Pak. J. Engg. & Appl. Sci. Vol. 10, Jan., 2012 (*p.* 103-113)

Heart Pleasing and Praiseworthy Buildings: Reviewing Mughal Architecture in the light of Primary Sources

Abdul Rehman[1] and Munazzah Akhtar[2]

1. arch.rehman@yahoo.com, Department of Architecture, University of Engineering and Technology Lahore, Pakistan
2. munazzaha@gmail.com, Department of Architecture, University of Engineering and Technology Lhr, Pakistan

Abstract

Saleh Kambo, a court historian of Shah Jahan (1628-58), while discussing the buildings, frequently used the phrases such as ***"makan dilnasheen hai az nasheman hai nuzhat aafreen"*** *which means "heart pleasing buildings and praiseworthy mansions". Every Mughal building designed surpassed its predecessor in terms of its design quality and decorative details. From the selection of the site to final design, specialized knowledge and expertise were employed to achieve the final product. The buildings and spaces around them not only had experiential qualities but were also practical in use. Throughout the Mughal period there has been constant experimentation in art and architectural design, which resulted in highly refined structures. This paper discusses the architecture of Mughal period, in terms of form, composition and its practical use, as described in the primary sources of the period. The paper also highlights the variety of expertise and knowledge, which Mughal architects and builders possessed, from the process of site selection to finalization of building designs and its minutest details.*

Key Words: Mughal Architecture, Garden and Landscape Design, Astrolabe, Geometry, Mathematics in Architecture.

1. Main Article

The magnificent era which we term as the Mughal period (1526-1849) in India, is without doubt an era in which many art forms flourished. This era, beginning with the empire formed by Babur (1526-30) and continued on by his successors; saw the refinement of many technologies. As a result of these refinements, the Mughal India became the originator of several innovations that are highly regarded in the history of civilizations.

Among many other assets the architecture of the Mughal Empire is exceptional and is admired worldwide for its imaginative design. The architecture was based upon a variety of experiences in the field of geometry, hydraulics and other building sciences. New ideas in building began to achieve their height of excellence, during Emperor Akbar's reign (1556-1605) throughout his Empire. It is also recognized that it was Emperor Shah Jahan (1628-58) who created the wonders of the world by refining the arts of architecture. In spite of its essentially practical nature, architecture in the Mughal period was also a way to exercise engagement in the divine nature. Today we live with the legacy of a cultural period devoted to the creation of beautiful buildings, which not only used to serve man's needs and still pleases the eye and refreshes the soul. In this way, Mughal architecture is full of experiences and surprises.

The ideas of the Mughal Imperial Architecture were mostly initiated by the emperors themselves, in particular by Shah Jahan, and then translated in to practical form by the architects. Saleh Kamboh has also narrated that in April 1634 AD, when Shah Jahan came to Lahore and resided in the fort, he diverted his attention towards the repair work of its buildings. As the buildings of *Diwan-i-Khas* (Hall of Special -Audience) and *Khwabgah* (sleeping chamber), in Lahore fort were found to be aesthetically unpleasing by Shah Jahan, on his orders engineers and architects prepared and presented to him the revised proposals out of which one was approved by the emperor. Later the officials completed the newer construction before Emperor's return to Kashmir, as ordered [1]. Thus, the whole process of architectural designing used to incorporate many different aspects and technologies. Besides being experts of designing and construction

technologies, the Mughal architects are found to be men of many talents. On numerous accounts the architects have been referred to as experts of many sciences including astronomy and knew the use of sophisticated instruments such as the *Asturlab* (Astrolabe).

2. The importance of Astrolabe in construction

The astrolabe is an ancient astronomical instrument for solving problems relating to time and the position of the sun and stars in the sky. Several types of astrolabes had been used in history but by far the most popular type is the planispheric astrolabe. The astrolabe represents the ingenious application of spherical geometry to map one's location on Earth, relative to the stars and sun on the celestial sphere. In the Islamic world, the chief uses of astrolabes had been to solve problems of spherical astronomy, to determine time of day or night for prayers, to fix the direction of *Qibla* (the direction that should be faced when a Muslim prays), to solve the problems of survey, i.e. depth of wells, height of a building, width of a river and longitudes of various planets, etc. [2]. Often considered the first modern scientific instrument, the astrolabe was used for many astronomical computations.

Although it was invented by Greeks; the astrolabe was extensively used by Muslim scientists. In India, the astrolabe is said to have been introduced by Firoze Shah who used to keep an astrolabe at his side all the time.[3] The construction of the astrolabe or *asturlab-sazi* became more common during the times of Emperor Humayun (1530-40; 1555-1556) who was fascinated with astrology and alchemy. The Emperor used to match the color of the robe he wore each day to the color of the planet that was believed to govern that day of the week.[4] He is said to have gained knowledge of astronomy during his stay in Iran when he was accompanied by two famous scholars Ilyas Ardbeli and Abdul Qasim Giryani [5]. Under his patronage the process of astrolabe making started in Lahore and such astrolabes were commonly known as *asturlab-humayuni* (Humayun's Astrolabes). Later, Lahore was recognized worldwide as one of the most important manufacturing centers of Astrolabes. At least three Mughal period astrolabes are presently located in the Lahore Museums.

Humayun's successors also made full use of this science, which reached its peak during the Emperor Akbar's time (1556-1605), as he shared Humayun's interest in astrology [6]. The term *asturlab shanas* (astrolabe user) is often found in Mughal period sources for the architects who worked on prestigious projects [7]. Site surveying and analysis required simpler features of astrolabes than did astronomy and astrology. The Mughal architects are believed to use the astrolabe for site surveys, site analysis, measurements of building heights during the whole process of construction.

Fig.1a&b: The two sides of an Astrolabe dated 1640 AD, made by Muhammad Muqim Ibn-e-Isa Ibn-al-Haddad Lahori. Courtesy of Lahore Museum.

If we take a look at the Mughal astrolabe intended for this use typically, its back includes a "shadow square," with a horizontal and vertical scale. The astrolabes could have been used by the architects to take the angular measurement and the height of different building elements, such as a minarets or domes, during construction. Using trigonometry, the lines of the shadow square, the height of the building or minaret and its distance to the observer formed triangles that could be used to find the actual height. The same procedure could have been used to determine distances or the depth of rivers, wells and other water bodies, which was helpful in making bridges, canals, and even gardens. In this sense, the astrolabe was a highly useful tool for all kinds of architectural projects.

The Mughals paid significant attention to each step of the building project. Selection of a suitable site for a project was an important step in any physical design. Babur (1526-30), is said to have searched a number of sites for the construction of a garden in Agra but every time he was dissatisfied because of their inappropriateness.

He clearly stated that:

> *"With this object in view, we crossed the Jun-water (river Jumna) to look at garden-grounds a few days after entering Agra. Those grounds were so bad and unattractive that we traversed them with a hundred disgusts and repulsions. So ugly and displeasing were they that the idea of making a Char-bagh in them passed from my mind but needs must! As there was no other land near Agra, that same ground was taken in hand a few days later*"[8].

Selection of appropriate site was also considered to be an important matter during Akbar's time. Emperor Akbar (1556-1605) appointed *hakims* (physicians) and *Akhtar shanas* (Astrologers) to select a suitable site for the construction of Gujrat town. Shah Jahan is also said to have ordered Khalil ullah Khan to select a site on the bank of the canal in consultation with *muhandis* (geometrician) and *mimars* (architect) for Shalamar garden at Lahore. Shah Jahan (1628-58) suggested that the site should have *nasheib-o-faraz* (contours) so that *abshars* (waterfalls), *nehr* (canals) and *hauz* (water tanks) may be constructed in it [9]. Thus the involvement of geometricians and architects in the site selection process was a requirement during Mughal era.

Fig.2: 19th Century miniature painting of Emperor Babur on ivory. Courtesy of Lahore Museum.

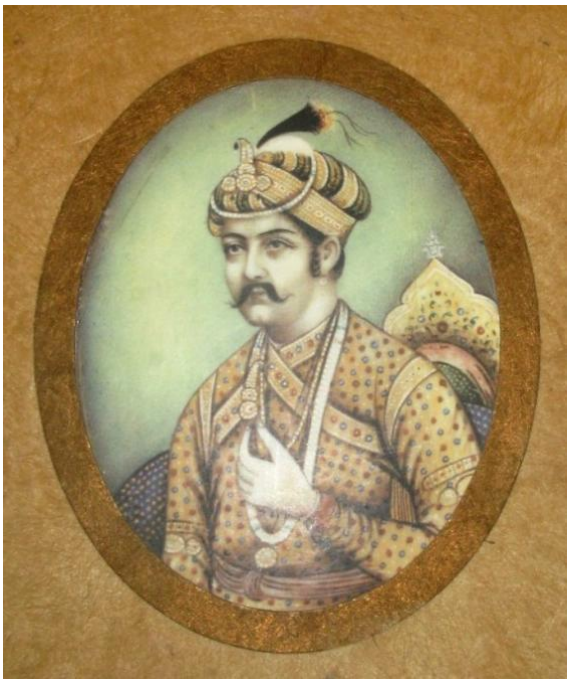

Fig.3: 19th Century miniature painting of Emperor Jahangir on ivory. Courtesy of Lahore Museum.

In an account of the building of Shahjahanabad, Shah Jahan (1628-58) again gave orders to his *Muhandisan asturlab shanas* (astrolabe understanding geometricians) and *Aqledas nazar* (Euclidians) [10] to select a specific site between Agra and Lahore. He demanded three significant characteristics in the site that it should be *dilnasheen* (heart pleasing), *behesht nishan (*paradise charactered) with praiseworthy quality of *aetadal aab-o-hawa (*moderate climate) [11]. From this description it becomes clear that these specialists must ascertain the suitability of site from different aspects that are important for physical design. Different sets of specialists were considered for different kind of sites; e.g. for the selection of town sites, astrologers, physicians and mathematicians were considered essential. Even in contemporary times, architects or specialist dealing with environmental studies are rarely hired for the selection of sites.

3. The Master Builders or Architects

After the selection of site the next important step was selection of *muhandis*, *mimar* or master builder. Although we do not find names of many architects during the early Mughal period, it is certain that they used to work with the Mughal court. Prior to the Mughals, Ahmad Ayaz, a disciple of the Khwaja Nizamud Din Auliya, designed several building for Sultan Ghiyath al Din Tughlaq. Firoze Shah Tughlaq had a special works department where Muhammad Shahna was the chief architect who not only designed new buildings but also supervised the conservation projects.

One of the first architects, whose name appears in the Mughal sources, is Muhammad Mirak son of Ustad Mirak Ghiyath who migrated to India from Herat and joined Babur (1526-30) at Agra. Both father and son were experts in layout of gardens. Ustad Mirak went back to Herat where he designed a number of gardens while his son stayed in India. The first major work credited to him is Humayun's tomb at Delhi. As a patron, Haji Begum, the widow of Emperor Humayun (1530-40; 1555-1556) took keen interest in its construction, devoting much of her time in overseeing the work. This tomb was planned in a *char-bagh* and set a new direction in the construction of funerary building in the Subcontinent. Another master builder, Mir Abdul Karim, with the official title '*Mamur Khan*' was the chief architect of Emperor Jahangir (1605-1627). He also rendered his services in the reign of Shah Jahan (1628-58). Mir Abdul Karim not only designed buildings in the Lahore Fort but also rendered services in the repairs of old palaces at Mandu on the order of Emperor Jahangir (1605-1627). Perhaps the most notable contribution during the reign of Shah Jahan (1628-58) was made by the family of Ahmad Mimar Lahori. The most outstanding contribution of Ustad Ahmad is the tomb of Taj Mahal and Red Fort at Delhi. Ustad Ahmad also designed Haveli of Asaf Khan at Lahore, garden and *sarai* at Hasan Abdal. Khair Allah Muhandis, having knowledge of astronomy designed observatories at Delhi, Banaras, Jaipur, Varanasi and Ujjain on the command of Raja Jai Singh during the reign of Muhammad Shah [12].

These architects not only designed buildings but also wrote on architecture and related sciences. Ustad Mirak wrote a Manual of Agriculture in which the last chapter specially dealt the layout of gardens [13]. *Biyaz-e-Khushbuhi* [14], by an unknown master builder, is an excellent manual of architecture and garden design. Several treatises written by the family members of Ustad Ahmad such as Ata Ullah Muhandis, Lutfullah Muhandis, and his grandsons Riyazi, indicates that all the imperative aspects of astrology, mathematics geometry and horticulture were very well known and practiced by them. Lutfullah's work related to the method of finding the direction of Qibla is well acknowledged [15]. Khair ullah Muhandis, grandson of Ahmad Mimar Lahori, wrote *Hashiya bar sharah* or marginal notes on the commentary of Nasir ud Din Tusi's *Bist bab dar asturlab* or twenty chapters on the Construction and Use of Astrolabes.

These skillful Architects designed the buildings in a very systematic and organized way, taking into confidence the Mughal Emperors. Any project which was taken up passed through a number of stages which included site selection (which was done by certain criteria). A number of sketches were prepared and presented to the emperor for final approval and was then minutely reviewed and rewarded. This is the reason that the Mughal architects were regarded with respect and were often well rewarded. For example, Abdu-l-Karim was promoted in with 800 personnel and 400 horses, and was dignified with the title of *Mamur Khan* (the architect-Khan) [16].

Ahmad Mimar was also honored with the title of *Nadir ul Asr* and was called *sar-amad mimaran nadira kar* (chief of architects and excellent artificer) [17]. Such titles, like *mimaran hindsa pardaaz* [18]. (geometrically expert architects), cannot be conceived of in the prevailing times.

The following account of Lahore is also evidence for the qualities of the architects:

> *"I started for Lahore, and the architects had built it after a design of their own. At least certain expenditure was made until a large sum was expended, and work went on the three or four years. I ordered that experienced architects should again lay the foundations, in agreement with men of experience, in several places, on a settled plan"* [19].

As previously mentioned, Mughal Imperial projects involved the input of many professionals who were masters in their own trade. These craftsmen worked as a team to produce a monument of exceptional quality. *Bayaz Khushbuhi* mentions the role of *chaman pirayan* (garden designer) in their landscape contribution in a project.

4. The Patrons

The role and involvement of a patron was most crucial in the final output. Mughal emperors and nobility took keen interest in their projects, which not only ensured the supply of adequate funding but took keen interest in all stages of work.

Emperor Shah Jahan (1628-58), especially used to take keen interest in examining a variety of works of art, e.g. drawings by architects, masterpieces by painters, carvers, goldsmiths, enamellers, etc. He encouraged the artists to innovate their compositions by using their own imagination as well as by getting inspiration from other traditions [20]. He also visited building sites during the construction stages, and gave specific instructions, either to make amendments in the design or for specific finishes to be employed in the buildings. In April 1634 the Emperor visited the buildings of Lahore Fort and expressed displeasure over the design of *Khwabgah* and *hammam* because of their inappropriate *waza* (design) and *sakht* (construction). *Muhandis* and *mimars* revised the designs and presented them to the Emperor for approval who approved one design and ordered that construction to be completed before his return from Kashmir [21]. In the tomb of Asaf Khan, the emperor specifically required the use of white marble as a finishing material over the dome. Similarly, the layout of Shah Burj was changed on the orders of the Emperor who felt dissatisfaction over its design, which was originally conceived during the reign of Emperor Jahangir (1605-1627). The keen involvement of the Emperor in a project used to raise the morale of all concerned with the project. It is also recorded that the planning of Shah Jahan's buildings was carried out by a team of architects who worked under his close supervision. He held daily meetings with them. In an account of the construction of the Taj Mahal, Lahauri mentions that Shah Jahan thoroughly discussed the designs by the skillful architects; asked competent questions and then made appropriate alterations to finalize the design of Taj Mahal" [22].

5. The use of geometry and mathematics in buildings

The architectural designs were based upon pure geometry, and the role of designers skilled in geometry was most crucial in any project. There has been significant use of two-dimensional geometry in layouts, on the floors, grills and building façades whereas three-dimensional geometry is evident in the volumetric compositions, and spherical geometry in the soffit of the domes and *pishtaqs.* The use of three dimensional spherical geometry may be seen in the form of *muqarnas* or *qalib kari* work employed under the soffit of the domes. The Mughal architects, like other architects of the Islamic word, extensively used *girah* modes in their buildings. This wide range of *girah* and many modes were derived from simple geometrical shapes to most complex forms based upon multiple geometrical shapes. The most common *girah* found in Mughal monuments are *char murabah girah, dohri ath girah, girah kataar dar* and *mauj-e-Akbar.* This geometry together with use of appropriate colors created "frozen music" to use Goete's phrase – in places where such schemes are executed.

It is important to note that the Mughal architects have always utilized the conceptual approach,

methods and mathematical rules to achieve the building designs. Mathematical rules, created golden-mean proportions and symmetry in Mughal buildings and thus the results were the *tarhi badee wa naqshe taza* [23] (rare compositions and fresh creations). Building plans followed the grid planning. The royal buildings were mostly symmetrical along one or two axis, creating two-fold, four-fold or eight-fold *hisht bihist* (eight paradises) plans. In case of ordinary common buildings, plans based upon definite rules of proportion and the same principles were applied in the building facades.

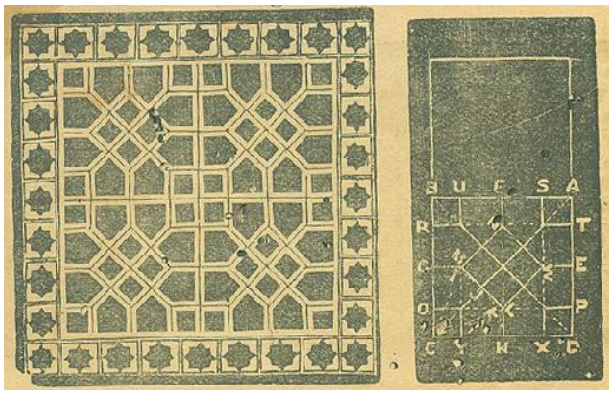

Fig 3: Char-murabah girah

Many Mughal architectural wonders astound the observers, both with their grandeur, visual satisfaction and structural stability. Such achievements are a result of the geometrical principles applied effectively by the architects. Almost all of the Mughal monuments and complexes are designed on a grid. The architects used to develop the plans involving 'generated' grid system, in which a specific length can be divided into modules or subdivisions in various ways – by halving them, e.g. 16, 8 etc., or by using tripartite divisions, e.g. 9, 12, etc., or by employing the decimal system [24]. In complexes, as in the Taj Mahal, individual buildings were designed on smaller grids and these grids were then proportionately superimposed overall. The entire complex of Taj Mahal was conceived on modular grids, not only in plan but also in elevation. Individual elements and features, in the outer buildings as well, are skillfully integrated into the overall scheme, combining various grids with remarkable dexterity [25].

The Mughal architects embedded basic mathematical principles into their building designs, thus blurring the borders between art and science. They applied mathematics not just as a tool but because the art of mathematics, like that of astronomy, was conceived as a resonance with nature and the universe. The implementation of mathematical principles is well defined with the use of 'The Golden Rectangle' based on the Golden Section within the Mughal monuments. The use of Golden Sections is also observable in the Mughal paintings, and in architecture can be best viewed in the case of the Taj Mahal. If the rules of the Golden Rectangle are applied on the front façade of Taj Mahal where a rectangle is formed, then it is observed that partitioning the original rectangle, according to the golden ratio, into a square and a new rectangle; resulting in this rectangle having sides with the same ratio. Taj Mahal, an exquisite monument, with its front gardens divided into four sections has its plan as well as its four minarets continuing the same symmetrical theme. Looking at the monument, one witnesses the combination of mathematics and geometry; creating symmetry, rhythm and harmony.

Fig. 4 The Great Taj Mahal, a combination of mathematics and geometry; creating symmetry, rhythm and harmony.

In discussing the experience of Mughal buildings, another point is the sensibility of the architects; that they have created the buildings in such a way that the visitors are guided, sometimes surprised (small doors hiding great courtyards and

scenes). A variety of compositions based upon pure geometry created magnificent, aesthetically pleasing and praiseworthy outcomes. Aesthetics is not just a visual criteria, but sound, touch, and smell, (if not taste), are all important in the creation of delightful architecture. It is extensively observed that this vocabulary of aesthetics was highly developed in Mughal architecture and applied not only to the building façade, but also to interiors, and the context including the surrounding landscape and buildings – thus to the whole of the site and the community at large.

6. Gardens and Landscapes

For the Mughals site planning and its design was also considered to be very important. The visual experience of the aura of the nature, the fragrance of the aromatic plants and flowers, the damp zephyr making its way through the fountains and pools, created an unforgettable experience both within and outside buildings. This deep relationship between gardens and buildings is further elaborated in the following inscription on Delhi Red Fort sleeping chamber (completed 1058 AH/1648AD.):

"The gardens are to these buildings as the soul to the body, and the lamp to an assembly; and the pure canal, the limpid water, is to the person possessing sight as a world reflecting mirror, and to the wise the unveiler of the secret world" [26].

The Mughal architects, as is well known, have actually utilized the emblematic images of paradise to fabricate their building sites. It was also their intention to represent 'infinity', which was an approach of all the architecturally strong civilizations. Nishat Bagh at Kashmir is an outstanding example of such gardens, which is designed with twelve terraces overlooks the mountains beyond, indicating the exceptional qualities of the Mughal architects.

Environmental considerations were also given importance in all Mughal building designs. The orientation of buildings, location and size, and types of opening were such that these buildings were comfortable in the extreme climatic conditions. Many of the historical writers, while describing Mughal buildings in their writings have mentioned the internal as well as the external environmental condition. Muhammad Latif describing the *Shah Burj* states that it was planned to have a quality of free circulation of the air so that a unique structure could be erected [27]. Thus, the architects always gave priority to adequate ventilation and free circulation of air to generate thermal comfort within the building interiors. It is here again, that the need for astrolabes was considered important, to finalize the orientation of the buildings with reference to the site conditions for air circulation and natural ventilation.

Fig. 5 Shish Mahal of the Shah Burj Complex, designed with openings for free circulation of air.

In many accounts there is good indication that in Paradise, four rivers source at a central spring, and separate the garden into north, west, south and east. This is undoubtedly what gave birth to the concept of the *char-bagh* garden which was introduced to India by the first Mughal emperor Babur (1526-30). The *char-bagh* is meant to reflect the gardens of Paradise, which in its architectural terms is also strongly associated with the Mughal architecture is also quiet celebrated for its utilization of greenery and water; both elements considered to be very important in almost every building typology, especially gardens.

A very strong relationship has been observed between Mughal building and its landscape: in fact it can be rightfully said that landscape was brought into the built environment in the Mughal era. The walkway flanked with flowering plants, water channels and *abshars* (waterfalls) were made important feature of the landscape. Abul Fazl

(c.1595) states that earlier the Indian *bustan-ha* (flower garden) were sown without any specific arrangement, and that during Babur's era *khyaban-bandi* (avenues along flower beds) and *tarh-arai* (well planned layouts) were introduced"[28].

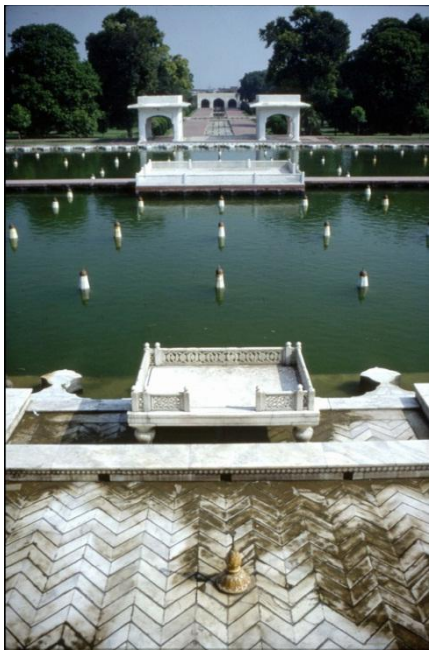

Fig.6: Picture showing middle and lowest terraces of Shalamar Garden.

Fig.7: Earliest abshar of Mughal period, found in Babur's Bagh-e-Neelofer

The extensive use of water in the form of rain water showers and fountains as well as courts full of green open spaces and interiors adorned with stone inlay or mirror work, formed the essence of Mughal landscape design. The object to note here is that these unique ideas of landscaping and irrigation, were in fact the outcomes of many external influences.

Mughal art and architecture is the product of the amalgamation of several art forms from surrounding regions and cultural sources. Ali Mardan Khan (d. 1657) [29], the Persian noble in Shah Jahan's court, originally belonged to Kerman, where he worked as an engineer with his father Ganj Ali Khan Zig [30]. Ali Mardan Khan is said to have managed the construction of gardens and *qanats* (a water management system to supply water for human settlements) built in his father's reign. The knowledge that he gained from his experiences at Kerman and Heart was then utilized under Mughal patronage in the form of several royal buildings in Kashmir, Delhi canal (which runs between the Red Fort and the old city) and the canal brought to Lahore from Madhopur headworks on the Ravi for irrigating gardens and landscapes, such as the Shalimar Garden. The levels of Lahore's Shalimar Garden were further refined and improved by Mulla Alaul Maulk Tuni, as he planned its unique hydraulic system. Mulla Ala-ul-Mulk Tuni was again a 17th century Persian engineer from Ferdows (named 'Toon' historically located in the northwest of South Khorasan province of Iran) who utilized his knowledge in Mughal India. Thus, the Mughal architectural wonders, resulting from overlapping cultural ideas, could rightfully be described as, *Imarat khatir pasand wa manazil firdaws manind* [31] (heart pleasing buildings and paradise-like destinations).

The introduction of landscape in residential architecture brought a new typology of garden and that is *khana bagh* (house garden). All major cities in the Mughal Empire had variety of *khana baghs* filled with variety of plants. William Finch has described one such garden of Asaf Khan designed by Ahmad Mimar Lahori built during the reign of Jahangir [32]. The house gardens brought a dramatic change in the local culture and lifestyle of the people of Indian subcontinent.

The aesthetics of Mughal buildings, their quality of spaces, the experience of living in them, their

grandeur and monumental scale, their decorations and richness in terms of elements, their surrounding gardens; the concepts and ideas and which were based on paradise, were all definitely exceptional. Muhammad Saleh Kambo defines those examples as being *nasheman hai ghareeb* (extremely rare residences) and *basaateen dilpasand nazar* (gardens with heart pleasing views)…" [33].

7. Aesthetics in Mughal Structures

The features and appearance of Mughal structures are thus coherently described in the primary sources. The most common terms used to describe the buildings are *wasee* (wide and capacious), *badee* (astonishing) and *waza nazara* (beautiful composition). These qualities were achieved by employing a number of techniques. Firstly, the buildings always rested on high *kursi* (platform) with defined *azara* (a low wall in front of a building) to make it *raafe'* (exalted). Secondly, the volumetric compositions of masses and volumes were evolved employing Euclidian geometry, monumental in scale, particularly in dealing with the main entrances. The geometrical analysis of Mughal period buildings clearly shows that the rules of geometry were strictly followed in both interior as well as exterior. Once the overall volumes are determined, the minor components are worked out using the same principles. The Mughal architects first used to analyze the whole perspective and then in relation to that, worked out the smaller details.

The major interior spaces were always double height, with adjoining spaces overlooking them. The interior and exterior volumes were composed in such a way that the overall impact always remained grandiose and unified. The beauty of the architectural composition is not only visible from the exterior but unfolds as one move from one space to another. These qualities are achieved through the use of dramatic light filtering into the interior in a variety of ways: there is direct light coming from the opening, skylights from clerestory windows at the upper levels of buildings.

Monumental scale was usually preferred in buildings that characterize the subsequent Mughal imperial architecture. The magnificent forts, palaces, gates, public buildings, mosques, water tanks and many other buildings built by the Mughals had façades which were taken as one composition and all the floors and levels within the building were made subordinate to it. All components of the building façades such as doors, windows, blind panels and *jharokas* (overhanging enclosed balconies at upper floor levels made in bricks or wood, used extensively in Mughal period architecture) were made part of and subordinate to the overall façade.

Akbar (1556-1605) was the first Mughal ruler who undertook constructions on a large scale and in his time he made an attempt to bring cultural fusion in architecture. He tried to incorporate the local architectural elements which were of Hindu origin along with the Persian, for aesthetics in the great architectural ensemble of Fatehpur Sikri. Akbar is also said to have invited the guilds of indigenous artisans from all parts of India and employed them and gave them full freedom for the display of their art. Finally the buildings that were erected combined the superb exuberance and grandeur of the indigenous arts. From then on there was no stopping for the great Mughal monumental architecture which reached its zenith.

These monumental effects were further highlighted by the use of purely natural materials for exteriors, for example red sandstone, brick along with the marble (especially white marble), which was a specialty of the Mughal architecture. The use of natural material was also associated with sustainability, as these external materials can well counter the climatic changes of the environment. As far as the structure itself is concerned the Mughals developed a roofing technology in form of flat roofs where the domical roofs were not needed. These flat roofs had a slight curvature in them for the internal side to achieve strength when they were made using bricks as the prime material. This style of architecture was not only restricted to the imperial buildings but was used extensively by the nobles and common people, thus giving the whole environment a monumental scale. Taken together, in respect to their scale, scheme and subjects, and novel in respect of magnificence and effect, unique structures were thus created by the Mughals, the likes of which the world had not seen before.

Another important design quality referred in the sources and most often describes by the *mimars*

(architects) is *hawa*. The term *hawa* denotes silhouette or profile of an architectural element. This quality is related to visual structural stability or aesthetic appropriateness of an architectural element. If an element such as arch is structurally sound but visually looks awkward or weak then it is considered that its *hawa* is not good. Therefore, *hawa* is a visual appropriateness of an architectural element such as arches, openings, and even the pillars.

8. Conclusions

It can be clearly concluded from the above description that the great Mughal architecture of the Sub-continent was a highly specialized and extraordinary field. It involved the building sciences and construction techniques, along with other fields of science such as geometry and astronomy. The practical training of architects was considered to be essential, as comparable to contemporary times. Thus, the Mughal architects were not only highly skilled in their work but also were men of many talents. They had a deep understanding of environmental studies, acoustical concerns and many other specializations, particularly with reference to sustainability. They also knew the rules of geometry and mathematics and were also experts of the Euclidian theories and astronomy. All these expertise's thus resulted in the great work of art and architecture of the Mughal era, which is, both unique and highly regarded in the history of architecture and human civilization. Principles, theories and sciences used by the Mughals should be understood in greater detail and documented for further studies, so that we can be benefit by their use in contemporary architecture.

9. References

[1] Kambo, Saleh Muhammad. *Shah Jahan Nama*. Transl. Zaidi, Nazir Hassan, Lahore:1974.P- 06.

[2] Dar, Saif-ur-Rehman. *Astrolabes and Astrolabe makers of Lahore*. Lahore Museum Bulletin, vol. VII, No. 1-2, Lahore:1994. P-66.

[3] Qaisar, Ahsan Jan & Verma, S.P. *Art and Culture*: *Painting and Perspective*. New Delhi: 2002. P-82

[4] Khavandamir, *Qanun-i-Humayun*. ed. M. Hidayat Hosain, Asiatic Society of Bengal, Calcutta: 1940. P-05.

[5] Dar, Saif-ur-Rehman. *Astrolabes and Astrolabe makers of Lahore*. Lahore Museum Bulletin, vol. VII, No. 1-2, Lahore:1994. P-163.

[6] Badauni, Abdul Qadir. *Muntakhab at Tawarikh*, *vol. II*. Transl. T.W. Haig 1899, reprint Karachi: 1976. P-268.

[7] Kambo, Saleh Muhammad. *Shah Jahan Nama vol. III*. Transl. Zaidi, Nazir Hassan, Lahore: 1974. P-27.

[8] Babur, Zahirud-din Muhammad. *Babur-Nama*. Transl. Beveridge, Annette S., London:1922.

[9] Kambo, Saleh Muhammad. *Shah Jahan Nama vol. II*. Transl. Zaidi, Nazir Hassan, Lahore: 1974. P-260.

[10] Denoting a system of geometry based on the rules of Euclid, 3rd Century B.C Greek mathematician.

[11] Kambo, Saleh Muhammad. *Shah Jahan Nama vol. III*. Transl. Zaidi, Nazir Hassan, Lahore: 1974. P-27.

[12] Chughtai, Muhammad Abdullah, *A family of great Mughal Architects*. Islamic culture, Hyderabad: 1937. P-202-03.

[13] Subtelny Maria E., *A Medieval Persian Manual in Context: The Irshad al zira'a in Late Timurid and early Safavid Khurasan*. Studia Iranica. No. 22- 2, Paris: 1993. P-26.

[14] Gauvin Bailey, *The Sweet Smelling Notebook: An unpublished Source on Garden Design*. Muqarnas: The Garden in the times of the Great Muslim Empires (special supplement VII), E.J.Brill, Leiden: 1997. P-129-39.

[15] Rabani, Ahmad. *Maqalaat-e-Molvi Muhammad Shafi, vol. IV*. Majlis Taraqeye-adab, Lahore: 1972. P- 33-43.

[16] Jahangir, Nooruddin Muhammad, *Tuzuk-I-Jahangiri*: *Memoirs of Jahangir*. (Ed.) Beveridge, Henry (transl) Rogers, Alexender, New Delhi: 1968. P-368.

[17] Kambo, Saleh Muhammad. *Shah Jahan Nama, vol. III*. Transl. Zaidi, Dr. Nazir Hassan, Lahore: 1974. P-28.

[18] Ibid, p.27.

[19] Jahangir, Nooruddin Muhammad, *Tuzuk-I-Jahangiri: Memoirs of Jahangir*. (Ed.)

Beveridge, Henry (transl) Rogers, Alexender, New Delhi: 1968. P-152.

[20] Beach, Milo C. & Koch, Ebba. *King of the world: the Padshahnama : an imperial Mughal manuscript from the Royal Library, Windsor Castle.* Washington D.C: 1997. P-131-32.

[21] Kambo, Saleh Muhammad. *Shah Jahan Nama, vol. II*. Transl. Zaidi, Dr. Nazir Hassan, Lahore: 1974. P-06.

[22] Lahori Abdul Hamid. *Badshanama. vol.I*. Transl. E.Koch, cf. transl. Nur-Baksh 1903-04. P-91.

[23] Kambo, Saleh Muhammad. *Shah Jahan Nama, vol. III*. Transl. Zaidi, Dr. Nazir Hassan, Lahore: 1974. P-28.

[24] Barraud, Richard Andre. *Modular planning of the Taj Mahal,* in *The complete Taj Mahal*. Thames & Hudson Ltd., London: 2006. P-108.

[25] Ibid, p 109.

[26] Rehman, Abdul & Anbrine, Shama. *Unity and Diversity of Mughal Garden Experiences*, in *Middle East Garden Tradition: Unity and Diversity*. (ed.) Michel Conan, Dumbarton Oaks, Washington D.C: 2007. P-225.

[27] Latif, Muhammad. *Lahore: The architectural remains*. Lahore: 1892. P-122.

[28] Mubarak, Abul Fazl. *Ain-i-Akbari, vol. I*. (Ed.) H. Blochmann, H. S. Jarrett, 1868. P-100.

[29] Ali Mardan Khan, a Persian from Kerman, was viceroy of Punjab (which then stretched from Kabul to Delhi) under the rule of Mughal emperor Shah Jahan. He was Qandahar's governor under Safavid ruler Shah Tahmasp before surrendering the province to the Mughals and taking refuge in Dehli in 1637. In 1639, Ali Mardan was given the title of Amir-ul-Umara and was made a Haft Hazari (commander of 7,000 troops), for his services to the Mughal court.

[30] Ganj-Ali-Khan was the ruler of Kerman, Herat, and Qandahar during the reign of Shah Abbas I from 1596-1621. His architectural undertaking in Kerman, Ganj-Ali-Khan Complex is well known. However, he was also the patron of many other buildings, gardens, and Qanats in his thirty years reign. Soroush, Mehrnoush and Khazraee, S. Emadeddin. *Patronage and the Hidden Aspects of the History of Iranian Art, GOLESTAN-E HONAR, Vol. 4, No. 3* (Serial No.: 13), 2008.

[31] Kambo, Saleh Muhammad. *Shah Jahan Nama, vol. II*. Transl. Zaidi, Dr. Nazir Hassan, Lahore: 1974. P-32.

[32] Foster, William. *Early Travels in India 1583-1619*. London: Oxford University Press, 1921. Reprint: Oriental Books Reprint Corporation, New Delhi: 1985. P-165-166.

[33] Kambo, Saleh Muhammad. *Shah Jahan Nama, vol. III*. Transl. Zaidi, Dr. Nazir Hassan, Lahore: 1974. P-31.