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**TYOLOGICAL STUDY OF DOMES IN ISLAMIC
ARCHITECTURE OF NORTH INDIA**

Asif Ali (a)*, Ahmad Sanusi Hassan (b)

*Corresponding author

(a) School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, Malaysia, asifali@student.usm.my

(b) School of Housing, Building and Planning, Universiti Sains Malaysia, Penang, Malaysia, sanusi.usm@gmail.com

Abstract

Since the ancient time, man had constructed domes as a roofing solution in the buildings. Ancient Romans and Persians utilized the full structural properties of arcuated system (structural system based on arches and domes). With the growth of Islam in Central Asia and Persia, Muslims adopted the arch and dome in the construction of their buildings and further developed and enhanced their visual and structural qualities. With the arrival of Muslims in India, along with a new culture, they introduced arcuated techniques of constructing buildings in the region. In the beginning, there were some stylistic conflicts but afterwards Indian masons learned the structural principles of arcuated system and enhanced its visual possibilities to its peak. During early Muslim period, the design and construction techniques of domes were flourished and further innovated by Mughals. This paper presents typological analysis of domes in Islamic architecture of North India and explores its stylistic development.

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Keywords: Mughal architecture, domes, architectural history, typological study, arcuated system, medieval India.



1. Introduction

From prehistoric period domes had been used by mankind and ancient Romans and Persians utilized the full structural properties of arcuated system (Buildings with arches and domes). Thus arches, vaults and domes turned into essential elements of Roman and Persian architecture. As Islam reached to Central Asia and Persia, Muslims used this indigenous technique of the region for their buildings. They further innovated and improved the arches and domes construction system. They developed pointed and horseshoe arches to the extremes of their aesthetic values and structural capabilities. When Muslims conquered India, they introduced these technologies to their new territory. As corbelled techniques were prevailed in the region, many Jain temples had been using corbelled dome as a roofing solution since ancient period (Khan, 2014). In the beginning, the Muslim rulers expected the construction of early buildings in India in an arcuated system. But Indian masons applied corbelled techniques for the construction of arches and domes, because they were not familiar with the technique of a true arch. The resulted alien structures resembled to arches and domes, however they were not truly based on arch action. Later the Indian masons learned the structural principles of arcuated system and enhanced the structural and visual possibilities of this technique. Appearance of first arch in India marked the beginning of new era in the realm of arch and dome construction. During Sultanate period the domes construction were experimented and developed and it reached at its zenith during Mughal period. Medieval Indian domes are broadly consist four components viz. finial, inverted lotus, dome and drum (figure 01).

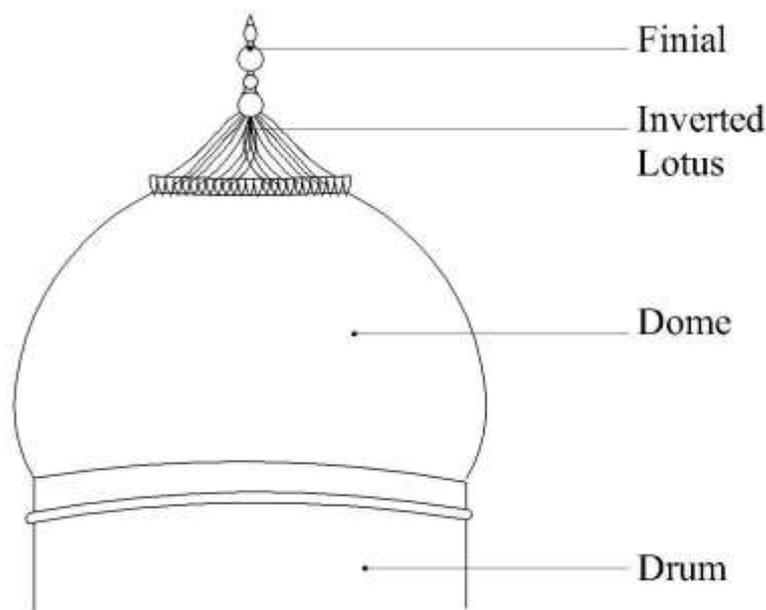


Figure 01. Components of a typical medieval Indian Dome (Source: Drawn by author)

The building elements in the past were first evolved due to structural significance and later with morphological refinements they reached to their aesthetic peak. The dome is primarily a structural solution for roofing but being a dominant element it had been experimented for their aesthetic value too. Shallow domes due to their non-appearance in the elevation were not considered to be embellished on the external surface. But as the domes got a significant mass, their positions over the top of the buildings dominated and

caught the attention of the viewer. They defined the skyline and governed the silhouettes of the cities. Domes apart from their structural and roofing function they also have symbolic value. This paper will investigate the typology of domes on the basis of their morphology from early Islamic era to late Mughal period in North India. The case studies were selected from Delhi and Agra, two capital cities of Muslim rule in North India (figure 02). The research will encompass the evolution and stylistic development and analysis of domes in chronological order and its classification on the basis of its form. This research shall fill up the gap in the literature available regarding Islamic architecture in India specifically pertaining to domes.

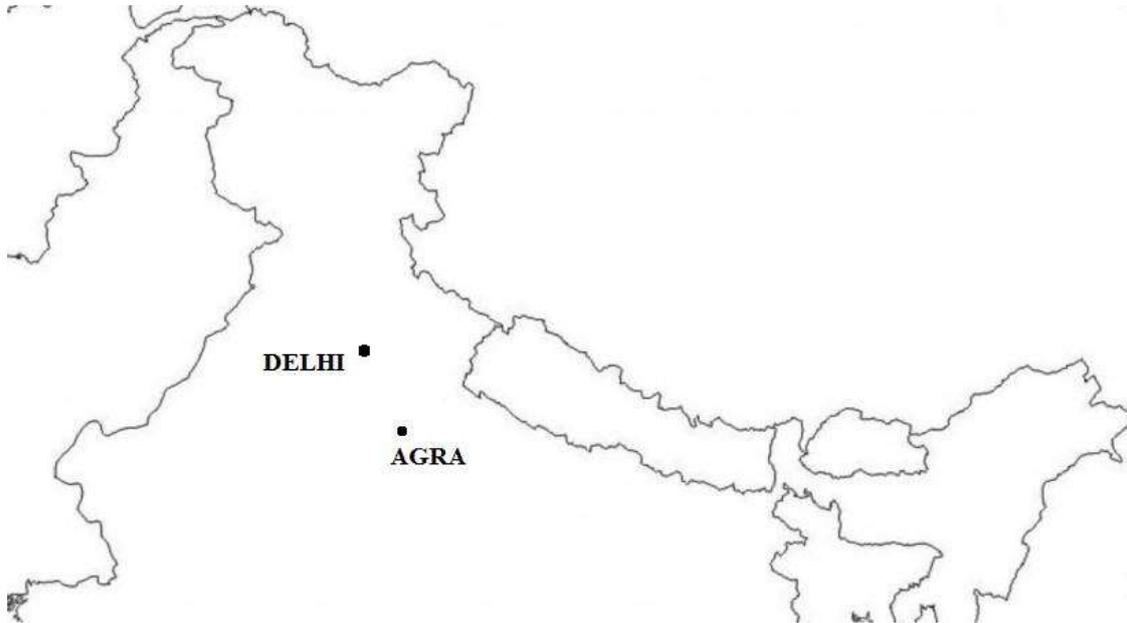


Figure 02. Map of Northern India

2. History

The dome of Sarvestan Palace (figure 03), the first brick dome with squinches was constructed by Persians (Bier, 1986), while the dome of the rock is considered the first dome of Islamic architecture (Grabar, 1963). Earliest domes are originated in Parthian and Sasanid period however; early Islamic domes in Persia were of conical type (Saoud, 2004). Some of the conical domes were double shell to protect the inner dome from humidity due to heavy raining (Mohammad Aliabadi, 2015). Chahar Taq concept of Sassanid was implemented for the construction of central portion of Islamic prayer hall and two wings were added to fulfil the purpose of liturgical worship in Islam. Before reaching India, Islamic architecture and culture travelled through Persia and Central Asia, almost a journey of five hundred years and by that time Islamic art and architecture had been reached to its matured stage.



Figure 03. Sarvestan Palace (Commons.wikimedia.org, 2017)(Source:-
https://commons.wikimedia.org/wiki/File:Sarvestan_Palace_4.jpg retrieved on 27/03/2017)



Figure 04. Humayun's tomb (Source: -Author)

Almost every Islamic dynasty in India had some innovation in the design of dome and maintained the continuum also. Five dynasties of Sultanate period, Slave, Khilji, Tughlaq, Sayyid, Lodi and finally Mughals contributed to the development of domes in India. In the beginning of Islamic rule, Indian masons build corbelled domes for the monuments of new conquerors and the best example can be seen in the earliest monuments like Quwwatul Islam mosque. Many artisans migrated from Persia and central Asia to India due to Mongol's devastation in thirteenth century. Later Suri's invasion in India and long stay of Humayun in Persian refuge influenced the contemporary architecture. Its greater consequences appeared in the form

of double domed building in India like Humayun's Tomb (figure 04). Double shell bulbous dome of Humayun's tomb was inspired from the architecture of Central Asia and Persia. Earliest examples of double dome could be seen in eleventh century Persia (Ashkan, Ahmad, & Arbi, 2012). In a double shell dome there is a considerable space between the two shells. The inner shell was semicircular and was proportionate with the internal space. The double shell dome was very common in Persia and central Asia. The practice of double shell dome was continued till late Mughal period and finally an onion shaped dome came into picture. The arcuated system was continued till the British period in designing public buildings in India (figure 05). However it is associated with religious buildings till date (figure 06). Because of their long association to religious buildings, these elements have symbolic and metaphorical value too.



Figure 05. Dome on Supreme court building built during British period (Igyaan.in, 2017)
(Source:https://www.igyaan.in/wp-content/uploads/2016/02/Supreme_Court_India_CSR_SLSV.jpg
retrieved on 25/03/2017)



Figure 06. Dome on a contemporary mosque, New Delhi (source: -Author)

3. Structural Support System

Geometrically dome can be generated by rotating a segment of arch around a vertical axis. The form of the dome depends over the position of centres of segment of arch with respect to its springing point (Elkhateeb, 2012). Any arch due to its self load or superimposed load tends to be flattening and exerts an outward force at the base. Abutments at the end provide a nullifying effect to this outward force. If the amount of force exerted by abutment is less to the outward force of arch, it may collapse. In the same way the outward force is exerted by the domes over the infrastructure partly. But dome due to its three dimensional shape and bonding of material also resist its circumference to be stretched. Thus the strength of a dome depends more on material and the mortar used. Dome exerts force to the around its perimeter which required a continuous support all around. This phenomenon devises to develop the transitional structural elements like squinches or pendentives from a square space to a circular base of dome. Squinches are diagonal niches at the corners in the form of arch/arches or corbelling to transfer the square into octagonal base to make it structurally stable (Figure 07). Dome surmounted over squinches were evolved in Persia while pendentives were first used in Byzantine. Pendentives are triangular arched segments pointed at the corner of square base and circular at the top to provide a base to the dome. Unlike squinches, pendentives don't have octagonal mass in between square and circle and they are pointed at their bottom. The stalactite is another way to fill the transitional gap between square space and circular base of dome. In this method the small squinches in the form of stone corbel projected at different level till it reaches to the circular base of dome. These stalactites are called muqarnas and they provide a smooth transition from square to circle. In India squinches were used in the early period but later, in Mughal period stalactites were used for transition of dome.

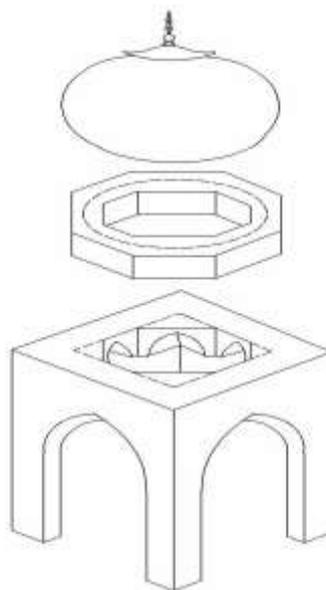


Figure 07. Squinches, as structural support to the dome

4. Research Methods

The study applied a visual and historical survey of domes by physical survey and analysing photographs of buildings. The shapes of the domes were taken from the photographs and traced their silhouettes on AutoCAD (figure 08). A maximum care had been taken to reduce the distortion of shape due to perspective illusion. On the basis of observation and documentation, the types of dome are recognised and representative buildings with peculiar shapes of domes were studied. The chronological orders of studies were considered but the stylistic typologies were not bonded with a particular dynasty. Study is limited to two Muslim capital cities in North India, Delhi and Agra, which remained the epicentre of Muslim rule throughout history. Due to many conservation activities the shapes of domes had been undermined and plastering and repairing changed their proportion. Those works which have been distorted the shapes due to poor restoration have not been included. For example in case of Bara Gumbad, dome look more hemispherical just because of its improper plastering and repairing while the contemporary domes have a sudden pitch of curvature at the upper part of the dome.

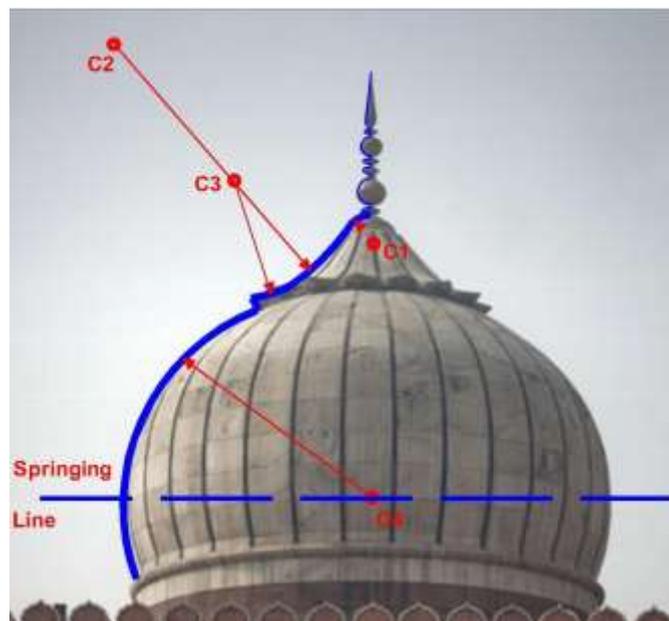


Figure 08. Profile of dome traced on Auto Cad (Source: -Author)

5. Findings

India has a long history of using corbelled domes and these were constructed in Jain temples first. In the early period of Muslim rule, many Indian artisans were employed for the construction of new monuments. Consequently the early domes in Islamic architecture of India were corbelled as part of indigenous roofing solutions. The first Islamic monument in North India, Quwwatul Islam mosque had been roofed with these types of domes (figure 09). Other example of this kind of domes in contemporary mosque is at Adhai din ka jhonpra at Ajmer. Scholars presume that the dome of Iltutmish tomb was built in corbelled technology but due to its huge structure it fell down later.

The first true dome was reflected in Alai Darwaza, a shallow dome with finial at its top (Saquib, 2014). During Khilji period shallow domes were predominated, its other example could be seen at Jamat khana mosque at Nizamuddin, Delhi (figure 10). The structure was supposed to build as a tomb for the great saint Hazrat Nizamuddin but he preferred to be buried in the open and later it was converted into mosque. In this mosque, three shallow domes are raised on octagonal base transited through squinches of multiple projecting arches. Shallow dome has its centre below the springing point and follow the segmental curve and the height of dome was lesser than the radius of its base. With the passage of time the height of the dome was necessitated to make it more proportionate to buildings outer profile. During Tughlaq' period the rise of dome was increased, like in case of Giyasuddin Tughlaq's tomb (figure 11). The dome seems multi central while its lower curvature has its centre at the springing plane. This dome is adorned with vase and melon finial (kalash and amala), a typical Hindu temple characteristic.



Figure 09. Interior of corbelled dome at Quwwatul Islam mosque (Shapedia, 2017) (Source:- <https://www.sahapedia.org/domes-of-delhi> retrieved on 30/03/2017)



Figure 10. Jamat Khana Mosque, Delhi (Archnet.org,2017) (Source:- https://archnet.org/system/media_contents/contents/112254/original/IAA124436.jpg?1464274257 retrieved on 20/04/2017)



Figure 11. Ghiasuddin Tughlaq tomb (Classconnection.s3.amazonaws.com, 2017) (source:- https://classconnection.s3.amazonaws.com/706/flashcards/4280706/png/tomb_of_ghiuas_ud-din_tughlaq-142E3FDD4093F48C5CB.png retrieved on 30/04/2017)

During Lodi period many octagonal tombs were built. The domes in this period were lofty in comparison to the previous dynasties. A high octagonal drum generally was used to increase the height of the dome. The shape of the dome looks very similar to semicircular but there is a sudden change of the pitch of the curvature of dome at upper part which makes it different from hemispherical dome (Figure 12). This kind of dome was continued till the early Mughal period and Shershah Suri's time. Monuments, like Masjid Bara Gumbad, Qila-e-Kuhna mosque, Khairul Manazil Mosque and Abd-al-Nabi mosque were surmounted by this type of dome.



Figure 12. Sikandar Lodi Tomb (Upload.wikimedia.org, 2017) (source:- https://upload.wikimedia.org/wikipedia/commons/a/af/Tomb_of_Sikandar_Lodi_011.jpg retrieved on 25/03/2017 retrieved on 30/03/2017)



Figure 13. Bulbous dome at Humayun's Tomb (source:- author)

A major change in the shape of domes in India was influenced with the introduction of bulbous dome in Humayun's tomb (Figure 13). The centre of the bottom curvature of the dome was lying above the springing point which casted a bulge out near the drum. The double shell dome not only provided a bulbous shape but it also made the outer shell proportionate to the outer mass of building. This may be observed in case of Taj Mahal more explicitly, where a considerable space was provided to bring in proportion with the external hierarchy of building masses. Bulbous domes were equipped with high drum and converted into many shapes. The drum is sandwiched between transition layers and the shells. Later the shapes presented more bulging out quality from the line of drum and an onion shaped dome was developed by raising the centre of curvature over the springing point (Figure 08). These domes look spherical with more elongated inverted lotus and high finial. This typology further experimented with more height in eighteen century and became a typical characteristic of religious buildings. Even many contemporary temples were also adorned with onion shaped dome as the dome was associated to the sacredness. Finally after the declination of Mughal rule the onion shaped dome was further used in the provinces with an inexpensive material. Onion shaped domes have comparatively larger diameter than its drum and its top curvature slanted steeply with a smooth transition to lower bulbous part. The constricted neck made the shape of the dome more prominently bulged out. Morphological changes in the shape of dome in chronological order have been presented in table-01.

Table 01. Chronological development of dome in North India

	1300AD	1400AD	1500AD	1600AD	1700AD	1800AD
	SLAVE	KHILJI	LODI	MUGHAL DYNASTY		
Corbelled						

Shallow					
Single shell					
Bulbous					
Onion-shaped					

6. Conclusion

Muslim already had been experimenting for a period of five decades on the design of domes in Central Asia and Persia but the Indian innovation could be clearly observed during Sultanate and Mughal periods. In the development of dome's changing morphology, every dynasty contributed remarkably. Similar to pre Islamic structures early domes of Islamic period were corbelled in India. Early true domes were shallow and later they became dominant visual elements of monumental buildings. During Tughlaq and Lodi periods the domes were lofted over octagonal drum and converted into more pointed shape. With the introduction of double shell dome in early Mughal period the dome took bulbous shape and it became a prominent structure of monuments. Later more bulging out characteristic of bulbous domes were developed into onion shape with constricted neck. Squinches were dominated primarily during Sultanate period for the transition from square to circle, while in Mughal period muqarnas were used. Inverted lotus with finial was a typical characteristic throughout ages to adorn the dome. The dome which was primarily a roofing solution became a dominated visual element in Islamic architecture in India. It is strongly associated with religious buildings in the contemporary world. This study provides a morphological analysis of domes in India which may help contemporary designers to develop the massing of the buildings with domes in appropriate proportion.

Acknowledgments

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