

PERSIAN DOMES: HISTORY, MORPHOLOGY AND TYPOLOGIES

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Abstract

Persian master builders had introduced an architectural innovation which had an imperishable effect on dome architecture in the Middle East and Central Asia: surmounting a dome on squinches. This paper aims to provide a broader perspective of Persian domes as the most significant feature of Eastern domes in the Middle East. As opposed to previous general historic studies, this paper introduces a new analytical approach directed towards analysis of architectural concepts and stylistic attributes of Persian domes based on an epistemological premise of their space syntax. By analytic reviewing of examples, the paper addresses the origin of Persian domes, their formal morphological constitutions, and their typological forms based on the diversity of the external shell over the specific timeline, from the pre-Islamic era through the Qajar period in Iran. The study of the Persian dome's characteristics can illustrate undiscovered information about the essences of developing dome constructions in the Middle East. It can also establish new design standards regarding the frameworks of domical building configurations to be used for creating typological diversity in dome design and to renew the morphological principles of the traditional dome compositions in contemporary architectural designs. Finally, the insights gained can inform conservation efforts on domical structures in the region and elsewhere.

Keywords

Dome history, Persian domes, Islamic domes, morphological constitutions, typological arrangements.

Introduction

The fundamental contributions of Persian architecture in dome development in the Middle East and Central Asia are firstly the establishment of the foundations for using masonry domes to cover the chamber halls, and secondly the innovation of an approach for transferring from the square to the circle, namely, squinches which mainly appeared in the Sassanid period. Domes are certain elements of Persian architecture which were widely developed after the coming of Islam. They differ considerably in type and shape. Persian domes are commonly well-known due to their various typologies, proportion of components, specific forms, and graceful designs.

One of the main reasons for rapid development of Persian domes in Islamic architecture is rooted in their specific symbolic meanings. Persian domes can be considered as a bridge between

the infinite unity of "centrality" and the duality of their symbolism that were used to concretize the four-sided chamber dedicated to the four natures of human beings. So far, the typological and morphological issues are hidden under the general historical surveys. Moreover, the dome architecture considerations according to analytical approaches have often been given less attention. In this regard, the main objective of this research is to provide a broader panorama of the formal architectural language of Persian domes including their morphological features and distinct typological characteristics, based on the essences of architectural composition structuralism. Additionally, to achieve such objectives, understanding of their conceptual evolutions and style developments over historic eras is required.

By analytical analysis of Persian domes, firstly, their architectural development issues can chronologically be discussed and addressed; secondly, it provides a new methodology for considering the architectural language of other types of traditional Islamic domes in the Middle East and Central Asia. Besides that, the compositional language of Persian dome styles can powerfully be translated as contemporary design principles to help preserve aesthetical aspects of traditional dome morphology and typological diversity in contemporary design. Understanding of various typologies of Persian domes also contributes to the formulation of valuable traditional standards which should be considered in conservation interventions.

Hence this paper is divided into three parts as follows: 1) a historical review of the Persian dome's evolution since the beginning until the Qajar period (the late Islamic era) by reviewing famous samples; 2) elaboration on their

common morphological features and typical arrangements of their components; and finally 3) classification of their common typologies based on distinct forms of their external shell over a specific time line.

Origin and Architectural Evolution of Persian Domes over Historic Eras

Persian domes display great diversity both in structure and aesthetics. According to Pope (1976), the dominant element in Persian architecture is the dome which immediately attracts visitors' attention. In general, several concepts of Persian domes demonstrated mankind's attempts to symbolize philosophical thoughts upon, firstly, traditional astrological sciences, and later mystical meanings of Islamic philosophies.

Architecturally, the vast diversity of Persian domes resulted in the fairly continued developments of previous traditions and experiences of dome practice over historic epochs. Historically, the most important sign of primary domes in the ancient Persian architecture are the remains of a large domical building excavated in the Parthian capital at Nyssa (Turkmenistan) (Grabar, 1963, p. 191; 2006, p. 87). There was a hall with thick walls surrounding four columns in the center and niches for statues on the walls and topped probably with a wooden dome (Figure 1).

In this regard, the second remaining types of the oldest Persian domes are innumerable samples of oval-shaped domes which were widely erected on the Zoroastrian temples, called, 'chahar-Taqi' (four vaults) (Pope, 1965). Their main features consist of a cubic base of

four supporting elements connected by arches and covered by a dome; these were the sacred places of the Zoroastrian eternal flame (Smith, 1971) such as Niasar Zoroastrian temple in Kashan and four-Taqi in Darehshar (Ilam) (Figure

2). Creswell (1958, p. 83) clearly demonstrated that these 'chahar-Taqi' in Persian pre-Islamic architecture have mainly influenced all later mosques' concepts after the coming of Islam.

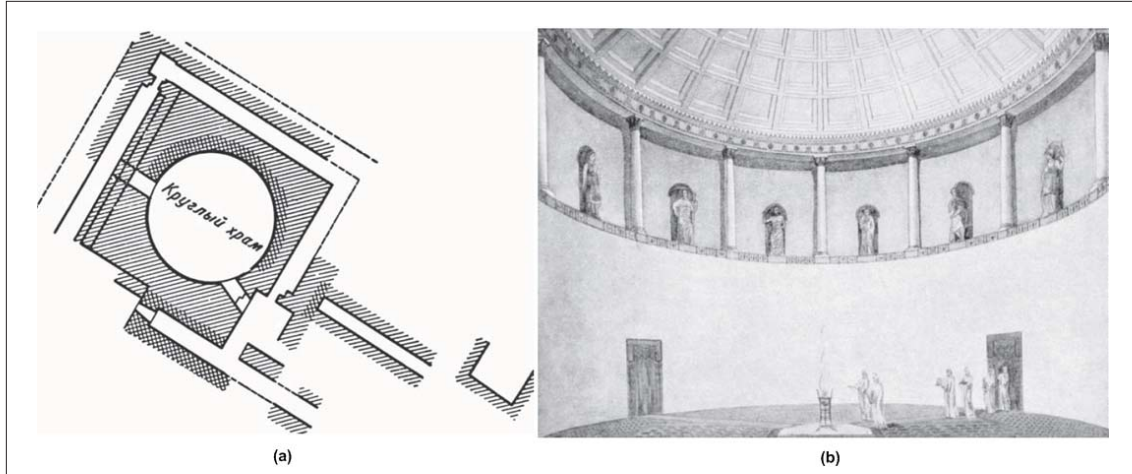


Figure 1: a) Plan of the circle hall, Nyssa; b) Reconstruction of circular hall. (Source: Grabar, 1963).



Figure 2: a) Four-Taqi (four vaults) in Darehshar, uncertain period, Ilam; b, c) Niasar Zoroastrian temple, Sassanid era, Kashan. (Source: Authors).

During the Sassanid Empire, the most essential innovations occurred in dome architecture with the construction of semi-elliptical domes which were often erected on reception halls of palaces such as domes over Sarvestan palace and Ardeshir palace (in Firuzabad) (Smith, 1971). These domes were placed on the first samples of squinches which had an everlasting effect on dome development in Islamic architecture (Creswell & Allan, 1990; Grabar, 2006). The squinches are conceptually mini-arches which were used for filling corners diagonally by building arches or numbers of corbelled arches (Hejazi, 1997). Bier (1986) believed that the domes of Sarvestan palace (also known as "The Temple of Anahita", about

350A.D.) are considered as the oldest brick domes in the world which topped the most splendid sacred monument constructed during this era. Its biggest dome, with a semi-elliptical 12.80 m span, and height of 20m, however, are not as enormous as the one surmounting the Ardeshir palace in Firuzabad (Figure 3).

According to Sykes (2003), the Zoroastrian temple and palace of Ardeshir in Firuzabad (c. 250 A.D.) is a famous and imposing domical monument of the Sassanid epoch. The building consists of three huge semi-elliptical domes (13.30m spans) rested on squinches as transition parts; these domes were constructed of local rocks and mortar with plaster work inside (Figure 4).



Figure 3: Domes of Sarvestan palace with primary samples of squinches, Sassanid era. (Sources, photos: www.treearth.com/gallery/Middle_East/Iran/East/Fars/Sarvestan/; The vertical section: Authors).

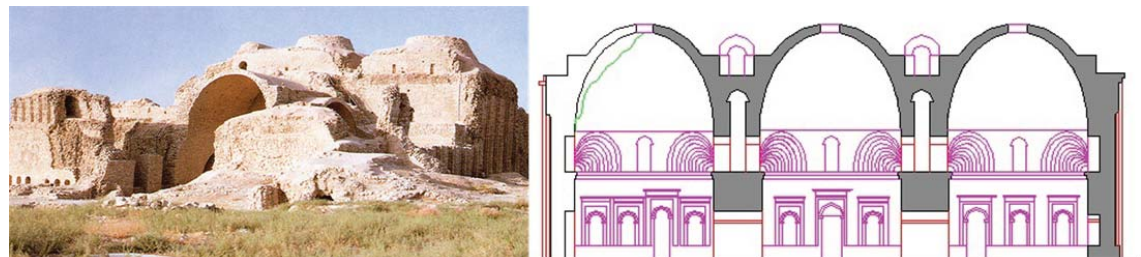


Figure 4: The Zoroastrian temple and palace of Ardeshir, Sassanid period, Firuzabad. (Source: Authors).

Architectural Evolution of Persian Domes after the Coming of Islam

With the Islamic conquest, Sassanid sacred 'chahar-Taqis' were easily converted into the mosque's main hall by inclusion of a 'mihrab' (Petersen, 1999, p. 124; Pope, 1976, p. 68). Nevertheless, the basic dimensions of the Sassanid domes also probably remained constant throughout the development of Islamic architecture (Wilber, 1969). The symbolic meanings of the pre-Islamic domes were often significantly traced and developed according to new religious thoughts (Kentish, 1997) such as: figuring paradise, the central focus of the Ka'ba on Earth, and the house of God (heaven). During Islamic eras, every dynasty had improved upon the previous technical methods and prompted new artistic qualities, without destroying the older aspects (Bosworth, 1996). Nevertheless, the course of Persian dome renaissances and their specific conceptual characteristics mainly occurred following the appearance of five specific dynasties. They are the Seljuks (1038-1194 A. D.), Ilkhanids (1256-1353 A.D.), Timurids (1370-1506 A.D.), Saffavids (1501-1732 A.D.)

and finally Qajars (1779-1924 A.D.) (Bosworth, 1996). These dynasties gave to the domical constructions their distinctive characteristics, as will be shown later by review of their dominant samples (Figure 5).

As the result of flourishing Persian architecture in the Seljuk era, the great diversity of funerary (more than religious) building usages have widely been built including single tomb towers (known as " Turkish Triangle") and cube mausoleums which were topped with several types of one and two shell domes (Hillenbrand, 1999; Saud, 2003). Various types of conical, semi-circular, and pointed shapes were considered as common appearances of the Seljuk dome (Saud, 2003). In this regard, the semi-circular dome over the Friday mosque of Qazvin (1200 A. D.) which was built on the Sassanid fire temple according to excavations (Figure 6) is the biggest Seljuk dome with a span of 15.20m and height of 22m (Memarian, 1988).

In terms of pointed samples, Taj-al-Mulk dome (with 10.70 m span and 19.50m height) of Jamek mosque (1086- 87 A.D.) in Isfahan is the

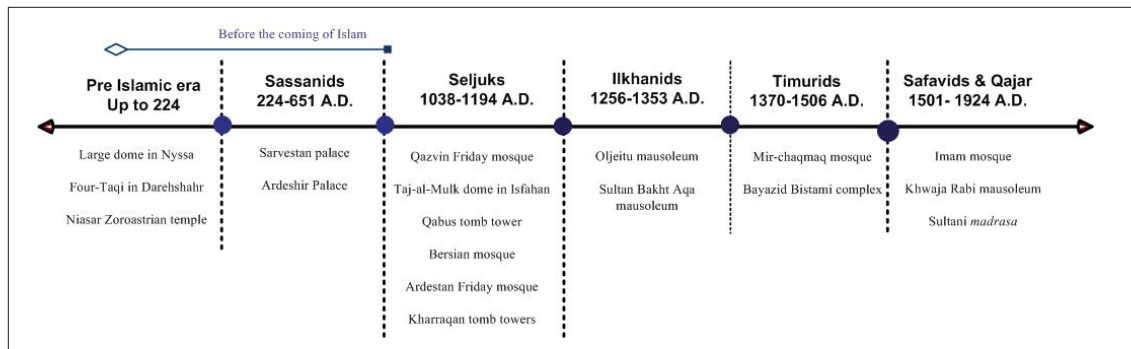


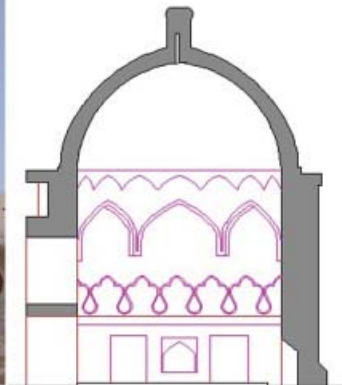
Figure 5: Illustration of the selected dynasties and their dominant selected samples. (Source: Authors).

most beautiful structure and ultimate sample of the Seljuk architecture in Persia (Figure 7). Its aesthetic and sophisticated application of its golden proportion had been demonstrated by several scholars such as Pope (1976) and Hejazi (1997). The thickness of its shell reduces from the base to the kick point of the dome.

The celebrated Gonbad-e Qabus (or Kavous) (Figure 8) is the earliest cylindrical tomb tower (over 1000 years old) with a conical top (9.70m span and 57m height) that holds an important place in Seljuk architecture; this style later spread to the other regions of the Middle East and Central Asia such as Turkey and Turkmenistan (Hillenbrand, 1994; Saud, 2003).



(a)

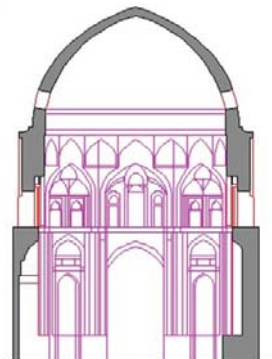


(b)

Figure 6: a) Jamek Kabir Mosque, Seljuk era, Qazvin (Source: www.members.virtualltourist.com/m/p/m/3dfa15/); b) The Transversal section. (Source: Authors).



(a)



(b)

Figure 7: a) Taj-al-Mulk dome of Friday mosque, Seljuk era, Isfahan. (Source: www.flickr.com/photos/21472558@N04/2915728769/); b) The vertical section of dome chamber. (Source: Authors)

Arguably the most important achievements of the Seljuk architecture are mainly two methods for resolving conflicts in the design using two shells in such a way that the external shell was divorced from the internal shell at a 22.5° angle from their bases. Regarding the primary method, Ayatollahi (2003) introduces two ample samples; firstly, the dome (10m span, 21m height) over the Bersian mosque, which is considered one of the oldest Persian mosques (1105 A. D.) located in Isfahan city, is conceptually and architecturally very similar to the Taj-al-Mulk dome of the

Friday mosque of Isfahan (1086- 87 A.D.) (Figure 9a). Its internal shell consists of eight brick ribs. Secondly, the continuous double-shell dome (10m span, 21.6m height) of the Ardestan Friday mosque (1000-1100 A.D.) which is considered the result of the continued evolutions during several building periods, was added in the early Seljuk era (Figure 9b). Compositions of its squinches tier and internal bearing walls are typical features of the Seljuk architecture and very similar to the previous samples such as Taj-al-Mulk dome in Isfahan. The second method

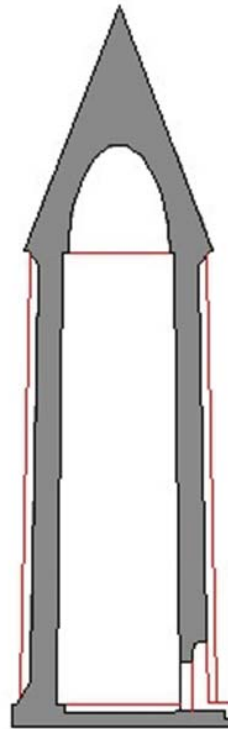


Figure 8: The famous conical Gunbad-e Qabus tomb tower, Seljuk era, Golestan. (Source: Authors).



Figure 9: Two main samples of the continuous double-shell domes in the Seljuk architecture. (Sources of both transversal sections: Authors): a) The Bersian mosque in Isfahan (Source: www.kousha.fotopages.com); b) The Friday mosque in Ardestan. (Source: www.archnet.com).

was the construction of the primary type of discontinuous double-shell domes in which the shells are completely disconnected. A couple of Persian tomb towers in Kharqan are considered as the earliest known discontinuous double-shell domes (6.45m span, 12.85m height) in the world (Figure 10; Mainstone, 2001, p. 124). Both their internal and external shells have similar thicknesses and profiles. They were also composed without internal connections and interconnecting wooden struts (Mainstone, 2001, p. 124).

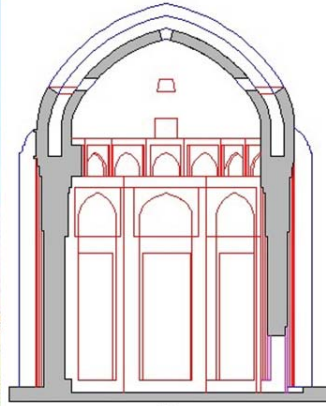
After architecture had suffered severe degeneration caused by several Mongol invasions, the material culture of Persia flourished again with the appearance of the Ilkhanids and Timurids and characteristics of their specific architectural characteristics: enhancing the enormous scale of domes by using high drums. The constructions of the tomb towers considerably decreased in comparison to the Seljuk era as a result of the development of several types of discontinuous double-shell domes (Michell, 1978). The systematic

architectural configurations of domes were extensively developed such as adding various compositions of internal stiffeners, increasing the number of shells from double to triple (in the conical typology), and developing proportionality of shells.

The best examples, which show the specific development of Persian domes in the Ilkhanid epoch include first the dome of Oljeitu mausoleum (1302-12 A.D.). It consists of two thin shells which are divorced at an angle of 22.5' (30m span, 52m height). Its shells, however, are connected by small brick connectors in regular distances in the upper part. Its oculus completely distinguished this dome concept from the other Persian domes (Figure 11; Stevens, 1979; Pope, 1976). Professor Piero Sanpaolesi strongly believed that this dome, due to some similarities existing in their configurations, might definitely be the origin of the dome of the Cathedral of Santa Maria del Fiore in Florence, built by the celebrated Italian architect Filippo Brunelleschi (Vasseghi et al., 2007).



(a)

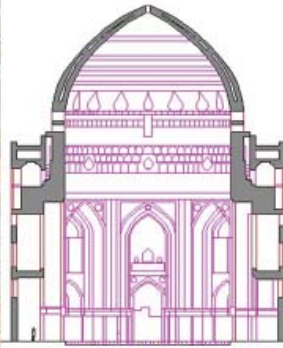


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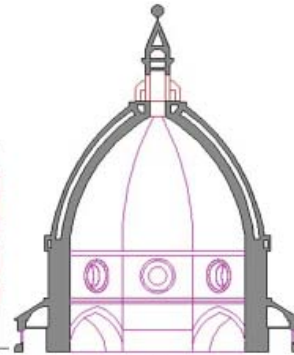
Figure 10: a) Tomb towers topped with the primary samples of discontinuous double-shell domes, Seljuk epoch, Kharragan (Huerta, 2001 and Authors).



(a)



(b)



(c)

Figure 11: a) The continuous double-shell dome of the Oljeitu mausoleum, Ilkhanid era, Sultaniya (Sources photo: www.flickr.com/photos/27784269@N06/2597944165/); b) The transversal section: Authors); c) Cross-section of dome of famous Cathedral Santa Maria del Fiore, Florence (Huerta, 2001).

The second sample is the dome over Sultan Bakht Aqa tomb (1351-52 A.D.) which indicates major advance in the design of Persian dome configuration. It is the earliest known example of a double dome (7.5m span, 18m height) with developed composition of radial stiffeners and wooden struts in which the inner and outer shells have substantially different profiles (Figure 12; O' Kane, 1998). This innovation for

differentiating between the internal spaces and the external appearances of domes rapidly spread throughout various regions of the Middle East and Central Asia, and contributed to the creation of the united styles of the Timurid dome architecture later on.

In the Timurid era, marked by collaborations of several celebrated mathematicians, a

variety of geometrical approaches had widely been used for designing domes (Hogendijk & Sabra, 2003). The well-known sample of Timurid

architecture in Iran is the shallow pointed dome (6m span, 14.3m height) of the Mir-Chaqmaq mosque (1437 A.D.) which marks the advanced

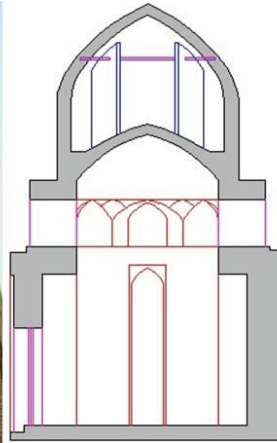


Figure 12: The discontinuous double-shell dome topped the Sultan Bakht Aqa mausoleum, Ilkhanid era, Isfahan. (Source: Authors).

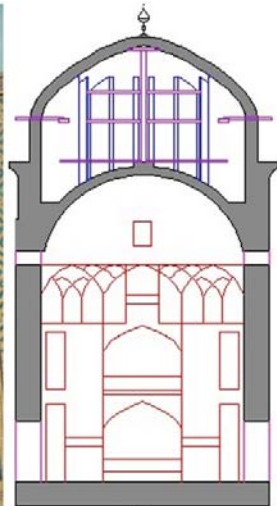


Figure 13: a) The Mir chaqmaq mosque, Ilkhanid era, Yazd. (Source: <http://archnet.org>); b) The vertical section of dome chamber. (Source: Authors).

(a)

(b)

composition of the internal stiffeners and wooden struts that ever appeared in Persian dome design (Golombek & Wilber, 1988). Its huge semi-circular internal shell was placed on the large console mini-arches as the squinches tier. The two-tiered circular drum is the significant feature of this pointed discontinuous double-shell dome (Figure 13).

In addition, the conical dome of the Bayazid Bistami shrine complex which is the oldest conical dome (span 8m, height 20m) with triple-shell, demonstrated the advanced

development of dome architecture in the Timurid era. It dated from the early Seljuk period and was compositionally developed in this era by the addition of a third shell (Figure 14).

The emphasis on the greatness of buildings, which reached its high level of development in the Timurid era (Gangler, 2004), continued to be a principle in the Saffavid Empire (16th -17th Century) including Persia and nearby areas. The most significant accomplishment of this era embraced distinct bulbous domes which are considered as the last generation of

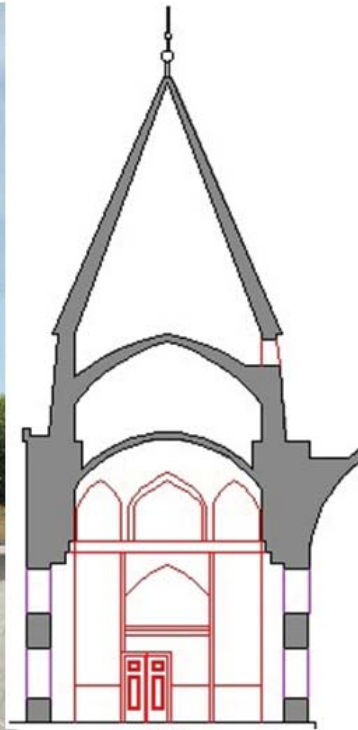
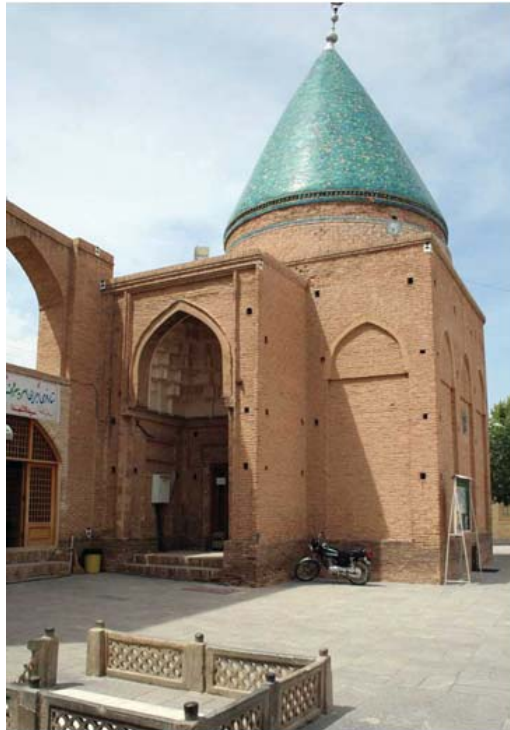


Figure 14: a) The conical dome of tomb of the Bayazid Bistami complex, Bistam. (Source of photo: www.panoramio.com/photo/9040385); b) The vertical section of dome chamber. (Source: Authors).

Persian domes. They exerted great influence on architectural styles of Islamic domes, especially in the late Mughal period in India (Stierlin, 2002). On the other hand, the dominant features of the Saffavid domes are general use of lighter structures (by reducing the thicknesses of shells and walls), lots of colored glazed tiles (e.g., yellow, green, blue, and gold), and complex nets of vegetation (Blair & Bloom, 1995). The dominant existing sample is the Imam mosque (Masjid-e Shah or Royal mosque, 1611ca. 1638 A.D.), which is one of the finest Islamic edifices in the world, topped with an imposing bulbous discontinuous double-shell dome (33m span, 52m height). The fact that under its internal shell a sound echo is equally heard in surrounding halls demonstrated the deep knowledge of the acoustic and structural designs of its master builder (Figure 15; Stierlin, 2002).

The second sample is the octagonal mausoleum of Khwaja Rabi (1617-1622 A.D.), which Byron (1982, p. 121) describes as the traditional Persian architectural typology. It embraces the oldest

version of the Saffavid onion dome (28m height) (Figure 16; Byron, 1982, p. 121; Pope, 1976).

With the appearance of movements for transferring from traditional to modern architecture, the innovation approaches in dome constructions became less important in Persian architecture in the Qajar period (1779-1924 A.D.). The few remained edifices are religious schools (madrassa) and these reveal simple appearances without utilizing the mass of tiled mosaics. One of the famous samples is the dome over Imam madrasa (or Sultani school, 1848 A.D.) which was replicated according to the typical bulbous concept of the Saffavid domes (22.5m span, 25m height). In fact, its shallow discontinuous double-shell with onion external shell shape is structurally lighter than the model domes of the Saffavid era in Isfahan (Figure 17; Memarian, 1988).

Nevertheless, in Persian architecture, the roles of quite special instructions of rulers and patrons in the creation of masterpiece domes such as

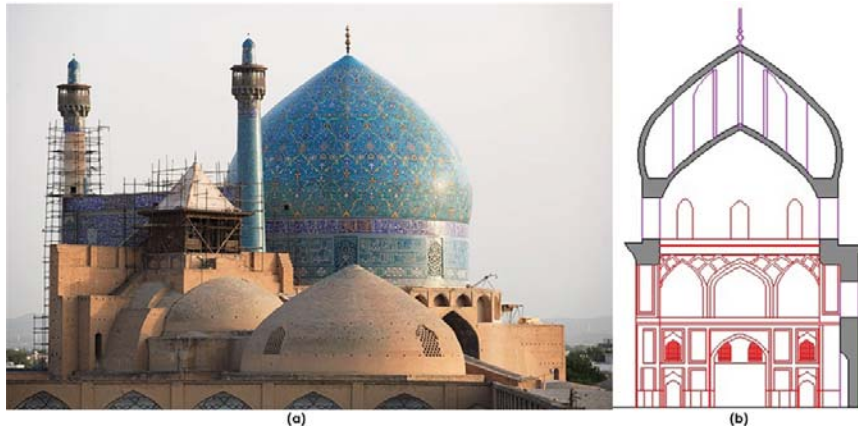
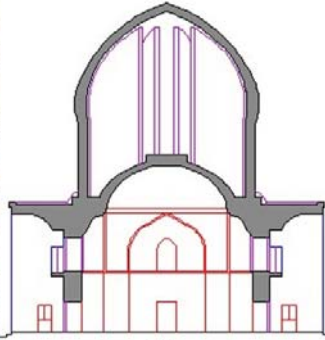


Figure 15: a) The bulbous dome of the Imam Mosque, Saffavid period, Isfahan. (Source: www.flickr.com/photos/cjb22222222/3177601447/); b) The vertical section of dome chamber. (Source: Authors).



(a)

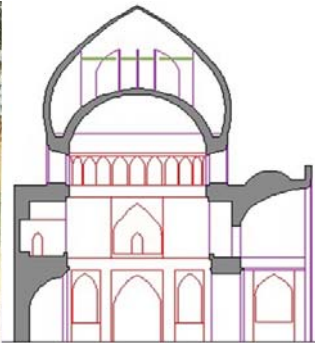


(b)

Figure 16: a) The mausoleum of Khwaja Rabi, Saffavid era, Mashad. (Source: www.panoramio.com/photo/20703444); b) The transversal section. (Source: Authors).



(a)



(b)

Figure 17: a) The bulbous dome over the Sultani school, Qajar era, Kashan. (Source: www.submission.org/efarsi/photos.html); b) The transversal section. (Source: Authors).

Oljeitu mausoleum in Sultaniya and Shah Mosque in Isfahan, cannot be overlooked (Pope, 1976, p. 68).

Common Morphological Constitutions of Persian Domes

In general, a Persian dome may be considered as a structural consonance or a hierarchy of ordered parts which manifested relationship between positive-negative spaces. The final

configuration of Persian domes resulted in the continuous architectonic development of their elements which mainly occurred until the Ilkhanid era. Then, the evolutions of these domes were restricted to the evolution of forms and geometrical design of their shells. Morphologically, the common identified components of Persian domes are: load bearing system, transition tier, drum, and shells (Figure 18). The composition of internal stiffeners and wooden struts appeared in the Ilkhanid era.

- Load bearing system: It is the main body of

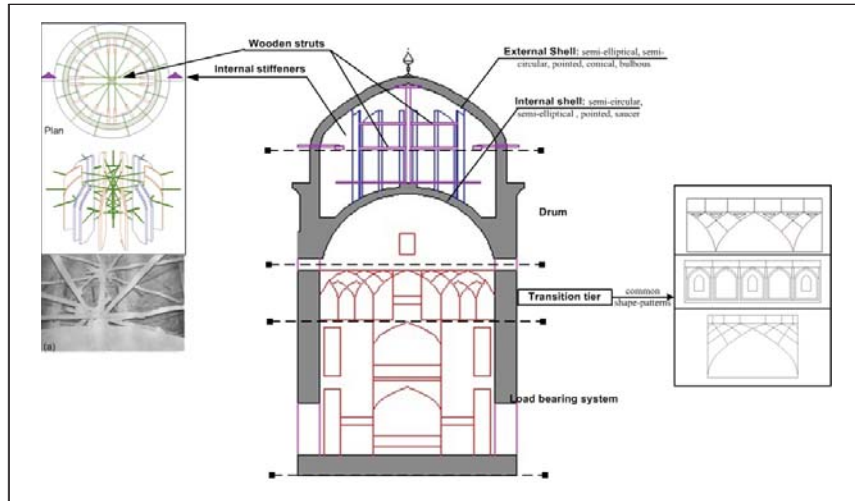


Figure 18: Illustration of the common morphological features of Persian domes. (Source: Authors); a) the sample of internal stiffeners and wooden struts of the Chahar Bagh (Madar-e Shah madrasa), Saffavids era, Isfahan. (Source: Memarian, 1988).

a domical building on which upper elements are rested. In fact, it is a special formation of its central plan shape (e.g., square, circular, and octagonal). The thicknesses of this element were likely be reduced since the beginning until the Qajar era following developments in structural knowledge. Conceptually, it consists of positive (often mihrab wall) and negative projected arches (surrounding opening sides) which are set out symmetrically. From the structural point of view, its main role is to transfer the loads to the ground;

-Transition tier: This is an essential component of the dome which made the difference in compositions over historic eras. Architecturally, in essence the meaning of squinches is stepped console spandrels which may also consist of rows of superimposed brick brackets. Its main function is to transfer from square to circular by means of the groined arches which diagonally span the corner of square plan and form the

octagonal lower base of the shell;

- Drum: This is the identical item in the majority of the discontinuous double-shell domes, especially after the Ilkhanid epoch, with the average height of 30-35 meters from the ground. It is the only component of the dome which embraces windows to provide lighting for internal spaces. Considerable thought and effort were often given by the designers to make domes as high as possible. The drum thicknesses must be sufficiently massive to transfer and neutralize the vertical thrust of the external shell to the lower items, especially the internal shell;

- Shell(s): What appears from the outside of the domical buildings is the shell (external shell in double-shell domes). It is the only architectural item which was formally found as a synonymous feature in several Islamic epochs. The shell thickness is proportionally reduced from the base to the tip at every 25' and 30' degree angles.

The double-shell domes consist of external and internal shells. The internal shell basically topped the dome chamber with a simple formation compared to the complicated forms of external shells. From the structural viewpoint, it is necessary that its geometric shape be fully conformed to the external shell in terms of providing the structural stability of the whole system. The common shapes of the internal shell are recognized as semi-circular, semi-ellipse, pointed, and saucer; and finally

- Composition of internal stiffeners with wooden struts: These are the common components of double-shell domes except for the conical samples. As late as the fourteenth century, various compositions of radial brick walls with

wooden struts also appeared for filling the empty space between two shells in the discontinuous double-shell domes and also for providing the structural stability of the whole system. Their settings and sizes strongly affiliated with the size of the span.

Common Typologies of Persian Domes

Substantially, the external shell, which is considered as the dominant synonymous feature of Persian domes, can be employed for categorizing their typologies. In this regard, according to the distinct forms of their shells (external shells in the double-shell domes), they may be sorted into semi-elliptical, semi-circular, pointed, conical, and bulbous shapes. The semi-

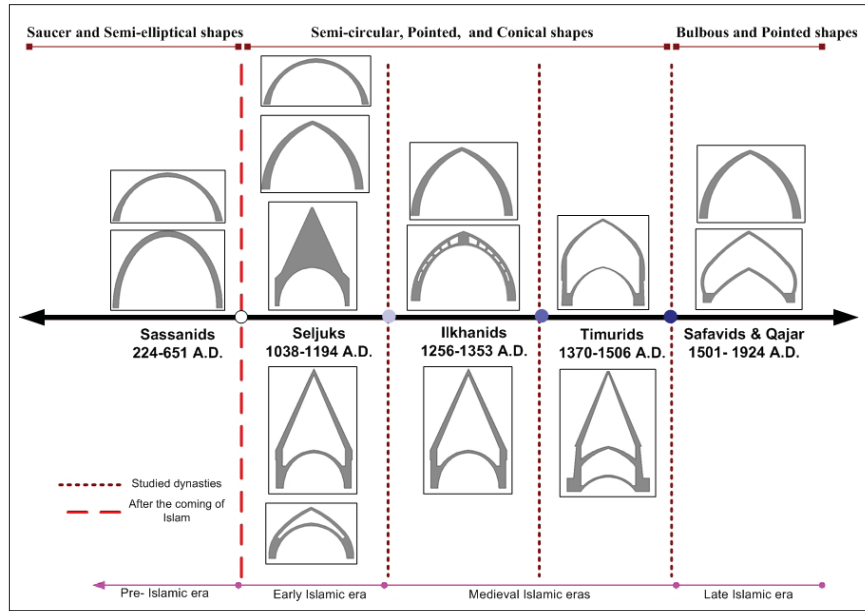


Figure 19: Illustration of the various typological features of Persian domes over historic era. (Source: Authors)

elliptical forms are common features of the pre-Islamic domes whilst the shallow semi-circular samples were mainly specified in the Seljuk era. The conical and pointed types embrace the majority of Persian domes over Islamic periods (Figure 19) than the bulbous type. Conceptually, the bulbous domes are considered the last generation of innovative approaches in Persian domes until the end of the late Islamic era due to a transition from the traditional to the modern architectural design in the Qajar era. Also, the numbers of shell(s) varied from one shell to triple-shell, based on dynasties' achievements over time.

Furthermore, in the double-shell domes, according to the variance existing in heights of the external shell, the pointed typology can also be ranked into three sub-types as shallow, medium and sharp whilst the bulbous typology only consists of two subdivisions: shallow and sharp. These characteristics, both pointed and bulbous typologies, fully conformed to the geometrical properties and shell designs of such domes (Figure 20).

Conclusion

The Persian domes are the main items among different Iranian heritage buildings which are considered as a fundamental issue in the life of modern societies. As the paper stated at the beginning, the Persian domes historically underwent systematic evolutions and continuous chronological innovations over the pre-Islamic and Islamic eras, especially during these specific six dynasties: Sassanid (pre-Islamic dynasty), Seljuk, Ilkhanid, Timurid, Saffavid, and Qajar. Morphologically, four main components were recognized, namely the load bearing system, transition tier, drum, and finally the shell which is divided into the internal and external shells. The composition of internal stiffeners and wooden struts mainly appeared in the Ilkhanid period through developments of the various types of discontinuous double-shell domes and improvements in structural knowledge.

Then, based on the identical shapes of shells, typological features of Persian domes are chronologically ranked as follows: the semi-circular and semi-elliptical as main styles in the

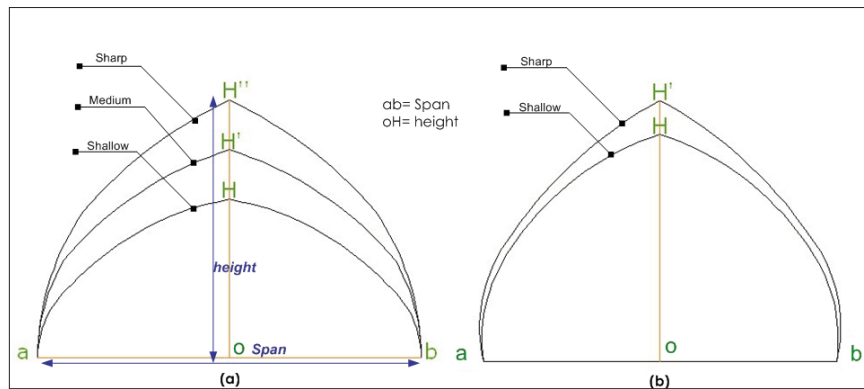


Figure 20: Classifications of the pointed (a) and bulbous (b) typologies into sub-types based on the various heights of external shell. (Source: Authors).

pre-Islamic era, the pointed and conical which were common types until the end of Timurid era, and finally the bulbous forms as the last generation of Persian domes appeared by the Saffavid epoch. These aforementioned typologies may, however, be additionally categorized into sub-types depending on their external shell heights (geometrically called raises) into shallow, medium, and sharp types, except for the conical domes. The numbers of shells are also chronologically varied from one shell to triple-shell domes. The one and double-shell domes are the most common types of the Persian Islamic domes all over Islamic periods. Triple-shell domes are mainly seen in the Timurid era and were almost not traced again later.

The morphological and typological analysis of the Persian domes may shed new light on the principles of conceptual characteristics and typological designs of traditional dome architecture which can be reflected as design standards in contemporary architecture; to preserve the close relationship between past and present architectures as well as to revive the design of certain typologies of traditional domes in modern architecture. The analysis given above will also aid in conservation efforts on Iranian domical structures and other domical structures in the region. Future researches can further explore the needs of detailed geometrical analysis and opening of new programs to realize the architectural essences of other sorts of Eastern domes such as bulbous and Mongolian domes.

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