necessity of orienting the mosque toward the Qibla has impacted the building's layout and organization. Architects have utilized this requirement to construct spatial hierarchies within the mosque, positioning the prayer hall and mihrab prominently while surrounding them with auxiliary spaces. This spatial arrangement enhances the mosque's overall functionality and flow. Moreover, figures 22(a and b) and 23(a and b) are the two mosques the author designed; these two mosques also faced the issue of orientation concerning the street line. So, the negative spaces that resulted from orienting the prayer hall towards the Qibla were treated well; some spaces were used for ventilation and verdant spaces, while the rest were used for the mosque's secondary utilities, such as toilets, an imam's room, a library, etc. Figure 22(a) describes Masjid Al Qasim, whereas Figure 23(a) describes the Bilal Mosque. In both pictures, the yellowish hue represents the mosque's location, while the internal black rectangle represents the prayer hall, precisely aligned with the Qibla direction. Figures 22(b) and 23(b) are floor plans of the two mosques, which illustrate the optimal use of acute angles and negative spaces in green spaces, ventilation, and mosque secondary utilities.

Here are five mosques (Table 1) in different areas of one Province in Pakistan, which the author recently designed. After analyzing the planning of these mosques, it was obtained that the planning of a mosque is not dependent upon access to the building, sunlight, contextual buildings, town planning, or plot orientation. However, it is only oriented towards the qibla direction.

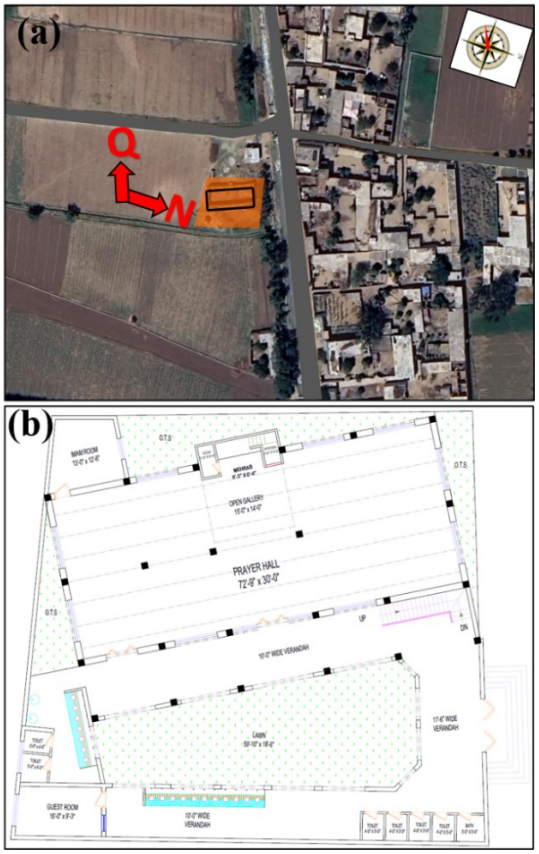


Figure 22. (a) Site of Masjid Al Qasim directed towards Qibla. [Google Earth, edited by author], (b) Architectural plan of Masjid Al Qasim. [Author]

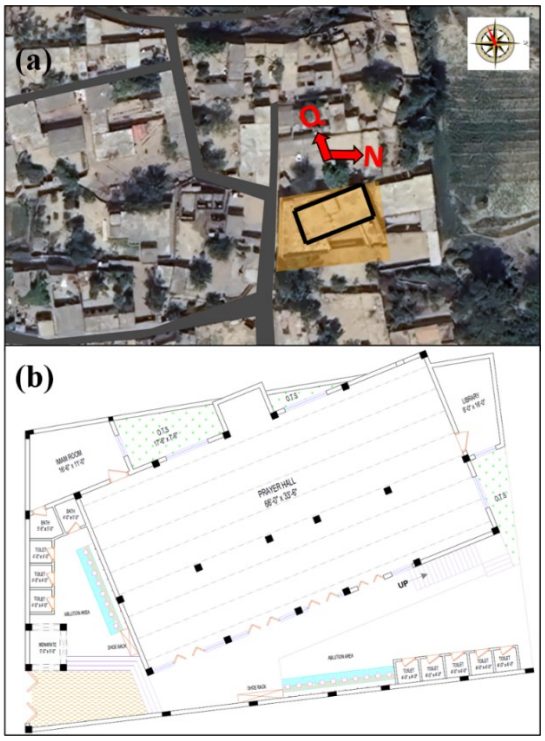


Figure 23. (a) Site of Bilal Mosque directed towards Qibla. [Google Earth, edited by author], (b) Architectural plan of Bilal Mosque. [Author]

Table 1 Orientation of three mosques in different regions of Pakistan. Source[author]

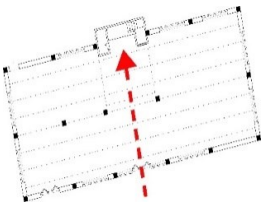
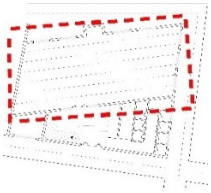
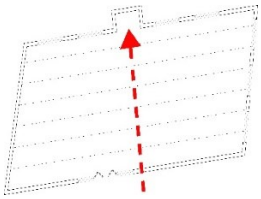
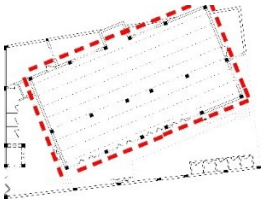
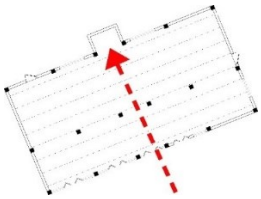
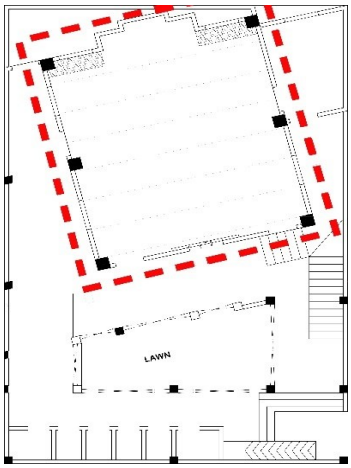
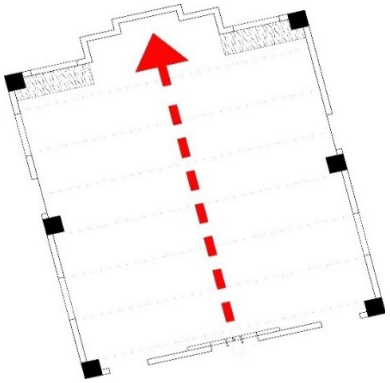
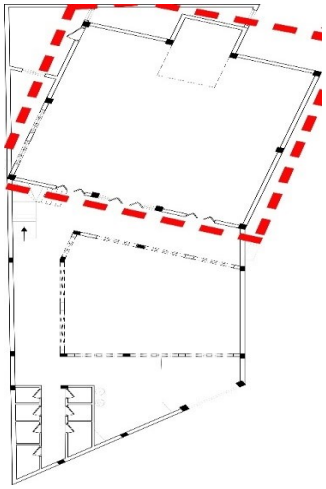
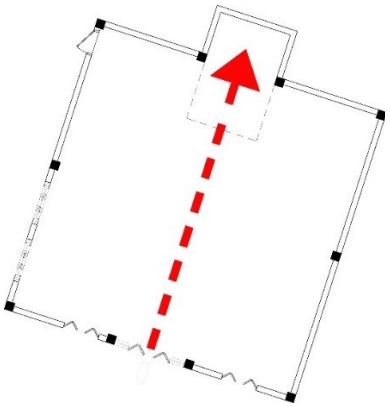
Mosque name	Location	Mosque plan	Zoom input towards qibla direction	Orientation From the main road or town grid line
Masjid Al qasam	Anbar Village District Swabi K.P Province Pakistan			Oriented 10 degrees anticlockwise from the street grid line.
Bilal Mosque	Jehangira Village District Swabi K.P Province Pakistan			Oriented 14 degrees anticlockwise from the Street grid line.
Masjid Abu Hanifa	Jehangira Village District Swabi K.P Province Pakistan			Oriented 22 degrees clockwise from the street grid line.

Table 2 Orientation of two mosques in different regions of Pakistan. Source[author]

Mosque name	Location	Mosque plan	Zoom input towards qibla direction	Orientation from the main road or town grid line
Masjid Awais Qarni	Dhodial Village District Mansehra K.P Province Pakistan			Oriented 76 degrees anti-clockwise from the town grid line.
Ayesha Masjid	Manki Village District Swabi K.P Province Pakistan			Oriented 144 degrees clock-wise from the street grid line.

Some major cities of Pakistan (Table 3) have been analyzed for the qibla determination angle and declination. Additionally, to these cities, Swabi City has been added to this analysis because most of the sites in the above tables are located in Swabi.

The qibla determination angle represents the angle between the true north direction and the direction towards the Kaaba in Mecca, and it is used to determine the direction towards the Qibla for prayer. The qibla determination angle is calculated based on the latitude and longitude of each city. So, the angle of qibla direction varies according to each site's latitude and longitude change.

Table 3 Determination of qibla angle of 5 cities of Pakistan [Source: Author]

City	Latitude	Longitude	Magnetic declination	Qibla angle	Qibla degree for compass
Islamabad	33°69'38" N	73° 06'52" E	+2.30°	255.91°	253.61
Karachi	24°86'08" N	67°01'04" E	0.74°	267.75°	267.01
Lahore	31°55'80" N	74°35'07" E	+1.68°	260.30°	258.62
Peshawar	34°00'80" N	71°57'85" E	+2.50°	254.05°	251.55
Swabi	34°12'02" N	72°46'98" E	+2.46°	254.70°	252.24

CONCLUSON

We concluded from the preceding discussion that the mosque is where Muslims assemble for worship and various cultural events. Every mosque has a courtyard, a prayer hall, a place for I'tikaaf, Mihrab, and minbar, and an area for performing ablution. Every mosque space has its designated function and cannot be used for additional purposes. For instance, the prayer hall may never be converted into a place for ablution, and vice versa. On the other hand, the minbar is used exclusively for a special speech by the Imam or the Khutba on Fridays and Eid days; therefore, this minbar may never be used by anyone other than the Imam or for any other purpose. As we discussed, the mihrab should only be placed on a wall facing the direction of the Qibla, and the minbar should be placed closest to the mihrab so that the Imam can use it effortlessly, as these are both concerning the Imam. On the other hand, we cannot design the ablution area inside the prayer hall because it has a foul odor, and it is preferable to keep it away from the main prayer hall, as well as because prayer can only be performed in an area that is pure and immaculately clean.

Our research determined that the mosque edifice is a specific structure. Architects should be familiar with certain Islamic facts and regulations that must be observed when designing a mosque. Typically, when we design other structures, we care for light, ventilation, town girds, etc. In contrast, mosques require an additional factor that must be considered a top priority: the qibla direction. The analysis of extant mosques in various countries proved this point, and it was evident that mosques have a significantly different orientation than other buildings in their context. None of the mosques in the world adhere to the city matrix of planning, roads, accessibility, contextualism, and a few other measures commonly observed in the design of other structures. We determined that the mosque's design does not adhere to plot style or sun angle. It is directed in a qibla direction and concentrates on the Kaaba, much like the surrounding iron bars on a magnet's surface.

AUTHOR CONTRIBUTIONS

Conceptualization, S.H. and F.J.; methodology, S.H. and F.J.; software, S.H. and F.J.; validation, S.H. and F.J.; formal analysis, S.H. and F.J.; investigation, S.H. and F.J.; resources, S.H. and F.J.; data curation, S.H. and F.J.; writing—original draft preparation, S.H. and F.J.; writing—review and editing, S.H. and F.J.; visualization, S.H. and F.J.; supervision, F.J.; project administration, S.H. and F.J.; funding acquisition, S.H. and F.J. All authors have read and agreed to the published version of the manuscript.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] M. Farhat, *Islamic piety and dynastic legitimacy: The case of the Shrine of 'Alī b. Mūsā al-Ridā in Mashhad (10 th–17 th century)*. Harvard University, 2002

[2] Z. Sardar, *Reading the Qur'an: The contemporary relevance of the sacred text of Islam*. Oxford: Oxford University Press, 2017

[3] A.P.D.A.H. Radwan, "The Mosque as a public space in the Islamic City-An Analytical study of Architectural & Urban design of contemporary examples", *Journal of Architecture, Arts and Humanistic Science*, vol. 6, issue 30, pp. 70-90, 2020, DOI: 10.21608/mjaf.2020.35199.1712

[4] K. Rizvi, *The transnational Mosque: Architecture and historical memory in the contemporary middle east*. UNC Press Books, 2015

[5] I.N. Al-Bukhari, R.F. Alsabban, and A.M. Shehata, "Characterization Framework of Contemporary Mosques in Islamic Cities", *Journal of Engineering, Computing and Architecture*, vol 11, issue 1, p. 12-17, 2020.

[6] V. Ilci, et al., "Investigation on the accuracy of existing qibla directions of the mosques from different periods: A case study in Çorum city, Turkey", *Tehnički vjesnik*, vol 25, issue 6, pp. 1642-1649. 2018. doi: https://doi.org/10.17559/TV-20170226111205

[7] N.A. Azmi, and M.Z. Kandar, "Factors contributing in the design of environmentally sustainable mosques", *Journal of Building Engineering*, vol. 23, pp. 27-37, 2019, doi: https://doi.org/10.1016/j.jobe.2019.01.024

[8] T. Ahmad, M. J. Thaheem, A. Anwar, Z. U. Din "Implications of stereotype mosque architecture on sustainability", *Procedia Engineering*, vol. 145, pp. 96-103, 2016, doi: https://doi.org/10.1016/j.proeng.2016.04.023

[9] L. A. Ali, and F.A. Mustafa, "The state-of-the-art knowledge, techniques, and simulation programs for quantifying human visual comfort in mosque buildings: A systematic review", *Ain Shams Engineering Journal*, vol 14, issue 9, pp. 102128. 2023, doi: https://doi.org/10.1016/j.asej.2023.102128

[10] Y. Ardhiati, "The new architecture of mosque design to express the modernity of moslems", *Global Advanced Research Journal of Arts and Humanities (GARJAH)*, volume 2, issue 4, pp. 75-78, 2013.

[11] A. Allahham, "Metamorphosis of mosque semiotics: from sacred to secular power metaphorism–the case of State mosques", *Archnet-IJAR:International Journal of Architectural Research*, 2019. doi: https://doi.org/10.1108/ARCH-11-2018-0001

[12] S. Buhlfaia, *Historical background of Libyan mosque architecture: assesment and criticism of mosquesin Ajdabiya city*, Middle East Technical University, 2006

[13] A. Mokhtar, "Design standards for Muslim prayer facilities within public buildings", *Proceedings of the 2009 Annual Research Conference on the Architectural Research Center Consortium: Leadership in Architectural Research, Between Academia and the Profession*, San Antonio, 2009.

[14] O.S. Asfour, "Bridging the gap between the past and the Present: A Reconsideration of Mosque Architectural Elements", *Journal of Islamic Architecture*, vol 4, issue 2, pp. 77-85, 2016, DOI: https://doi.org/10.18860/jia.v4i2.3559

[15] N. Iqbal, *Mosque In The Valley: A Space For Spiritual Gathering & Cultural Learning*, Master Theses, University of Massachusetts Amherst, 2015.

[16] M. Tayeb, "Islamic revival in Asia and human resource management", *Employee relations*, Vol. 19 No. 4, pp. 352-364, 1997. doi: https://doi.org/10.1108/01425459710170086

[17] M. Jawaid, *Celebrating the Revelation of the Quran*, 2020.

[18] M.R. Amiryousefi, , et al., "Is It Possible to Quench Thirst Using Licorice-Enriched Barley Bread during Islamic Fasting?" *Journal of Fasting & Health*, vol 5, no 4, pp. 151-157, 2017, Doi: 10.22038/jfh.2018.28595.1108

[19] M. Frishman, and H.-U. Khan, *The mosque: history, architectural development and regional diversity*. Thames & Hudson, 1994

[20] A. Mokhtar, "Challenges of designing ablution spaces in mosques", *Journal of architectural engineering*, vol 9, issue 2, pp. 55-61, 2003, doi: https://doi.org/10.1061/(ASCE)1076-0431(2003)9:2(55)

[21] S. Malik, and B. Mujahid, "Perception of House Design in Islam: Experiences from Saudi Arabia and Pakistan", *Journal of Islamic Thought and Civilization*, vol 6, issue 2, pp. 53-76, 2016.

[22] N.H.A. Majid, et al., "Shariah compliance hospitality building design: A Malay Muslim oriented architecture", *Procedia-Social and Behavioral Sciences*, vol 201, pp. 136-145, 2015, doi: https://doi.org/10.1016/j.sbspro.2015.08.159

[23] M.M. Rahman, "Islamic architecture and arch", *International Journal of Built Environment and Sustainability*, vol 2. no. 1, 2015, DOI: https://doi.org/10.11113/ijbes.v2.n1.52

[24] J. Bloom, S.S. Blair, and S. Blair, *Grove Encyclopedia of Islamic Art & Architecture: Three -Volume Set*. Vol. 2, Oxford University Press on Demand, 2009

[25] N. Chikhaoui, and F.J. Casewit, "The minbar: symbol of verticality and elevation", *Sacred Web: A Journal of Tradition and Modernity*, vol. 14, pp. 91-107. 2004.

[26] A. J. Wensinck, "□ibla: Ritual and Legal Aspects", *The Encyclopedia of Islam, New Edition*, 1986.

[27] D. A. King, "The enigmatic orientation of the Great Mosque of Córdoba", *Suhayl: International Journal for the History of the Exact and Natural Sciences in Islamic Civilisation*, vol 16-17, pp. 33-111, 2018

[28] G. Pantazis, and E. Lambrou, "Investigating the orientation of eleven mosques in Greece", *Journal of Astronomical History and Heritage*, vol. 12, pp. 159-166. 2009.

[29] R. Akbar, and R. A. Mustaqim, "Theoretical Study of the Use of the Polaris Star as a Reference for The North Point in Determining the Qibla Direction", *Jurnal Ilmiah Islam Futura*, vol. 22, issue 1, pp. 16-28, 2022. DOI: http://dx.doi.org/10.22373/jiif.v22i1.9411

[30] A. Asmuni, H. Matsum, and I. Muttaqin, "The true north urgency of the earth in determining the direction of the Qibla according to Fiqh and Falak science", *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, vol. 3, issue 4, pp. 3353-3358. 2020.

[31] M. Vandestra, and I. Muslim, *Kitab Hadist Shahih Muslim Ultimate*. Dragon Promedia: 2017.

[32] R. Akbar, and A. Asman, "SOCIAL CONFLICT DUE TO THE CONTROVERSY OF MOSQUE'S QIBLA DIRECTION IN SEJIRAM VILLAGE, SAMBAS REGENCY", *Jurnal Ilmiah Al-Syir'ah*, vol. 18, no. 1, pp. 1-12, 2020, DOI: http://dx.doi.org/10.30984/jis.v18i1.926

[33] M. Mustamin, "Studi Konflik Sosial di Desa Bugis dan Parangina Kecamatan Sape Kabupaten Bima Tahun 2014", *Jurnal Ilmiah Mandala Education*, vol. 2, no. 2, pp. 185-205, 2016, DOI: http://dx.doi.org/10.58258/jime.v2i2.109

[34] J.E. Lumbard, "Covenant and Covenants in the Qur'an", *Journal of Qur'anic Studies*, vol 17, No. 2, pp. 1-23, 2015, DOI: https://doi.org/10.3366/jqs.2015.0193

[35] M. Yilmaz, "Historical mosque orientation in Turkey: central-western anatolia region, 1150–1590". *Journal of historical geography*, vol.38, no. 4, pp. 359-371. 2012. doi: https://doi.org/10.1016/j.jhg.2012.06.002

[36] G. Almakky, and J. Snyder, "Calculating an azimuth from one location to another a case study in determining the Qibla to makkah", *Cartographica: The International Journal for Geographic Information and Geovisualization*, vol 33, No. 2, pp. 29-36, 1996, DOI: 10.3138/C567-3003-1225-M204

[37] H.R., Turner, *Science in medieval Islam: an illustrated introduction*, University of Texas Press 2010.

[38] W.M. Sanjaya, et al. "Determining Qibla Direction using al-Biruni's First Method from Kitab Tahdid Nihayat al-Amakin with The Implementation Based on Board Arduino MCU, GPS Module, and Digital Compass", in *2019 International Seminar on Application for Technology of Information and Communication (iSemantic)*. pp. 513-518, 2019, doi: 10.1109/ISEMANTIC.2019.8884330

[39] A. Latif, *Development of Pharmacology (Ilmul Advia) During Abbasid Period and its Relevance to Modern Age*, Prowess Publishing, 2019,

[40] D. A. King, *Astronomy and Islamic society: Qibla, gnomonics and timekeeping*, in *Encyclopedia of the history of Arabic science*. p. 128-184, Routledge, 2019.