ARCHITECTURAL DISSERTATION

ECO-FRIENDLY MOSQUE

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For the award for the degree of

BACHELOR OF ARCHITECTURE
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BY
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This is to certify that AR515: Architectural Dissertation **"ECO-FRIENDLY MOSQUE"** submitted by **KAYSAR QAYOOM LONE** bearing registered number **317106101001** on this day of _____________ in partial fulfilment of the requirement for the award of degree of BACHELOR OF ARCHITECTURE of this University is a bonafide work to the best of our knowledge, and it may be placed before the jury for consideration.

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INTRODUCTION

1.1 INTRODUCTION.

A Mosque has always been known as a centre of a Muslim community. Traditionally, mosques, perform more functions than just being a place of worship. A mosque is not only for the Muslims to perform prayer in the congregation but also as a place to generate economy, education and social cohesion of the community. Hence, a mosque can be considered as a living nexus; the mosque itself is living and bringing life to the community it serves. Therefore, both mosque and its surroundings are living symbiotically together. The concept of "eco-friendly mosque" would be abstracted as a mosque and its atmosphere that are not harmful for the environment but promotes ecology, protects environment towards ensuring sustainability. This is the timely-need concept that must be implemented in the present environmental situation of the world. As we all know that Mosque is a place where most of the Muslims are engaged in every day for praying their obligatory daily-prayers and especially prayer on Friday and in other religious festivals and occasions as well. It's time we understand the link between man and his stewardship responsibilities towards the planet and future generations.

The Mosque is the epicentre of the community and an important learning place. To amplify the environmental stewardship responsibilities, there is no better place to teach than by way of an example of an eco-friendly Mosque.

1.2 AIM OF THE STUDY.

- The aim of this study is to design a prominent communal mosque and understanding on how these mosques are developed to fulfill the needs of the Muslim community and create a sustainable environment.

1.3 OBJECTIVES OF THE STUDY.

- To improve thermal performance of mosque buildings with the assistance of passive cooling systems.
- To Design a Mosque with the environmentally friendly building materials.
- To create a healthy indoor environment.
- To study how to adopt more eco-friendly design approach and use of renewable energy source amongst others as key for achieving eco-friendly mosque.

1.4 NEED AND SCOPE

The rapid increase in industrialization and subsequent environmental pollution has become one of the biggest problems of the 21st century. As a result, increasing use of renewable energy with increasing global warming and climate changes has made keywords such as sustainability and ecology very popular. The fact that global warming, environmental pollution, carbon dioxide emission and many subsequent problems are highly related to the building sector has led to the introduction of many new concepts in architecture such as global warming, ecology, sustainability, renewable energy, environmental design, smart structure, energy efficiency conservation and green architecture.

In today's Architectural practice, there is a struggle to find the ways to balance or harmonize environmental technology, protection of resources and aesthetic content. And the world has witnessed some level of significant industrial and technological revolution. The revolution, despite its acclaimed benefits to humanity has resulted to a worrisome level of interaction with our environment. One point of a great concern, with regard to the eco-system, is that as the global greenhouse gas level continue to rise, the planet's temperature with corresponding rise, resulting in the melting of the ice caps and seriously altering global weather conditions. Current estimates calculate that the world built environment account for approximately one third of all global greenhouse gas (GHG) emissions whilst consuming 40% of the world's energy. However, the challenge facing environmental architecture is meeting the increasing demand for revolutionary architectural solutions while mitigating its impact on the eco-system.

The human population has increased so great and their impact on the natural world grown so devastating that what was regarded a progress in the past may soon turn out to be a source of our civilizational downfall. Without a doubt, the world of architecture is set to become a means and tool for such a downfall. It is set to gradually emerge as the main culprit and, at the same time, one of the main victims of the situation's adversity.

The fact that global warming, environmental pollution, carbon dioxide emission and many subsequent problems are highly related to the building sector has led to the introduction of many new concepts in architecture such as global warming, ecology, sustainability, renewable energy, environmental design, smart structure, energy efficiency conservation and green architecture.

The main feature of green buildings or ecological buildings is that they do not disturb the ecological balance. Although there are so many man-made factors that disrupt the ecological balance in nature, buildings that are designed not to disrupt the ecosystem are important for awareness. The aim is to produce structures that will benefit both nature and human beings. The purpose of this eco-friendly mosque concept is to promote the truly ecologically-responsible mosque in all around the country and the world as well. Mosque plays a significant role in the Muslims life and in their community, it should be designed and run for utilizing the maximum benefit of it for the humanity through ensuring sustainable eco-friendly environment. It has a scope of encouraging and supporting coexistence between humanity and nature at all levels in a healthy, supportive, diverse and sustainable condition, recognizing their mutual subtle interdependence.

1.5 LIMITATIONS.

The design of the Mosque will be limited to 3000 Worshippers.

1.6 METHODOLOGY

The project will be oriented to meet the requirements for the completion of Bachelor's Degree in Architecture. Though it is an academic requirement, it will be based on ground reality.

The following methodologies will be adopted in two phases to come up with the final design.

Research phase

- Literature Review
- Case study

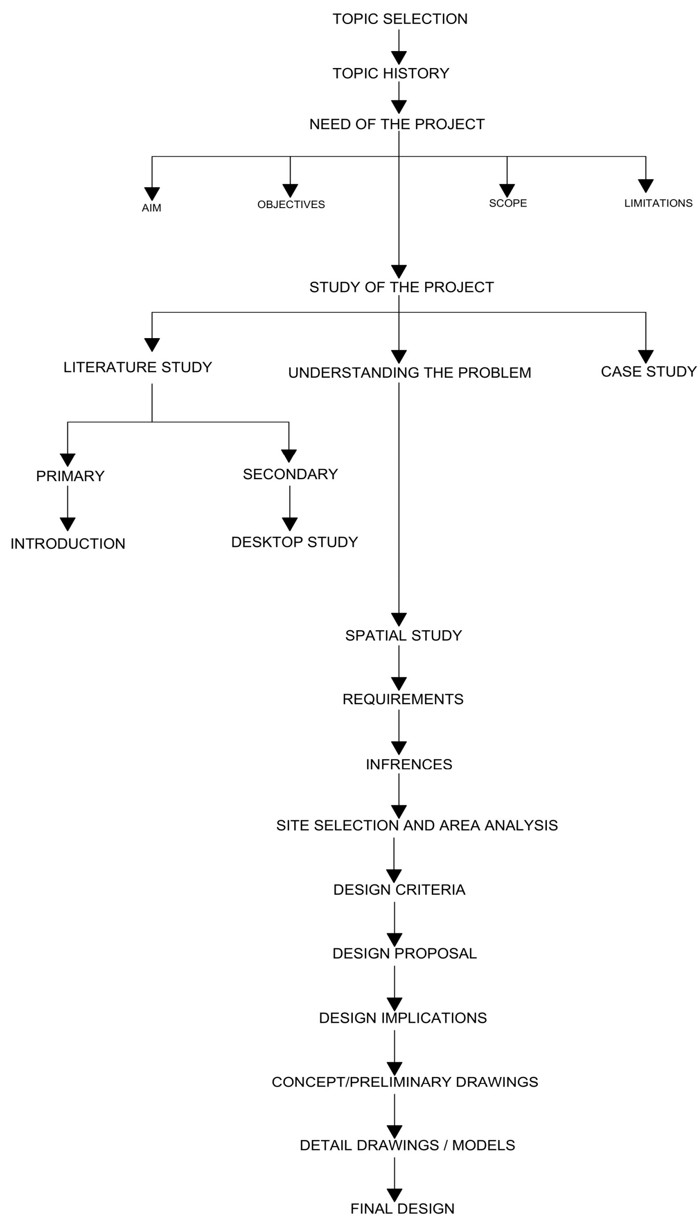
This is preparatory phase for thesis project in which data, facts, spatial needs and requirements are studied focusing on the approved topic. We will study the present functioning and organization of spaces through case studies. All the findings gathered in this phase will be applied in our design phase.

Design phase

- Site selection and analysis
- Program formulation and zoning
- Conceptual design
- Design development
- Analysis and evaluation of output design

- Preparation of architectural drawings, 3D views, model, report for final presentation

This phase will orient itself on creating proper design of thesis topic selected where the combination of all knowledge gathered form research phase would be applied. This could be better understood from the charts



CASE STUDIES

1. Badriya Jum'a Masjid, Kodi Village, Kundapur Karnataka
2. Ayodhya Mosque, Dhannipur. UP (in construction)

DESKTOP STUDIES

1. The Cambridge Central Mosque, UK
2. Khalifa Al-Tajer Mosque, Dubai.

2. LITERATURE STUDY

2.1 MOSQUE ARCHITECTURE.

The word 'mosque' means masjid in Arabic. A mosque is a religious gathering place for prayer for Muslims. Masjid means "place of prostration.'' Though it is said that most of the five daily prayers prescribed in Islam can be done anywhere, all men gather together at the mosque for the Friday noon prayer. Mosque is considered the centre of the Islamic urban communities. It has a central role in the Muslim society, as it not only a place of worshipping Allah but a school, an institute of science and technology, Arts, leadership and orientation Other than religious purpose, the mosques are also used in for other functions like study, socializing space, recreational zones etc.
Certain Mosques acts as centres of learning, some mosques become places where jurist five out judgements. In most of the places Mosques also act as Kitchens were food is served for poor and needy. Some mosques even act as hostel for students. In all major cities, towns there exists main mosques which are used as gathering space of men for Friday prayers, such a mosque is called Jami Masjid, literally meaning "Friday Mosque". The style, layout and decoration of a mosque reflect the Islamic culture in general but also it can give information on the period and region in which the mosque was constructed.

The first mosque in Islam was built by the Prophet Muhammad (pbuh). It was simple rectangular plan, built with palm trunks and mud bricks. During the next centuries, the mosque construction witnessed tremendous development. Mosque designs varied in different countries and cultures where Muslim live. Most mosque buildings today neglect the positive use of natural environment and consume a lot of energy in order to provide comfortable internal environment for the worshippers.

The architecture of a mosque is shaped most strongly by the regional traditions of the time and place where it was built. As a result, style, layout, and decoration can vary greatly. Nevertheless, because of the common function of the mosque as a place of congregational prayer, certain architectural features appear in mosques all over the world.

2.1.1 MOSQUE BUILDINGS IN ISLAM

The first mosque was constructed with mud bricks and part of the roof was covered with palm leaves whilst the other part was left open. Figure 1: showing the plan of the Prophet's mosque, based on historical narratives [Creswell,1940]. Afterwards, Muslims followed this model to build up many mosques like the Basra Mosque built in the year 14 AH considered the second mosque to be built after the Mosque of the Prophet, and then the Mosque of Kufa built in the year 17 AH. Also, Amr Ibn Al-A'ss followed this in the same model in building his mosque in Fustat town of Egypt in the year 21 AH. With the spread of the mosque buildings in the Islamic history in consonance with the geographical spread of Muslims in different part of the globe whereby the civilization mission of the mosque is linked to the faith in Allah (SWT) and their worshipping of Him.

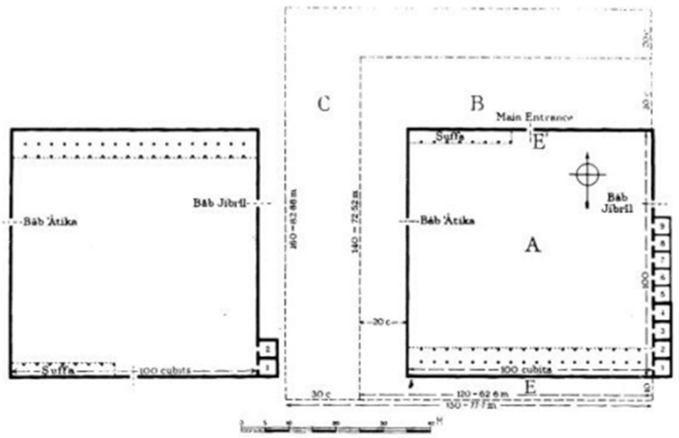


Figure 1: showing the plan of the Prophet's mosque, based on historical narratives [Creswell,1940].

Mosque buildings are considered an expression of “cultural identity” for the Muslims nation, distinguishing it from other nations, religions and peoples, in terms of civilization and culture.

In the ancient Islamic architecture many natural building materials available in local environment were used in the construction of many mosques, in the past. Also architectural designs which help provide shadow in daytime and store cool air in the night were used, wind catchers were used, as well, for indirect ventilation. The wooden bars were also used for the façade to break the direct sunshine. All these construction elements and others helped, in the past and are still capable of giving the building of the mosque either old or modern a high degree of harmony with its environmental surrounding in terms of economizing the energy consumption and providing thermal comfort to the worshippers with natural techniques.

Many mosques, nowadays, particularly in hot regions, suffer from problem that contributed, to a large extent, to the increase of the rate of electricity consumption. These problems include constructing mosques without using thermal insulators, exaggeration of size of mosques, flaunting in the use of electricity lamps beyond necessity and sometimes extending the base of the mosques without corresponding number of worshippers, fixing air-conditioning equipment beyond the required limit, lack of appropriate way of operating the air-conditioning equipment and use of the artificial lighting.

In the recent times many Muslim communities carried out awareness programmes on the consumption of electricity and mosque buildings for consistency with the general global trend of reducing dependence on the traditional energy in operating and constructing mosques.

Islam and Muslims reached different parts of the world with varying cultures and environments accompanied with varying means and forms of construction of mosques while maintaining the basic elements of the mosques based on the Prophet Mosque model in Madinah Al-Munawwarah. Also, the architectural approaches of the mosque building elements varied to reflect the local mosque building environments to enable the building to achieve thermal comfort for the worshippers in and around the mosque. Some architectural approaches that help enhance thermal performance, most important among which are the open courtyard, wind catchers, walls and openings design, roof design and harmonization elements of the location.

2.1.2 FUNCTIONS OF MOSQUE.

Mosque has many functions, namely: the mosque is a section of the department of information and culture, the mosque is a university for learning and teaching, the mosque is a place of worship and prayer and the mosque is a jami'a.

The mosque is a section of the department of information and culture because the mosque is regarded as an important centre for Islamic information, since it is the scene of political, social, cultural and ritual life. All the important news relating to vital issues are announced in the mosque and it also ensures direct contact between the carrier and the receiver of the Message. It is considered to be one of the most effective and successful means of da'wah and of giving information. The summon prayer, for instance, is information about the time of prayer and at the same time it is also a means of campaigning for Islam and spreading it. The pulpit is a place for information about the campaign and on it the principles of the campaign are explained and its rules announced. Prayer is another tangible method of giving information, especially the group prayer. Circles for studying the Qur'an and fiqh, meetings and conferences are considered to be successful methods of departing information about Islam.

The mosque is also a university for learning and teaching. The mosque teaches the basics of the 'aqeedah (creed), the acts of worship and the Shari'ah rules in all their types, political, economic, social, judicial and others. Its policy is based on the Qur'an and the Sunnah with the aim of building and educating Islamic personalities by way of study circles, debates, and conferences. The mosque is a university that welcomes everyone, by day or by night, in summer or in winter, not turn anyone away be they young, old, male, female, Muslim, non Muslim, black, white, Arab or non Arab. Moreover entry into the mosque does not require any fee, insurance or permission. There are no hindrances or obstacles, and the mosque does not differentiate between a scholar and a non scholar, nor between a ruler and his subject.

The mosque is surely a place of worship and prayer. The prescribed prayers are held in the mosque, and from it the call of Allah swt is initiated. It is a major cultural centre where the learned scholars hold study circles, debates and talks on the sciences of Qur'an, hadith, fiqh and the Arabic language.

2.1.3 GENERAL ARRANGEMENT

The word mosque is derived from the Arabic 'place of prostrations', (and it does not necessarily therefore have to be a building); it is both a house of worship and a symbol of Islam. Its built form is derived from that of the Prophet's house in Medina.
The mosque has a number of standard components, which will vary depending on whether it is local (masjid), congregational or principal (masid-i jami), or a Friday mosque (masid-i juma). Traditionally, mosque design has followed climatic needs: for instance, shade and cooling has been obtained through use of arcades and courtyards incorporating areas of water. Open areas for prayer are, however, useless in wetter and cooler climates.
In the West, there is an increasing practice to provide an Islamic Centre, comprising a mosque, library and lecture rooms, etc. Islam has also made an enormous contribution to architectural design in the areas of calligraphy, geometry and garden design.

Mosque design can be categorised into no more than five basic patterns:
• Arabia, Spain and Africa: the hypostyle hall and
• Anatolia and SE Asia: a courtyard with a massive times a day giving of alms Ramadan undertaken at least once open courtyard central dome or pyramidal pitched roofs
• Iran and central Asia: the bi-axial four- iwan type
• Indian subcontinent: an extensive courtyard and
• China: a walled garden enclosure

2.1.4 Segregation of Men and Women in Mosques

Sometimes women are not allowed to pray in mosques. When they are allowed in they are often relegated to small screened off areas. In some cases they have to enter through a back door and pray on a balcony and are only to able communicate with men through notes that are delivered by their children. Women are not allowed to speak through microphones, it is sometimes said, because their voices are said to be sexually alluring to men. Women that ignore rules about praying in the men's areas are admonished and scolded and banished from the mosque.

Similar restrictions are the norm when men and women pray outside of mosques in public buildings. Men say their prayers in a spacious room while women are confined to much smaller room with prayers piped in from the men's room.

2.1.5 Detailed requirements

Planning generally For congregation, allow an area of **1** m2 per person. When assembled in lines parallel to qibla wall, allow 1.2m between lines when standing, and 0.8m when sitting. Carpets and other floor coverings are required as the faithful remove footwear: storage space for shoes is required.

Congregational area A partly open courtyard (sahn) and partly roofed area for prayer, usually surrounded on three sides by colonnades. The open courtyard gives access to the roofed prayer hall (haram). All worshippers must face Mecca when at prayer, and should theoretically be equidistant from the qibla wall, thus forming parallel

Decoration It is a generally accepted Islamic premise that the representation of living beings is unacceptable. This rigidly observed tradition does, however, allow rows.
free use of calligraphic devices from the Qur'an, which forms a valuable counterpart to otherwise plain surfaces and basic architectural forms.

Dikka A wooden platform, of single storey height with staircase access, positioned in line with the mihrab (sometimes located in the external courtyard). It is used for chanting and liturgical responses, particularly where there is a large congregation.

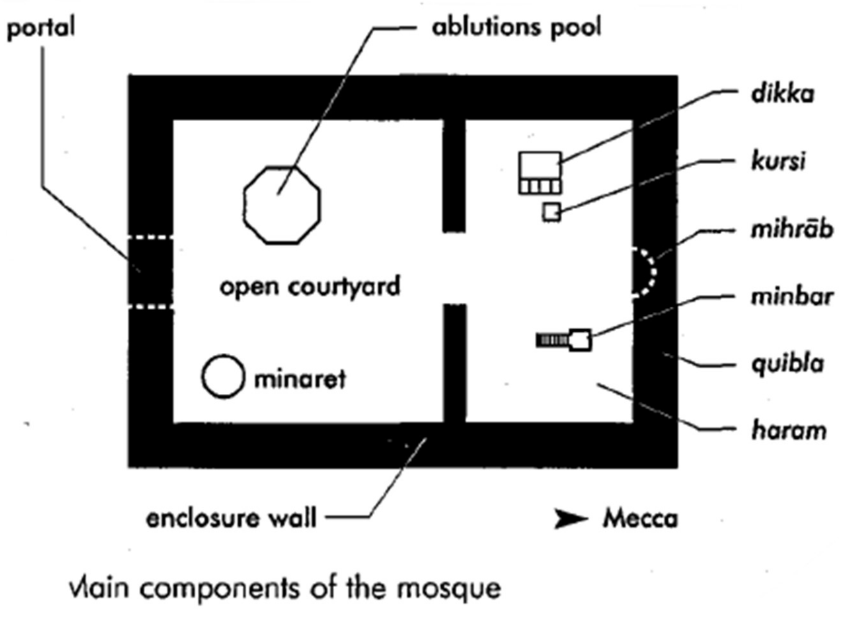


Fig. 2

Haram The sanctuary or covered prayer hall. Usually square or rectangular, with the roof either of a hypostyle pattern (i.e. a flat roof supported by a large number of evenly spaced columns) or covered by a large dome on pendentives, or a number of small domes.

Iwan Vaulted hall, one on each side of the courtyard.

Ka'bah The ancient shrine in Mecca; it is almost the only Islamic symbol.

Kulliye Associated buildings to a mosque (e.g. those used for medical or teaching purposes).

Kursi The lectern on which the Qur'an is rested; usually placed next to the dikka.

Maqsuru Originally a raised platform with screens provided to protect the imman (the prayer leader); it is often offers an opportunity for special decoration.

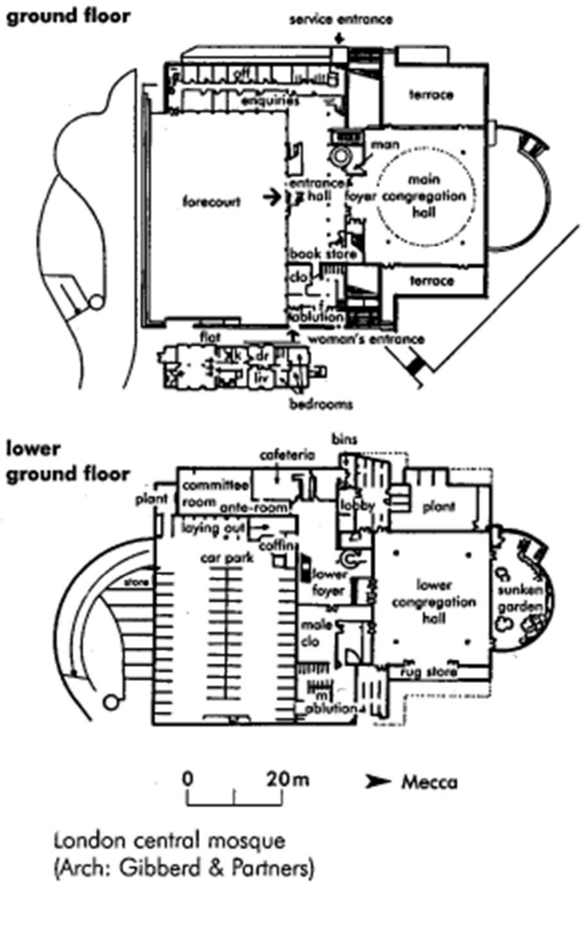


Fig. 3

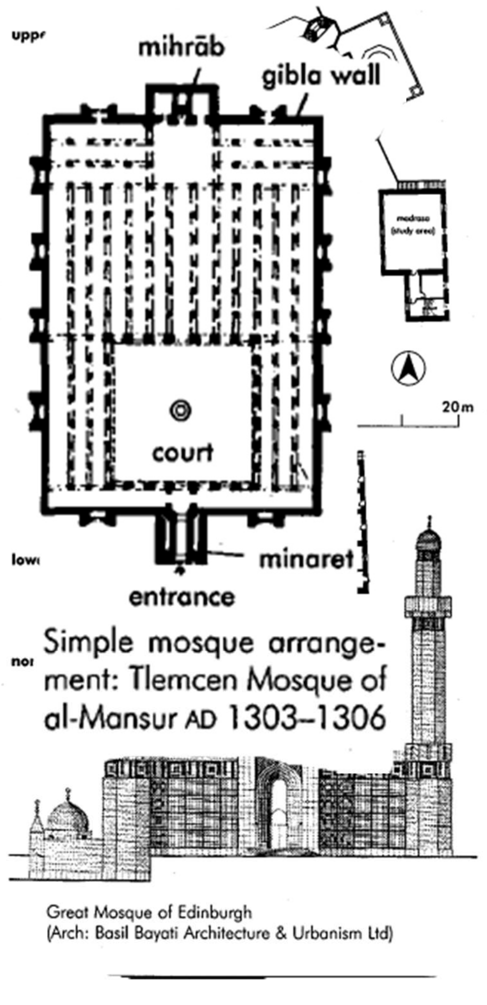


Fig. 4

2.2 MOSQUE FEATURES

Mosques are generally built around open courtyards, off of which are one or more *iwan* (prayer halls). The iwan facing Mecca is the main prayer hall, or *mihrab* apse, where the imam leads the faithful in prayer. Often, in the courtyard or in front of a mosque are pools, where the faithful wash before entering the mosque. The main doorway is oriented in the direction of Mecca. Most mosques have a *qibla* (a marking the showed the direction of Mecca).

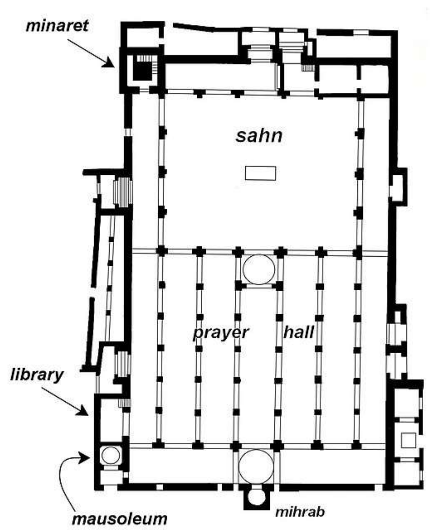
There are two main styles of mosque architecture: 1) hypostyle, in which the roof is supported on pillars: and 2) domical, where the walls are surrounded by a dome. There are few hypostyle mosques and they tend to be old or very basic. Mosques are focused on their large central prayer room and lack the processional and ceremonial spaces found in cathedrals.

Most mosques feature a single chamber entered through doors topped with cusped arches. Above the chamber is a dome. The idea of a mosque is to create as much space as possible for the uninterrupted communion between worshipers and God. For many Muslims, the dome symbolizes oneness with God. The main dome is usually above the *mihrab* apse. Some mosques feature dozens of domes.

Dr. Carool Kersten of Kings College London wrote for the BBC: “The prayer hall, also known as the "musallah", is a large open space, where everyone sits on the floor. Mosques were designed to house the entire male population of a city or town. Women can attend Friday prayers, but are not required to do so. Women are traditionally segregated from men by tradition rules and pray in a separate space or chamber. [Source: Dr. Carool Kersten, Kings College London, BBC |::|]

“A "mihrab" is a semicircular niche in the wall of a mosque that indicates the direction of Mecca. The direction towards Mecca is known as the "qibla". Mecca is the city where the Prophet Muhammad was born and is the site of Islam’s holiest mosque, Masjid al-Haram. Next to the "mihrab" there is a "minbar". This is a pulpit from where an imam or khatib delivers a sermon. |::|

“Ablutions area: Before prayer, Muslims perform ritual washing, or “wudu”, in the ablutions area. Larger mosques have an ablutions fountain in their entryways or courtyards. In smaller mosques the restrooms may be used for ablutions.



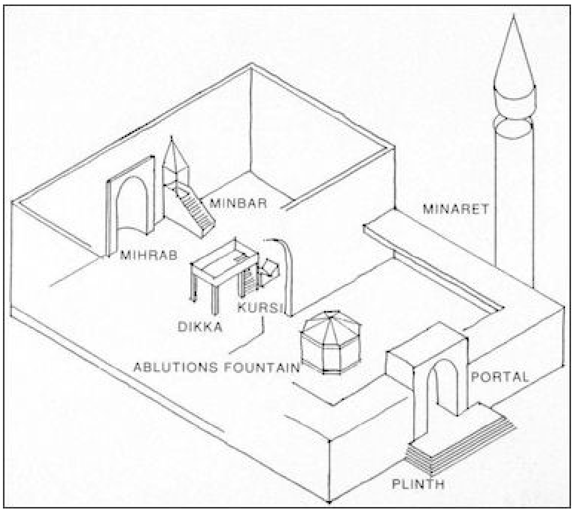


Fig. 6 Mosque Features

Mosque Domes

Domes are central to mosque architecture. Dr. Carool Kersten of Kings College London wrote for he BBC: “The dome, or "qubba", is often placed directly above the main prayer hall as a symbol of both the vaults of heaven and the sky. Early mosques had a small dome taking up part of the roof near the mihrab. As time passed, bigger domes were built, some of which encompassed the entire roof above the prayer hall. [Source: Dr. Carool Kersten, Kings College London, BBC

The main dome is usually above the mihrab apse. Some mosques feature dozens of domes. They can be decorated both inside and outside with a variety of geometric shapes and other designs. The placement of a round dome on a square hall is a achieved with the help of a squinch or pendentive, sometimes with man-made stalactites for decorations.

One of the greatest challenges of building a mosque is constructing the circular dome over the square prayer hall. The hemispherical shape of the dome creates hidden forces that try to push the sides outward. Arches and piers are designed not only to support the dome but also reduce the outward stress on the walls. Supports generally have to be built on the outside of the walls to push them in.

Sahn (courtyard)

The most fundamental necessity of congregational mosque architecture is that it be able to hold the entire male population of a city or town (women are welcome to attend Friday prayers, but not required to do so). To that end congregational mosques must have a large prayer hall. In many mosques this is adjoined to an open courtyard, called a sahn. Within the courtyard one often finds a fountain, its waters both a welcome respite in hot lands, and important for the ablutions (ritual cleansing) done before prayer.

Mihrab (niche)

Another essential element of a mosque’s architecture is a mihrab—a niche in the wall that indicates the direction of Mecca, towards which all Muslims pray. Mecca is the city in which the Prophet Muhammad was born, and the home of the most important Islamic site, the Kaaba. The direction of Mecca is called the qibla, and so the wall in which the mihrab is set is called the qibla wall. No matter where a mosque is, its mihrab indicates the direction of Mecca (or as near that direction as science and geography were able to place it). Therefore, a mihrab in India will be to the west.

Minaret (tower)

Minarets are the tall, slender towers outside a mosque. They typically have a balcony at the top used by the muezzin to call the faithful to prayer. Some are purely ornamental. In the old days the muezzins climbed the stairs inside the minaret to the calling area. In famous mosques tourists are sometimes are allowed to climb the stairs. The word "minaret" comes from the Arabic "manarah", which means lighthouse.

Minarets are the tallest parts of a mosque. The highest minaret in the world is located at the Hassan II Mosque in Casablanca, Morocco. Minarets symbolize both the supremacy and the oneness of God. To some Muslims they represent the Arabic letter alif , the first letter in Allah's name. Minarets are typically made of brick, and sometimes covered with tiles. The name of Allah and invocations to God are typically written in Arabic calligraphy at the top.

Most mosques have at least one minaret. Some have only one. Many have four, one on each corner of the mosque ground. None are not supposed to have seven because only the Great Mosque of Mecca is allowed to have that number.

Most mosques have at least one minaret. Some have only one. Many have four, one on each corner of the mosque ground. None are not supposed to have seven because only the Great Mosque of Mecca is allowed to have that number.

One of the most visible aspects of mosque architecture is the minaret, a tower adjacent or attached to a mosque, from which the call to prayer is announced. A minaret is a slim tower with balconies or open galleries from which a mosque's muezzin calls the faithful to prayer five times each day. Minarets are distinctive traditional features of many mosques, though they vary in height, style, and number. Minarets may be square, round, hexagonal, octagonal, or even spiral and they are usually covered with a pointed roof.

The word minaret derives from the Arabic word for "lighthouse" or "beacon."

Fig. 7 Qutub Minar

Muezzin

"Before the five daily prayers, a Muslim crier, or "muezzin", stands at the top of the minaret and calls the worshippers to prayer, a ritual which is over 1,400 years old.

At one time the muezzin was a man who stood at the top of a minaret and called all the faithful to prayer through cupped hands with a waling, mellifluous chanting of Qur'anic verses. Now the muezzin either sits in the mosque and summons the faithful with a microphone and a crackling set of loudspeakers or he slips a cassette of an imam with a "particularly beautiful voice" into a cassette player.

The muezzin typically calls: " Allah akbar ! Allah akbar ! Allah akbar ! Allah akbar !---"God is Great! God is Great! God is Great! God is Great--- followed by "There is no God but Allah. There is no God but Allah. Muhammad is God's messenger. Muhammad is God's messenger. Come to pray. Come to pray. Come to security. Come to security. Prayer is better than sleep. God is Great. God is Great. The is no God but Allah." Many people stop what they are doing and prostate themselves on the streets towards Mecca. No noise can be transmitted over the system except for the voice of an imam reading the from the Qur'an.

The muezzin has traditionally been built without scaffolding until reaching the height of the balcony---which bulges outward from the rest of the structure. The tower and the stairs are often built together with the builders simply building the structure upwards as they go

Ablution Area

Fig. 8 Ablution area, Sultan Qaboos Grand Mosque, Muscat, Oman. Richard Sharrocks / Getty Images

Ablutions (ritual washing or *wudu*) are part of the preparation for Muslim prayer. Sometimes a space for ablutions is set aside in a restroom or washroom. Alternatively, there may be a fountain-like structure along a wall or in a courtyard. Running water is available, often with small stools or seats to make it easier to sit down to wash the feet.

Currently, there are hardly any uniform design specifications for the construction of ablution places at mosques. Designs of ablution places are usually copied from designs of ablution places in other mosques or based on individual perspectives. Based on the researchers' anecdotal observations, most of these designs are non-ergonomic, uncomfortable, and less user-friendly for ablution in either sitting or standing position, especially for the elderly. In such designs, water splashing is common because of inappropriate heights of platforms or seats, insufficient distances between seats and faucets, and improper shapes and depths of water drain.

Mosque Interior

The inside of a mosque is surprisingly empty and generally pretty austere. There are no seats, little furniture and often few decorations. Worshipers tend to sit and pray on the floor facing the mihrab that indicates the qibla (direction) of Mecca. Chairs or benches would only get in the way of the praying, prostrating and standing up.

The floors are often covered in carpets. There are few internal walls. This is because the mosque is designed for single space worship of a given Muslim community. A screen in a mosque provided privacy for important people or women. There is special stand that hold the Qur'an.

The *mihrab* is a small alcove-like niche, which marks the direction of Mecca and the entry point to paradise. It is often empty, which symbolizes the simple perfection of Allah. Decorations around it on the qibla wall are intended to focus attention on its simplicity. Many mosques are designed so that the maximum number of people can see the mihrab. The arched shape of the mihrab is one of the few permitted Islamic motifs. It is often seen on prayers rugs and decorative wall tiles. Some tiled mihrabs are regarded as among the finest works of Islamic art.

Minbars

Fig. 9 Minbar at Sultan Hassan mosque Near the mihrab is a stepped pulpit called the *minbar* (also minber).

This is where the imam or khatib gives his Friday sermon. It is often ornately decorated and the only real structure in a mosque. The preacher usually speaks from a step below the minibar platform because the platform is reserved for the Prophet and Caliphs who occupy a higher position. Below the minibar steps is a small door concealed by a curtain. No one but the imam is supposed to enter this door.

Many minbars are portable pulpits that look like decorative wooden staircases on wheels. They are kept in closets most of the time and are wheeled out for Friday sermons. Some minbars are also exquisite examples of Islamic art, ornately decorated with carved geometric patterns and inlayed with ivory and precious woods."

Describing a minbar in a great mosque in Cairo, Michael Glover wrote in the Times of London, "We approach the great *minbar* , the wooden pulpit with double doors and steep steps up which the imam ascends to lead Friday prayers. It is adorned with the most exquisite ivory panels: extraordinarily delicate wheels and trapezoidal shapes...The extraordinary thing about a minbar such as this one is that it's a bit like a flatpack from Ikea in certain respects. It would have been constructed to be use in a mosque such as this one, but you could take it apart and erect it elsewhere."

Mosque Decoration

In keeping with the Muslim prohibition on representations of animals and people, the tiles, walls and arches were decorated with calligraphy, mosaics, floral designs and geometric shapes. The calligraphy is often either in the stylized kufic script favored the Timurid or the often foliated *thulth* scripts.

Many mosques and Islamic buildings are famous for their colorful tilework. They not only make the building look beautiful they also make them appear lighter. The tiles are se up to reflect the desert sun. Ones that are deep cobalt blue or turquoise (meaning "color of the Turks") are often featured in domes.

The tiles come in variety of styles: stamped, chromatic (one color painted on and then fired), polychromatic (several colors painted on and then fired), and faience (carved onto wet clay and then fired). Other decorative features include carved and painted woodwork. patterned brickwork, colored marble and stucco, and carved *ghanch* (alabaster).

Mosque Customs

Wudhu (Ablution)

The Muslim faithful are expected to remove their shoes and wash their feet in a basin before they enter the mosque. If no water is available Muslims are supposed to wash themselves with sand. Foreigner visitors s can usually get away with just removing their shoes and are not required to wash their feet. In any case, make sure you feet or socks are clean. Dirty feet in a mosques are regarded as an insult to Islam. In large mosques you remove your shoes and place them on a shelf with a number.

Inside a mosque don't walk in front of someone who is praying, don't touch the Qur'an, never sit or stand on a prayer rug and never place a Qur'an on the floor or put anything on top of it. Also, don't cross your legs in front of an older people and don't step over someone who is sitting down Show respect, remain quiet and stay out of the way. Taking photographs is frowned upon.

Fig. 10. Abulution Space

2.3 EARLY MOSQUES

Early mosques were influenced by Byzantine architecture and local styles. Mosques were converted Persian halls or rectangular fields surrounded by a ditch or a fence.

The designs of early mosques was relatively simple and they were enlarged by simply knocking down some brick walls and shuffling around the columns.

2.3.1 DEVELOPMENTS IN MOSQUE ARCHITECTURE

Because wood and stone were not very plentiful in the deserts and steppes in the Middle East, North Africa and Central Asia, where Islam grew up, brick became the desired building material. Building were traditionally designed to beat the heat, with lots of shade and large openings facing the wind. Fountains and pools an even streams were placed in courtyards to provide a cooling effect.

Central mosques and the squares in front of them were often placed in the centre of cities and towns in the same way that cathedrals and market square were often situated at the centre of European cities. Markets were often set up in the squares in front of mosques. Niches in front walls of mosques were used by merchants.

Important advances in Muslim architecture included the development of fired bricks in the 10th century, coloured tile work in the 12th century, polychrome tile in the 14th century, and the squinch (a kind or bracketing used in making large domes).

Mosque construction provided lot of work for artists, craftsmen and tile makers. Whereas cathedrals were often built to impress with their size and scale, mosques were often built to impress with their details.

2.4 ORIENTATION SPECIFICATIONS OF A MOSQUE

Turning towards Mecca (Qibla direction) is a prerequisite for a Muslim prayer. While some time the correct direction is not clear, due diligence in finding the Qibla is required. Muslims have turned in the early days of Islam towards Jerusalem, then, they were ordered to turn towards Mecca. Finding the right direction is not a trivial task, it involves the use of coordinate system, and the knowledge of spherical geometry. Such tools enable us to solve the problem easily nowadays, but in the past, people have to resort to different ways to find the Qibla, chief among them is the use of astronomical alignments. These days, it is almost agreed upon that the correct direction is by following the great circle path, however, it is not explained in terms of the requirement of the prayer, and instead it is advocated because it is the shortest distance between the observer and the target (Mecca). That explanation has given ammunition to the proponents of Rhumb line (the straight line between the two points on the Mercator projection or map) as the more direct line to the target, and they argue that the shortest distance is not part of the religious requirements. Therefore, there is a need for stating the requirements clearly and translating that into geometrical specifications to help in settling endless debates about the subject.

REQUIREMENTS:

The requirement for turning towards Mecca is stated in the Quran as:

“فول وجهك شطر المسجد الحرام و حيث ما كنتم فولوا وجوهكم شطره

Turn your face towards the sacred Masjid, and wherever you were turn towards it” (2,144)

Clearly, the requirement can be fulfilled by facing the Kabba, however, if the person doesn’t see the Kabba, then we have to assume that a tower is extended over the Kabba and goes up vertically until it can be seen by our observer. Therefore the requirement becomes facing this imaginary tower if we don’t see the Kabba itself.

2.4.1 GEOMETRICAL EXPRESSION OF THE REQUIREMENT:

Before we get into translating the requirement into geometrical conditions, we would like to introduce some terms: Azimuth angle: The angle measured from the North in clockwise direction. Sometimes the terms: Bearing , and Orientation are used for the same purpose. When a person faces a target, that person and the target form a plane as shown in Figure The direction of the plane with the North depicts the azimuth angle or the bearing of the target. Therefore, to face the Kabba, the observer and the Kabba have to be in the same plane, and we call this plane “the observation plane”.

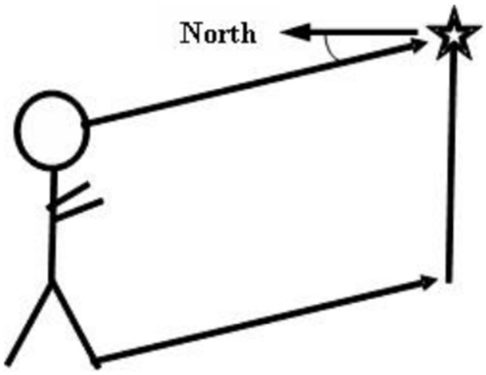


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Fig. 11 The plane of observation that contains the observer and the target

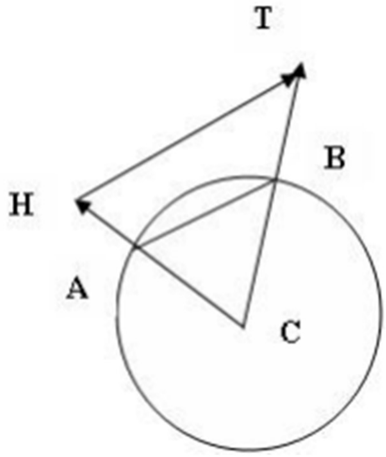


Fig. 12 The Great Circle plane containing the Observer AH, and Target BT

Such an arrangement would meet the requirement as stated in the Quran, and that is true if we were on a flat surface or on the surface of a sphere. If the observer and the target are on the surface of a sphere, as in the case of being on the surface of the earth, then we still have a plane that combines the observer and the target. The plane cuts a circle into the sphere. This circle is called the great circle as can be seen in Figure . The observer is at point A, and rises to H, while the target is at B and extends to T.

The vector AH, and the vector BT intersect at point C (the center of the sphere as well as the center of the great circle) and form a plane -the observation plane- such a plane intersects with the sphere producing the great circle. The chord AB is the direct straight line between the observer at A and the target at B, while the arc AB is the most direct route on the surface of the sphere. Note that the plane of the great circle (which is the same as the observation plane) contains the points A,H,B,T, and C, and therefore, the chord AB as well as the line of sight HT belong to the great circle plane too.

The plane would make an angle with the North, and that would give the azimuth angle. To calculate the azimuth angle, we use spherical geometry relations. The needed information is the coordinates (latitude and longitude) of the target, -in this case it is Mecca- and the current location –observer location. The formula for calculating the azimuth angle is

Where: θ: The azimuth angle (radian).

ATAN2: Trigonometric Inverse tangent function with two arguments.

Sin: Trigonometric Sine function.

$$\theta = ATAN2\left[\frac{\sin(b1-b2)*\cos(a1)}{\sin(a1)*\cos(a2)-\cos(b1-b2)*\cos(a1)*\sin(a2)}\right]$$

Cos: Trigonometric Cosine function.

a1, b1: The latitude and longitude respectively of Mecca.

a2, b2: The latitude and longitude respectively of current location.

There are other ways to find the azimuth angle, but this is the most straightforward

2.4.2 CARDINAL DIRECTION:

After calculating the azimuth angle for the Qibla, we need to find the North direction or any other cardinal direction. To do so, the first thing people will think about is the use of magnetic compass as a stand alone instrument or as part of mobile devices such as "Smart Phone". While it is straightforward to use this device, it is not recommended for finding Mosque orientation because it could introduce large errors. More accurate methods should be used for such a purpose. One possible method is the use of the Sun. It is well known that the shadow of objects in the northern hemisphere points to the true north at the transit time (local noon). The other method is to use ubiquitous satellite maps that give the direction for the north.

Once the north is identified, the direction of the Qibla is found by plotting the calculated azimuth angle. As people try to turn to the right direction, there is going to be errors that would be part of the process, and in the following sections we will try to analyze them.

2.4.3 ERRORS DUE TO THE SHAPE OF THE EARTH:

The earth is nearly a sphere with the equatorial radius a = 6378.1370 km, while the polar radius b = 6356.7523 km. The average radius of the sphere is calculated in different ways, for example, according to the International Union of Geodesy and Geophysics(IUGG):

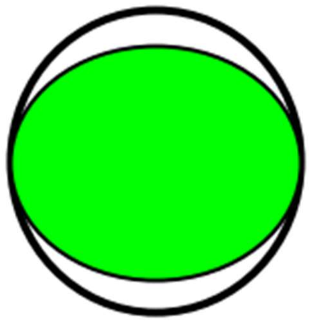
R =2a b /3

R = 6371.009 km (3958.761 mi = 3440.069 nmi).

To increase accuracy for navigation, the oblate earth is modeled as an ellipsoid of revolution. An example for such a model is the World Geodetic System WGS 84 that is used in GPS systems. In this model, the equatorial section is a circle, while the polar section is an ellipse that has major axis as equatorial diameter, and minor axis as the polar diameter. Such an ellipse would have eccentricity e = 0.08182, and compression ratio of k =

0.99665. A cross section of this model is shown in Figure 3. In the figure the difference between the circle and the ellipse is exaggerated, otherwise, it will be very difficult to distinguish the two shapes. For the purpose of finding the Qibla orientation, the error due to the use of a spherical model is very small, for example, the difference between the spherical model and WGS84 when calculating the Qibla orientation from Detroit is about 0.07° or 4 arc-minutes, and that is 0.13 %.

Therefore, modeling earth as a perfect sphere is a very good model



Exaggerated ellipse and circle representing earth oblateness

Fig.13

2.4.5 ERRORS IN DIRECTION DUE TO STANDING IN A STRAIGHT LINE:

Another potential source of error stems from the arrangement of prayer in lines. In this case, if the imam is in the middle and in the direction of the Kabaa, the people in the line (straight line) will not be in the direction of the Kabaa. Obviously, inside the Sacred Masjid, people pray in arcs so that they face the Kabaa. But once we go outside the Sacred Masjid, it becomes very quickly unnecessary to pray in an arc formation, and straight line becomes the practical manifestation of turning towards Kabaa as depicted in figure 4. It is easy to show that the error due to straight line formation is very small with the following example.

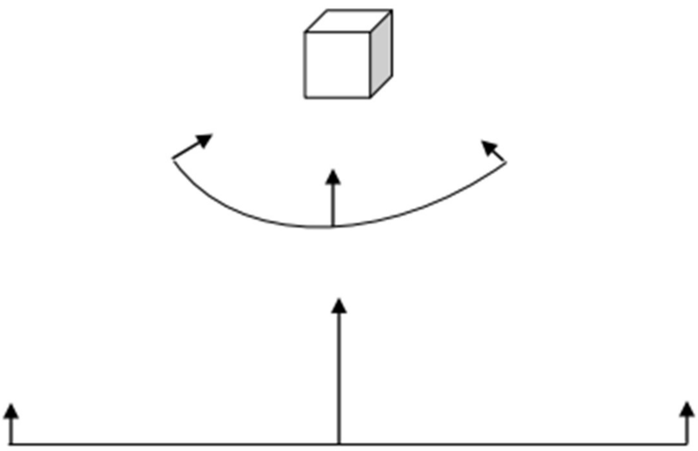


Fig. 14 Qibla Facing Illustration

The height of Kabaa is 13.1 m, so on a perfect spherical earth with no mountains or valleys, theoretically, it should be visible from around 13 Km. If we have a straight prayer line with a width of 400 meters (would have about 1200 persons) and the Imam in the center is in the exact direction of Kabaa, then, the person on the edge would have the most error. If the person on the edge would turn towards the Kabba, then, his angle shown in Figure would be given by the equation:

$$\alpha = ATAN(\frac{13000}{200}) = 89.1^{\circ}$$

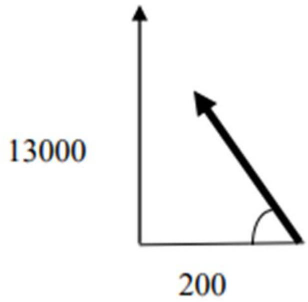


Fig. 15   Example of the angle correction

Therefore, for the person standing in a straight line at the edge of this very long line he would have an error of less than one degree. Of course the above scenario is fictional, and the Kabaa is in a valley, and therefore, it wouldn't be possible to view it from such a distance. In addition, normal lines are much shorter than that. Therefore, if we combine normal line width with a longer distance from Kabaa, then, the error quickly diminishes, and it becomes clear that such an error is not an issue. For example, the direct distance between the Masjid of the Prophet in Medina and Kabaa is about 340 Km, and therefore, for a prayer line with a width of 400 meters, the error for the person on the edge would be 0.03 degrees. Even inside Mecca, for a distance of 5 Km from Kabaa, and for a line of 50 meters (about 150 persons in such a line), the error for the person on the edge of the line would be slightly less than 0.3 degrees. Therefore, it is not an issue even for people very close to Kabaa let alone people who are far away, in addition, such an error will not affect the Imam of the prayer, therefore, it is not an issue.

2.4.6 OTHER ERRORS:

There are errors in the coordinates due to GPS errors for example, however these errors depend on the technology used, but overall they are really small, for example, Garmin (www8.garmin.com/aboutGPS/) advertised its newer models as having an error of less than three meters on average, and this will produce very insignificant error. Some people have pointed to the plate tectonics as a source of error. In very simple terms, the earth crust consists of huge plates that move with respect to each other, therefore, locations can be constantly changing. The continents are moving a few centimetre a year, and at such a rate, it would take about a hundred thousand years for the error to start getting noticed.

2.4.7 STANDARDS FOR ORIENTATION ERROR:

How accurately should we turn towards Kabaa ? It is a legitimate question that requires some analysis, but before we get into that, we suggest that we should distinguish between two things: orientation for Masjid, and orientation for individuals. This differentiation is necessary because the Masjid is a fixed structure that is used by many, many people, and besides being a symbol for Muslims, the Masjid is used as a reference, therefore special care should be taken in deciding its orientation. Some people have argued that there should be no specification because they want to maintain "the simplicity" and straightforwardness of the faith. However, this argument in our opinion has no merit. For one thing, mosques these days are structures that cost millions of dollars, and have to meet local codes, and are designed by engineers, and not by ordinary average folks. It makes no sense to pay attention to the smallest details, but when it comes to the primary purpose of the facility –prayer and its requirements- poor and casual work is acceptable ? !.

As for the individual, due diligence is required, but circumstances for individuals are different, therefore, different outcomes are normal, and it would be hard to demand a specific accuracy, however, it is useful to examine how people perceive error in orientation

2.5 THE ISLAMIC GARDENS & LANDSCAPE

Islamic gardens represent cultivated spaces across the diverse span of Muslim history and geography, created and set apart from wilderness of various kinds. They were designed to enhance the humanly constructed environment, to ornament the landscape, and to symbolize cultural and religious values and aspirations. As such, they are together with architecture and the arts among the most significant and enduring of Muslim expressions of the role and relationship of nature in its broader sense to human beings. Gardens and landscape architecture in Muslim societies have been an important expression of ethical assumptions about stewardship, ecology, and beauty. This heritage of spaces and values has in recent times come under increasing pressure because of very high levels of demographic change, desertification (the degradation of formerly cultivated land), burgeoning urban growth, and general neglect.

Gardens are experienced by human beings who view them as spatial constructions and also apprehend them through the auditory and olfactory senses. Islamic gardens were often stocked with nightingales and doves that delighted listeners with their singing and cooing, and countless poems mention them. In describing a garden along the Caspian
Sea, the great Persian poet Firdawsi wrote, “The nightingale sits on every spray/ and pours his soft melodious lay.”3 Another poet, Manuchihri, described Spring in a garden: “The dove is the muezzin and his voice is the call to prayer.”4
Gardens were also filled with the scent of flowers; a grove of orange trees in bloom is an intense sensory experience that envelops the person to the extent that one momentarily forgets sight and sound, closes one’s eyes, and inhales. A great many trees and plants were cultivated in gardens, not only for their appearance but also for their pleasing perfume and the taste of their succulent fruit.

Furthermore, gardens can appeal to the senses through views and vistas, as well as hidden refuges. A view that looks straight along a level axis is entirely different from a panoramic view afforded by an elevated stance.

2.5.1 Islamic Gardens in History

Muslim rule and territorial control expanded rapidly during Islam's first two centuries, eventually encompassing significant areas around the Mediterranean Sea as well as former Byzantine and Sassanian-ruled territories in North Africa, Spain, the Middle East and Central Asia. This diversity of landscapes, climates, and geographical settings influenced the utilization and development of land. Patterns of existing use and the availability of water were major factors in transforming the landscape to mirror the changes in control, settlement, and cultural values.

Persia had a long history of gardens that predated Islam, a tradition that Muslims adopted and continued. Many of the earlier examples of Persian gardens have not survived; recent excavations, however, provide evidence of the extensive development of gardens under successive dynasties. The original Persian garden (bāgh) was irrigated by canals diverted from a river or stream. The new towns and cities under Muslim rule, including capital cities like the Baghdad of the Abbasids, contained several gardens influenced by the Persian pattern. Rulers continued to build gardens in newly established population centers, using existing water installations or creating new channels for irrigation. Muslim travelers' accounts from the medieval period describe a profusion of richly endowed gardens, public and private, with fountains and pavilions. One of the patterns that came to dominate the design of these gardens, though not exclusively, was the chahār-bāgh —the foursquare garden, often linked to the Qurʾanic allusion to the four rivers of paradise. The Safavid gardens, particularly in Isfahan, are a fine example and extension of this foursquare style.

The Muslim Umayyad rulers of Andalusia continued Roman and local Spanish traditions in order to develop exquisite gardens, some of which survive in the early twenty-first century, as in the Alhambra. The excavations of the Umayyad palace city, Madīnat al-Zahra, destroyed in the eleventh century, reveal the presence of gardens, fountains, and pavilions. Most of these structures were created to reflect a symmetrical design, organized to present dramatic vistas, and also to afford a sense of privacy, intimacy, and leisure. It has been suggested that these gardens were framed within a geometrical pattern intended to reflect order, authority, and symmetry in nature as well as in society, thus simultaneously evoking religious, aesthetic, and political meanings. Another historical example of extensive garden construction is that of the Mughal period in Central and South Asia. Several of these gardens have survived in Afghanistan, India, and Pakistan. They illustrate connections with new landscapes combined with visions of spaces that mark transitions to the afterlife and the rich imagery of the Qurʾān.

The Qurʾanic image of the garden and the rich enhancement of landscape throughout Muslim history have made these concepts a fertile source for Muslim poetry and literature. Two of the classics of Persian literature, Sa'di's Rose Garden, or Gulistân (c. 1256 ce), and his Fruit Orchard, or Bustan (c. 1257), are inspired in their form as well as their imagery by garden motifs. Much of Muslim mystical poetry builds on the symbolic meanings of the garden, its geometrical design, water, profusion, greenery, the budding of the rose, the bee among the flowers, the harmony of form and essence, and the transient and created nature of the earthly garden. The archetypal space is the site of the meaning of human life, its exalted destiny as well as the focus of its memory. The garden may represent both the place of transition as well as arrival, and of ultimate repose in the world or an anticipation of the hereafter.

2.5.2 Islamic Gardens in Modern Times

Pressures resulting from population growth, urbanization, climate change, and economic underdevelopment have led to the neglect, degradation and even extinction of public and private green spaces across the Muslim world. Many of the emerging Muslim nation-states and societies have sought to restore and revive their gardens through local initiatives or assistance from global organizations committed to preservation, restoration, and recreation. The erosion of the heritage is now balanced by such new efforts as the landscaping around the airport in Jakarta, the Bagh-e-Ferdowsi in Tehran, the reforestation project on the campus of a university in Ankara, and the Al-Azhar Park project in Cairo. There are many other cases that need to be addressed to repair both natural and human-made disasters. The heritage of gardens is inseparable from the vitality of culture in the Muslim world and the ecological aspirations of human beings that transcend time and space.

2.5.3 The Elements of Landscape in Islamic Garden Design

Islamic gardens have appeared as a unique art of landscape influenced by the religion, climate and the affiliated geography and shaped since 7th Century in accordance with the culture and traditions of various societies. The development of the gardens throughout the history of art of landscape has been influenced by the local and regional natural conditions such as soil formation, climate, flora and ecology. Overall, the Islamic gardens, in consideration of the geographies that Islam has expanded, have been shaped within the regions with hot, arid and mild rainy climate conditions. Islamic gardens have always been perceived as a representation of heaven and further designed as spaces and localities of daily life.

2.5.4 Naissance of Islamic Art of Garden Landscape

The Islam Empire, starting from the establishment of the first Islamic state in Medina, has sustained its existence for centuries until the peak period of the Ottoman Empire in the 16th Century (Md Jani, Harun, Mansor, & Zen, 2014).

Spreading with the great pace and covering almost the half of the entire world, Islam Civilization has dominated an era hosting many nations within and shaping the history of the humankind. In this era, Islamic landscape shaped under the influence of Islam circled around a society representing the incarnated form of Islamic principles and values, reflecting the spirit of religion of Islam in terms of form, design and functionality and inhering functionality (Spahic, 2005).

Therefore, it would not be accurate and right to attribute Islamic culture and art to a specific country or people, because Islamic culture has developed on the culture and art traditions of the aforementioned civilizations and emerged as an independent branch of art incorporating its essence and common features in the entire civilizations (Akdoğan, 1974).

Although we observe a substantial influence of the philosophy of the religion of Islam on the shaping of the Islamic landscape (architectural, garden, etc.), the geography of Islamic expansion having hot and arid climate conditions has exerted an influence on this process. Significant Islamic gardens have been designed in West Asia (Iran, Turkey and Arabian Peninsula), Southeastern Asia (India, Pakistan, Kashmir, Uzbekistan and Afghanistan), Middle East (Syria, Lebanon, Iraq, Palestine, Egypt, Morocco and Tunisia) and Europe (Granada, Cordova, Sevilla and Toledo) under the influence of Islamic monarchs reigned during this period (Md Jani, Harun, Mansor, & Zen, 2014).

Islamic gardens have been designed to be the representation of heaven on earth, and this term has first revealed in the seventh century during the establishment of the Persian Gardens (Haaga, 2005). The description of heaven mentioned in the Qur'an has quite a significant place in the creation of the gardens. Heaven is the ultimate destination desired to be reached by both Muslims and the communities living within the entire eras, and it is the herald of the happiness for they have been waiting. Muslim communities endeavored to fulfill their longing for the paradise by establishing gardens representing and depicting the place of paradise in the realm they live in. These gardens established are shaped by the idea of a place of happiness.

As a result of the studies conducted, the opinion has been embraced that the Persian garden is considered as the foundation of the Islamic gardens and moreover, served as a source of inspiration for other notable Islamic gardens such as the Mughal gardens in Kashmir, India and the Al-Andalus and Generalife in Southern Spain. Following the Persian gardens, the Islamic gardens in Spain have revealed its influence until the 20th Century. For instance, it is quite possible to witness such influences in California and Mexico. The Islamic gardens promotes the concept of simplicity and therefore the insight of the Islamic gardens have been adopted outstandingly throughout the world. Petruccioli (1998) highlights that the Islamic gardens primarily served as a source of inspiration for the European culture in the 17th Century.

The influence of the Islamic garden can be seen on certain landscape designs in Florence and the Royal Pavilion in the United Kingdom. The expansion of the influence of the Islamic garden has become a glamorous trend in the 19th Century and thus, has claimed its place as one of the official architectural styles in the Exhibitions of the World.

The influences of the Islamic garden before gradually getting disappeared due to contemporary trends, have been sustained throughout the 19th Century and by the early 20th Centuries (Md Jani, Harun, Mansor, & Zen, 2014).

The historical development of the Islamic gardens is as presented in the figure.

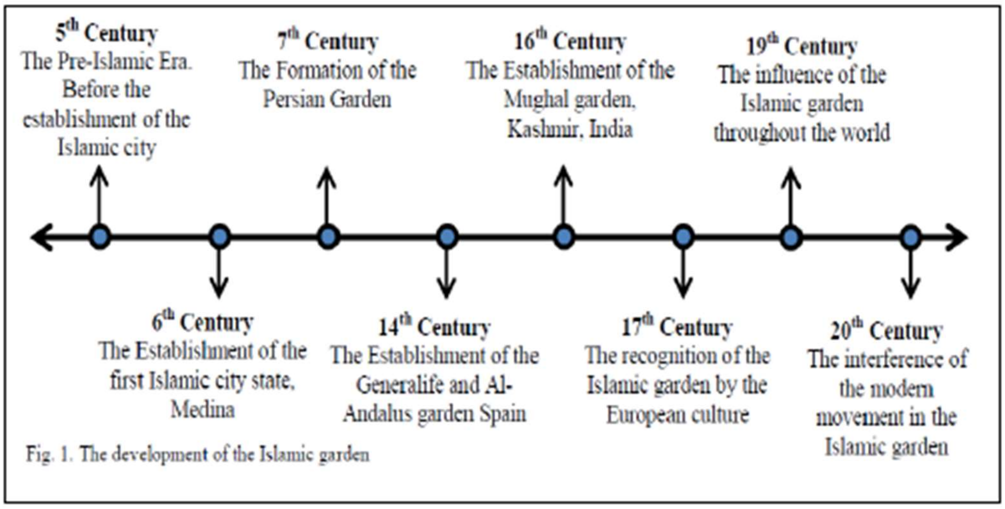


Fig. 1. The development of the Islamic garden

Fig. 16 The historical development of the Islamic gardens

Prior to establishment of the Persian garden, the gardens have been referred to only as a part of an outdoor area. However, after the development of the established Islamic city-state, certain Muslim rulers has begun to embed the Islamic concept in the garden design. For instance, the fourth Mughal Emperor Jahangir (1569-1627) had a black pavilion built in Kashmir (Kausar, 2005).

Seyyed Hossein Nasr et al. (1993) has highlighted the “Islamic” term of Gulzar Haider. Based on that, the foundation of an Islamic landscape or garden is not merely the development of patterns or structures. The atmosphere promoted by the garden is the core element defining the Islamic garden. It is an environment evoking the memory of God and displaying the values within the concepts such as Tawhid (Providential), Khalifa (Vicegerent), Creation (Landscape) Jihad (Dedication), Adl (Justice), Worship (Worship). Therefore, every garden promoting similar values is regarded as the Islamic garden (Gulzar Haider, 1984).

The first ones springing to minds regarding the Islamic gardens are Persians, Turks, Arabs and Spaniards and the gardens established by these nations expanded towards the major parts of the world. These gardens have been emerged as a result of mutual interaction of the traditions, customs and art apprehension of the aforementioned nations with the religion of Islam (Korkut, Şişman, & Özyavuz, 2010).

The remains of certain Islamic Gardens expanded from one region to another within the regions where these civilizations have been established, have managed to be preserved and have survived to the present day.

However, the physical remnants have been gradually diminished due to the changes in monarchs and particularly the termination of the sultan-khalifah reign in the final periods of the Ottoman Empire (Md Jani, Harun, Mansor, & Zen, 2014).

However, despite this situation, Generalife Alhambra in Spain, the Mughal garden and the Taj Mahal in India, palaces and pavilion gardens in various provinces of ours particularly the Topkapı Palace in Turkey are the gardens remaining as 92

legacies of the ascendant rulers reigning the Islam civilization and appreciated to the greatest extent, bearing the historical significance.

2.5.5 In the Pursuit of the Paradise on Earth

The etymon of the word garden is Persian meaning “minor vineyard”. Overall, it is further defined as an allotment in where herbaceous and woody ornamental plants with certain visual qualification, fruits, vegetables and herbs are grown, and moreover, the beauties, verdant green and soothing and relaxing properties of nature are supervised by humans. Large or small scale, environmentally integrated, inward-oriented courtyards or gardens are the spaces reflecting the living conditions, economic and cultural qualities of societies in certain periods of history, and shaped in line with the characteristics of the region they are hosted. In this sense, Changes created by humans and the diversification in the purpose of garden landscaping have introduced many differences to the concept of garden in emotional and morphological terms (Aliasghari, Erdoğan, 2012).

Gardens, within the entire periods, referring a paradise lifestyle and dreams, which are inaccessible, are places people have tried to reach and dreamed of evading pain and stalemates through it.

Paradise is a locality aimed to be reached within the entire periods and thus, becoming the herald of happiness and serenity long waited by the humans.

These opinions have a decisive influence on the themes of the structures and garden culture of the western civilization. In this context, it is of utmost importance that the words “garden” and “heaven” have a common origin of language. The lexical meaning of heaven is pairi-dae`-za in Persian, which in fact, is synonymous with paradise. An ancient word of “paradisu” is another expression of pairi-dae`-za and solely means a confined or a walled and fenced area. “Pardes” in Hebrew and “Paradeisos” in Greek are also other synonyms and characterize the gardens of pleasure of the Persian rulers (Aliasghari, Erdoğan, 2012).

Gardens, following the emergence of the religion of Islam in the 7th Century, have been defined as the metaphor of Heaven, Paradise or El-jannah (garden). When paradise is mentioned in the sacred verses of the Quran, it is described with flowing water and fruit bearing trees. It is highlighted that there are shadow-forming trees, flowing waters, sweet fruits (garden) and fragrant flowers (gulistan).

The concept of Islamic garden is based on the depiction of paradise in the Quran. “flowing waters, blossoming trees and all sorts of fruits” indicated in the verses have formed the thought of a place of happiness.

Although the Islamic gardens in Spain, Iran and India reveal common religious characteristics, their roots are based on different cultures, climate and soil structure. Islamic gardens in India have been designed to include large areas, depending on an entirely symmetrical order with the water conduits and ponds.

The Islamic gardens in Spain have been adorned with cypress and hanging gardens on terraces built on hills and slopes as a response to the challenges introduced by the topography.

Persian gardens, on the other hand, have been designed in a formal order in hot and arid regions, with ponds and flowerbeds formed by four water conduits vertically 93 intersecting each other, known as “Chahar Bag” (Kluckert, 2000).

Humans value the nature and furthermore, establish intercorrelation with the landscape and the elements of landscape based on principles and values originating from their ethos.

Therefore, it is of utmost importance to recognize and describe the state of elements of landscape depending on the belief and culture of the society. According to the Iranian-Islamic culture and belief, elements of landscape such as water and plants are considered divine verses and symbols, and this condition is frequently observed in Islamic documentation due to its significance.

The most beautiful physical incorporation of water and plants reveals itself in the Persian art of landscape. The art of landscape in Iran has precious traditions and a spiritual power (Hobhouse, 2004).

Water and plants in such gardens have been used in three ways as “conceptually, functionally and aesthetically”. The use of water is among the substantial elements standing out in the Persian. The ponds are placed in the most notable part of the courtyard or the garden. Numerous pond structures in the garden and their interconnection with the conduits provide sensation of coolness and flow of air and water with music. The ponds built on a slight slope ensures the water to overflow from the pond and thus forming small cascades. Colored ceramics have generally been used in the decoration of the small conduits surrounding the pools. The use of colored ceramics in the ponds is another typical feature of Persian Islamic gardens (Aliasghari, Erdoğan, 2012).

The word “Heaven” or “Paradise” is named by the following 7 different expressions based on the verses of Quran;

- • Jannatu -al Kjaled (al-furgan) “garden of eternity” or “garden of eternity”,
- • Darul-us -Salam (el-anam, 6: 127), "Land of Peace"
- • Darül-El-Qarar (el Mu'min, 40:42), “Garden” or “Garden of Happiness”,
- • Jannatu-al-adn (el-Bara'ah, 9: 72-73), "Garden of Eden" or "Garden of Eternal Happiness”,
- • Jannaty-al-Ma'wa (el-Sajdah, 32: 19), "Garden of Hospitable Houses",
- • Jannatu-al-naim (el-Maidah, 5:70) "Paradise",
- • Jannatu-al-firdaus (el-kahf, 18: 107), " Garden of Eden" (Ansari, 2012).

2.6 Characteristic Features of the Islamic Gardens

The Islamic gardens re-memorate the phenomenon of paradise as a perfect place for living and resting. Islamic gardens have emerged as a distinctive and unique garden art since the 7th Century, shaped in line with the cultural and traditional aspects of various societies, depending on the influence of religion, climate and the geography. However, although the gardens are located in various countries, they have been built in accordance with the common design criteria. The basis of the Islamic gardens comprised of “Chahar Bagh” or water conduit system. The central point of the garden is formed by the intersection of two water conduits within the “Chahar Bagh” system. Generally, the main pond or structure is located at the intersection point. “Chahar Bagh” forms four symmetrical parts and thus introduces a formal layout. The structure, with respect to the use of conduit system, is placed on the land overlooking towards the panorama and water conduits and water bowls or ponds interconnecting these conduits are located in front of the structure. Privacy has always been prioritized and in the foreground in the Islamic gardens. The area is encircled with high walls and consisting of various courtyards within. The indispensable element of these gardens, generally having a formal layout scheme, is the water. Water is supplied to every part of the gardens through the ponds/conduits designed with the static or dynamic form. Although certain Islamic gardens are located within the regions of arid and hot climate, water is supplied through the gardens by means of employing various methods and through the underground conduits from the mountains. Walking trails are located around the water conduits as well as the formal layout dominating the garden. These trails provide the opportunity to thoroughly wander around the garden. A perspective imagery is revealed by the formation of an alley layout with the tall trees planted on trackside.

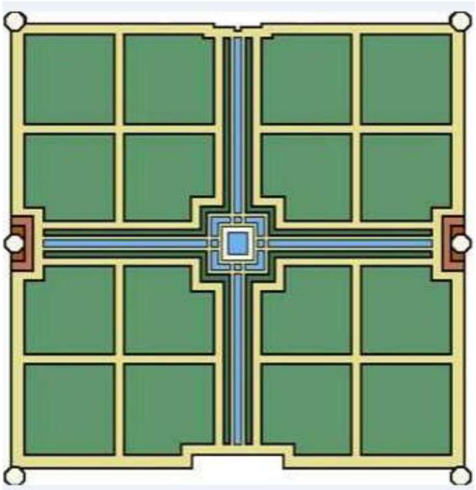


Fig. 17 Persian Garden Layout

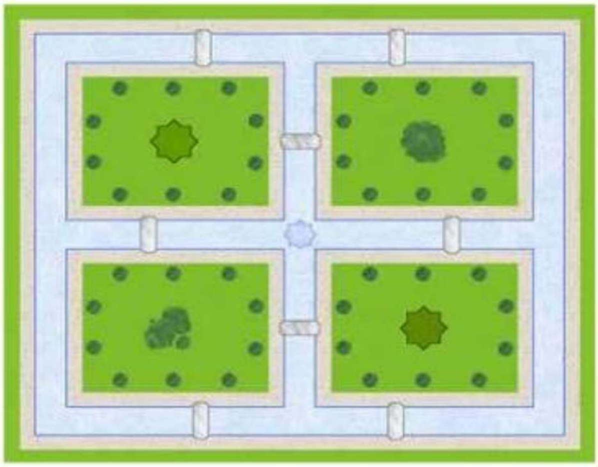


fig. 18 Chahr-Bagh

2.6.1 Structural and Botanical Materials Used in the Islamic Gardens

Although the Islamic gardens have made progress in accordance with the climatic conditions, cultural and historical values of each country, the use of structural and botanical materials reflecting common characteristics can be as follows;

• Structures Within the Garden:

The buildings located within the Islamic gardens are generally positioned within the outdoors or the garden/courtyard based on the qualifications thereof. Certain structures have been designed for residential purposes while some of them have been designed as summer pavilions.

For instance, the Generalife palace located within the Royal Alhambra Palace in Granada has been designed as a summer palace by Nasrid (1232-1492), ruler of the Nasrid Dynasty to spend his summer months. The Chehel Sotoun palace located at the Isfahan province of Iran has been used by Abbas I of Persia, the Safavid Shah for the purpose of hosting the entertainments and receptions.

Fig.19Generalife Palace, (Original,2019)

Fig. 20 Humayun's Tomb and Garden (Afzal, 2018)

• Floor Covering

Sand-gravel mixture or stone cladding technique is generally employed for the outdoors. In certain the Islamic gardens survived to this day, it is determined that patterns have been created with the stone cladding technique, while in some, the marble or "zellige" has been used.

El Palacio de Carlos V., Alhambra/Granada (Original, 2019

• Water Structures

Water is the fundamental element of the Islamic gardens. Water for the gardens has often been designed to provide contribution in both functional and aesthetic terms. However, various methods have been employed for water supply in countries with hot and arid climate. Apart from the rainy season, water is known to be supplied from water catchment basins, rivers, conduits and rainwater store reservoirs. Water supply has been provided to the palace gardens by means of the method most frequently employed, which was establishing surface conduits and providing water from the water resource on the sloping land by the gravity.

Fig. 20 Fountain of Islamic Architecture

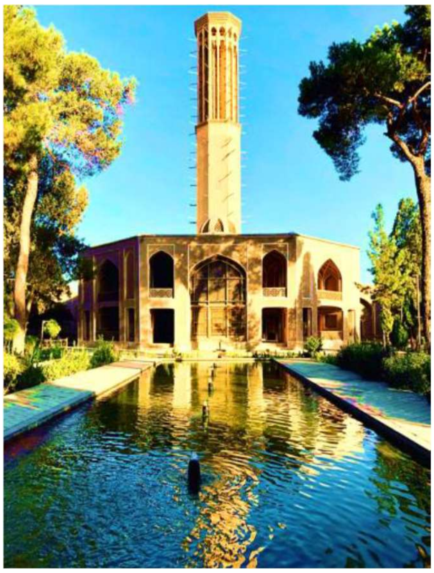


Fig. 21 Waterbody from Islamic Architecture, spain

Noria has been used in the event that the spot to where the water was intended to be conveyed was higher in elevation than the spring. Noria (water wheel) guides the flowing water to the conduit, and thus allowing the water to reach the desired area on the sloping land.98 Qanat refers to the technique as the most prevalent conveyance method for the water on the arid lands. As regards to this system, a well, lake or an underground reservoir cave with a water bearing geological layer is required. The underground conduit is exposed to the area where the water is to be supplied from the underground water source, and shafts are formed along the underground conduit for the purpose of creating an air supply and not to pose a danger during the construction phase of the conduits. The qanat system has often be utilized as the Persian Islamic gardens are located in the arid and desert region.

• Botanical Materials within the Islamic Gardens:

In consideration of the botanical material used in the Islamic gardens, it is observed that evergreen trees are generally used, taking into account the geography and climate conditions. It is further observed that the botanical design is applied around the pathways and water elements for the purpose of bringing out the geometry and the formal landscape dominating the garden. Fruit trees were also used in addition to the said botanical elements in order to create functional areas.

Fig. 22 Bagh e Sultan, Iran

Fig. 23 Bagh e Shahzadeh, Iran

Botanical Materials within the Islamic Gardens

Evergreen Plants	
Latin Name	**Common Name**
Taxsus baccata	English Yew, Common Yew
Cedrus sp.	Cedar
Washingtonia robusta	Maxican fan palm or Skyduster
Cupressus sempervirens	Persian Cypress or Pencil Pine
Buxus sempervirens	Common box
Phoenix dactylifera	Date Palm
Chamaerops humilis	European fan palm
Olea europaea	Olive
Nerium olender	Oleander
Ilex aquifolium	Holly
Citrus sinensis	Orange Plant
Non-Evergreen Plants	
Platanus orientalis	Oriental Plane Tree

Carpinus betulus	Common Hornbeam
Philadelphus coronarius	Sweet mock-orange
Myrtus communis	True Myrtle
Crateagus monogyna	Common Hawthorn
Hibiscus syriacus	Rose of Sharon
Prunus avium	Sweet Cherry
Punica granatum	Pomegranate
Ficus carica	Common fig
Bulbous Plants	
Narcissus sp.	Daffodil
Hyacinthus sp.	Garden Hyacinth or Dutch Hyacinth
Tulipa gesneriana	Tulips
Iris germanica	Iris Sp.
Lilium candidum	Lilium sp.

The beliefs of the religion of Islam, the climatic and characteristic properties of the geography where Islam has expanded have been influential to the greatest extent in the emergence and development of the art of the Islamic Garden. Any and every civilization reigning in the geography of Islamic expansion in particular, have introduced new contributions to the art of the Islamic Garden in concordance with its own geography and lifestyle without neglecting and ignoring the beliefs of the faith of Islam.

2.7 GARDENS IN CENTRAL ASIA, INDIA AND PAKISTAN.

Central Asia

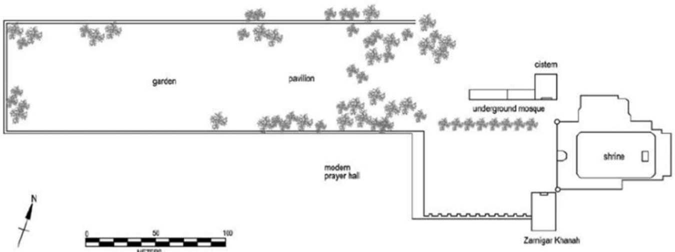
Herat

Shrine of ‘Abdallah Ansari

The shrine was built in 1425 in Gazur Gah about 5 kilometers from Herat by the Timurid ruler to commemorate the remains of Khvajah ‘Abd Allah Ansari (d. 1089). Because of the saint’s importance, the shrine was expanded and altered many times subsequently. The mausoleum consisted of a raised plinth open to the sky (a hazira) with a balustrade and framed by an iwan. To the west there was a pavilion (namakdan) that stood in a walled garden, probably dating to the seventeenth century and the era of Safavid patronage. The shrine was situated at the foot of mountains and about two kilometers from a river; the garden was watered by canals built in 1451–69. One of the more interesting features of the shrine is two groups of seventeenth-century paintings: one group shows trees, foliage, pavilions, and palaces, while the other shows a hilly landscape with clusters of dwellings.

Bagh-i Kalan

Outside the small village of Istalif about twenty miles north-northwest of Kabul, Babur bought a site called the Bagh-i Kalan (“Big Garden”) in 1504–5. There he planted ineyards and made a terraced garden, straightening the course of a natural stream to doso. When Elizabeth Moynihan visited the site in the 1970s, she saw this terrace and its watercourse, still surrounded by aged plane trees (chenars) encircled by raised, earthen, grass-covered platform

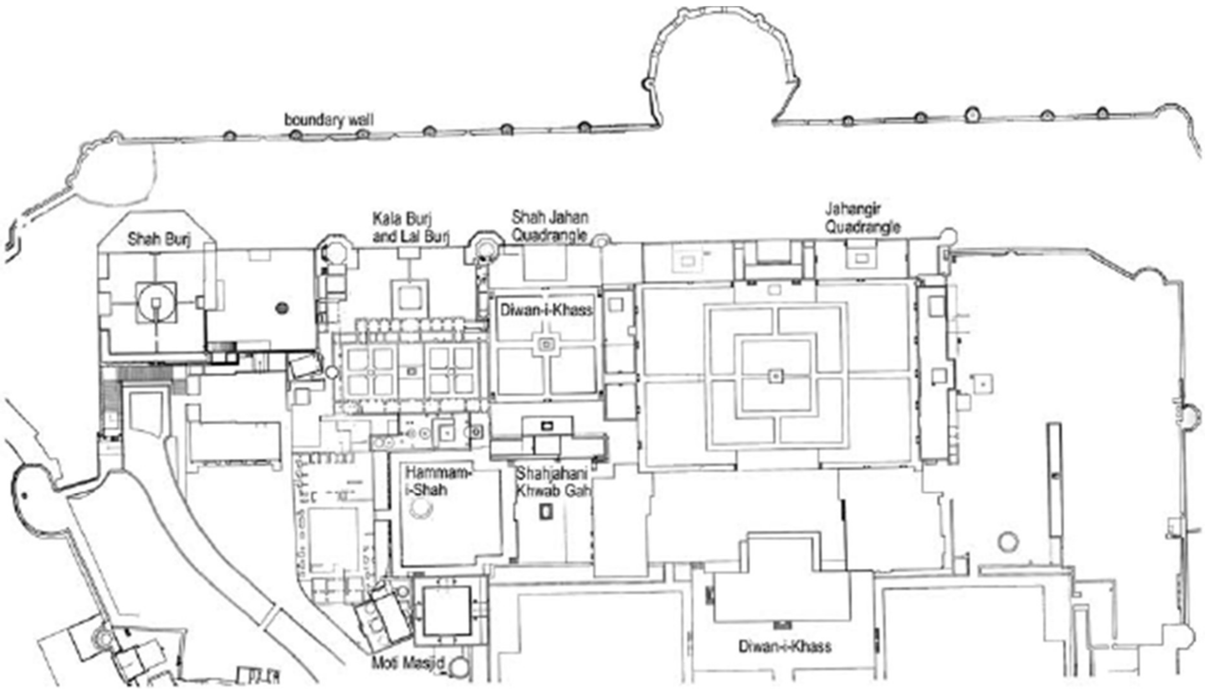


Shrine of ‘Abdallah Ansari (after Lisa Golombek)

Bagh-i Kalan, Istalif (Ratish Nanda)

P a k i s t a n

Lahore*Lahore Fort*Built upon older remains by the Mughal Emperor Akbar in 1566, the Lahore Fort was almost entirely rebuilt by Jahangir and Shah Jahan in the seventeenth century. It stands on the river Ravi's left bank in the northwest corner of Lahore's old walled city. As in the Agra and Delhi Forts, handsome pavilions overlooking interior gardens were built along the north perimeter of the Fort: the Shah Burj with its exquisitely



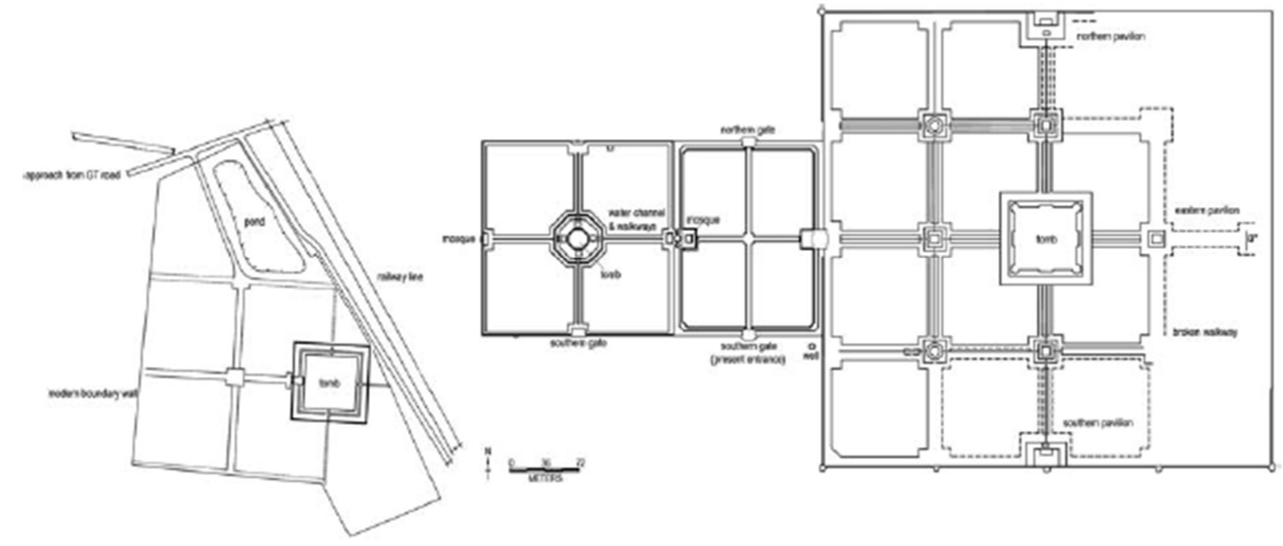
carved sunken basin, the twin projecting towers called the Kala Burj and the Lal Burj, the Shah Jahan Quadrangle, and finally the enclosed garden known today as Jahangir's Quadrangle (Plate 24). That courtyard (112.5 by 73.8 m) was finished by the emperor in 1620. On the courtyard's north side, the Khawabgah held his personal sleeping quarters fronted by a hall giving onto the garden. The layout of the Jahangir Quadrangle is unusual, for instead of a quadripartite organization, as seen in both the garden of the Shah Jahan Quadrangle and the Shah Burj's courtyard, the plan consists of concentric rectangles articulated in sandstone pavement, with a fountain at the center. The effect is like a flat maze. How it would have looked with plantings, and whether the nested beds formed by the pavements would have accentuated the plan, is unknown.

Hiran Minar

Hiran Minar, in Sheikhupura, near Lahore (Pakistan) is a Mughal hunting park set amidst scrub forest. It had no formal gardens and was not intended for long-term residence but allowed royal visitors to enjoy the semi-wild environment and indulge in the popular pastime of game hunting. At its heart is an enormous square tank (approximately 229 by 273 m) with an octagonal pavilion in its center that dates to the reign of Shah Jahan. A long walkway with its own gate connects this lake pavilion to the edge of the tank where a 30–meter high minaret (from where this photograph was taken) was built in 1606 by Jahangir to mark the grave of a pet antelope. The tower was inscribed with a eulogy. On the sides of the tank, brick ramps slope into the water to facilitate access for the animals and waterfowl that the hunters sought. The tank was supplied by an ingenious means of water collection: at its corners were square structures that drew water from underground

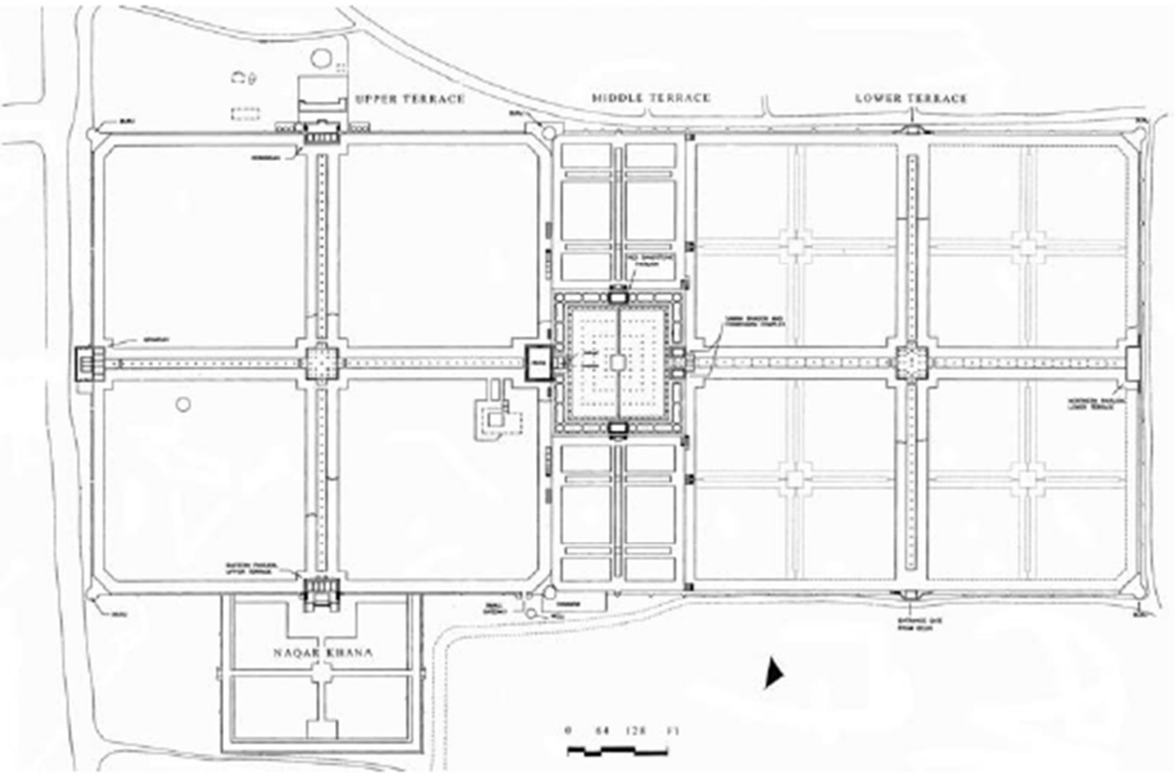
Tombs of Jahangir, Asaf Khan, and Nur Jahan

Outside of Lahore in the Shahdara gardens, the tomb for the Emperor Jahangir was probably built by his son, Shah Jahan, although there is some evidence for the Empress Nur Jahan as the patron. The simple mausoleum (built 1627–37) departs from the tradition of earlier imperial mausolea with monumental domes, for it consists simply of a cenotaphon a broad platform (*chabutra*), open to the sky above it, its corners marked by minarets. The cenotaph was originally surrounded by a marble screen which is missing today. The platform (84 m square) stands in a 55–acre chahar bagh, subdivided into sixteen units, which is preceded by a forecourt (*chawk-i jilau khana*) with a mosque. In this outer court, visitors would formerly dismount and leave their weapons when entering the tomb precinct. As is the case with so many Mughal tomb gardens, the plantings today are not original, but an eighteenth-century painting on cloth (in the Royal Asiatic Society, London) shows trees lining the principal walkways dividing densely planted quadrants. Eight wells just outside the garden enclosure supplied the water which was lifted up to aqueducts that ran on top of the walls and flowed into the eight fountain basins and channels that marked the garden's subdivisions. West of this tomb garden was the tomb of Asaf Khan, Jahangir's *wakil* (the highest Mughal administrative office) and the brother of Nur Jahan. He was buried about 1645 in a domed mausoleum set within a chahar bagh that was one quarter the size of Jahangir's. The tomb of Nur Jahan (d. □645) was situated adjacent to Asaf Khan's tomb garden and had the same dimensions. It was a platform type with a cenotaph surrounded by a marble screen (now missing). Formerly, it would have stood in a chahar bagh, although the original garden was destroyed in the late nineteenth century when the British ran a railway line through it. The present garden was created by the Archaeological Survey of India in 1911



Shalamar Bagh

The riverside site for this garden near Lahore was selected in □64□ for the Mughal Emperor Shah Jahan and the garden itself was begun soon after. It was modeled after the Shalamar Bagh of Kashmir. However, unlike the mountainous topography of Kashmir, Lahore was flat and lacked naturally rushing torrents to animate the garden. Instead, water was brought by canal to the south end of the complex and raised by waterwheels to cisterns poised above the gardens. The architects took advantage of a raised bluff overlooking the Ravi River, northeast of Lahore city, stepping the gardens in three great terraces just sufficiently to allow water to flow through a central canal. At the south end the highest terrace, reserved for the women of the court, consisted of a quadripartite garden with the four arms of its axes terminating at the Aramgah, the empress's residence (Begum Ki Khawab Gah), the Jharokai Daulat Khana-i-khas-o-'amm, and at the juncture with the middle terrace, the pavilion known as the Aiwan (Plate 22). The Aiwan looks across the middle terrace's enormous rectangular pool (6□ m wide) to the handsome Sawan Bhadon, a white marble pavilion surrounded by chini khana panels. The lowest terrace mirrored the layout of the uppermost, and in both the chahar bagh was subdivided into sixteen plots. Despite the natural conditions of the site, water is ever present in the Shalamar Bagh, flowing under platforms (including the marble throne), through pavilions (*baradari*s), over textured chadars and chini khana, and in fountain jets set in channels and elegant scalloped basins. It sustained lush plantings that included orange, lime, pomegranate, and cedar trees. Shalamar replaced the Lahore Fort as the emperor's preferred place of residence.Furthermore, it served as a magnet that attracted development to its suburban vicinity, reconfiguring the settlement patterns in that region.

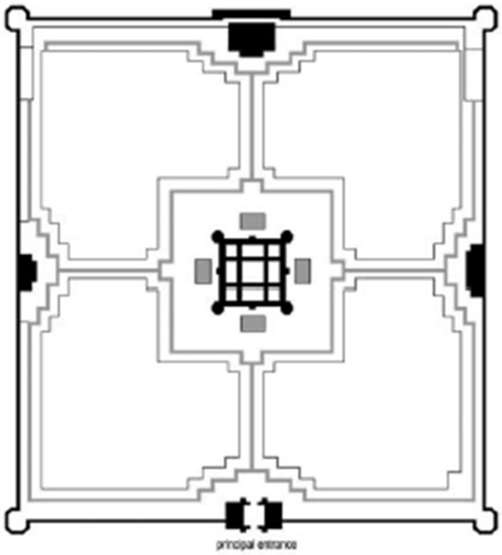


I n d i a

Agra

Tomb of I'timad al-Daula

The Empress Nur Jahan built this tomb in Agra between 1622 and 1628 for her father,the prime minister Mirza Giyas Beg (d. 1622), called I'timad al-Daula ("Pillar of the Empire"), and her mother, Asmat Begum, who died a few months previously. While the mausoleum adheres to the typical hesht behesht plan, its second story is realized with a canopy-roofed rectangular aedicule rather than the monumental double-shell dome of imperial Mughal tombs. It stands at the center of a chahar bagh (165m square) that could be entered through a large gate on the land side to the east or by a boat landing and red sandstone riverside pavilion on the west side. This multiwindowed pavilion together with the chhatri-topped towers placed at the corners of the garden provided pleasant views of the curving Yamuna River and the more than thirty gardens lining its banks. The theme of pleasure gardens and nature permeates the iconography of the site, for the white marble floors and walls of the pavilion and the tomb were variously painted or inlaid with semi-precious stone representing scrolling vines, fruit and cypress trees, flowers in vases, and drinking vessels—the very accoutrements that Nur Jahan and her entourage might have used at a picnic in this garden. While the images in stone are stylized and rigidly symmetrical, the wall paintings on the interior of the tomb are more naturalistic and reflect, perhaps, a fascination with the contemporary European botanical treatises and prints that were in circulation in the Mughal court. In particular, red poppies and red lilies—literary symbols of death and suffering—abound

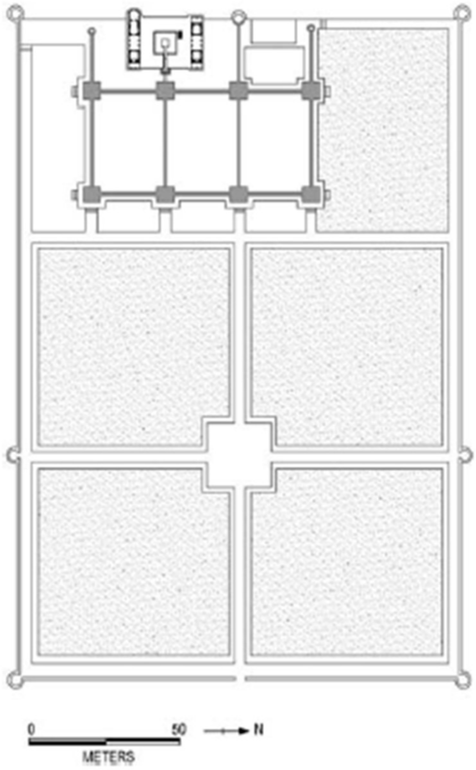


Mahtab Bagh

The Mahtab Bagh ("moonlight garden") is a recently excavated imperial pleasure garden of 9.7 hectares (24 acres) that stands across from the Taj on the Yamuna River in Agra. Its dimensions and layout clearly indicate that it was designed as a visual extension of the Taj, and it appears to have been built in conjunction with that project between 1632 and 1643. In the late seventeenth century, when its origins were already forgotten, its barely discernible traces gave rise to the mistaken identification of the site as the "black Taj," a tomb purportedly intended for Shah Jahan himself. An octagonal lotus-shaped sandstone pool occupied the Mahtab Bagh's river edge, complementing the position of the Taj on the opposite bank. Similarly, the red sandstone wall that defined the riverfront of the Mahtab Bagh was marked at each end by graceful chhatris that correspond to a similar wall with chhatris across the river. At the foot of both these walls, there were riverside landings for access by boat. The visual axis of the central water channel that flows through the Taj is continued across the river in the watercourse that drops from the large octagonal pool (17.3 m on each side) into a lotus-shaped basin and flows from there to the chahar bagh's central square pool (6.9 m each side) and axial arms. The water came from a cistern and river-charged wells in the southwest corner of the garden. Severe flooding of the Yamuna in 1652 or a bit earlier erased much of the surface of the garden, so that its original plantings and form remain somewhat speculative

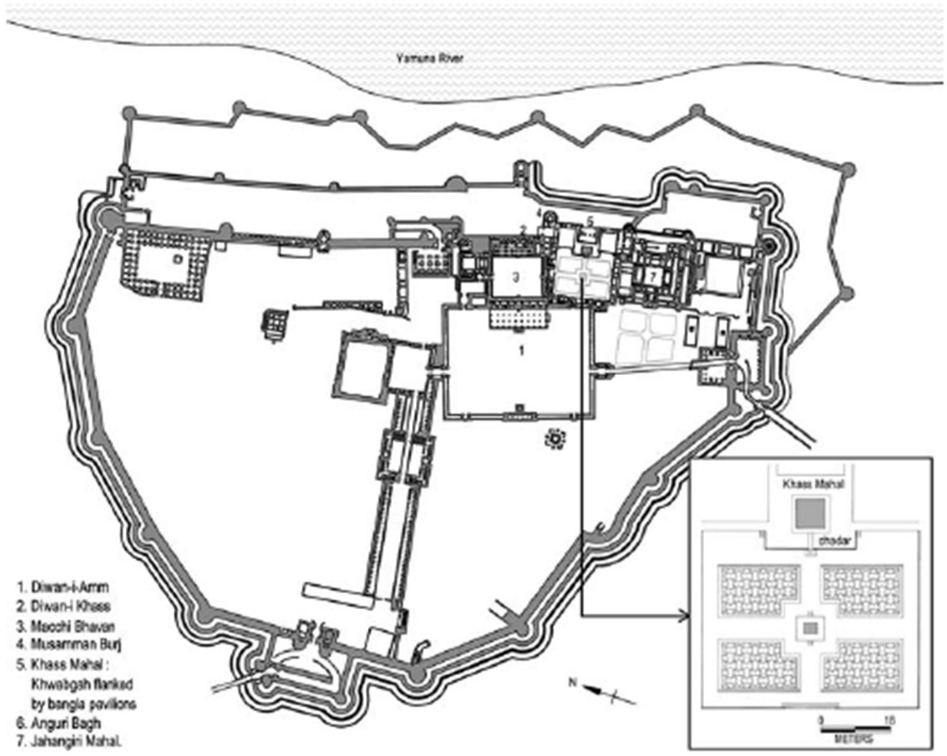
Ram Bagh

This is the modern name of the Bagh-i Nur Afshan ("lightscattering garden"), finished for the Mughal Empress Nur Jahan sometime before March 1621 along the east bank of the Yamuna River in Agra. It probably replaced an earlier garden of Babur's period. The garden is a chahar bagh (340 by 227m) defined by water channels and walkways; however, unlike previous gardens, there is no central pavilion. Instead there is a broad terrace (□36 by 96 m) on the garden's river side with two contraposed pavilions. The oblong pavilions, which consist of three verandas alternating with two enclosed chambers, flank a rectangular water pool. The terrace was elevated, since water lifted from the river to its level could then be released into the garden beds at the lower level. Ebba Koch also notes that while the raised terrace allowed the garden's residents to approach the edge for excellent views of the river, it nonetheless formed a visual barrier that shielded them from public view. An eighteenth-century map of Agra's riverscape shows this barrier effect and a variety of mature trees growing in the garden. The disposition of the pavilions on a raised terrace overlooking the river may have had Persian origins, since such an arrangement is described in the *Irshad al-zira'a*. Nur Jahan, who was Persian, is a logical agent of transmission of the type. Once introduced among the Mughals, it soon became a standard type for not only pleasure gardens but palaces and eventually tomb enclosures as well.



Red Fort

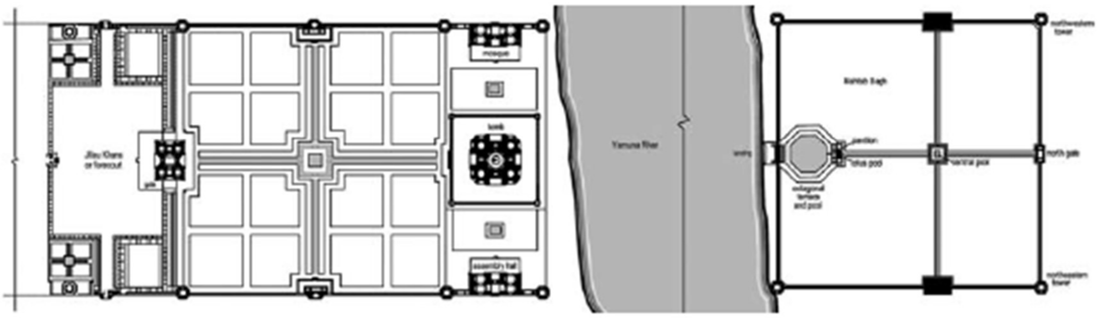
The Red Fort was rebuilt by the Mughals between 1564 and the 1570s from Lodi-period foundations; the massive walls, imposing gates, and the so-called Jahangiri Mahal (the zenana quarters) date to this period. However, most of the other halls that lined the river façade were the work of Shah Jahan in the period 1628–37. Among the gardens that were attached to these, the Anguri Bagh ("grape garden") still remains. The Machchi Bhawan ("fish house"), although often identified by modern historians as a garden, was a courtyard enclosed by arcaded wings where the emperor could observe his horses and hunting animals from the terrace of the Daulat Khana-i Khass (now called the Diwan-i Khass). The Anguri Bagh was similarly overlooked by the trio of pavilions called the Khass Mahal, consisting of the central Aramgah flanked by the *bangla*-roofed sleeping chamber of the emperor on the north side and to the south, for symmetry, the apartment of his daughter Jahanara. The garden was a classic chahar bagh with a raised pool at the intersection of the defining axial walkways of white marble. From the elegant lotus-shaped pool on the Aramgah's terrace, water poured over a chini khana panel into a basin from where it flowed to the rest of the garden. The garden's four quadrants were further articulated with ornate parterres formed by red sandstone dividing walls that recent excavations have revealed extended to an extraordinary depth of approximately six feet.



Taj Mahal

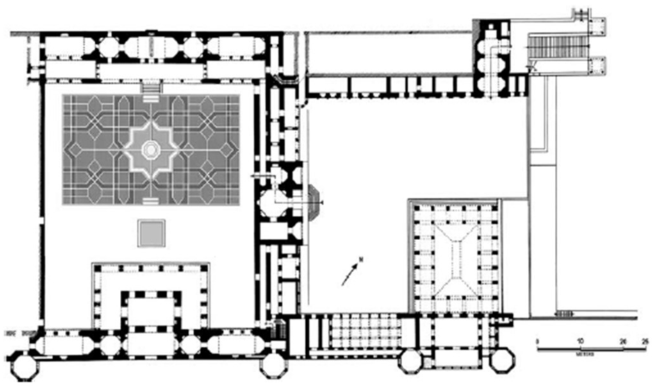
Standing on the banks of the Yamuna River in Agra, the Taj Mahal was built by the Mughal Emperor Shah Jahan from 1632 to 1643 for his wife, Mumtaz Mahal. The monumental white marble tomb on a raised plinth dominates the garden from the north end. It is flanked by a mosque on the west side and on the east side, a symmetrically placed meeting hall. The garden is a classic chahar bagh with a raised pool at the meeting of the four arms of the north-south and east-west axial walkways. The mausoleum stands not in the center, as in previous imperial and subimperial tombs, but at one end on an elevated terrace, like the pavilions ranging the riverfront of the Agra Fort. To the south, the central axis is further lengthened by a huge gate dividing the chahar bagh from a large forecourt which itself is preceded by the Taj Ganj, a bazaar and residential area for tomb staff and traders who served the seventeenth-century visitors to the complex. Water was drawn from the river in successive rehants (a bullock-driven version of the rope-and-pulley mechanism), filling a storage tank outside the west wall of the complex, from where it was released as needed to the grounds of the garden. Additionally, a tower in the southwest corner of the terrace contained a deep well. With other demands on the river, the hydraulic resources for the Taj are now considerably diminished. The vegetation today suffers from this lack and reflects British colonial taste from the year 1903 when the garden was replanted; but in 1663 the visitor Bernier described pavements raised by “eight French feet” above beds with flowers and shady trees.

Amber



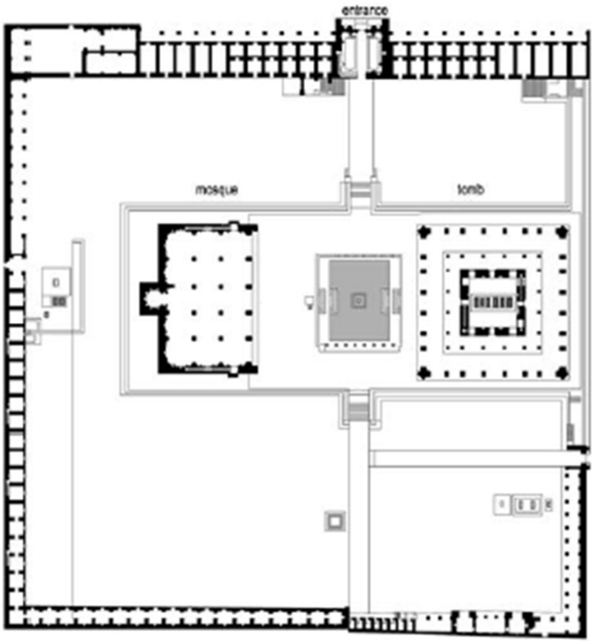
Amber Fort

The fort and the palace within it were built in Amber at the beginning of the seventeenth century by the Kachhwahas, a prominent Rajput family. (It stands about 14 km above Jaipur, which was not founded until 1727). Subsequently, Mirza Raja Jai Singh I (r. 1623–68) added two courtyards, one of which contained a lovely garden with an elaboration of a chahar bagh concept: the hexagonal geometry of sunken beds was defined by narrow channels of white marble that met at a star-shaped pool in the garden centre. On the east and west sides stood two luxuriously ornamented halls, the Jai Mandir and Sukh Nivas. From the latter, water poured over a scalloped chadar into the channels of the garden, while the Jai Mandir had a terrace from which water cascaded over a panel of chini khana niches. This pavilion had a second story called the Jas Mandir with a rooftop terrace and kiosk that enjoyed far-reaching views of the mountains and valley, where a stream was dammed to create an artificial lake, following the typology of the classic Mughal waterfront garden. On the edge of this lake was built the Maunbari garden, an artificial platform with a garden of three terraces divided into an ornate system of parterres. The smallest and topmost terrace followed the plan of a chahar bagh with a scalloped basin at its center. Water was raised from the lake by a system of staggered rehants (similar to the Taj Mahal). There were no trees, ensuring visual clarity when the garden was viewed from the palace quarters above.



Bijapur

Ibrahim Rauza



On Bijapur's west side, Ibrahim II of the Adil Shah dynasty completed a complex in 1626 to house the graves of his wife, himself, and various family members. A domed tomb and domed mosque face each other across a tank of water on a raised platform (120 by 50 m) that stands within a square enclosure (137.2 m each side). The platform and its architecture stand within a walled garden (maintained as turf today) that enhances the meaning of both mosque and mausoleum. For the latter, the garden is a visual metaphor for the paradise to come, and indeed an inscription over the doorway announces: "Heaven stood astonished at the elevation of this building, and it might be said, when its head rose from the earth that another heaven was erected. The garden of paradise has borrowed its beauty from this garden." The mosque addressed the garden in a different manner, for from its side walls projected balconies that offered views onto the verdant surroundings

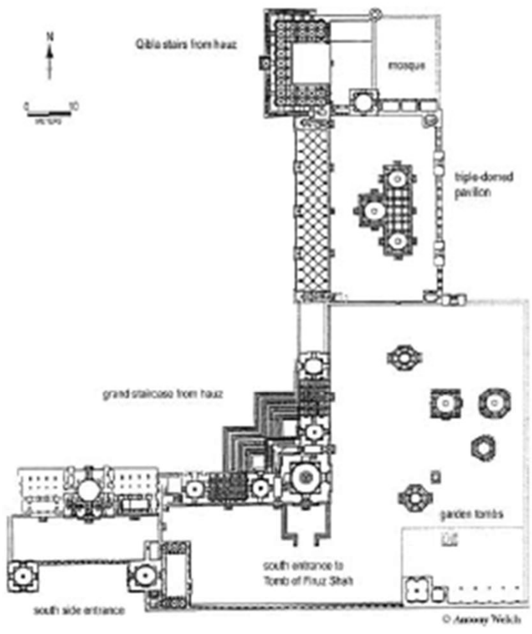
Delhi

Bagh-i Jud (Lodi Gardens

When New Delhi was created as the new British capital in the first quarter of the twentieth century, the British redesigned major portions of the older areas nearby. One such area, which had several fifteenth-century Lodi tombs and mosques, was restyled as an English park of approximately one hundred acres, known today variously as the Jor Bagh or simply the Lodi Gardens. While the principal architectural works—the four octagonal domed tombs of the Lodi dynasts (1450–1526)—were preserved in relatively good condition, their context changed radically when the cemetery became a place for public gathering and leisure. The free-standing tombs thus became garden follies and acquired new meaning as focal points in an otherwise picturesque landscape of rolling green lawns, groves of trees, stands of bamboo, and winding pathways bordered by bright annual flowers. In the 1970s, the New Delhi Municipal Committee undertook a renovation of the park based on plans by Garrett Eckbo and J. A. Stein. Their installation of modern metal and concrete lights and planters was sharply criticized as unsuitable for a funerary complex of significant historicity; however, it is unclear to what period of history the park "belongs."

Hauz Khas

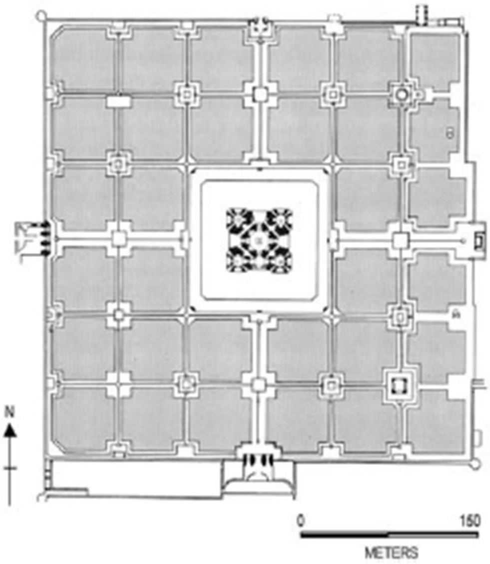
This madrasa-mausoleum complex in Delhi was built adjacent to an enormous reservoir dating from the Khalji sultanate (1296–1316). It was enlarged by the Tughluq ruler Firoz Shah beginning in 1352 when he built the handsome two-storied madrasa (teaching college) that rose above the southeast corner of the complex. A huge flight of steps wrapped itself around the inside corner of the enclosure wall and led from the madrasa down to the reservoir. This reservoir filled seasonally with monsoon water which it stored for much of the rest of the year. Such grand architectural and irrigation projects were typical of Firoz Shah (r. 1351–88), who proclaimed that he had a God-given love of architectural patronage and that, as well as constructing mosques, madrasas, and religious hostels, he dug canals and planted trees. The precinct of his madrasa was walled and gardened with hyacinths, roses, tulips, and a multitude of varied fruit trees. It was embellished with pavilions including, eventually, Firoz Shah's own tomb. In his era and today, the elevated grounds provide pleasing and panoramic landscape views and they provide a popular yet tranquil escape from Delhi's summer heat. At the northern end of the complex stood a mosque with five mihrabs. The open grillwork of three of the mihrabs was distinctly unusual, for the screens not only allow light and cooling breezes into the prayer hall but also permit a limited view through the qibla wall to the reservoir and its verdant rim of vegetation. Furthermore, the main mihrab projects from the outer wall and serves as a portal, each side of which has a flight of steps leading down to the reservoir below. That a mihrab should have such functional flexibility as both a door and a window is a rare phenomenon



Hauz Khas
(Anthony Welch)

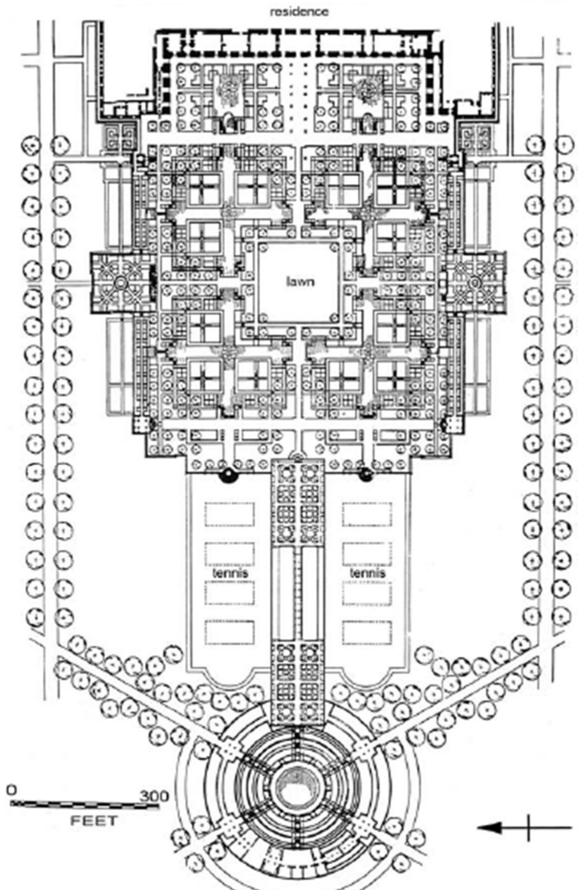
Tomb of Humayun

This tomb was erected in Delhi for the Emperor Humayun (r. 1530–39 and 1555–56), probably by his widow, Hajji Begum, in either 1565 or 1569. The first imperial Mughal tomb, it followed Timurid models of a tall double-shell dome rising from a hesht behesht plan on a raised plinth (6.5 m above ground level) that itself was raised one meter above the level of the surrounding walkways. The mausoleum stood at the center of a huge chahar bagh, 12 hectares (30 acres) enclosed by a wall 6 meters high. Each quadrant of the four-part plan was subdivided into nine units, articulated by broad walkways with water channels that expanded to square pools at their points of intersection. There were great gates on the center of the west and south walls, and these were complemented on the north and east walls by pavilions for the sake of symmetry. There were numerous other tombs and residences just outside these walls, such as the Tomb and Mosque of 'Isa Khan (1547–48). The Tomb of the Barber was apparently added to the southeast quadrant of the chahar bagh in about 1590. The restoration of the garden and its hydraulic infrastructure were completed in 2003 by the collaborative efforts of the Archaeological Survey of India and the Aga Khan Trust for Culture under the aegis of the National Culture Fund.



Rashtrapati Bhawan (Viceroy's Palace)"Mughal" Gardens

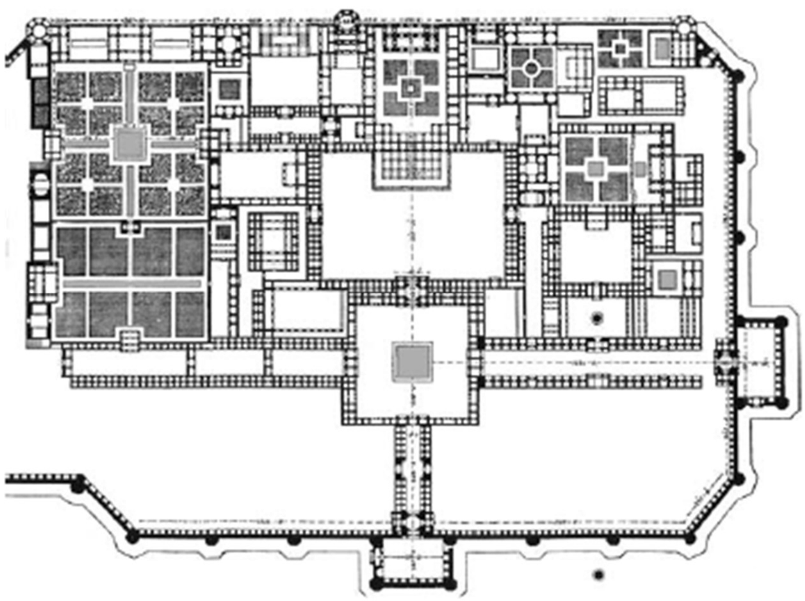
In 1931 the British inaugurated New Delhi as the new colonial capital of India. A Tripartite Planning Committee had been formed in 1912 to plan the layout of the new city, and that committee chose Sir Edwin Lutyens and Sir Herbert Baker to design it. For the centerpiece of the new city, Lutyens built the Viceroy's House (today appropriately renamed the Rashtrapati Bhawan, or President's Palace) on the Raisina Hill and the extensive gardens on its west side. W. R. Mustoe served as the director of horticulture for the project, supervising a staff of 418. The 15-acre garden, which was but a small portion of the 250-acre grounds, had three parts united along a long central axis that was generated from the architectural axis of the palace and New Delhi's principal artery, the King's Way (now Raj Path). The first part had a geometrical plan reminiscent of a chahar bagh, although its center, where a tomb might stand in a Mughal garden, consisted of an island of turf used for outdoor receptions. Lutyens had studied the Mughal gardens of Kashmir, Agra, and Delhi and reinterpreted Mughal and Indic elements in this colonial setting: orthogonal channels spanned by flat slab bridges, textured surfaces that were modernist interpretations of a chadar, and fountains made of eighteen overlapping sandstone disks to suggest lotus pads. Along the watercourses, steps led down to the water, like ghats along a sacred tank or river. The plantings were similarly subordinated to geometry: even the trees were carefully pruned to form solid volumes that contrasted with the flatness of the ground plane. The central portion of the garden consisted of tennis courts flanking a sandstone pergola that marked the central axis. The axis terminated in



a walled circular perennial garden. Steps led up into the garden gate, and then descended into the garden's three concentric terraces. In contrast to the first garden, this one evoked an English garden and surely satisfied the occasional nostalgia of the British inhabitants.

Red Fort

This fort, built in Shahjahanabad by Shah Jahan beginning in 1639, was intended to improve upon and regularize the planning and architectural splendor of the older Agra Fort. Its enclosure walls form a slightly irregular octagon 2.4 kilometers in circumference. They rise 18 meters above ground on the river side, and they rise above a broad moat (22.5 m wide) on the land side which was formerly filled with water and stocked with fish. An earthquake in 1719, battles in 1759, and the British neglect of the fort after the Mutiny of 1857 caused serious damage to the buildings and the overall plan, so that today the only portion that retains a sense of the original is the string of riverfront pavilions including the Mumtaz Mahal, the Rang Mahal, the hammam, and the Moti Mahal that together constituted the more private quarters of the complex. Running through these was an ornamental canal, the Nahr-I Behesht ("stream of paradise") which was brought from a canal drawing from the Jumna at a sufficiently high point about 10 kilometers upstream. It entered the fort through a carved marble chadar in the Shah Burj pavilion. Of the many gardens that formerly complemented the pavilions, there remains the eastern half of the Hayat Bakhsh, extending between the Moti Mahal on the riverfront, the symmetrical pavilions named Sawan (the first month of the Indian rainy season) and Bhadon (the second month of the rainy season) to the north and south, and the Mahtab Bagh on the western side, which was lamentably replaced by military barracks in the modern era. Observers described grass with jonquils and roses shaded by fruited trees, including oranges, in a large chahar bagh with a huge square tank in its center decorated with 161 jets. The Zafar Mahal that stands in the middle of the tank presently is a nineteenth-century addition of Bahadur Shah II. The garden that one sees today is largely reconstruction made on the basis of excavations carried out in 1904–5.



Tomb of Safdar Jang

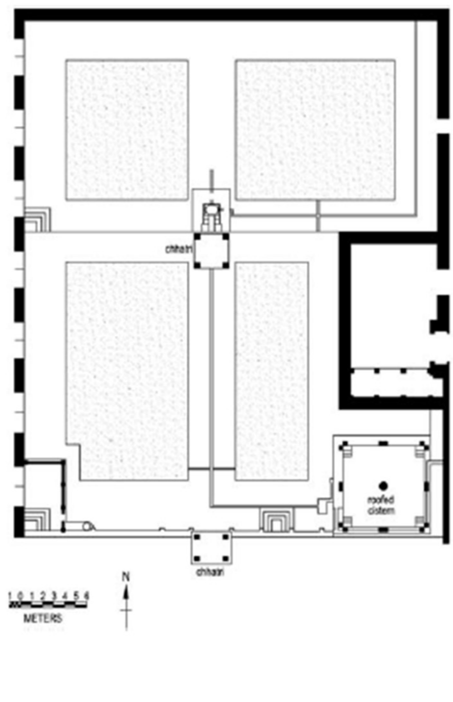
Safdar Jang (1739–54) was a Nawab (governor) of Awadh (Oudh) in the period when the Mughal empire had shrunk to Delhi (ruled by Nasir al-Din Muhammad Shah) and the few provinces such as Awadh that did not claim independence. The shi'a Nawabs (1722–1856) built more than six hundred monuments. Safdar Jang's son built the tomb and garden for him in Delhi after Safdar Jang's death in 1754, the pink and white stone platform pierced with regular iwans, and simple chahar bagh plan evoking the first imperial Mughal tomb of Humayun. The garden measures over 300 square meters and is a four-part plan subdivided into smaller

quadrants with a large gate piercing its eastern wall. The tomb's nostalgia for earlier Mughal prototypes was embraced by other rulers of Awadh. For example the tomb of Shuja' al-Daula (1775), popularly called the Gulabari, and that of his wife (just after 1816), both in Faizabad, continue the by now antiquated tradition of tall domed mausolea set within four-part gardens.

Fatehpur-Sikri

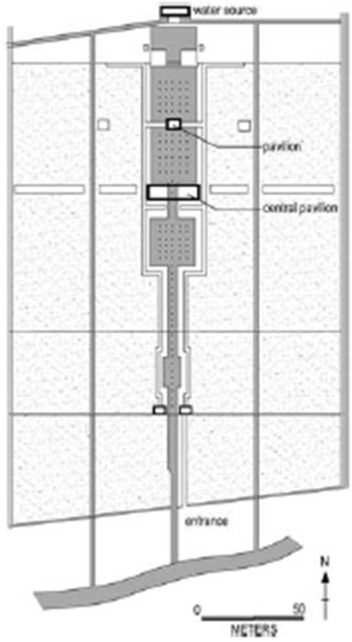
Zenana Garden

This royal palace city and shrine complex was founded in 1571 by the Mughal Emperor Akbar at the home of his spiritual advisor, Salim ad-Din Chisti, 38 kilometers east of the Mughal capital, Agra. Eleven kilometers of fortified wall enclose the site which rises on a natural sandstone ridge that is visible from a considerable distance. Along the northwest perimeter, the city had an artificial reservoir that was tapped by wells. In one, water was lifted up to the palace via a man-powered treadmill to a succession of holding tanks and an aqueduct that was passed through building walls and traversed gardens. It filled a roofed cistern in the zenana (women's quarters) from where it was released as needed for the nearby baths and the small stepped garden, north of Jodh Bai's palace. This garden consisted of two stepped levels (one 27 by 28.4 m, and the other 37 by 19 m) bisected by a central water channelthat flowed beneath diminutive chhatris. Few other original gardens can be discerned in the complex today, but the omnipresence of water channels incised in the stone pavements indicates that water was transported— at great effort—throughout the palace to fill basins and tanks such as the Anup Talao's square sunken pool and probably to irrigate gardens as may have existed just east of the Pachisi courtyard or in the courtyard of the Diwan-i 'Amm.



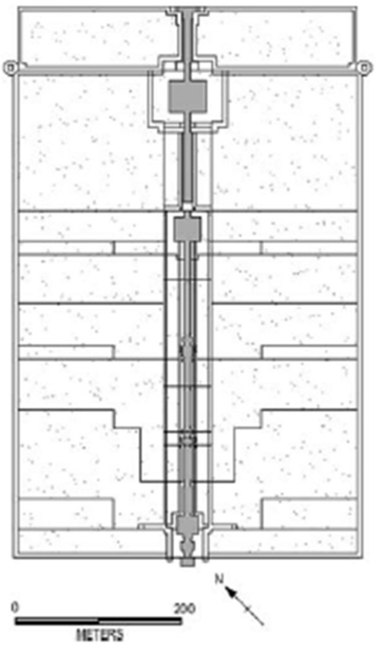
Kashmir

Achabal Bagh



Located in the same river valley as Srinagar, but 50 kilometers south, Achabal Bagh was built by Nur Jahan, wife of the Mughal Emperor Jahangir, sometime soon after 1620 and refashioned by Shah Jahan's daughter, Jahanara, in 1634–40. The primary axis is a broad channel that runs down from the source, a sacred spring at the foot of a hill, in a striking waterfall at the elevated northern end of the garden, expanding into rectangular pools with a grid of spraying fountains. Two parallel narrower channels run along either side. In the Mughal era, the water force was so intense that excess was carried off by underground channels. The garden's four stepped terraces adapt to the sloping skirt of the mountainside. According to Attilio Petruccioli, "Monumentality is not achieved by the heroic scale, but by mastering the force of the natural elements"

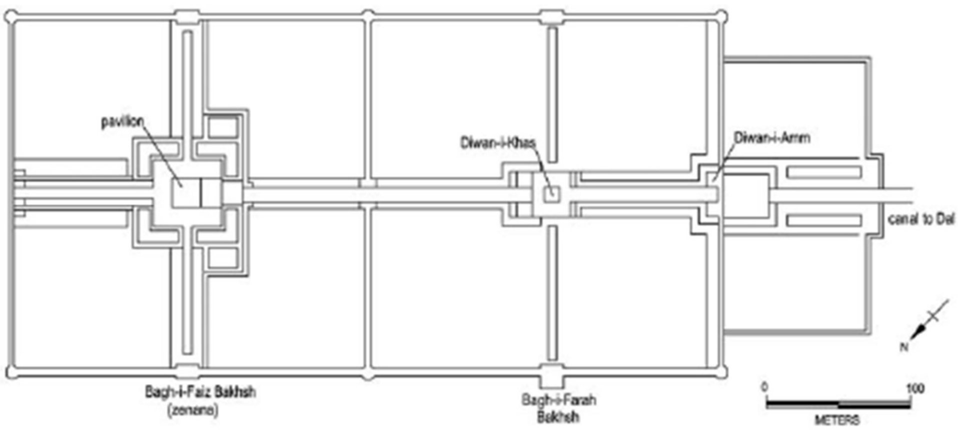
Nishat Bagh



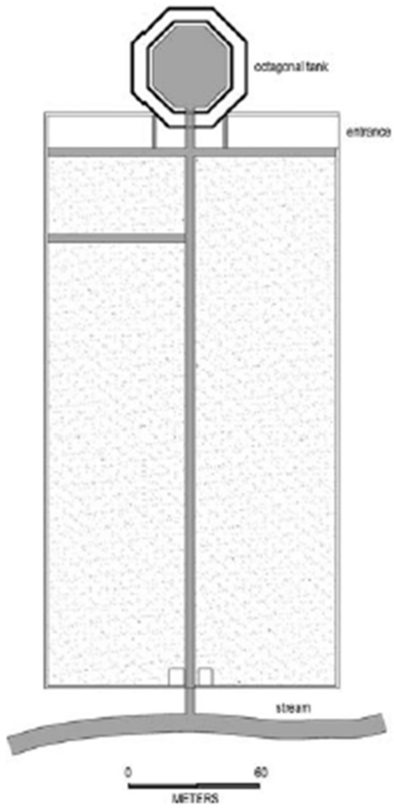
Nishat Bagh, the "garden of delight," was the work of Asaf Khan, the elder brother of the Mughal Empress Nur Jahan, in 1625 in Srinagar and is widely regarded as the finest of the Kashmir gardens. Like Shalamar Bagh, it enjoys a magnificent setting between vertiginous, snow-capped mountains and the calm Lake Dal below, but its plan is more sophisticated. Its original plan had twelve levels corresponding to the signs of the zodiac (the lowest portion has been erased by a modern road). These descended from the topmost terrace, the zenana, which was set apart from the rest by a six-meter-high wall of blind arches with octagonal pavilions marking each end and providing views across the lower gardens to the lake and its distant shore. A broad watercourse runs down the central axis of the garden and at each change of level, it pours over a differently textured chadar. The dynamism of the water as it splashes boisterously in fountain jets and cascades contrasts pleasantly with the serene horizonality of the lake.

Shalamar Bagh

One of many gardens built in the reign of the Mughal Emperor Jahangir, who loved the dramatic landscape of Kashmir (1,500 m above sea level), Shalamar (near the city of Srinagar) consisted of two great four-part gardened terraces with a smaller entry court at lake level. The older and upper gardens, called the Bagh-i Fayz Bakhsh, were built by Jahangir in 1619–20, while the later lower Bagh-i Farah Bakhsh was the addition of Shah Jahan around 1630, advised by the Empress Nur Jahan. The uppermost garden served as the zenana and had a pavilion of black marble set within a square pool. The middle terrace had a more public function including an audience hall, while the lowest and most public level had the Diwan-i ‘Amm, a hall of public audience. The mountains form a stunning backdrop to the garden and provide a constant torrent of water that not only pours vigorously down the successive levels but also powers fountain jets and, formerly, supplied the baths of the second terrace. A central channel (6 m wide) runs straight through the three terraces, with a cross-axial channel on the uppermost level. The watercourse swells to form pools in the center of the two chahar baghs, and at the entrance at the bottom of the garden it disappears below ground level to reemerge on the other side as a canal that flows to Lake Dal. On each terrace, a pavilion stands in the center of the pool or straddles the water channel, and all along the channel there are broad stepping stones, bridged walkways, and platforms (*chabutras*) that seem to invite one to step into the water. As for the original planting at the site, the visitor François Bernier described turf and poplar trees in 1665. Manuscript paintings of other imperial Kashmiri gardens show plots filled with colorful flowers.



Verinag



Verinag is built at a sacred site at the Banihal pass on the way to Kashmir, at the source of the Bihar River, amidst a pine forest. The water in the garden flows from a deep spring-fed octagonal pool that is surrounded by an arcade and overlooked by a domed pavilion. From there it courses in a straight, 330-meter long, stone-lined channel that divides the enclosed garden symmetrically. Although much simpler than the other Mughal gardens in Kashmir, Verinag is similarly set in a dramatic landscape between mountains and a body of water, in this case a stream. It was built in 1609, according to an inscription containing the following praise: “this canal is like the canal of Paradise; this cascade is the glory of Kashmir.” The octagonal pool was built by Jahangir just before his ascension to the throne in 1605, according to Shah Jahan’s biographer. The garden was a favorite of Shah Jahan, who called it Shahabad and developed it further by adding pavilions, baths, tanks, chadars, and fountains.

2.8 Mosque Architecture Styles Around The World

‘’The soul has been given its own ears to hear things the mind doesn’t understand” Rumi.

As Islamic architecture provides a constant insight of beliefs and practices to Muslims throughout history. Also, it perfectly adapts and responds to varied cultures and traditional practices in the areas it exists in. So, in this section we’ll view various examples of Islamic architecture buildings and see how they blend with their surrounding country environment. We’ve searched the globe for the most eye-catching examples of Islamic architecture that are diverse in form yet delightful in core. As the most important building type in the Islamic architecture is the mosque, which is the center of Islamic culture and society, so the article will present various mosques in various forms.

The Great Mosque of Djenné, Mali

Described as the largest mud-built structure in the world and one of the early mosque examples. The Great Mosque of Djenné is definitely one of the most unique religious buildings in Mali that flourished as a great Islamic center of commerce, learning and congregational prayer. Moreover, it’s one of the finest examples of Sudano-Sahelian architecture style. To illustrate, what marks this style is the use of mud bricks and adobe plaster with large wooden-log support beams. These beams also act as scaffolding for reworking and involves the local community building. So, everything from its minaret-structures to its walls is constructed from mud. Therefore, this mosque is a true example of Muslim architecture blending with regional techniques.

Nasir Al Molk Mosque, Iran

One of the most elegant and most photographed pieces of Islamic art and architecture that are found outside Isfahan in southern Iran of the 19th century. The hypostyle mosque features many elements of traditional Islamic architecture like iwan arches and a central fountain for ablutions. However, we can trace some features of European influence found in the mosque decoration, which spread in Iran in the time of construction of the mosque. Some of these western influences included stained-glass windows and colorful tiles which were relatively rare in Islamic architecture back then. The designers Muhammad Hasan-e-Memar and Muhammad Reza Kashi Paz-e-Shirazi created a space where light and worship intertwine. So, when you experience the mosque from inside, you will find yourself surrounded by a rainbow of colors.

Sultan Ahmed Mosque, Turkey

Sultan Ahmed is an Ottoman mosque located in Istanbul, built between 1609 and 1616 and famously known as the Blue Mosque, Sultan Ahmed's mosque architecture features traditional Islamic designs. Therefore, it was designed with the idea of making the mosque have an overwhelming size, majesty and splendor. Moreover, the interior of the mosque is an absolute delight of more than 20,000 blue breath-taking tiles. The Blue Mosque is one the greatest feat of Ottoman architecture.

Xi'an Great Mosque, China

The Great Mosque of Xian serves over 60,000 Chinese Muslims in the Xian area. Founded in 742 during the Tang dynasty, the mosque was the religious center for Arab merchants operating in China. Unlike the Islamic architecture in Arab countries, the Great Mosque of Xian has neither domes nor minarets. The style is almost wholly Chinese, except for the Arabic lettering and decorations that list the 99 names of God and verses from the Qur'an. So, the mosque is a gorgeous blend of Chinese and Muslim architecture, one of the most distinctive mosque architecture styles around the world and an Islamic-Chinese traditional mosque.

Jama Masjid, India

It was where the city's Muslims traditionally gather for the communal Friday prayer; *Jama Masjid* is Arabic for "Friday mosque. Moreover, it's one of the largest mosques in Old Delhi, India. Its construction started in 1644 and completed by Mughal emperor Shah Jahan. The construction of the mosque's courtyard was in red sandstone. The mosque's courtyard is also so huge as it can accommodate 25,000 devotees at one time. This mosque is an impressive example of Islamic Mughal Architecture.

Complex of Sultan Hassan, Egypt

Massive yet elegant, this grand structure is one of the finest piece of early Mamluk architecture in Cairo. Built between 1356 and 1363, the Complex of Sultan Hasan included a madrasa, congregational mosque, and mausoleum. The mosque stands out not only as means of prayer, but as a symbol of unity as its courtyard opens from each of its sides into iwans where followers of the four schools of Sunni Islamic thought would learn. This building combines strength and splendor, elegance and beauty, as well as a multiplicity of decoration. The complex of Sultan Hassan is a Mamluk Architecture gem.

Qolşärif Mosque, Russia

Qolşärif Mosque was first constructed in the 16th century in the Muslim-dominated Khanate of Kazan. After its destruction which shorty followed its construction. The mosque was rebuilt in a more modern style in 2005, so it’s not stuck in the past. However, the dome-shaped administrative building that flanks the prayer hall gives it an edge with soaring teal-topped minarets the new mosque design connects the old Kazan Khanate with modern Russian and Islamic architecture.

Cologne Central Mosque, Germany

The mosque was built in 2009 and is the largest and grandest mosque in Germany. It is a prime example of modern Euro-Islam architecture. To clarify, it features two minarets where each minaret is 55m high and a dome of glass and concrete structure. The complex is mainly characterized by the prayer hall, which consists of several shell-like walls. In the center these walls build the light-flooded dome. The mosque a perfect example for contemporary mosque architecture.

Malacca Straits Mosque, Malaysia

Built in 2006, this beautiful structure gives the impression of floating Mosque in the water if viewed from a distance. Its 30-meter minaret works as the guide for water crafts, boats and air ships to stride safely across the sea. The mosque has a Middle-Eastern dome with four corners of turrets decorated with Malaysian roof lines. The large double equilateral archways that formed at the mosque's main entrance and provide openings to the prayer hall.So, when you visit it you will enjoyed the amazing atmosphere and fresh breeze coming from the ocean. This mosque is a mix of Middle Eastern and Malaysian architectural motifs and stands out for its novel design and color scheme.

Bait Ur Rouf Mosque, Bangladesh

Designed in 2005 in Bangladesh, the mosque operated with donations from the community. So, Use of local materials and craftsmen were primary. Ventilation and the play of light make this neighborhood mosque a refuge for spirituality as the mosque breathes through its porous bricks. The mosque received an Aga Khan Award for Architecture and became an inspiring Traditional Islamic Architecture case. It's definitely one of the magnificent mosque architecture styles around the world.

2.9 Environment Friendly Techniques in Green or Eco-Friendly Building.

Green Building is generally defined as a building, which utilizes less external energy and is capable of producing ample amount of energy for its intended use itself without causing harm to the environment. Green Building is called energy efficient building or eco-friendly building. These buildings are called green due to their similarity with trees…as trees generate their food only by the use of sun light and air, these buildings are also capable of producing energy and utilizing it properly without damaging the environment. A Green Building depletes the natural resources to the minimum during its construction and operation. The aim of a Green Building design is to minimum during its construction and operation. The aim of a Green Building design is to minimize the demand on non-renewable resources, maximize the utilization efficiency of these resources, when in use, and maximize the reuse, recycling, and the utilization of renewable rsources. It maximizes the use of efficient building materials and construction practices; optimizes the use of on –site sources and sinks by bio-climatic architectural practices; uses minimum energy to power itself; uses efficient equipment to meet its lighting, air-conditioning, and other needs; maximizes the use of renewable sources of energy; uses minimum energy to power itself; uses efficient waste and water management practices; and provides comfortable and hygienic indoor working conditions. It is evolved through a design process that requires all concerned- the architect and landscape designer and the air conditioning, electrical, plumbing, energy consultants –to work as a team to address all aspects of building and system planning, design, construction and operation. They critically evaluate the impacts of each design decision on the environment and arrive at viable design solutions to minimize the negative impacts and enhance the positive impacts on the environment. In sum, the following aspects of the building design are looked into in an integrated way in a Green Building.

Global warming and climate changes have become a major concern for mankind today. In order to ensure that, development and environment conservation go hand in hand, major corporations around the world are empowering projects to slow down depletion of natural resources.

We spend 90% of our lives in buildings that protect us from the extremes of the nature like heat, cold, rain, wind, snow etc. However, our buildings use enormous amount of energy, water, and material throughout their life cycle. They also create a large amount of waste and have a profound effect on ecosystem.

The economic, health and environmental impact of our built environment is apparent in our society. To meet the challenges of our built environment, a new way of designing & construction has evolved. It's a Green Building, this system follows design and construction practices that significantly reduce or eliminate the negative impact of the building on the environment and the occupants. In this section we discuss structural and civil aspects for construction of Green Building.

2.9.1 Features of Eco-Friendly or Green Building

- Green building materials
- Reduced Energy Use
- Reduced Waste

Building Simulation Analysis

Building simulation solutions allows us to address the thermodynamic complexities involved in construction of a building and undertake integrated performance appraisals of various options at a reasonable cost. For the first time, the construction industry has the computer aided tools to make assessments that are very close to the physically validated results. Simulation provides a way to assess the benefits of particular schemes, improve life cycle performance, enhance design quality, appraise climate change mitigation measures, undertake scenario based energy planning, link energy and health and enable inter-organization partnerships. The biggest advantage for simulation at the design stage is to integrate the different technical domains and identify the trade-offs to arrive at an optimum solution. Building simulation analysis follows a systematic approach to ensure the most accurate output. It includes a detailed study of the following factors:

- Energy Analysis
- Solar Isolation Analysis
- Daylight Analysis
- Location Analysis
- Light Pollution Analysis
- Reflection & Glare Analysis
- Shadow Analysis
- Visibility Analysis
- Acoustic Analysis

Energy Analysis:

The purpose of energy simulation is to estimate the total annual energy consumption of buildings so as to inform the building design process to create energy efficient choices. Energy analysis takes into account variety of factors involved in the design, including but not limited to.

Solar Isolation Analysis:

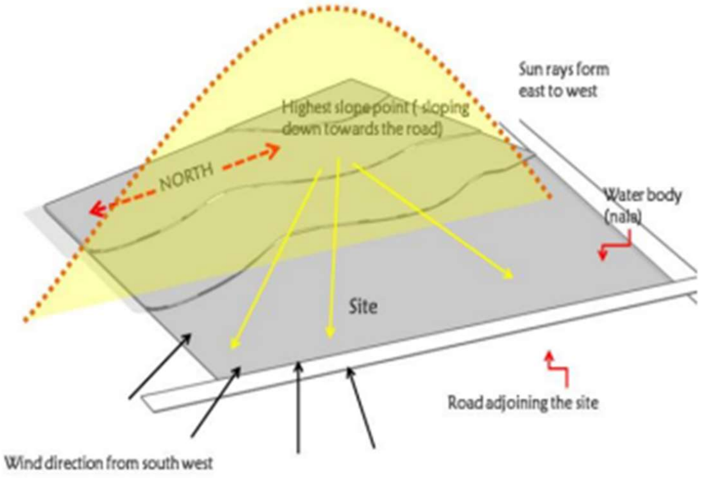
It is the amount of electromagnetic energy (solar radiation) incident on the surface of the earth. Solar isolation analysis is the study of incident solar radiation impacting on building. Incident solar radiation (isolation) refers to the wide spectrum radiant energy from the Sun which strikes on surface. This includes both a direct component from the Sun itself (sunshine) and a diffused component from the visible sky (skylight). Depending on the site chosen, it can also contain a reflected component from other surfaces in the model and the ground. The objective of the analysis is to determine the amount of radiation received on the various surfaces of the building being analysed to identify options for installation of Photovoltaic modules. It also helps in selection of facade materials that would support better interior environmental quality while improving energy efficiency.

Daylight Analysis:

Good design for building requires sufficient daylight for tasks performed within a space. This is achieved by providing enough means to let in diffused light from the sky, but keep out direct light from the sun to prevent heat gain and glare. Daylight analysis is the process by which the amount of diffused sunlight that enters into the interior of a building is estimated. This analysis does not take into account the direct sunlight entering into the building, but it uses the luminance of the standard overcast sky from weather files as the measure of the exterior diffused sunlight. It helps us assess the impact of the exterior surfaces on the entry of this light into the interior floor space of the building.

Location Analysis:

The early consideration of environmental constraints and possibilities will help the creative designer to conceive a building whose design draws upon these factors. Location analysis enables designers to exploit climatic conditions in order to maintain comfort, minimizing the need for artificial control or the choice of suited materials. A typical location analysis covers: Wind patterns: Prevailing wind conditions, seasonal wind and the temperature of wind Temperature: Average, maximum and minimum rainfall Humidity: Humidity conditions persisting in an area and in selection of appropriate materials for facade and building interiors Climate summary: The micro-climate of a site dictated by topography, altitude and urban density Rainfall: Average daily rainfall



Light Pollution Analysis:

Light pollution is excessive or obtrusive artificial light that disrupts ecosystems and has adverse health effects. It covers the following aspects.

- Light trespass: Luminance values at certain site physical locations Over Illumination: Evaluation of areas exceeding the suggested lighting power density
- Sky Glow: Brightening of sky caused by outdoor lighting and natural atmospheric and celestial factors

Reflection & glare Analysis:

Reflection analysis helps in understanding the glare-pattern on the site. This helps in designing the facade of the property with an understanding of its implications to nearby locations (e.g. pools, parking, roads). Using reflection analysis, it is possible to calculate and display the effects of reflections in the same way as shadows. Using a sun-path diagram, the entire annual potential for reflections at the selected focus point on a building can be obtained at any given point.

Shadow Analysis:

As shadows and reflections are an important aspect of building design, shadow analysis enables an understanding of the extent to which shadows from other local structures affect the specific property that is being designed. This helps to take the right decisions regarding placement of parking lots, solar panels, windows etc. Viewing shadows in this manner allows the designers to focus on specific objects that can hinder or support some of the functional aspects of the design, or quickly see the location of sun-patches as they travel across the floor and up a wall.

Visibility Analysis:

Even at a preliminary design stage, it can be important to know the degree of visibility of specific objects from different parts of the building and workspaces. Visibility analysis helps in obtaining a useful assessment of the areas in a room that have adequate views to the outside through windows and openings. This analysis involves setting up the points over the floor plane of each room of analysis and then selecting the appropriate windows, allowing quick calculation of the exact area of unobstructed window visible from the point.

Acoustic Analysis:

Acoustics plays major role in degrading the environmental quality of space which may lead to occupant discomfort. Acoustic Analysis deals with analysis of sound inside the room, sound transmission through rooms, speech intelligibility and background noise levels inside the room. The main objective of this analysis is to reduce reflections of sound inside the room, reduce the sound being transmitted from outside and increasing the quality of speech inside the room.

Building simulation program analyses the various components of the structure at every step, allowing practitioners to explore a building's life cycle performance at the design stage, so that problems can be identified and corrected before they arise.

2.9.2 Green Techniques:-

Emphasis of four '3 R's:-

Via sound designing, construction and building commissioning without compromising structural durability, indoor pollutant levels, ventilation, building code requirements, or marketability includes:-

Reduce:- lower quantity of building material, resources, and embodied energy are used. Reuse:-construction materials that are practical and structurally sound are reused.

Recycle: - recycled materials are used, and home is designed for recyclables.

Renewable:- energy from natural sources and renewable building materials are emphasized. The technique which emphasizes these four "**R**''s are called as Green Techniques. These Green techniques can be classified as follows:-

- Structural or civil techniques.
- Electrical techniques
    - Conservation techniques
    - Generation Techniques
- Special systems/ techniques

2.9.3 Structural Techniques:-

Insulated wall:- All of us pay to heat and cool our homes and wish we could pay much less than we do. In a typical home, space conditioning and comfort bills can account for up to one-half of a home's energy bills with the remaining portion due primarily to water heating, lighting, and appliances.

Installation of the cost-effective level of insulation is extremely important. Homeowners can affect their energy usage, save money, and help the environment all at the same time. Investing in energy-efficient options, such as insulation, will provide a continued payback to the homeowner and a more enjoyable and comfortable living environment for many years, as well as a reduction in emission of greenhouse gases.

Types:-

1. Air gap insulation

2. Cotton insulation

3. Mineral wool insulation

4. Plastic Fibre insulation

Green Cement:- Green Cement is a combinations incorporating limestone, fly ash or ground granulated blast-furnace slag can be specified and, in some exposure conditions, may be more appropriate. The cement industry is actively recovering the energy from wastes by increasing the use of non-fossil fuels such as waste solvents; refuse derived fuel (RDF), certain non-recyclable paper and plastics, sewage pellet, and meat and bone meal. Using these alternative fuels not only reduces the need for landfill sites or disposal by incineration but also helps preserve our finite reserves of fossil fuels.

Fly ash brick:- This is a fine, glass-powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. When mixed with lime and water the fly ash forms a cementations compound with properties very similar to that of Portland cement. Because of this similarity, fly ash can be used to replace a portion of cement in concrete, providing some distinct quality advantages.

Adding fly ash to stabilized soil bricks or ordinary bricks can increase their compressive strength. Other benefits include:

1) Low water absorption

2) Less consumption of mortar

3) Economical & eco-friendly

4) Low energy consumption

5) No emission of green-house gases

Transparent roof / sustainable day lighting

Lighting accounts for around 15% of the energy bill in most homes, and around 25% in commercial buildings. The most sustainable lighting is natural daylight. It is not only a free renewable resource but it also has well-documented health benefits. Careful architectural design is required to maximize natural light in a building while maintaining indoor temperature regulation and reducing direct light glare. The strategic placement of windows, skylights, light shafts, atriums and translucent panels in harmony with other building components, such that light is reflected evenly throughout internal spaces, is known as day lighting design.

Green Roofs:- It consists of covering the roof by the plantation of the different types. Other than enhancing the aesthetic sense it acts as the natural insulation.

Construction:- The basic build up of a green roof is three layered: - drainage, filter and vegetation layer. Each layer needs to fulfill several functions to decrease the height and the weight of the overall build-up.

Vegetation:- Type of planting depends on depth of the growing medium layer as well as other factors.

Growing medium:- Grain size, water retention, air volume, and weight and nutrient reserves. The soil needs to be stable, not prone to settlement, well aerated even with water saturation and free of weeds.

Drainage:- This layer retains drains water off the roof, protects the root proof layer from being mechanically damaged, retains water for times of drought and provides the substrate with a balanced supply of water and air.

Insulation: Warm roof rigid insulation

Root membrane:- This prevents roots from damaging the waterproofing. The membranes specification depends on the planned landscape and the slope of the roof.

Green Paints:- According to the EPA, the air inside a home is, on average, two-to-five-times more polluted than the air outside. Paint is a large contributing factor to poor indoor air quality and can emit harmful chemicals, such as VOCs, for years after application. There are serious health and environmental concerns surrounding paint. Using paints that are free of Volatile Organic Compounds (VOCs) such as benzene and toluene, free of heavy metals such as lead or cadmium, and/or made of post-consumer recycled content can aid in reducing exposure to toxics both for you and your environment.

Eco Wood:- Eco wood is the wood produces and processed by the man himself by recycling. Also the wood manufactured from baggase of sugarcane can be classified into this category. This type of wood can again be recycled and reused. Thus it helps to keeps to environment healthy.

Green Glasses Green Glass products are used in exterior applications both for energy generation (glass for photovoltaic applications) and energy conservation (tinted glass, solar control reflective glass, low-e glass etc.) as well as for interior applications (arsenic-free designer range, environmental friendly copper and lead free mirrors etc.)

2.9.4 Electrical Techniques:-

Conservation Techniques

1. Optimum use of natural light.

2. Replacing incandescent lamps by compact fluorescent lamps (CFL‟s).

3. Replacement of conventional fluorescent lamp by energy efficient fluorescent lamp.

4. Replacing of mercury/sodium vapour lamp by halides lamp.

5. Replacing HPMV lamps by high pressure sodium vapour lamps.

6. Replacement of luminaries by more energy efficient luminaries.

7. Replacement of conventional ballast by energy efficient ballast.

8. Obtain flexibility in light control circuit by using sensors, microprocessors.

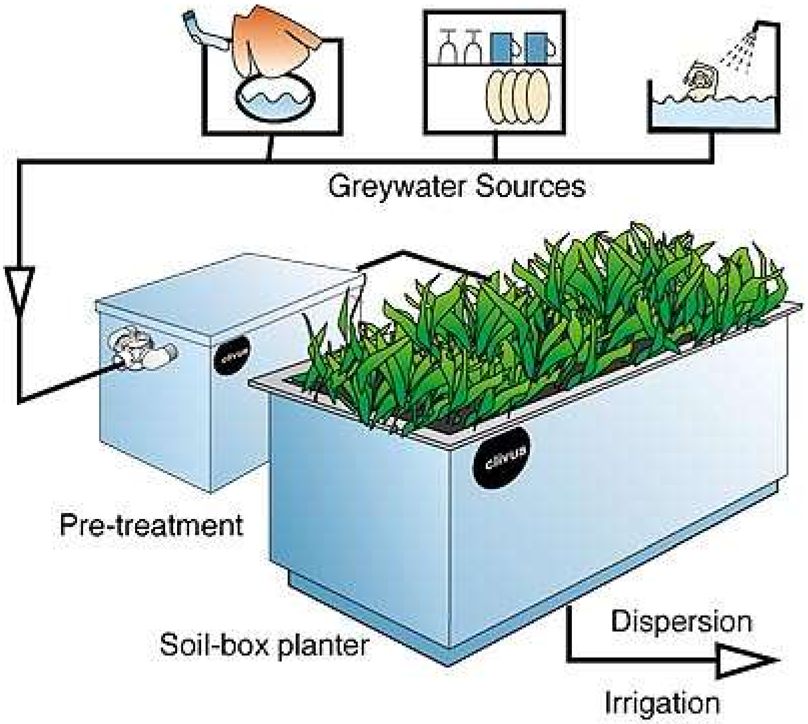
Generation Techniques Solar Lighting:- The system is provided with battery storage backup sufficient to operate the light for 10-11 hours daily. The system is provided with automatic ON/OFF time switch for dusk to down operation and overcharge / deep discharge prevention cut-off with LED indicators. The solar street light system comprise of :-74 W Solar PV Module 12 V, 75 Ah Tubular plate battery with battery box Charge Controller cum inverter (20-35 kHz)11 Watt CFL Lamp with fixtures 4 meter mild steel lamp post above ground level with weather proof paint and mounting hardware. The SPV modules are reported to have a service life of 15-20 years. Tubular Batteries provided with the solar street lighting system require lower maintenance; have longer life and give better performance as compared to pasted plate batteries used earlier

Other Green Techniques in Electrical Field includes Energy Conservation in the appliances like Refrigerator, Oven, Air Conditioners etc.

Solar-Wind Hybrid:- Hybrid systems are usually a combination of photovoltaic with wind turbines and/or generators running on diesel or biofuels. Power generated by the PV array during the day is stored in the battery bank through an energy manager, which controls the complete system. Hybrid systems make optimal use of sunlight and wind speeds - the two main resources readily available in the South Asian sub-continent. When the solar resource is low during the monsoon, the wind is quite strong and vice versa. The resultant hybrid system thus offers an optimal solution at a substantially lower cost. It is ideal for electrification of remote villages in India.

2.9.5 Special Techniques:-

Grey water Management:- All household wastewater, except toilet waste, is called grey water. Grey water from washing dishes, showers, sinks and laundry comprises the largest part of residential wastewater. This water when Filtered and recycled can be used in the toilets, or for irrigation.



Afforestation:- This green technique includes planting of deciduous trees around /surrounding the building. This trees have special property that they shade there leaves in the winter and allow the sun's heat to enter inside the house. While during summer it has maximum leaves so that the building gets natural cooling.

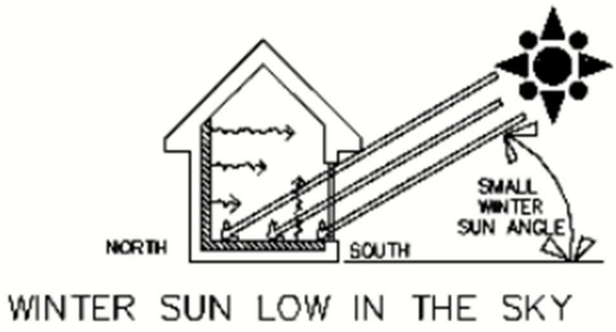
Rain water harvesting:- Rain water harvesting is a process of collecting the rain water that falls on terraces and roof tops during the monsoons and storing it in tanks, pits, trenches, bore wells, unused wells etc. or directing it so that it percolates into the ground water. Rain water harvesting includes:-

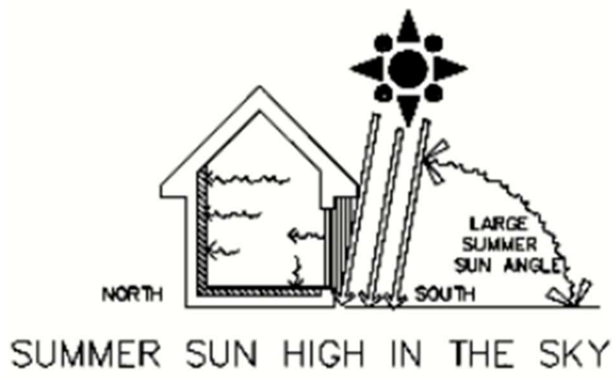
1. Collecting rain water.

2. Purifying it to an extent.

3. Directing it to subsoil spaces below the plot where it can be stored, by gravity or mechanical means.

Passive solar heating and cooling Passive design is design that does not require mechanical heating or cooling. Buildings that are passively designed take advantage of natural energy flows to maintain thermal comfort. Our building's windows, walls, and floors can be designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design. Unlike active solar heating systems, passive solar design doesn't involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move the solar heat. Passive solar buildings range from those heated almost entirely by the sun to those with south-facing windows that provide some fraction of the heating load. The difference between a passive solar home and a conventional home is design. The key is designing a passive solar building to best take advantage of your local climate. You can apply passive solar design techniques most easily when designing a new commercial building or home. However, existing buildings can be adapted or "retrofitted" to passively collect and store solar heat





Incorporating the principles of passive design in a building significantly improves comfort. ·Reduces or eliminates heating and cooling bills. ·Reduces greenhouse gas emissions from heating, cooling, mechanical Ventilation and lighting.

Prevention of soil erosion

The goal of this strategy is to reduce or eliminate runoff due to impervious (watertight) surfaces. Minimizing or eliminating impervious surfaces by designing driveways, walkways, and patios that allow storm water runoff to infiltrate into the ground minimizes the impact on aquatic systems. Un-compacted gravel, crushed stone and open or porous paving blocks can be used for Walkways and other light traffic areas.

What kind of paving is required depends on the porosity of the soil below the paving. Runoffs cause serious erosion problems. Wash water from vehicles could contain harmful elements which can damage water systems below the ground. A carefully designed paving system can filter off the damaging elements from such wash water and filter only good water into the ground water reserves below. While the filtering process happens, micro-organisms in the soil can digest oil s and greases and break into harmless gases.

2.10 Environment Friendly/Sustainable Building Materials

Material technology continues to advance, creating new and novel possibilities for the construction industry. Today, there is a growing variety of sustainable construction materials taking the place of traditional materials. Traditional sources of material range from lumber, brick and concrete to steel and glass, but that barely scratches the surface on all the materials utilized in a construction project.

Picking the right sustainable construction material for project depends in large part on location. For some, wood may not be so easy to source sustainably, so choosing other options such as concrete may be more cost efficient and sustainable.

The search for environmentally friendly building materials represents a response from the building sector intended to reduce the environmental cost of making and using buildings. Environmentally-friendly building materials may come from traditional sources, such as earth and stone materials, they may come from existing industrial processes, found by life-cycle-analysis to be the most environmentally benign, or they may come from new processes or raw material inputs such as industrial waste. Whatever their source, environmentally friendly materials are just one part of the necessary range of responses required to make buildings and cities that are more environmentally responsible. Many other factors such as operating energy efficiency, integrated design, reduction of water consumption and waste, reduction of private automobile use etc. are at least as important as environmentally-friendly materials alone. Furthermore, the way materials are selected and applied in a building is also a very significant component of resource efficiency. For example a floor system may be as complex as a framing layer, a structural sub floor layer, a flooring underlayment, an adhesive or fastening layer and a finish layer. Alternatively, a single material such as a reinforced concrete suspended slab may be finished with a colorant and sealer and serve all these functions. Some of the important efforts worldwide to mitigate the environmental impact of building materials that are as,

- Resource efficient materials; those that, by good engineering design, use less raw material or more environmentally benign raw material.
- Reused materials; those that recapture, by direct reuse, the value in materials being removed from use.
- Recycled content materials; those that are made from consumer waste or the waste stream of an industry.
- Advanced process materials: those that are made in a highly energy-efficient “closed system” that releases minimal waste.
- Healthy materials; those that avoid toxic substances in their manufacture and use, and do not release harmful agents into buildings.
- Traditional, pre-industrial materials; those materials such as earth and agricultural waste that are readily available with minimal processing.

At present the demand for a more sustainable way of building is no longer a matter of personal choice, and the sector has been now regulated for the purpose of implementing measures that improve the infrastructures´ and buildings´ environmental behaviour.

Buildings consume 20 – 50% of the physical resources

We are wrong to consider vehicles as the only polluting factors, as buildings consume 20 – 50% of the physical resources, according to their environment. The building trade is a great consumer of natural resources such as wood, minerals, water and energy. In addition, buildings, once built, continue to be a direct cause of pollution because of the emissions produced in them or their impact on the ground.

In building, environmentally-friendly materials (also known as green building materials) are those in which, for their production, placing and maintenance, actions of low environmental impact have been performed.

They have to be durable, reusable or recyclable, include recyclable materials in their composition and have to be from resources of the area where the building activity will take place –they have to be local materials.

These materials also have to be natural (soil, adobe, wood, cork, bamboo, straw, sawdust, etc.) and must not be spoilt by cold, heat or humidity.

Sustainable tech materials and products

They have to be highly durable and can incorporate different technologies, such as capturing energy, capturing C02 while removing pollution. They are used when, in the long term, they have a lower environmental cost than the natural materials.

Which are the sustainable materials most widely used for construction?

Timber is the material with the lowest environmental impact

Sustainable building materials: Timber is the material with the lowest environmental impact on its production and life cycle, and has to be certified so that we can be sure about its sustainable production and origin.

Isolation renewable materials: These are completely recyclable and compostable, such as cellulose, which can be derived from newspapers or paper that are discarded. They cannot generate wastes and must attain the highest efficiency when regulating the temperature.

Paints and wood treatments: These have to be natural with no substances harming the ozone layer and without solvents or any other chemical products.

Which recycled materials can be found?

Vegetal fibres mixed with cement work as insulators.

There is a reuse of wastes that are generated in other sectors for the production of building materials, such as quarry wastes (marble, slate, etc.). Also, we have wastes generated by industrial processes like ashes or mud that are used, or the urban solid ones.

There are other original techniques, such manufacturing concrete with recycled tyre rubber; using the mud from sewage plants for making bricks, or wood and cork remains (pruning, sawmills, sanding dust, etc.), and especially vegetal fibres (bamboo, coconut, etc.) that, once mixed with cement, also work as insulators.

WHY USE SUSTAINABLE CONSTRUCTION MATERIALS?

The environmental benefits to incorporating sustainable materials into construction projects are numerous:

- Reduces landfill waste
- Conserves virgin resources
- Promotes healthier indoor air quality; sustainable materials limits the use of toxic materials such as asbestos for insulation or chemically treated wood.
- Supports the local communities when sourced locally
- Cheaper transportation costs if bought locally.
- In some cases, it offers a cheaper alternative (e.g. straw, recycled plastics, etc.)

Conventional Eco-friendly materials

1. Bamboo, Bamboo Based Particle Board & Ply Board, Bamboo Matting
2. Bricks sun dried
3. Precast cement concrete blocks, lintels, slab. Structural and non-structural modular elements
4. Calcined Phosphogypsum Wall Panels
5. Calcium silicate boards and Tiles
6. Cellular Lightweight Concrete Blocks
7. Cement Paint
8. Clay roofing tiles
9. Water, polyurethane and acrylic based chemical admixtures for corrosion removal, rust prevention, water proofing
10. Epoxy Resin System, Flooring, sealants, adhesives and admixtures
11. Ferro-cement boards for door and window shutters
12. Ferro-cement Roofing Channels
13. Fly-ash Sand Lime Bricks and Paver Blocks
14. Gypsum Board, Tiles, Plaster, Blocks, gypsum plaster fibre jute/sisal and glass fibre composites
15. Laminated Wood Plastic Components
16. Marble Mosaic Tiles
17. MDF Boards and Mouldings
18. Micro Concrete Roofing Tiles
19. Particle Boards
20. Polymerised waterproof compound
21. Portland Pozzolana Cement Fly-ash / Calcined Clay Based
22. Portland Slag Cement

23. RCC Door Frames
24. Ready Mix Cement Concrete
25. Rubber Wood Finger Joint Board
26. Stone dust
27. Waterproof compound, adhesive, Polymer, Powder

Potential Eco-friendly materials & techniques

1. Bagasse Board - BMTPC
2. Bricks from Coal Washery Rejects -CBRI, Roorkee
3. Building Blocks From Mine Waste - SERC
4. Burnt Clay FlyAsh Bricks - CBRI, Roorkee
5. Coir Cement Board - CBRI, Roorkee
6. Compressed Earth Blocks - BMTPC
7. EPS Composites and Door Shutters -CBRI, Roorkee
8. Fibre Fly Ash Cement Boards -BMTPC
9. Fibre Reinforced Concrete Precast Elements, Wall panels, Blocks, Manhole Covers - SERC
10. Fibrous Gypsum Plaster Boards - CBRI, Roorkee
11. Fly Ash Cellular Concrete, Fly Ash Cement Brick, Blocks - BMTPC
12. Fly Ash Lime Cellular Concrete - CBRI, Roorkee
13. Flyash Lime Gypsum Brick - BMTPC
14. Insulating Bricks from Rice Husk Ash- Central Glass and Ceramic Research Institute, Kolkata
15. Jute Fibre Polyester -BMTPC
16. Non Erodible Mud Plaster - CBRI, Roorkee
17. Polytiles - CBRI, Roorkee
18. Timber from trees such as Poplar, Rubber, Eucalyptus - BMTPC
19. Precast walling roofing components - CBRI, Roorkee
20. Prefab Brick Panel System - CBRI, Roorkee

2.10.1 Recommended eco-friendly alternatives

1. Structural System – Alternatives to Cement Concrete (plain / reinforced) - cement, sand, aggregate, steel Base Materials for R.C.C. and Steel Systems a. Pozzolana Material content (Fly-ash / Slag / Calcinated Clay) attained through use of Blended Portland Cement (BPC) and /or direct addition of pozzolana material b. Sand and aggregate from pulverized debris and /or sintered fly-ash for concrete and mortar c. Recycled steel forms and reinforcement bars Alternatives Systems a. Ferro cement and b. Pre-cast components for columns, beams, slabs, lofts, balconies, roofs etc. c. Ready Mix Concrete d. Use Resinous curing agents

2. Masonry Alternatives to Fired clay bricks, cement concrete blocks, stone a. Use of Fly ash + sand + lime bricks / blocks b. Pulverized debris + cement bricks / blocks, c. Industrial waste based bricks / blocks, d. Aerated lightweight BPC concrete blocks, e. Phospho-Gypsum based blocks f. Lato blocks (laterite + cement)

3. Mortar a. Sand from pulverized debris and / or sintered flyash b. Pozzolana Material content

4. Plastering – Alternatives to Cement, sand, plaster of paris, gypsum a. Calcium Silicate Plaster b. Cement Plaster c. Use of Fiber reinforced clay plaster d. Phospho-Gypsum Plaster e. Non-erodable Mud Plaster f. Use Resinous curing agents

5. Roofing and ceiling- Alternatives to Ferrous / non-ferrous sheets, tiles, thatch a. Fibre Reinforced Polymer Plastics instead of PVC and Foam PVC, Polycarbonates, acrylics & plastics b. Micro Concrete Roofing Tiles c. Bamboo Matt Corrugated Roofing Sheets

6. Flooring, paving and road work –Alternatives to wood, stone, ceramics, concrete a. Fly ash / industrial waste / pulverized debris blocks in BPC b. Lime-pozzolana concrete paving blocks for all outdoor paving. c. Bedding sand from pulverized debris

7. Tiles for interiors a. Terrazzo floor for terraces and semi covered areas b. Ceramic tiles (non-vitrified) c. Mosaic Tiles/ Terrazzo Flooring d. Cement Tiles e. Phospho-Gypsum Tiles f. Bamboo Board Flooring

8. Windows, Doors and openings – Steel, aluminum, timber, glass, R.C.C., PVC, Stone a. Ferro cement and Pre-cast R.C.C. lintel, chajja and jalis b. Masonry bond combinations for jali work Alternatives to Timber and Aluminum / Steel frames a. Ferrocement b. Pre-cast R.C.C. Frames/ Frameless Doors c. Bamboo Reinforced Concrete Frames d. Hollow recycled steel channels and recycled Aluminium Channels and Components Shutters and Panels – alternatives to timber, plywood, glass, aluminum a. Red Mud based Composite door shutters, b. Laminated Hollow Composite Shutters c. Other wood alternatives

9. Electrical Alternatives for Aluminum, brass, PVC, G.I., S.S. a. Use unplasticised PVC or HDPE products b. Where applicable use products with recycled aluminum and brass components

10. Water supply, Sanitary and Plumbing System a. R.C.C., uPVC, G.I., C.I. pipes instead of lead, A.C. pipes b. Where applicable use products with recycled aluminum and brass components for fittings, fixtures and accessories c. Use Polymer Plastic (Random) hot / cold water system instead of G.I. d. Manholes and covers - use Pre-cast cement concrete and high strength unplasticised PVC instead of C.I.

11. Wood Renewable timber from plantations with species having not more than 10 year cycle or timber from a government certified forest / plantation or timber from salvaged wood Plywood should be phenol bonded and not urea bonded Use of MDF Board Instead of Plywood: Bamboo Ply/Mat Board/ Fibre Reinforced Polymer Board,/ Bagasse Board /Coir Composite Board /Bamboo mat Veneer Composite/ Finger Jointed Plantation Timber Board / Recycled Laminated Tube Board / Aluminium-Foil+Paper+Plastic Composite Board. e. Use of Mica Laminates and Veneer on Composite boards instead of natural timber.

12. Water proofing chemicals, additives, sealants and adhesives a. Use of water based chemicals instead of solvent based. b. Epoxy resins instead of tar felt / pitch 13. Painting, Polishing, Priming and similar surface finishing a. Use of Cement Paint / Epoxy Resin Paint for external surfaces b. Use of Water based paints, enamels, primers and polishes Faswal is a great alternative to traditional foundation materials. It uses waste materials from wood mixed with cement to create a strong and durable foundation material. Faswal can be used instead of cinder blocks and is excellent for bottom foundation and wall construction. It is naturally strong, fire and wind and sound resistant, and has excellent insulating factors. Two great choices for insulation are straw bale and cotton. Straw bale is used for many reasons; it is generally less expensive than other forms of insulation and has great insulating factors. It is very durable and can easily support a lot of weight; additional supports are not usually needed, which cuts down on the use of treated lumber Cotton insulation is a good alternative to fiber glass insulation. This type of insulation is derived from natural cotton fibers that are recycled into insulation. It is very convenient and comes in a similar batting shape as traditional insulation. It is also very easy and safe to install and has a high fire rating and wonderful sound insulating qualities. Earth plaster and milk paints are excellent eco-friendly choices for building materials. Earth plaster is made out of mud and can be used as an interior or exterior finish. You can manipulate the plaster to create various finishes; including curves, angles, and clean finished walls. It does not need to be painted, as it comes in a variety of colors that are natural to the mud. Milk paints are made up of milk earth and pigments from the earth in a variety of colors. Milk paints provide for a wide variety of colors without the use of harsh chemicals that are found in traditional house paints. There are some great choices for eco-friendly flooring; cork flooring, bamboo, and recycled wood flooring are all excellent options. Cork flooring is a great alternative to wood; it is environmentally friendly; it only uses the bark from the tree and does not kill the tree as a result from harvest. The bark is a great renewable resource as it grows back completely within nine years. Cork flooring is very comfortable, durable, and insulating, and can last for many years. Bamboo is another great choice for a renewable resource. Bamboo is not a wood at all, but rather a grass that only takes three years to fully mature. When processed, bamboo can have an attractive appearance similar to wood flooring. It is a very strong and durable type of flooring and performs very much like a traditional hardwood floor. If you are determined to have wood floors, recycled wood flooring is a great option. This type of flooring often uses hardwood that would otherwise never be used again. The wood may be taken from demolition sites or trees that were torn down but never used. It is often cheaper to prepare recycled wood instead of new wood product and is just as beautiful and durable as new wood. There are even materials for countertops that are eco-friendly. Two great choices are recycled glass/cast concrete and recycled plastic. Recycled glass/cast concrete uses both recycled glass and concrete with recycled materials in it. The glass used in this material can not be broken down any further, so it is a good fit for countertop construction. It can also be used in the bathroom and surrounding fireplaces. Recycled plastic is another good option for countertops. You can obtain many different styles using different types of recycled plastic. It can also be used in bathrooms and other places around the home. It is very durable and can stand up to heat, depending on how it is manufactured, and is very water resistant. There are many different eco-friendly building materials available on the market today. You can virtually build and furnish an entire home from only eco-friendly materials. Eco-friendly materials are not only good for the Earth, but are equally good for your wallet. Many of the building materials that are eco-friendly have great insulating factors or are cheaper to produce than traditional materials.

3. DESKTOP STUDIES

-THE CAMBRIDGE MOSQUE

The Cambridge Central Mosque is Europe's first eco-friendly mosque and the first purpose-built mosque within the city of Cambridge, England. Its mandate is to meet the needs of the Muslim community in the UK and beyond by facilitating good practice in faith, community development, social cohesion & interfaith dialogue. The Cambridge Central Mosque was opened to the public on 24 April 2019.

Religion	
Affiliation	Islam
Region	Romsey, Mill Road
Status	Active
Location	
Location	Cambridge, United Kingdom
Geographic coordinates	52.197°N 0.152°E : 52.197°N 0.152°E
Architecture	
Architect(s)	Marks Barfield
Type	Mosque
Style	Eco-technology design
Completed	Q1 2019
Construction cost	£23 million (194 Crore INR)
Specifications	
Capacity	1,000
Dome(s)	1
Minaret(s)	0
Materials	Timber, bricks and tiles

After the £4m purchase of a one-acre site in 2009 on Mill Road, Marks Barfield Architects was appointed to design the new mosque in association with Professor Keith Critchlow, a world leading expert in sacred architecture and Islamic geometry along with the UK's leading Islamic garden designer Emma Clark.[6] Marks Barfield Architects are known for innovative designs such as the London Eye and Kew Gardens Treetop Walk, to name a few. Plans for the mosque were submitted to the Cambridge City Council by the MAT and it was approved by the council in 2012. The project however was controversial and it was met with objections.

With its emphasis on sustainability and high reliance on green energy, the mosque is Europe's first eco-mosque. In addition to the mosque's dedicated areas (ablution, teaching, children's area, morgue), there is a café, teaching area and meeting rooms for use by the local Muslim and non-Muslim communities. It can accommodate up to 1000 worshippers.

The mosque sits back from Mill Road, in a traditionally working-class neighbourhood of the city, far from the mellow stone colleges to the north-west. Around are tightly packed grey-yellow gault-brick terraces and a few light industrial sites.

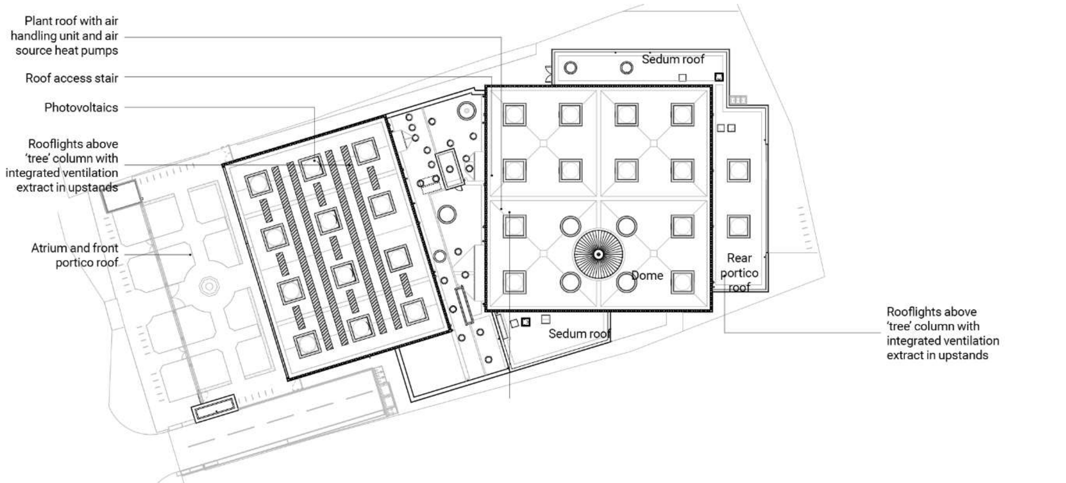
The deep site extends northwards back from the roughly east-west orientation of the street. Marks Barfield has used this depth to create a series of threshold spaces, working back from the main south entrance. These begin with a community garden lying alongside the pavement, beyond which railings enclose a more formal Islamic garden, on to which opens the lofty entrance loggia to the mosque. Beyond this, a glazed wall fronts a square-set atrium, behind which, past a lobby, sits much the largest space: the prayer hall of the mosque, also square in footprint, but twisted on plan so as to be orientated on its eastern side to face Mecca.

The Islamic garden is divided into quarters, with four paths meeting at a central fountain. The layout and water both reference Paradise in Islamic tradition, as does its planting with fruit trees – crab apples here replacing the quinces usually found in Middle Eastern Islamic gardens. The garden is open to the public during the day as a place of contemplation and rest, but after Eid prayers it is packed, full of people chatting and kids running up and down the paths.

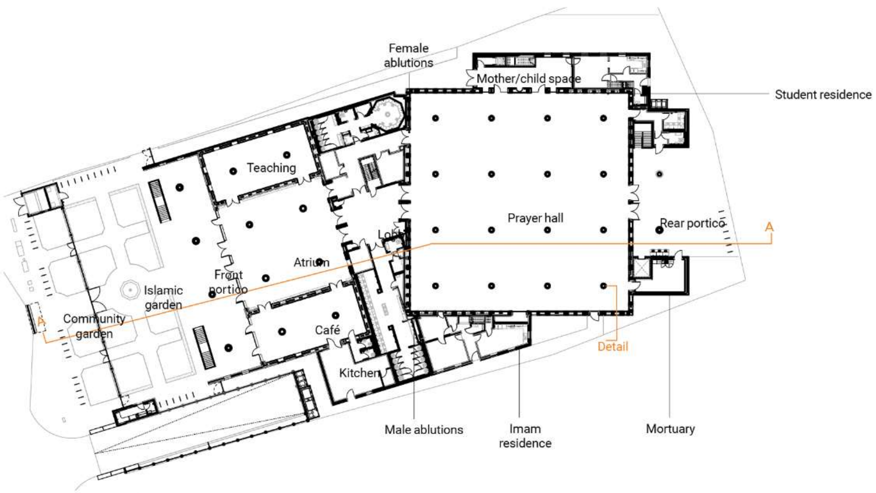
While the clear intention for the mosque to be a piece of contemporary architecture, there was also the requirement for it to be 'sacred' architecture, a less definable concept but one that, as the competition brief rather cryptically attempted to describe, 'may require a totally different appreciation from that of modern architecture, one that is not necessarily centred on architecture as the work of the individual, but … on the architect's particular expression of a universal principle'. It was, perhaps, a caution against starchitect posturing.

It was important, too, that the design should 'reflect the local culture' without resorting to pastiche. This complex brief – to combine the transcendent with the contextual – was something that clearly fired up Marks Barfield, which won the competition in 2009. As it late co-founder David Marks said in 2013: 'The opportunity to do something English, something British, excited us. Now that there is a significant Muslim community in the UK, it's time to work out what it means to have an English mosque.'

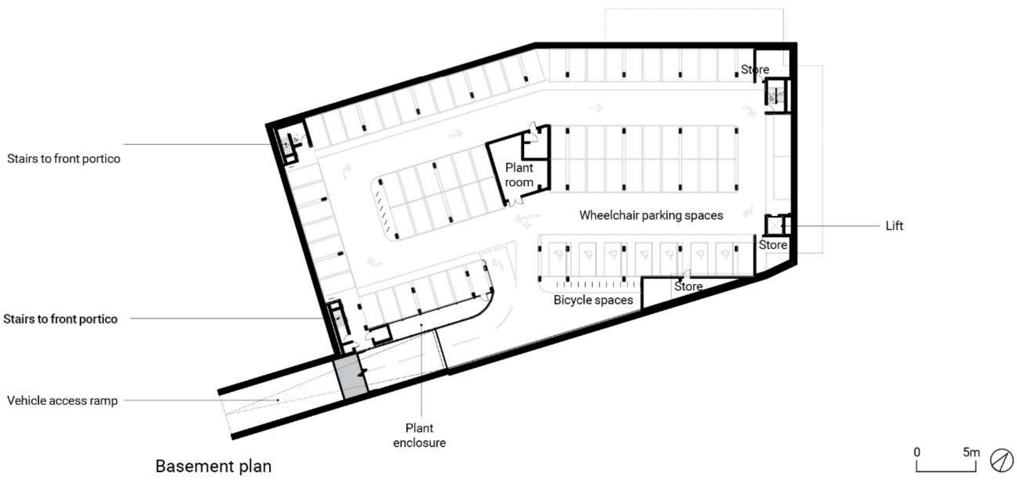
Plans



Roof plan

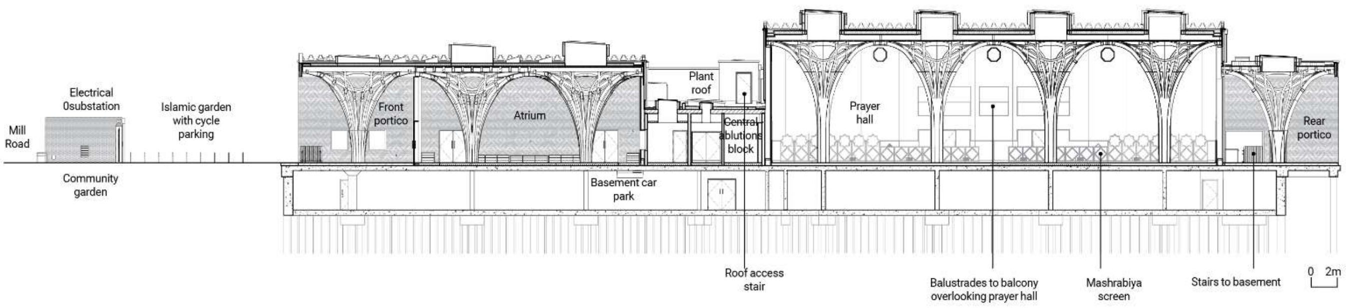


Ground floor plan

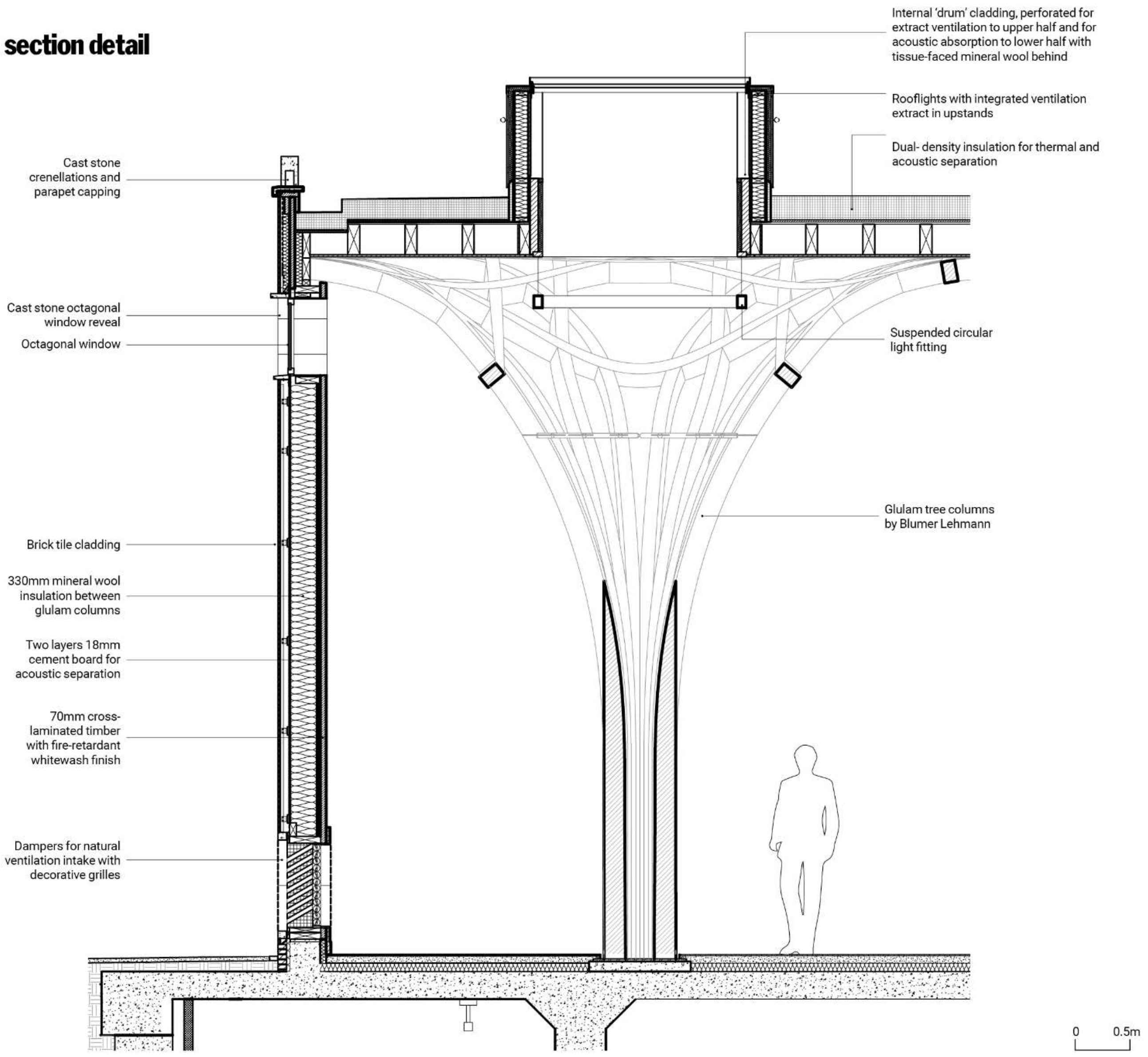


Basement plan

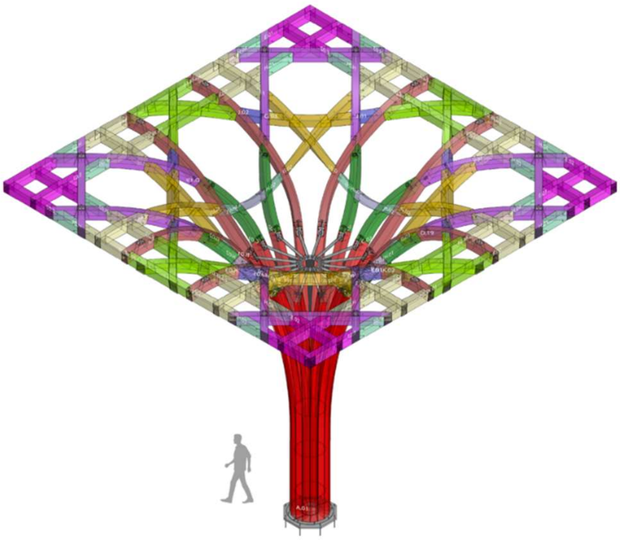
Section A-A



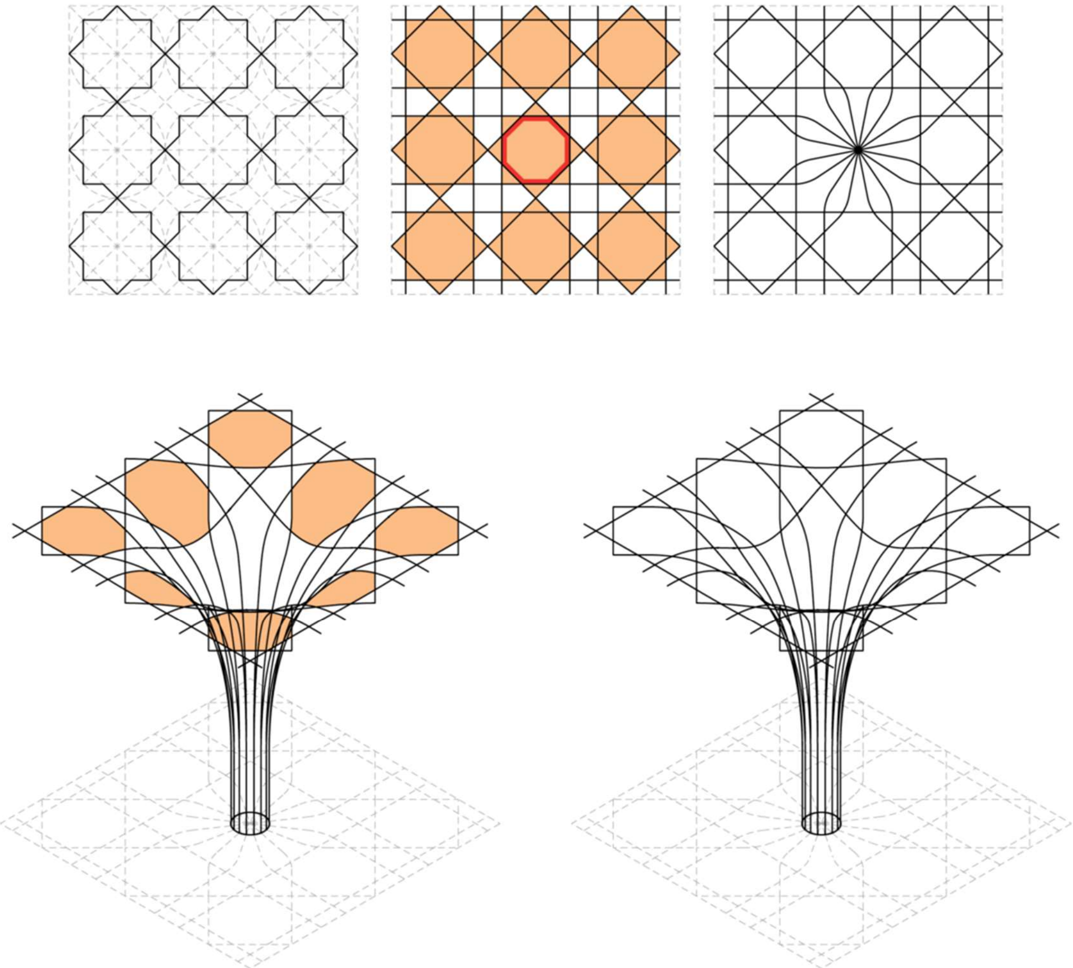
Wall section detail



Tree perspective diagram



The compassionate pattern



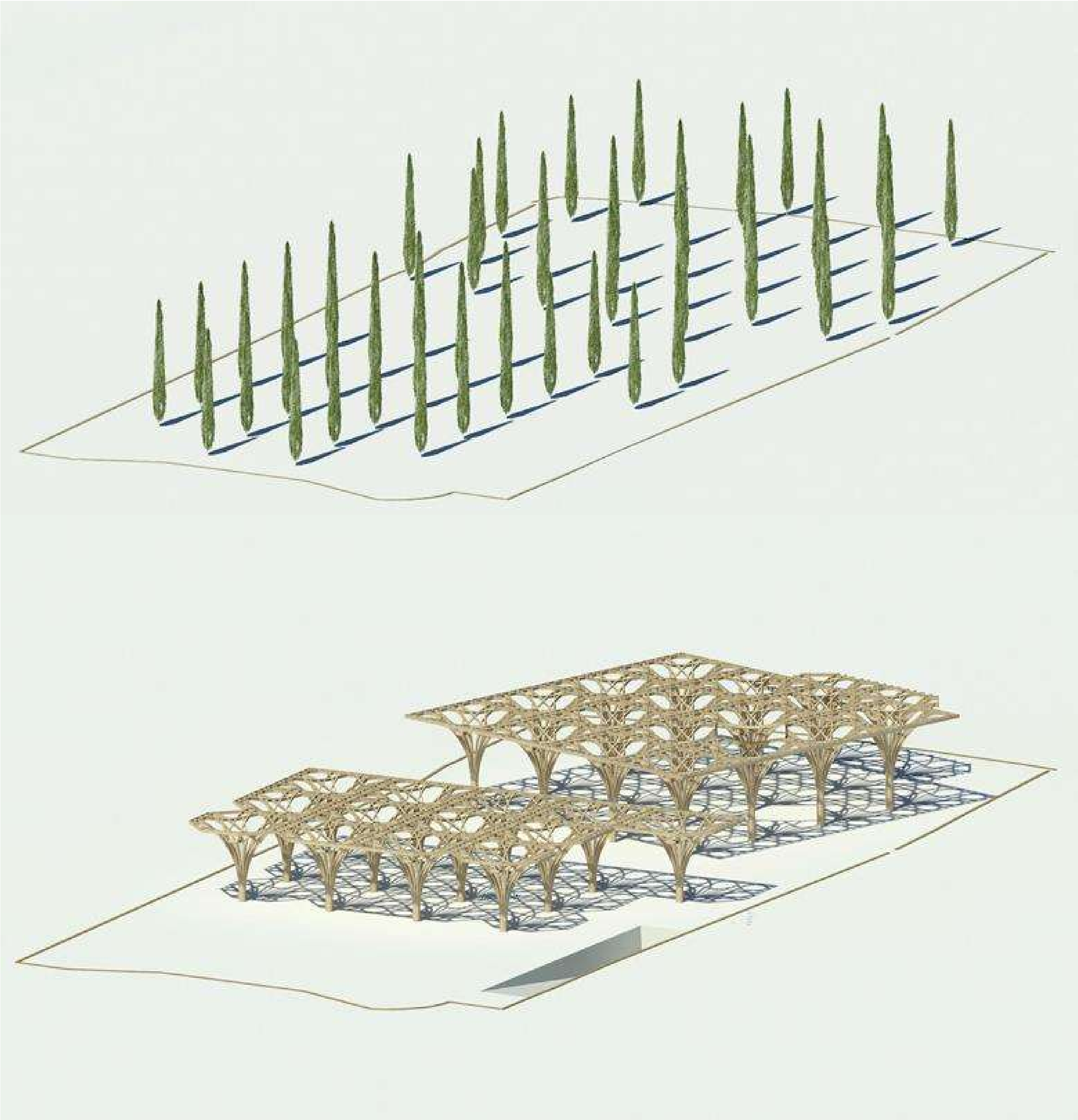
The use of timber throughout underlines the project's overall ambition to be as carbon-neutral as possible – both in its fabric and operation. The mosque is designed to be naturally lit throughout the day and naturally ventilated, even at peak occupancy, while using a combination of green technologies, including rainwater harvesting, air source heat pumps and photovoltaics to minimise its carbon footprint. The only element that undercuts this somewhat is the concrete basement car park – a feature that sits oddly with the green intentions elsewhere.

The columns are remarkably successful, bringing a grand, celebratory yet warm and welcoming sense to the internal spaces

Functionally, the building has a sophisticated simplicity to its plan – almost Beaux Arts in its geometries of primary spaces arranged with adjacencies to more secondary service rooms, which occupy poché-type spaces between. Thus the four-square entrance atrium is flanked by two supplementary spaces: one intended as a flexible teaching area – for anything from religious study to yoga; the other as a café-cum-event space, its kitchen still under commission. All three can also be combined to host events such as weddings or indeed the celebratory meal that had just occurred there as 500 people broke fast at the end of Ramadan.

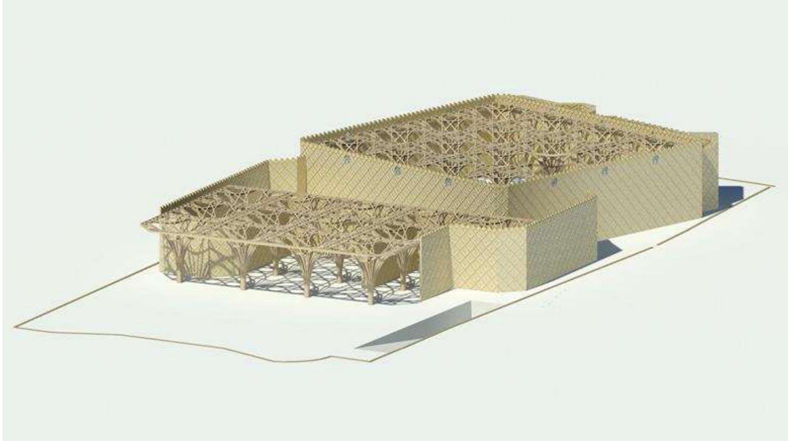
To the north side of the atrium is the lobby leading to the prayer hall, off which to the right are male toilets and a washroom for ritual ablutions and to the left, the same for women, who then pass through this to access a separate women's door into the prayer hall. Within the hall, a Mashrabiya screen separates the women's area from the men's, although its staggered height allows for different levels of visibility and separation for individuals and it also has a break in the middle. At the back of this, a glazed room creates a relatively soundproofed but connected environment for mothers with small children, while above this, a gallery space allows for further separation for some women from the main body of the prayer hall as required by certain traditions. These spaces are indicative of the thickness of the flank walls to the prayer hall, which also contains an adjacent duplex flat for visiting scholars and students, and on the eastern side another duplex for the imam.

The roof concept was derived from an oasis of trees which were developed into columns and branches



The roof support structure required a high degree of organisation. The architects created a detailed 3D parametric model. then worked with digitalisation experts from Design-to-Production (D2P) and engineers from SJB Kempter Fitze to create the complete digitalised prefabrication and assembly model.

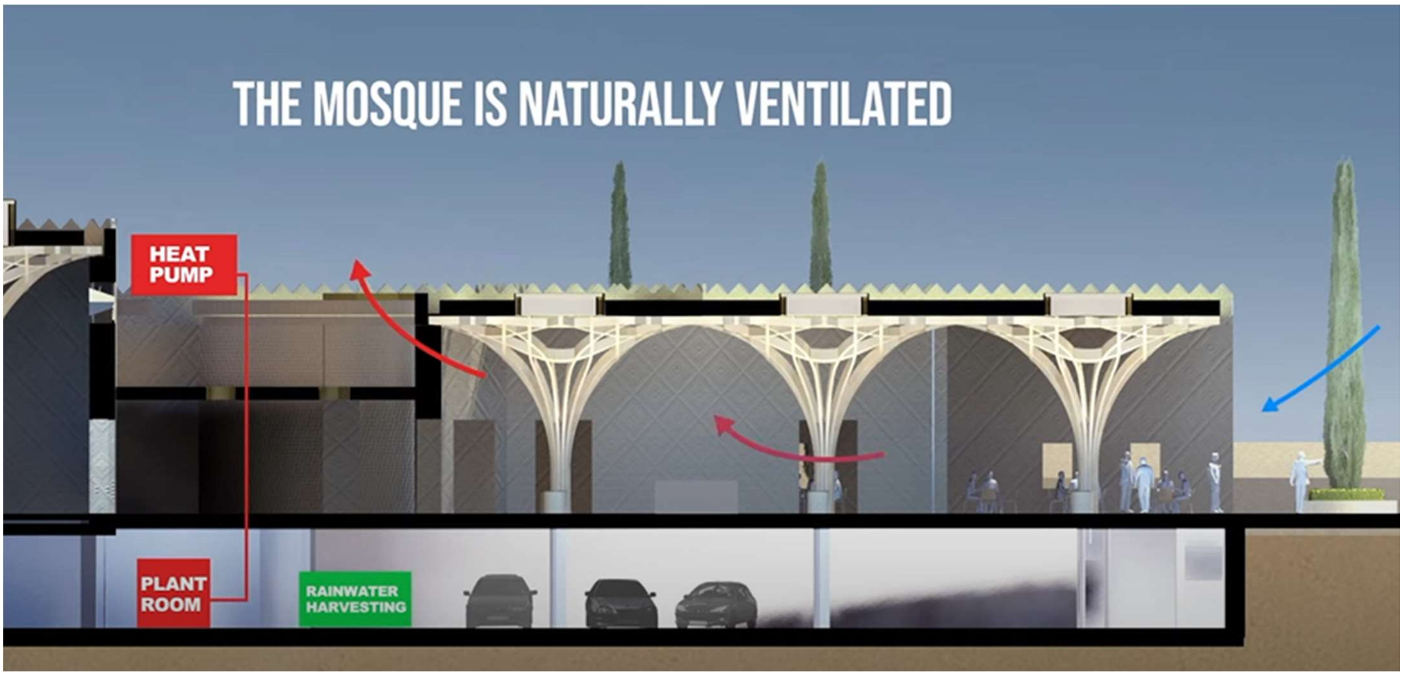
Reduced 2,746 segments down to 145 different component types based on just 23 different types of laminated timber blanks. These blanks, some of which are straight and some of which have single- and double-curved source elements, were all processed with 5-axis milling. The approach required a meticulous production strategy and further development of the software. The joints between the segments in the complex support structure also required painstaking planning.

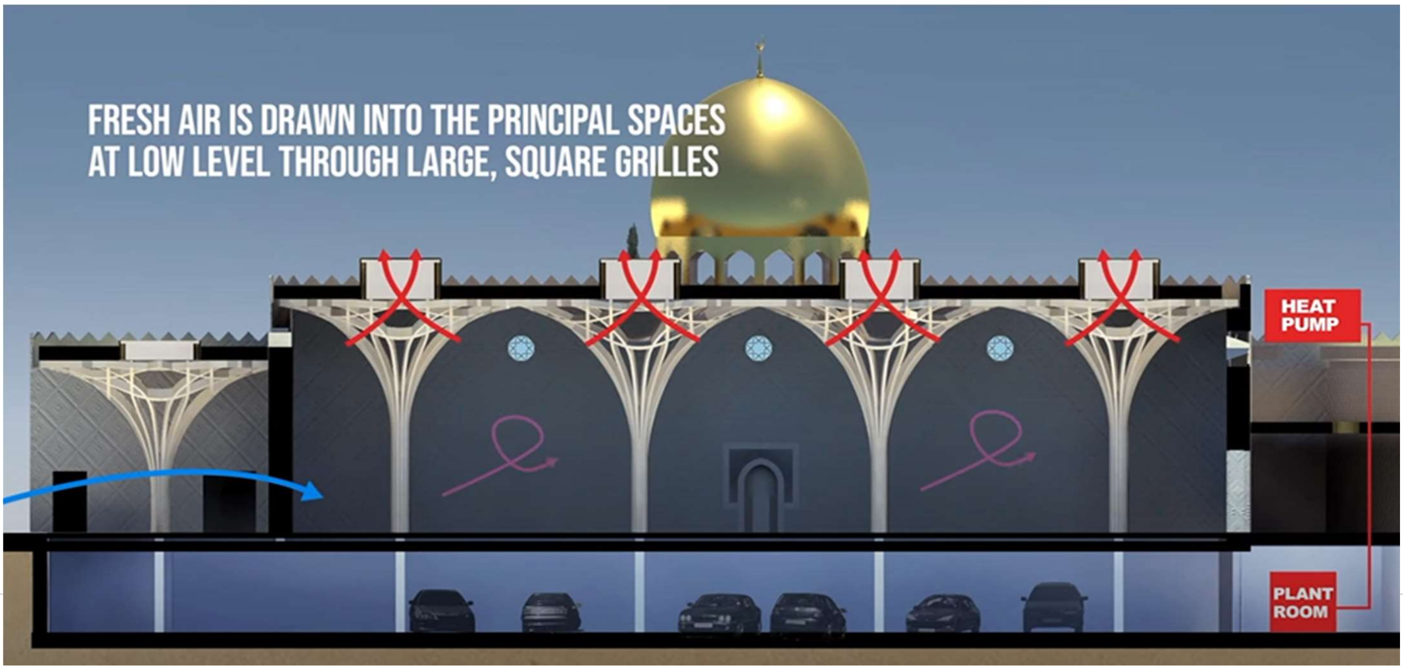


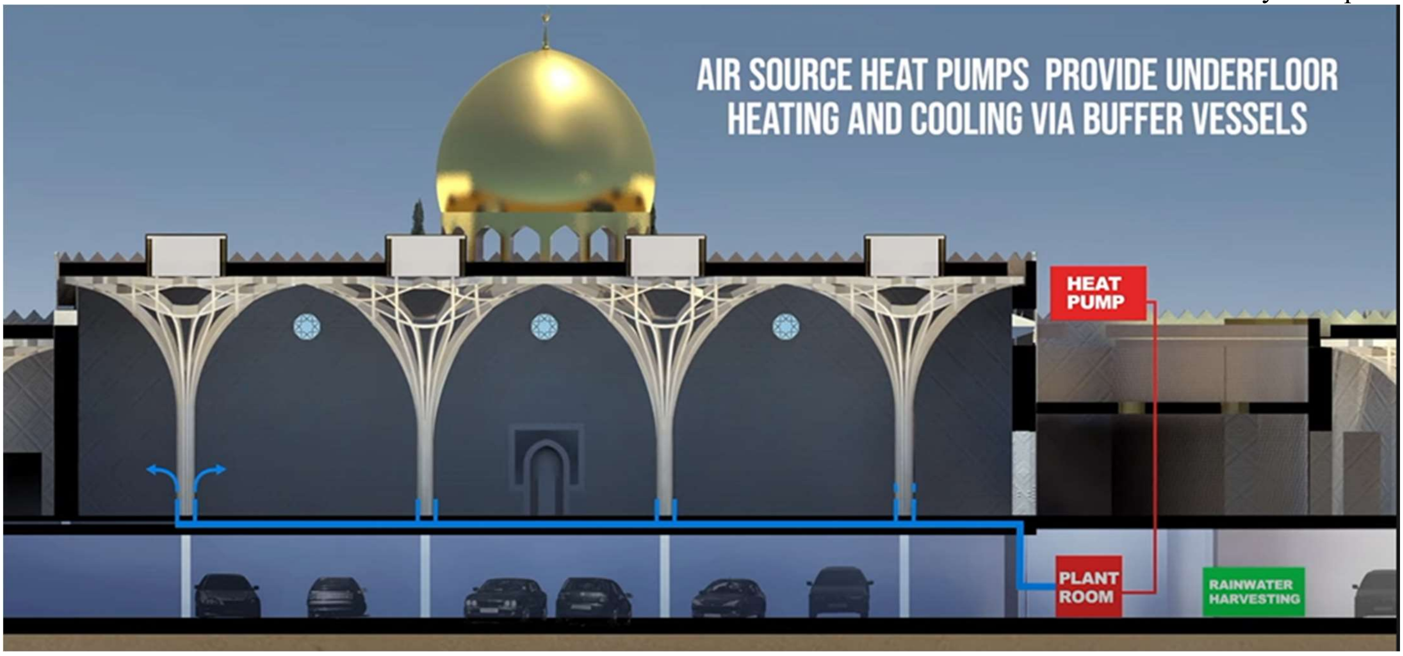
Slotted plates and Idefix connectors, among others, were used for the cross-grained joints in the lengthwise direction of the beams. Lateral butt joints were lap-jointed and screwed together, but not glued. With the curved areas in particular, the insertion of the halving joints had to be simulated in advance to validate the geometry of the assembly sequence.

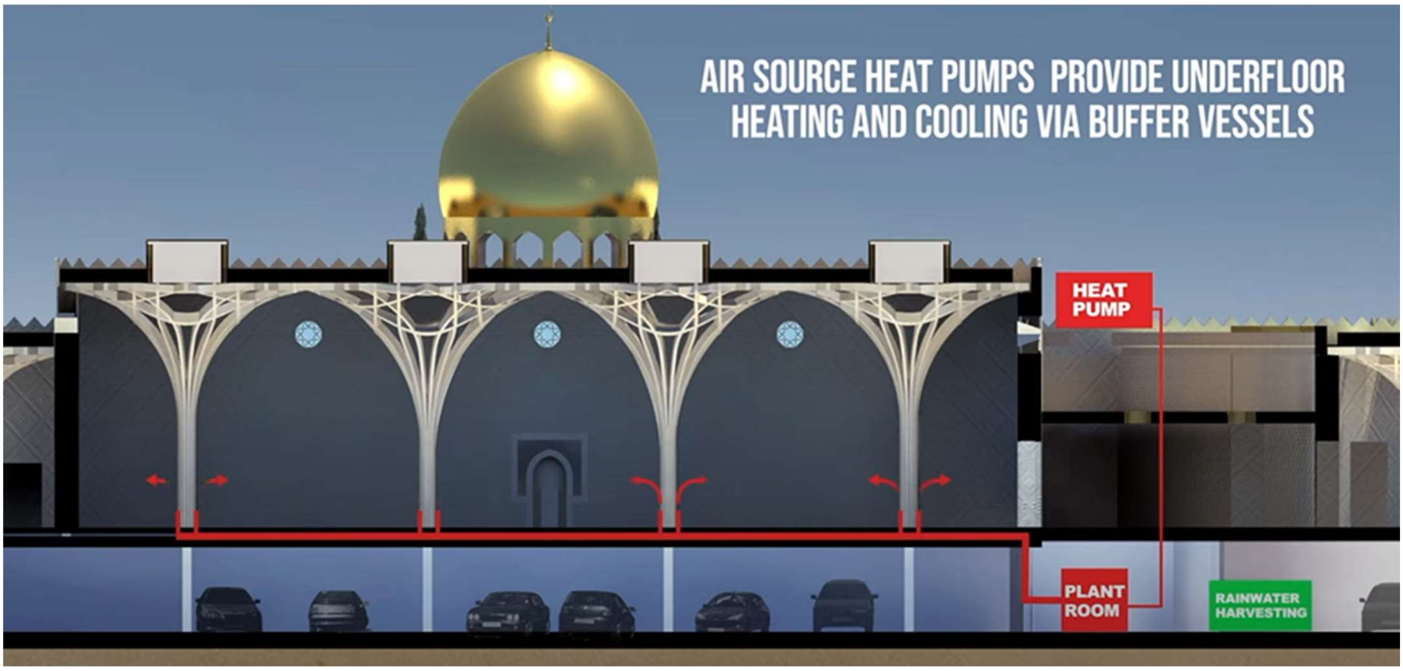
A total of 80 lorry loads carrying nearly 3,800 components made the 1,100km journey to Cambridge from factory in Switzerland. This required careful planning, including the assignment, labelling and sequence of all parts. Each part had to arrive at the construction site at exactly the right moment for the assembly to go to plan.

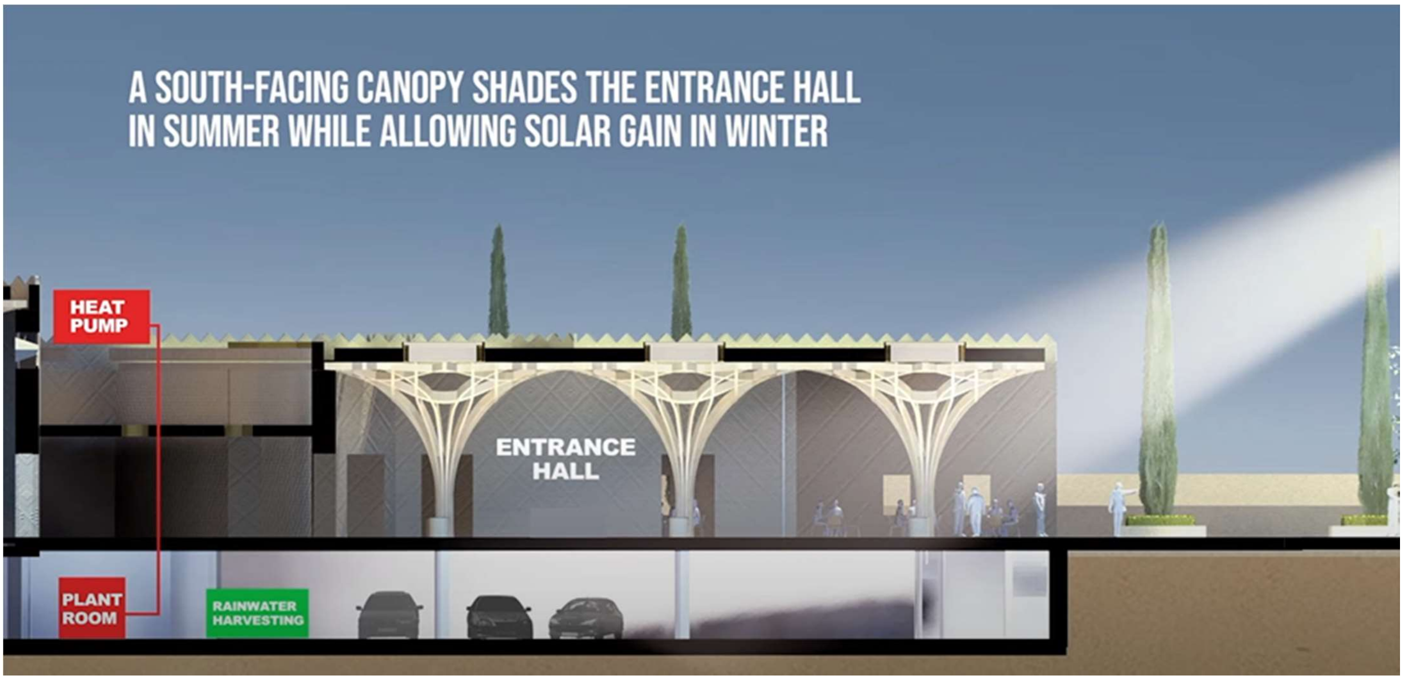

THE SUSTAINABLE DESIGN AT
CAMBRIDGE CENTRAL MOSQUE
HEAT PUMP
PLANT ROOM


THE MOSQUE IS NATURALLY VENTILATED
HEAT PUMP
PLANT ROOM
RAINWATER HARVESTING


FRESH AIR IS DRAWN INTO THE PRINCIPAL SPACES
AT LOW LEVEL THROUGH LARGE, SQUARE GRILLES
HEAT PUMP
PLANT ROOM


AIR SOURCE HEAT PUMPS PROVIDE UNDERFLOOR HEATING AND COOLING VIA BUFFER VESSELS
HEAT PUMP
PLANT ROOM
RAINWATER HARVESTING


AIR SOURCE HEAT PUMPS PROVIDE UNDERFLOOR HEATING AND COOLING VIA BUFFER VESSELS
HEAT PUMP
PLANT ROOM
RAINWATER HARVESTING


A SOUTH-FACING CANOPY SHADES THE ENTRANCE HALL IN SUMMER WHILE ALLOWING SOLAR GAIN IN WINTER
HEAT PUMP
ENTRANCE HALL
PLANT ROOM
RAINWATER HARVESTING

Structure: The laminated timber ‘forest’ of roof supports, the largest structure of this kind in the UK, was made in Switzerland and assembled on-site, as was the mosque’s onion-style dome.

Insulation and air tightness: Insulation & air tightness is better than part L of the building regulations. Its EPC is A - very close to being a zero-carbon building.

Heating, ventilation and shading: Air source heat pumps in the basement heat water for underfloor heating, with sophisticated controls so only the occupied zones are heated. The heat pumps can also provide cooling in the summer. Energy use will be minimised by using mixed mode systems – static heating and natural ventilation, supplemented by displacement cool air supply at times of high occupancy or high heat gains. The main entrance foyer is arranged for maximum passive solar heat gain from the low sun in the winter months. Conversely there are external canopies to shade the building and reduce solar heat gains in the summer months.

Lighting: The mosque is designed so that no artificial lighting will be necessary during daylight hours. At other times natural light will be supplemented by low energy LED lighting. Roof lights have been specially designed to maximise daylight in all key areas but prevent direct sunlight reaching the space.

Water conservation: Rainwater harvested from the roof will be used in low flush W.C.s and for irrigation for the grounds and landscaping.

Electricity: A 115m2 solar PV array will help offset the electricity used to power the heat pump, reducing the overall carbon emissions by an estimated 10%. The building's low initial carbon footprint will improve over time as mains electricity production from renewable sources increases.

Bikes, gardens: The Mosque has ample space for bikes, along with underground parking for 82 cars, with charge points. Upon entering the mosque, visitors walk through a permeable green edge created by an enlargement of an existing community garden. This provides a cooling microclimate, including a fountain, providing shade, evaporative cooling and cleansing before the air enters the building. The external walls have tile cladding, echoing Cambridge bricks, while incorporating Islamic calligraphy. Maximum height is 3 storeys to be in keeping with the surroundings. With its emphasis on sustainability and reliance on green energy, the Cambridge Mosque is Europe's first eco-mosque and a true landmark building for the city of Cambridge and its residents.

Key features

1. • Timber frame structure
2. • Insulation & air tightness
3. • Air source heat pumps for heating & cooling
4. • Building energy management system
5. • 115m2 rooftop solar PV array
6. • Good daylight plus LED lighting
7. • EPC A rating: close to zero carbon
8. • Natural evaporative cooling

9. • Natural & controlled ventilation with heat recovery
10. • Shading & overhangs
11. • Materials chosen for durability and long life
12. • Microclimate control and gardens
13. • Off-site construction reduces waste

Architect's view

We researched the architecture of mosques and observed that, for centuries and throughout the world, mosques have adapted to their local conditions – cultural, climatic and constructional – using the local vernacular. So we asked ourselves how should a British mosque be designed for the 21st century?

The idea emerged of a calm oasis within a grove of trees. We were inspired by elements from both Islamic and English sacred architecture, in particular English fan vaulting as seen in King's College chapel, together with sacred Islamic geometry. Worshippers and visitors take a journey from the street through an Islamic garden, to a covered portico and into an atrium, preparing them in a gradual transition from the mundane world towards the lofty prayer hall and an underlying spiritual reality – orientated towards Mecca.

The defining feature of Cambridge Mosque is its timber structure – timber being one of the most sustainable of all building materials. The timber columns, or 'trees', reach up to support the roof using an interlaced octagonal lattice vault structure. Rooflights above the trees create a prayer hall bathed in natural light. The external walls are made of cross-laminated timber, clad in brick tiles of the traditional Cambridge Gault and red brick colours. They form a pattern of Kufic calligraphy.

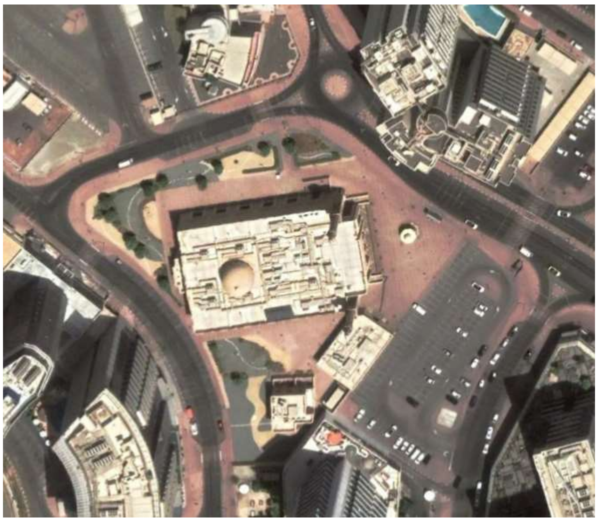
The mosque is intended to be nondenominational, inclusive, open and welcoming to the wider community – a meeting place and a cultural bridge where modernity and innovation meet timeless sacred principles. It also hopes to be one of the UK's leading women- friendly mosques.

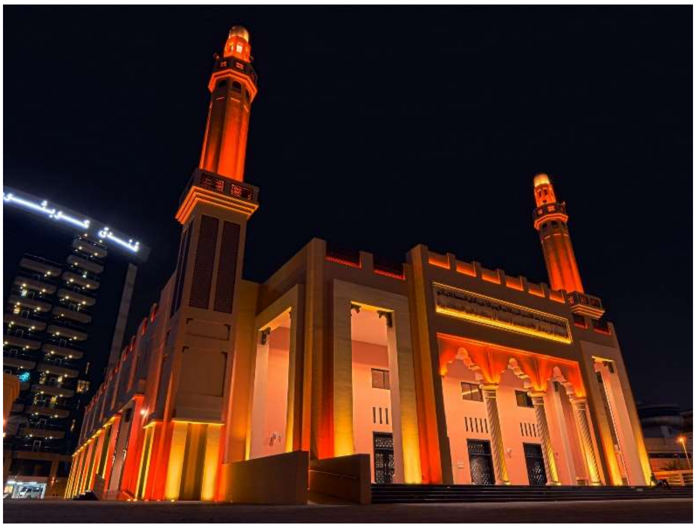
Performance data

Percentage of floor area with daylight factor >2% 95%
Percentage of floor area with daylight factor >5% 80%
On-site energy generation 15.9 mWh/yr / 8.2 tonnes CO_2
Heating and hot water load 36.2 mWh/yr / 18.7 tonnes CO_2
Total energy load Regulated + PV: 64.2 mWh/yr / 33.1 tonnes CO_2
Carbon emissions (all) 70.9 tonnes CO_2 including unregulated
Airtightness at 50pa 2.75 $m^3/hr/m^2$
Design life in years 60 years

DESKTOP STUDY- 2

KHALIFA AL TAJER MOSQUE, DUBAI.





MIDDLE-EAST's FIRST ECO-MOSQUE

Located in Deira, which boarders Dubai's waterfront, the Khalifa Al Tajer Mosque, otherwise known as the "green mosque," has opened its doors to worshippers. The mosque cost AED/SAR 20 million to build and spans over 4000 square-meters. It holds a capacity of 3,500 worshippers throughout the grand payer hall, daily prayer hall, and a woman's prayer hall. Powered by solar panels, the mosque utilizes thermal-insulation systems to mitigate energy consumption. It is also fitted with sensors that control air conditioning and energy-saving LED lights—all a first in the Islamic world.

Located on 105,000 square feet of land, the new green mosque was designed with energy efficiency in mind and was built with environmentally friendly materials.

The building which covers 45,000 square feet uses green building materials, thermal-insulation systems for lowering energy consumption and air conditioners that emit reduced greenhouse gases.

The mosque was built to meet guidelines set out by the US Green Building Council Standards and Specifications. The mosque integrates renewable energy solutions in its design.

This is illustrated in the exterior lighting poles that are fitted with solar panels, battery storage system that is powered by solar energy, and the use of solar panels instead of energy draining electric heaters for the purpose of water heating,

The exterior lighting poles of the mosque are fitted with solar panels, whilst the battery storage systems and water heaters are also powered by solar energy.

Energy-saving LED lights are used throughout the building, and are controlled by a sensor system that automatically switches them on or off as appropriate to conserve energy.

There is also a climate control system installed for regulating the air-conditioning units.

The mosque has awarded the LEED Silver Certificate for green buildings, and it's considered an environmental friendly building.

Generation of electricity from renewable energy resources:

Some applications were used to generate electricity from renewable energies in the mosque, as show in figure. Special columns are equipped by solar panels and special batteries were used to provide the mosque with the required electrical energy. Solar heaters were used on the roof of the mosque to heat the needed water for ablution . Energy- efficient lighting units (LED) are used in the mosque, as shown in figure , with an automatic lighting control system to control the required time for lighting which is during prayer times, to reduce energy consumption.

The use of Smart Systems:

Lighting sensors were used to use the minimum operating time of artificial light and to rely on the maximum amount of natural lighting throughout the mosque and accessories to reduce the consumption of electrical energy, with the use of special smart systems for air conditioning units to reduce the consumption. The use of these systems is saving 30% of the electricity consumption.

The use of solar energy to heat the water:

The mosque is equipped with solar heaters, which rely on solar energy to heat water instead of using electricity to reduce the electricity consumption.

High quality of thermal insulation works:

The thermal insulation works for the mosque are achieved with high quality for the walls and ceiling to reduce the thermal transmission from outdoor to indoor or vice versa, which reduces the burden on the air conditioning system, and also the openings are equipped with double glass with special treatment, to reduce thermal transmission through glass.

Air conditioning system that saves energy consumption:

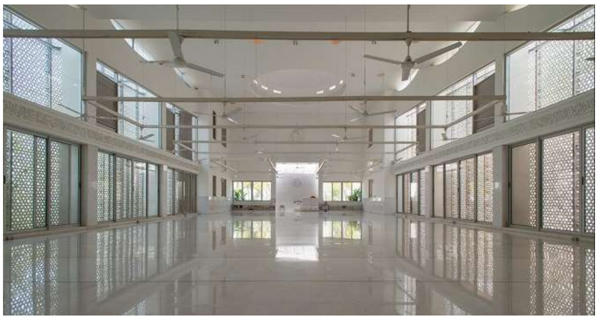
The mosque includes an advanced system for automatic control of cooling systems to save energy consumption. This system controls the cooling devices according to the need, according to prayer times, and according to the number of worshippers in order to save energy consumption. The air conditioning systems reduce the use of gases that negatively affect the ozone layer, as well as increasing the purification of internal air.

The use of recycled water to reducing of water consumption:

The water consumption in the mosque has been reduced during ablutions. Special water taps have been used to suit with the consumption of water which works to reduce the speed of water flow during ablution with providing only with the suitable amount of water, and also, some processes are doing to the ablution water after use like filtration, treatment and recycling processes to reuse the water in irrigation and in toilets flush systems, these methods reduced water consumption by 40%.

DESKTOP STUDY - 3

Badriya Juma Masjid, Karnataka.



Featuring sustainable technologies, the Badriya Jum´a Masjid in Kodi, Karnataka, represents an evolution in mosque architecture...

Kundapur Badriya Juma Masjid is located in Kodi, Udupi district, Karnataka, India. This mosque was constructed by Sayyed Muhammed Beary, owner of Beary Business Groups located in Bangalore, Karnataka. Located in 2 acres opposite to Arabian sea, this masjid is considered to be worlds first zero energy eco- friendly green mosque. The construction of this mosque designed by architects Manoj and Sandeep based in Bangalore was completed in January this year and after that it was opened to devotees. Moulana Sayyed Mohammed Rabey Hasani Nadvi, AIMPLB(All India Muslim Personal Law Board) president from UP inaugurated the masjid. Lets check the special features of Kundapur Badriya Juma Masjid.

Badriya Juma Masjid in Udupi has been awarded with Indian green building council 2016 platinum award. The building design is an evolution in mosque architecture that embodies sustainable technologies. Built in accordance with the most modern principles of eco-friendly construction.

Design and construction strategies: While the mosque had to be built on the same site where the old one existed, 100 per cent of demolition and construction waste was reused or recycled; iron grills and covers, RCC drain covers, curb stones, pedestals, etc, were manufactured from the waste. The next imperative was to cool the structure naturally, minimising the need for fans and investment in expensive renewable energy. Also, the project focused on largely using local construction materials, labour and contractors from the village itself, except for cement, marble and steel. This minimised transportation and accompanying CO_2 emissions.

Ideal orientation: The building is L-shaped, which, along with its green vegetation, enables a naturally cooled environment. It is mostly oriented along the east-west axis to minimise solar heat ingress. The L opening on the southern side improves ventilation from strong southwest winds. The mosque is open on three sides: East, north and south. The envelope consists of glass reinforced concrete (GRC) arabesque screens with more than 60 per cent openings. Thus, there is a non-conducting envelope and the openings boost air velocity and allow natural light. The mosque is painted white to reflect sunlight. The west side is a green wall covered with vines for shading and cooling. The prayer hall is raised from the ground level to improve natural air flow. The project has a lawn and low-level shrubs and plants have been planted around the building to cool the structure through evaporation. Trees with thick canopy such as coconut trees have been planted to cool the building without obstructing breeze. Also, natural elements have been used to cool the building and improve indoor and outdoor air quality, maximise natural ventilation and ensure optimum daylight. Further, the lattice tower structure of the windmill is mounted atop a 70-ft minaret. This increased height of the turbine has improved energy yield. The top of the minaret is open on the west and south sides and shaped to act as a wind scoop to provide a cool air draft to the prayer hall.

Eco-friendly materials: The west wall has been constructed with local lateritic bricks, which block solar heat ingress and endure even in an atmosphere with seawater moisture. Further, a number of water bodies have been created on the ground. These serve for wazu (ablution) as well as dissipate structural heat to the earth. Also, mosquito-repelling plants have been used around the building. The solar heat reflecting terrace floor has been laid with white china mosaic and fitted with turbo vents, which keeps the building cool and reduces warming of the local micro climate. The temperature reduction from atmospheric air temperature would be around 5-7oC; it is now further cooled by shallow water pools.

Efficient fixtures: The entire energy requirement for the mosque is met through renewable energy, both wind and solar, making it among the world's first´zero-energy´, eco-friendly, green mosque. The place receives strong winds from June to October but low solar insolence. From November to May, solar insolence is good but wind speeds are low. Therefore, a hybrid system with 60 per cent wind energy and 40 per cent solar energy has been installed. The project has fitted LED and T-5 light fittings and energy-efficient BEE-certified fans to minimise building power demand. Further, the mosque has utilised local resources on the principle of˝ Reduce-Reuse-Recycle-Regenerate´ and is equipped with´Pressmatic´ water fixtures such as low-flow taps and dual flow flush to conserve water.

Project details

Area: 2 acre; height: 45 ft;

built-up area: 16,686 sq ft

Cost: Rs.3.8 crore

Completion: January 2016; applied for IGBC certification in 2016

Contractor: Bearys Infrastructure & Construction Engineering...

INFERENCES

- The greenness, wind, hot, cold and light from our nature is very well utilized in the construction of this mosque.
- Built in L shape, with an aim to divert the wind blowing from sea into the mosque, this is an eco-friendly masjid that attracts lots of devotees from different parts of India.
- In order to lower the atmospheric temperature, a beautiful garden full of trees(including coconut and date trees) and plants is maintained around the masjid.

- The roof top of this masjid is constructed in a slanting position. White china tiles that will reflect sunlight are fixed on the roof top.
- This masjid is constructed in such a way to get proper air circulation.
- Other attractions include a 70 ft heigh minar. The construction of this minar is built in a good way so as to get good cold air from outside to the inner portions. Apart form this, there is a wind mill placed at the top of the minar for producing electricity from wind.
- The solar panels are placed in the terrace. About 6 kilowatt electricity is needed for this Juma Masjid built in 15,000 square feet. All lights are LED. The rest of the electricity produced by solar panels and windmills are given to Karnataka Electricity Board.
- About Rs 3.8 crore was spent for the construction of this mosque. Here the energy requirement is mainly met through hybrid renewable energy that is mainly in the form of solar and wind.
- In addition, the masjid is having facilities for storing rain water. There are seating facilities for 2000 persons. One can even see stylised Japanese, Arabic and Chinese languages on the walls of the mosque

4. SUMMARY

4.1 Conserving energy

This approach is to operate the building with the minimum unrenewable energy. This is through the following methods:

- The building may be designed in elongated form in order to bring the light inside. Other attempt is to use skylight in areas which do not have direct sunlight.
- The building can use sunlight as thermal energy to produce electricity by using photovoltaic devices. In addition, the uses of sunlight can also be used by tilting the roof facing the east-west walls or in line with the sun path.
- The building should use low level electric devices and controls the high uses through automatic devices.
- The building must be applied sunscreen on windows which can adjust the light intensity getting through the interior.
- Interior uses light colors to enhance light intensity.
- The building should avoid artificial heater. The heat should come from the inhabitants and the sunlight entering the building through ventilation.
- The users should minimize the use of air conditioning to reduce the energy consumption.

4.2 Working with climate

This approach can be achieved through these following ways:

- To locate the building orientation against the sun path.
- To apply air pump system and cross ventilation.
- To use plants and water as climate adjuster.
- To use windows and roof which can be opened and shut depending on the users' need.

4.3 Respect for site

This approach requires interaction between the building and its site. This can be achieved through the following ways:

- To minimize site alteration by deploying design following the site condition.
- To use minimum building coverage ratio and to favor vertical building approach.
- To apply local materials available from the surrounding area

4.4 Respect for users

- This approach plays an important role as building has a close relationship with the users, activity and needs.

4.5. Limiting new resources

- This approach is to limit the use of new resources and use the current available resources.

4.6 Holistic approach

- This approach is aimed to design a mosque by applying these five principles. These green architecture design are linked and cannot be separated.

5. CONCLUSIONS

- In this study, it can be concluded that there is a bigger perspective to the definition of a eco mosque. A eco mosque is not only a green building. A eco mosque is a lively mosque filled with green environment, strong sense of community and vibrant economy. In that account, it is recommended that more communal activities such as a playground or sports facilities could be integrated into the design of eco mosque to attract users of different ages especially children and youth
- The study shows that designing a building requires comprehensive strategy in formulating the concept based on the existing site condition. Green architectural approach should be then applied to minimize the environmental damage, reduce the building cost yet accommodating user's need.
- Applying the green approach enables users to maintain the building easily and at the same time reducing the running cost.
- Three main aspects of sustainability which are environmental (site location, accessibility, green space, resource conservation), social (activities, communal space, and collaborative participation) and economic (local business and cost-saving) match the essence of a mosque as a living nexus.
- Social sustainability plays an important part as another requirement for green and sustainable approaches in mosques. The social and spiritual sustainability of the community can be increased through the religious activities conducted at the Mosque. A mosque should be designed as multifunctional and have communal space for having diverse activities and possessing community space.
- Because Mosque is a central place for Muslims to do their religious activities, Mosque must have good indoor air quality. To stay in one place for quite a long time, people need to feel comfortable. Indoor air quality depends on the airflow behavior, the distributions of temperatures and relative humidity, and the concentration of carbon dioxide due to the high occupancy load of people. Healthy Indoor air quality can be achieved by providing good ventilation.
- Islamic gardens have traditionally focused on the garden as an enclosed, bounded entity with a definition as precise as that of a building. While this is a successful strategy for considering some aspects of the garden such as patronage and typology, it excludes other aspects of garden-making such as views, the ecological issues of water management and botany, and the ways that an enclosed garden can respond spatially to the surrounding topography.
- One of the hallmarks of Islamic gardens is the four-part garden laid out with axial walkways that intersect in the garden centre. This highly structured geometrical scheme, became a powerful metaphor for the organization and domestication of the landscape, itself a symbol of political territory. However, the cross-axial plan was not the only means of organizing the garden. In imperial, sub-imperial, and ordinary house gardens, the space might be as simple as a paved courtyard with a fountain or sunken basin surrounded by potted plants. It might take the form of a single long rectangular bed with a central watercourse, or multiple beds aligned end to end in terraces on a sloping hillside as occurred in the Mughal Nishat Bagh in Kashmir. And just as one architectural plan may yield buildings with strikingly distinct appearances due to the use of different materials and manipulation of structural elements, as in the case of the Tomb of Humayun and the Taj Mahal, so may a four-part garden plan. It may have deeply sunken quadrants planted with shrubs whose leaves just barely reach the surfaces of the elevated paths, or shallow expanses of sturdy turf suitable for sitting. At the beginning of the seventeenth century in Mughal South Asia, the simple rectilinear geometry of the chahar bagh and its water basins was embellished and transformed by elaborate curvilinear and stellar patterns.
- Islamic garden designers followed the Roman model of geometrically laid out gardens with central axes in the form of walkways and watercourses, but they did not embrace the colorful garden murals and the embellishment of green spaces with copious figural statuary.
- The Mosque should be designed following the green principles which carefully looks at the site, space, form and facade as well as interior. This can be achieved through the following ways:

(1) to position the building orientation against the sun path and wind direction.
(2) to provide absorption well and biopori system to catch ground water.
(3) To maximize cross ventilation and passive cooling by providing green areas surrounding the mosque in order to avoid the use of Air Conditioner.
(4) to use plant as climate adjuster.
(5) to use low-cost local material but environmentally friendly.
(6) To provide open court as transitional space between inside and outside.
(7) to provide parking lot and green areas as much as possible.

By applying this, the users will have a different perception while having activities in the mosque. In this case, green architecture does not only deal with the physical appearance only but can also provide a positive psychological effect to the users.

The suggested sustainable design strategies for mosques

Sustainable Design Principles	Sustainable Design Strategies for Mosque
Energy Efficient	Solar PV Wind Turbine Water treatment
Climate Condition	Daylighting Natural ventilation Thermal comfort
Sustainable material	Local material
Indoor air quality	Natural ventilation Daylighting
Socially sustainable Mosque	Muslim's religious activity

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