ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2018; 4(12): 75-78
www.allresearchjournal.com
Received: 03-11-2018
Accepted: 05-12-2018

Dr. Rahul Maurya
Ph.D., National Museum Institute, New Delhi, India

Correspondence
Dr. Rahul Maurya
Ph.D., National Museum Institute, New Delhi, India

A brief history of materials and construction techniques of Mughal architecture

Dr. Rahul Maurya

Abstract
Art and architecture present a live depiction of the culture and reflect the concept and approach of the contemporary society. When Islam reached Hindustan, it brought distinctive features of architecture in India such as dome, arch, minarets and vaults and also the techniques, tools and of course building materials. On the other hand, prevailing Indian elements were flat roof, corbelled bracket, tapering dome, pillars and columns etc. The monuments in early of Islam during Slave dynasty were created with basic Islamic features like arch, dome etc which made by corbelling technique, so the quality of the construction was low in terms of elements as well as strength. With this, it show deficiency of materials used in the construction, which were obtained from the demolition of the Indian architecture. Later on, it had some improvements with construction techniques and elements during Khilji's and further ruling dynasties. But when Mughal established the rule in India they created much refined monuments by using of sophisticated techniques and advanced building materials. Their buildings show the purity and grandeur of Islam. They used true arch and other sophisticated elements in their construction and applied them in different pattern according to the need of decoration. Apart from this, using of massive gateways and domes and four quartered garden pattern etc shows marvellous effect on Mughal monuments. Such a grand and splendid construction could not possible without exact and proper building materials. This article discusses the structural development and use of building materials and techniques adopted by Mughals for construction of their monuments. It deals with description of historian evidences with special reference to Akbar's reign for material and construction techniques. It investigates how the engineer, builders and other renowned workers had knowledge to build massive fort, palaces and other religious monuments in a very short period of time.

Keywords: Indo-Islamic architecture, mosque, Mughal architecture

Introduction
Mughal architecture is a distinctive feature of Indo-Islamic pattern, encompasses a wide variety of the type of architecture both secular and religious. The mosque is main building under Islam and it was necessary to construct a mosque for establishing religious and social significance of new Islamic Empire of early Sultanate period. The actual journey of Islamic architecture began in India with the construction of Mosque at Qila Rai Pithora known as Qubbat-ul-Islam which was built over the ruins of 27 Indian temples in presence of local workmanship. Although, the plans and fundamental features were Islamic but used materials were remains of temples. Thus, the new compilation included Islamic, Indian and local elements introduced Indo-Islamic architecture. So architectural elements were created by fundamental Islamic features but decorative part mostly remained same as in Indian architecture. When Babur laid the foundation of Mughal Empire in Hindustan, Hindustan had made a lot of progress in the field of architecture. Babur was much passionate about the garden craft rather than building construction and he loved terraced garden of Persia. He built artificial terraces with water chutes and cascade. Though, he built Kabulibagh mosque at Panipat, Jama Masjid at Sambhal and mosque at Ayodhya which were made over the demolition of pre existing monuments. Thus, building materials were obtained from the remains of the buildings and the surrounding areas. During the reign of Humayun, architecture has mostly been ruined. The magnificent architectural work has been occurred during Akbar’s reign. Mughal architecture gained recognition throughout the world and he established a fresh construction of red sandstone at the site of Badalgarh known as Agra Fort and built many palaces and mosque at Fatehpur Sikri and also constructed forts and palaces

in different parts of his territory. The magnificent edifice the tomb of Humayun was also constructed in Delhi during his reign. Thus, the architecture developed under Mughal is built with qualitative building materials in which red sandstone and white marbles were principle and mortar was prepared with source of lime. The basic ingredients of mortar were lime, water and *surkhi.* Apart from this, various type of coloured stones, precious and semi precious gems were also used for decoration of monuments.

Building Materials

Abul Fazl records that his majesty fixed the price of construction material after doing careful inquiry of profit and loss. He describes various kind of building materials with their price and availability. Red sandstone was easily obtainable in the hills of Fatehpur Sikri and perhaps the best marble was brought from Makrana in Rajasthan. Irregular broken pieces of stones (*sang ghulula*) were brought at the work site of Agra from Delhi as Arif indicates. Other stones used were yellow (*sang zard*), white (*sang Safed*), black (*sang siyah*), and marble (*sang marmar*) and others were *sang musa, sang abri or sang maryam, sang yashm, sang mahtabi* etc. He mentions that three kinds of bricks were used i.e. burnt, half-burnt and unburnt. First kind of brick was used intensively and most probably half-burnt and unburnt were used in the house of middle class and poor people. He describes seventy two kinds of wood of which eight were important i.e. 1. *Shisham* was famous for its beauty and durability which has same value today, 2. *Nazhu* called in Hindi *Jidh* (*chidh*), 3. *Dasang* or *kari*, 4. *Ber*, 5. *Mughilan* (*Babul*), 6. *Sirs*, 7. *Dayal*, 8. *Bakayin*. Lime (chuna or qalai) had various kinds in India and Abul Fazl describes three kinds of Lime (*chuna* or *qalai*) that is (a) Sweet lime stone or *gaj-i-shirin* produced from limestone (b) lime prepared from *kankar* (gravel) and (c) lime obtained from fresh water or marine shells. The main source of sweet lime was gypsum, sulphate of Lime which refers as *gach* in Persian source and was employed for mortar, plaster and whitewashing. Most general source of building lime in India was *kankar*. Second category or c*huna* was largely derived from *kankar*, a kind a solid earth resembling stone in hardness. And third category was various kind of sea-shells also yield lime. Abul Fazl used term *qalai* in both for tin-coating and whitewashing.

Simple cementing agent was plain earth or clay mixed with water but it is obviously weakest and it made improvement with mixing of *bhus* (a kind of straw) this mixure known as *gara*. Abul Fazl gives detailed list of reagents of which few important are mentioned here. *Bhus* or wheat straw was used for fixing of mortar, *sirish-i-kahi* or reed glue is mixed with sweet lime stone, *simgil* or silver clay is white and greasy clay used for white washing, *gil-i-surkh* or reed clay prepared with *geru* brought from the hills of Gwalior. Abul Fazl records two types of reed, *patal* and *sirki* which were used to cover roof and another reed was '*kah'* for thatching (*chappar*) and, *baans* or bamboo was used as supporting agent. These materials like *bhus* or wheat straw, glue and clay were mostly used in the houses of poor people. Bernier records "Very few are built entirely of brick or stone and several are made only of clay and straw, yet they are airy and pleasant, most of them having courts and gardens, being commodious inside and containing good furniture. The thatched roof is supported by a layer of long, handsome, and strong canes, and the clay walls are covered with a fine white lime". Ropes were made of a kind of grass known as *munj*.

Metals were also used in construction in different form and functions such as iron cramps, Iron door knockers, *gul mekh* (large nails with broad heads), screw and nuts, ring. *khaprel* or burnt tile was used to make roof of building. Glass used for window and other purposes fitted in niches and fixed in *hamam* too, were imported from Haleb (Syria) called *shisha-i-halebi*. Shish Mahal is most prominent example of glass work which was built during the reign of Shahjahan. *Qulba* or water spouts was an instrument used in construction.

The mortar was important material to build a palace, fort or other strong buildings. Iltutamish was the first ruler who erected all buildings using *rekhta* which means mortar or plaster. This type of building is called *pucca* building made of stones or bricks joined together. The early mortar was plain earth or clay mixed with water called *gara* which was the weakest and generally used in houses of poor as mentioned above. It was improved by mixing straw with clay and water and used as plaster. It is supposed that lime mortar introduced into India by immigrant Muslim. Only lime is not valuable for making mortar rather it need number of gelatinous, glutinous, resinous and non-resinous cementing agents were used to mixture of lime and water depending of its demand. The fundamental building materials (*masalah-i-imarat*) were clay (*gil*), bricks (*khist, ajur*), stones (*sang*) and lime. The ingredients of mortar in medieval India were lime, water and *surkhi*. *Surkhi* was pulverized bricks which took the place of sand in India. The special mortar for water proof construction was made of lime, sand and wood ash. It was called *saruj* and supposed be used on paved stone floor and Jahangiri Mahal is best example of it. The plaster was also made of *chuna, qalai, surkhi* and *san* (hemp) with other ingredients. Any type of white washing was prepared of *qalai* and water with other ingredients. It was improved with effect of *simgil* (white and greasy clay) or *geru*. *Sandalkari* was special form of white washing which was done after plastering in order to give brightness and smoothness. Prior to the plastering of walls and ceilings, a thick coating of *kahgil* (a mixture of straw, earth and water) was applied.

Tools and Techniques

The drawing or plan of the building was the main part of construction after choosing the site. Chief architect and other planners would prepare the plan of the building then it was shown to ruler or emperors who finally passed the map. The symmetry of the plan and drawing were prepared through exact measurement of each section and apartments and accurate figures followed during digging up of foundation. Architects also calculated the expenditure and estimate of the building.

The first work to construct a building was digging the foundation trench. It was done by *beldars,* the spade and digging was done deep to rock or water level as required for monument. Abul Fazl records the foundation of Agra fort which was carried through the seven strata of earth. Taj Mahal was digging up very deep to the water level of river Yamuna. The next work was to lay the foundation by using stones and plaster mortar. Lahauri uses *saruj* for mortar and Abul Fazl describes it *sang*-o-*gach* which was used to the moat of Agra fort with stones. The main function of plaster mortar was to protect the building foundation damaged by

flood. Stone masons and brick layers work known as *raj* which is corruption of Arabic word *Raz* which means a builder or architect. He used trowel (*karni* or *kanni*) for spreading mortar and wooden rectangular object applied for smoothness and levelled the mortar.

Stone cutter or *sangtarash* was another important worker to construction of the building. There were three categories of stone cutter i.e.1. *Sangbar* (man who work in quarry), 2. *munabbatkar* and *naqqash* (embosser and tracer) and *parchinkari* (inlayer) 3. *sadakar* (plain stone cutter). They used two types of nails; thick and small to cut the stone into the pieces according to size. The nail was set on the slab by one hand and hit with double headed hammer by other hand. The tracery made with chisel then polished and burnish was applied on the surface of stone to get shining and smoothness. Iron work was done generally by ironsmith who manufactured nails, screw, nuts, clamps, knockers and other equipments. He fixed iron clams and iron string to adjoining stones together. Father Moneserrate records "The stones of these buildings are so cunningly fitted that the joints are scarcely visible, although no lime was used to fix them together. The beautiful colour of the stone, which is all red, also produced the same effect of uniform solidity". The wooden work was done by carpenter using different tools like saw (*arra*), auger (*barma*), adze (*basoola*), axe (*kulhari*), plane (*randa*), chisel (*sumba/tesha*), hammer, and hand saw (*arri*).

Gypsum or lime was common bonding agent of mortar and was used in foundation and wall of the building. Generally the mortar of earth and straw were used in laying of unbaked bricks and gypsum for burnt. The deep foundation of the building was filled with rough uneven blocks or stones and mortar, and inner walls were prepared by roughly shaped blocks and fixed together with gypsum mortar then thick plaster applied onto the walls to make smoothness. Gypsum was also cementing agent of plaster and it was used as water proof component. After that it was clad with red sand stone or other marble required. If uneven blocks were not covered with stones or marble then thick plaster was applied on them and made the white wash to decorate the building.

During the construction, the windlass consisting stone blocks, rubble and mortar were carried on the top level using the lever, the pulley, the wedge and screw. These all five members the windlass, the lever, the pulley, the wedge and screw worked together. Large sections of stone were brought to site by animals where they split to the required size.

Most of Mughal buildings at Agra during the reign of Akbar were constructed with flat lintel and ceilings, yet arch was the fundamental architectural feature of Islamic architecture and frequently observed in Mughal architecture at Agra and Fatehpur Sikri. An arch is the structural element which spans a space and supports structure and weight below it. A space between two walls or piers spans a space at lintel level. The centre of hemisphere space was made by framework of timber and bamboo and temporarily the space between silhouette of arch and lintel was filled with layer of bricks. The voussoirs were laid on it until the arch is completed and self-supporting.

Major three types of domes appeared in the Mughal architecture but various types of dome were developed in different period in different parts of the world. The earliest construction was ribbed dome which was originally associated from Buddhist architecture in India. Most of Indian temples had corbelled dome with square ground plan in pyramid form often reduced to an octagonal shape by architraves set diagonally across the corner and the circular course rested over the octagonal base. The Indian architectural tradition did not include arches but flat corbels were used to transition from the corners of the room to the dome, rather than squinches. The pre Muslim roofs were constructed with ribbed dome prepared by a framework of bamboo canes tied together at the vertex. A dome was constructed by a framework which silhouette took on the shape of circular arch.

The domes were prior construction of Hindus and there were two methods of construction, ribbed dome and corbelled dome. But after advent of Islam in India, a dome constructed in addition to the straight architrave, there is appeared the Islamic pointed arch and joins point towards the centre of hemisphere so called 'true dome'. The Persian architects proceeded from the fact that by changing a square ground plan into an octagon, the dome could rest upon eight points. Thus Indo-Islamc architecture comprises three domes. The domes were constructed with stone, brick and mortar, and iron dowels and cramps. The dome is composed of eight intersecting arches which span across the corners of the square to support the dome and rise to the vault. The technique uses arches to span the corners support for more weight called 'squinches'. The squinch can be a single arch or more projecting nested arches placed diagonally over an internal corner. The arch to a gateway is built up with two piers of bricks and timber lintel to support the centering used to construct the structural arch. The lintel allows access through the gate while it is being built. Above the gate, a small brick dome is being constructed with the bricks laid in concentric rings to eliminate the need for centering. Thus, number of timbers and bamboos were required for the centering to support the arches during the construction. Use of brick centering was an alternative temporary support to the arches. Once the permanent arches and pendntives were formed in the vertical base then the dome could be built. The temporary framework of timber, bamboo and other required materials were supported on the balcony around the base of the dome. After the main domed roof built from brickworks or rough blocks then it could be plastered and also could be clad with sandstone and marble. The marble blocks attached to the core by alternating wide and narrow layers secured by use of iron cramps. Iron cramps may also help form a tension ring at the base of the dome and used to improve the strength of the building.

Another type of ceiling frequently appeared during the reign of Akbar called coved ceiling. This was constructed over square or rectangular room. This type of ceiling was erected with stone framework of stone ribs. Coved ceiling is found in Jahangiri Mahal and Diwan-i-Khaas at Fatehpur Sikri. Bengali roof is another type of curved roof or barrel vaulted roof which appears in Shahjahan's palace.

Conclusion

To Sum up, the Mughal architecture is known for its refined and chaste technology. Early Indo-Islamic architecture could not be developed systematically but Mughal architecture was built with extraordinary tactics and engineering. Some of the techniques and ideas were carried from Baghdad and Persia and also have influence of Timurid and Turkish architecture. Accordingly, construction

materials used by Mughal have played an important role in their grand and magnificent monuments. The use of red sandstone, white marble and precious and semi-precious gemstones could not be fixed without knowledge of exact ratio of building materials such as limestone, sand, clay, water etc. Such a huge construction could not be completed without intellectual knowledge of architects and planning. Thus, the building material became a key factor to build a large construction and the monuments constructed by Mughal demonstrate advanced workmanship ability.

References

1. Ahsan Jan Qaisar, Building Construction in Mughal India: The Evidence from Painting (Delhi, Oxford University Press, 1988, 1-33.
2. Abul Fazl, *Ain-i-Akbari*, Trans. H. Blochmann (Calcutta: Asiatic Society of Bengal, 1873; 1:222-226.
3. François Bernier, Travels in Mugal Empire: AD. 1556-1568, Trans., Archibald Constable and Vincent A. Smith (London, Oxford University Press, 1916, 245-247.
4. The Commentary of father Monesettare, Trans, JS. Hoyland and SN. Banerjee, (London: Oxford University Press, 1922, 32-36.
5. Andreas Volwahsen. Living architecture*: Islamic India* (London: Macdonald & Co., 1970, 179.
6. Praduman K Sharma, *Indo-Islamic Architecture* (Delhi and Agra) Delhi: Creative Offset, 2003, 15-29.
7. Harish Chandra Verma, Madhyakalin Bharat, Delhi: Hindi Madhyam Karyanvayan Nideshalaya DU, 2015, 322-328.
8. Percy Brown. Indian Architecture (Islamic Period) Delhi: Kiran Book Agency, 2010, 9-15.
9. Nath R. History of Mughal Architecture, New Delhi: Abhinav Publication, 1985; 2:102-134.