

Morphology and Typology of Islamic Dome Architectural Design in the Middle East and Central Asia: Persian Islamic Dome

Sharifah Fatimah Azzahrah¹, Sarah Abdulkareem Salih¹, Azmal Sabil³, Nayeem Asif² & Sumarni Ismail¹

¹Department of Architecture, Faculty of Design & Architecture, Universiti Putra Malaysia, Serdang Selangor, Malaysia, ²Department of Architecture, KAED, IIUM, MALAYSIA,

³Architecture Department, Faculty of Civil Engineering and Built Environment, Universiti Tun Hussein Onn Malaysia Johor, Malaysia

Corresponding Author Email: sumarni@upm.edu.my, nayeem@iium.edu.my

To Link this Article: <http://dx.doi.org/10.6007/IJARBSS/v13-i9/18436> DOI:10.6007/IJARBSS/v13-i9/18436

Published Date: 15 September 2023

Abstract

Dome has been a significant element and structure in the architecture of Islam, where it usually can be found in mosques from many years ago, which started from the Umayyad period in Jerusalem (691 AD). However, the persistent practice of domes in modern Islamic architecture led to the development and evolution of dome concepts and types. Therefore, the current paper aims to analyze and classify the dome architectural design and how it evolved in Central Asia and the Middle East over time. The current paper used a systematic search and narrative review of 26 publications published in English in Scopus and ScienceDirect databases before 2023. The current study reviewed the Islamic dome's morphology in six different periods that emerged in Central Asia and the Middle Eastern: the pre-Islam, early Islam, Seljuk era, Ikhanids and Timurids era, Safavids and Qajar era, and Contemporary period. Further, it highlighted three main stylistic classifications of Islamic domes: dome shape, type of shell, and type of support. The current review study contributed to a deeper understanding of the Islamic dome's morphology and stylistic classifications through time.

Keywords: Dome, Evolution, Central Asia, Islam, Middle East, Morphology, Persia

Introduction

Domes have been a significant architectural feature, symbolic and a physical depiction of the sky and the infinite since ancient times. A dome is usually shaped with a hollow upper half of a sphere, and the definition of a dome varies from time to time with the evolution of forms, functions and structural elements that have been developed until modern times (Hassan and Ali, 2019; Ashkan and Ahmad, 2009). Dome played a critical role in highlighting the structural patterns of the mosques' elevation as structural aesthetic elements. It developed with a great

architectural lineage and history, as found in several civilizations, such as Persian, Roman, and Islamic cities, as domes have been built since ancient times, specifically during Mesopotamia. The initial manifestation of domes was in the form of compact mounds and construction methods that were limited in their applicability to relatively diminutive structures, such as round huts and graves seen in the ancient regions of the Middle East, India, and the Mediterranean (Hassan and Ali, 2019).

In the Middle Ages, dome structures were highly influenced in Europe and Islam and are notable in Byzantine and Sasanian architecture (Ashkan and Ahmad, 2009). Domes are also one of the core elements of Middle Eastern architecture, which spread persistently with the birth of Islam. Over the ages, Islamic dome structure has been significantly improved and developed to several forms and complexities. The Umayyad and Abbasid dynasties saw the refinement of dome construction techniques. The Great Mosque of Damascus (706 CE) and the Great Mosque of Samarra (9th century) featured innovative domes with tall drums and external ribbing (Hassan and Ali, 2019). During the Islamic rule of Spain, the Great Mosque of Córdoba (10th century) displayed stunning multi-lobed domes. The Alhambra Palace (14th century) showcased intricate muqarnas (stalactite) dome designs (Hejazi et al., 2015). Persian architecture is also among the first to acknowledge the usage of masonry as the foundation of domes to support some structures and introduce the approach of shifting shapes from square to circle, namely, squinches, which largely appeared during the Sassanid period (Hosseini and Ghazizadeh, 2022; Chen et al., 2015). Persian and Ottoman domes came in various types and forms with significant meanings and values behind them. Persian domes are extremely related to their symbolic meanings in Islamic architecture, regarded as the bridge of infinite unity of centralism (Chen et al., 2015; Ashkan and Ahmad, 2009). Then, the Indian subcontinent saw Islamic and Hindu architectural elements integrating into dome structures. Taj Mahal (17th century) is a prime example with its bulbous dome and decorative finial. After the decline of the Ottoman Empire, Islamic architecture continued to evolve, incorporating modern construction materials and techniques while preserving traditional aesthetics. Contemporary Islamic architecture often combines traditional dome forms with innovative designs, as seen in structures like the Sheikh Zayed Grand Mosque in Abu Dhabi (Askarizad et al., 2022; Toorabally et al., 2016).

The persistent practice of domes in modern Islamic architecture led to the development and evolution of dome concepts and types. Thus, domes maintain an active role in modern Islamic architecture. Domes have a critical role emphasised in their functions, environmental effects, and other architectural factors. However, there is a lack of evidence to historically study and analyze the shape of dome evaluation. In this regard, the paper's main objective is to analyze and classify the design of the dome and how it evolved in Central Asia and the Middle East over time. To achieve the study objectives, the current review will concentrate on the fundamentals and morphology of the Persian dome's architecture as a case study. With the analysis of these domes, further discussions on the architectural development will be stated, and the compositional language of the dome styles will be translated.

Islamic Historical Impact towards the Growth of Domes

Developing traditional Islamic dome structures is a fascinating journey through architectural history. Islamic architecture has produced some of the world's most iconic and beautiful domed buildings. These domes have evolved over the centuries, reflecting both the architectural ingenuity of Islamic civilization and its cultural and religious values (Koliji, 2012). Islamic architecture's phenomena of dome evolution go beyond simple structural change to

encompass a rich tapestry of philosophical, technical, and cultural advancements. The complex development of domes in Islamic architecture presents an enthralling story of invention and symbolism that has permanently altered architectural design heritage. Islamic domes stand out among the wide range of Islamic architectural expressions for their distinctive structural qualities and profound design philosophies (Yari et al., 2018; Sarhangi, 2016).

The Islamic Persian dome emerges as a paramount element, capturing the immediate attention of beholders with its captivating presence (Hejazi et al., 2015). Rooted in a convergence of artistic finesse and spiritual profundity, Islamic domes signify architectural advancements and repositories of philosophical paradigms, especially the Persian and Ottoman. The initial discourse revolves around integrating traditional astrological sciences into architectural articulation, followed by a profound infusion of mystical connotations drawn from Islamic philosophy (Hejazi et al., 2015). The trajectory of Islamic architectural evolution reverberates with an innovative spirit that spans eras, manifesting in many advanced practices dedicated to the refinement and transformation of dome structures (Hejazi and Pourabedin, 2020).

An example of this evolutionary journey is the remnants of a monumental domed edifice discovered in the Parthian epicentre of Nyssa in Turkmenistan, as mentioned by Koliji (2012). This historical marvel is a testament to the inception of primary dome formations in ancient Islamic architectural landscapes. As we delve deeper into the architectural chronicles of Islamic domes, it becomes evident that their evolution transcends physical metamorphosis, encompassing a profound odyssey of cultural, philosophical, and technical advancement (Binyaseen, 2022; Hejazi et al., 2015). The evolution of domes in Islamic architecture, particularly in the Central Asia context, is a testament to human ingenuity's boundless scope and its ability to infuse the spiritual and the scientific, the aesthetic and the metaphysical, into awe-inspiring architectural forms that continue to resonate with meaning and significance across the ages (Binyaseen, 2022).

Method

The paper's main objective is to expose, classify and analyze the Islamic domes design and how they evolved in Central Asia and the Middle East countries. To achieve such objectives, this paper will concentrate on the fundamentals and morphology of the Islamic Persian dome. With the analysis of these domes, further discussions on the architectural development will be stated, and the compositional language of the dome styles will be translated. Based on the objective of the current review, this paper will underline two main aspects as follows: (1) a timeline that narrates the evolution of Islamic Persian domes until the Qajar period (the late Islamic era). (2) Central Asia and the Middle East dome classification that sorted by standard features based on distinct forms and values.

The current review implemented Green et al (2006) guidance for simple narrative review using systematic search. Therefore, a narrative review and systematic search of previous literature were used to synthesise and analyze the existing evidence on traditional Islamic dome evolution. Two databases were reviewed, including Scopus and Science Direct to search text materials using keywords related to traditional Islamic dome evolution in an architectural context. Three inclusion criteria were identified in the systematic search: (1) The included text material should be a journal article and conference paper published before 2023 to ensure the proper quality of the selected text materials. (2) The included text material should be written in the English language. (3) The included studies should focus on Islamic dome

architecture in Persia (as a case study on Central Asia and the Middle East). Studies focuses on dome architectural design in general were excluded. Therefore, this systematic search yielded 620 documents published between 1982 and 2022 from the two electronic databases. After extracting duplicated studies and including studies published in English, 592 remained; 427 were excluded based on the title and abstract screening, and 142 were excluded based on full-text screening. Therefore, 26 studies are included in the final narrative review.

Result and Dicussion

Timeline of Islamic Persian Dome Evolution

The evolution of Islamic Persian dome architecture is a rich and diverse journey that spans centuries, encompassing various dynasties and periods of cultural and architectural development. Islamic period in Persia dominated the course of Persian dome renaissances and their distinctive conceptual characteristics. Ashkan, M., & Ahmad, Y. (2012), Here is a timeline highlighting the key phases and examples of Islamic Persian dome evolution (see Figure 1)

First period: Pre-Islam (Sassanid) Era (224 – 651 AD): Pre-Islamic Persian architecture laid the foundation for Islamic dome design, especially in the use of brick construction and the concept of the dome. The birth or, in other words, the first appearance of domes in Persia provided the people with a religious context sample. According to Hosseini and Ghazizadeh (2022), numerous examples of oval-shaped domes in the Sassanid era appeared as four arches called Chahar-Taqi (four arches). It also can be found in other eras and places. Figure 2 shows the second oldest Persian domes that remain with primary features where the dome is connected with the arches as the supporting elements (Labisi, 2019; Hejazi etal., 2016; Ashkan and Ahmad, 2009).

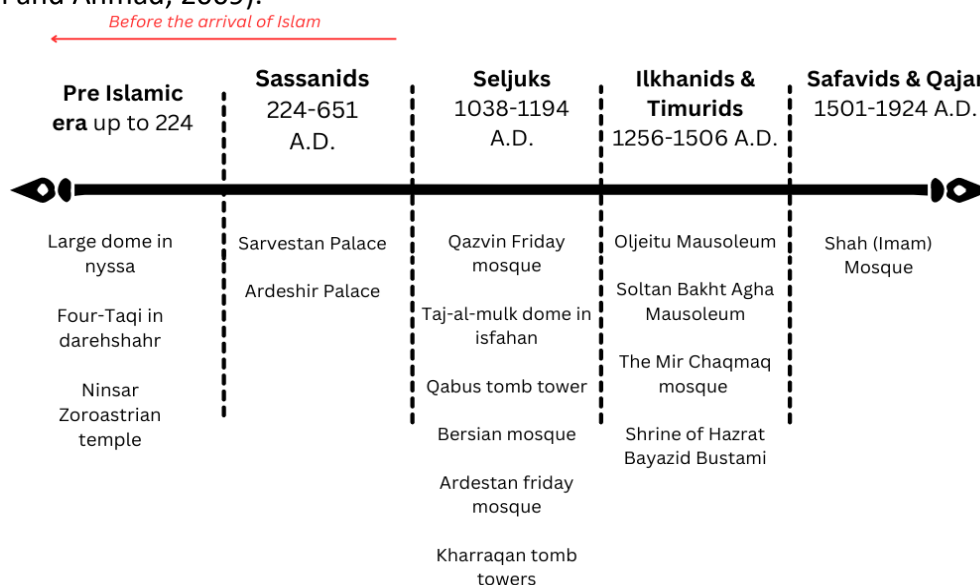


Figure 1 Timeline of the Persian dynasties with related mosques
Source: Ashkan and Ahmad (2009)

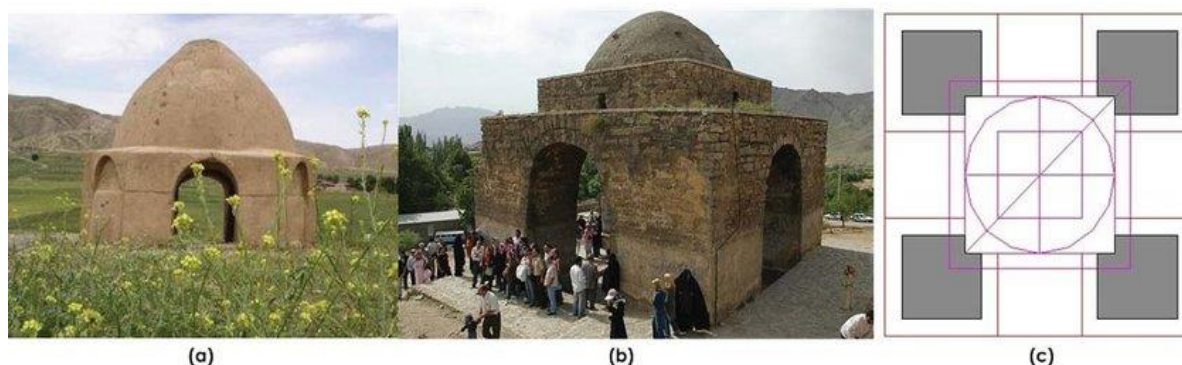


Figure 2 Pre-Islam Persian Dome: (a) Chahar-Taqi (four arches) in Darehshar. (b) Chahar-Taqi of the Neyasar, Sassanid era, Kashan. (c) the plan of Chahar-Taqi with 4 supporting structures
 Source: Ashkan and Ahmad (2009)

Afterwards, the construction of semi-elliptical domes, which were often erected in the reception halls of palaces like Sarvestan Palace during the Sassanid Empire, represented the most significant innovation of domes in architecture (Hosseini and Ghazizadeh, 2022). These domes were erected on the first examples of squinches, influencing the development of domes in Islamic architecture for a long time. The squinches are conceptually equivalent to miniature arches constructed to fill diagonal corners with arches or corbelled arches (Koliji, 2016, 2012). According to Ashkan and Ahmad (2009), the domes of Sarvestan Palace—also known as "The Temple of Anahita"—are considered the oldest brick domes in the world. These domes stood atop the most magnificent sacred structure built during this period. It has a 20-meter height and a 12.80-meter semi-elliptical span, but its largest dome is smaller than the one that tops the Ardeshir Palace in Firuzabad (Figure 3). Ashkan and Ahmad (2009) also claimed that the Zoroastrian temple and palace of Ardeshir in Firuzabad, built around 250 A.D., is a well-known and impressive Sassanid domestic structure. The structure comprises three huge semi-elliptical domes spanning 13.30 meters and are supported by squinches as transitional parts. These domes had plasterwork inside and were made of mortar and local rocks (Ivashko and Dmytrenko, 2020; Ashkan and Ahmad, 2009).

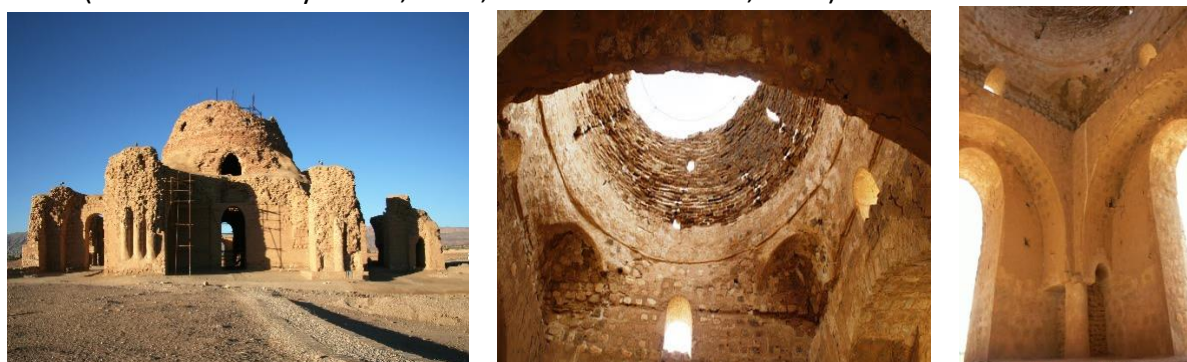


Figure 3 Sarvestan Palace from exterior, interior and squinches structure - Sassanid era
 Source: Lendering (2010)

Second Period: Early Islamic Era (651-900 AD): In the early 7th century, the launch of the Islamic revolution began and set up some contributions in Iranian architecture, which enhanced their identity and culture. It emphasises the beauty in which domes epitomise Islamic appeal (Hejazi et al., 2015). Islamic rule in Persia brought about the integration of Persian and Islamic architectural styles. The early Islamic Period saw the construction of simple domed structures, often combined with square chambers. Notable examples include

the Dome of Soltaniyeh, which appeared in the 11th century (Labisi, 2019; Hejazi et al., 2015). The evolution of the early Islamic domes from the conceptual structure of the Sassanid's dome (Chahar-Taqis) used in the mosque's main hall (Hosseini and Ghazizadeh, 2022). These types of domes take an onion form about 30 meters in width and 50 meters in height, such as the bulbous onion dome of the Shah Mosque. Hosseini and Ghazizadeh (2022) Islam ideas significantly shaped the symbolic meanings of the pre-Islamic domes, such as conceiving paradise as the home of God and the focal point of the Ka'ba on Earth. However, the basic structural elements of Sassanid domes, such as minarets, are preserved and have not changed.

Third Period: Seljuk Era (1038 – 1194 AD): The Great Seljuk Empire was a high medieval, culturally Turco-Persian empire founded and governed by the Qiniq branch of Oghuz Turks. It encompassed a total area of 3.9 million square kilometres (1.5 million square miles) from Anatolia and the Levant in the west to the Hindu Kush in the east and from Central Asia in the north to the Persian Gulf in the south (Hosseini and Ghazizadeh, 2022; Peacock, 2004). Seljuks exercised full control over Islamic Central Asia and the Middle East between 1038 and 1194. The Seljuk experienced a time of material and cultural prosperity and inventiveness after they succeeded in building a massive empire in just 55 years (Moradi, 2020; Shadravan and Shadravan, 2019).

The Seljuk Turks introduced innovative architectural techniques, such as using squinches, to transition from square bases to round domes. The Great Mosque of Isfahan (11th century) and the Friday Mosque of Isfahan (11th century) showcase these developments (Hosseini and Ghazizadeh, 2022). Flourishing Persian architecture resulted in various funerary building uses, including single tomb towers (the "Turkish Triangle") and cube mausoleums with a variety of one and two-shell domes on top: single-shell and double-shell. As Hejazi et al (2015) stated, Seljuk architecture showcases significant advancements in the construction of vaults and domes. Seljuk domes also introduced several shapes of domes, such as conical, semi-circular, and pointed shapes in one or two shells.

In the 11th century AD, they pioneered the creation of the world's first double-shell dome, a technique that would be widely adopted between the 11th and 14th centuries AD, see Figure 4). Yari et al. (2016) and Ashkan and Ahmad (2010) explained the double-shelled and triple-shelled domes appeared in the Seljuk era. Morphologically, few samples of the triple shells emerged in comparison to large numbers of the other sorts, which can thus verify its origin from the double-shell domes (Ashkan and Ahmad, 2010). Yari et al. (2016) stated that the double-shelled dome could disperse meridian forces uniformly, preventing concentrated stress spots like those found in other systems, including the thrust points of the beam and vault. This trait makes it possible to solve any technical issue quickly. Rib vaults, specially shaped to match the outer dome's curvature, form the dome's main structural component. These very important vaults connect the internal dome and the outside column (Hosseini and Ghazizadeh, 2022; Yari et al., 2016).

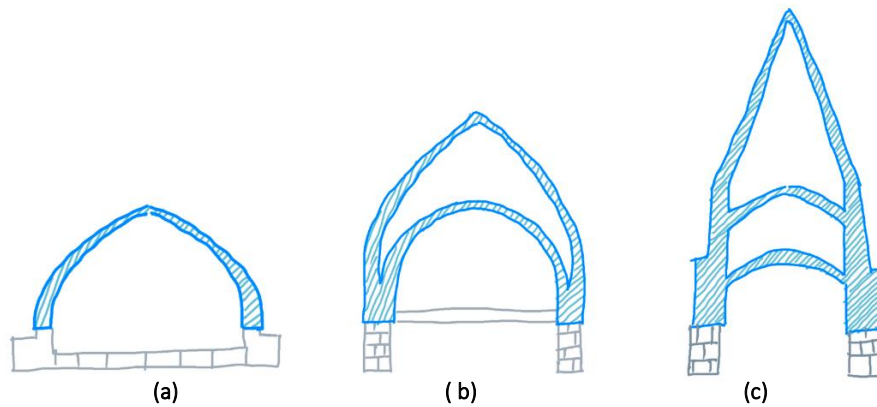


Figure 4 Three types of domes internal structure. (a) single shell, (b) double shell, (c) triple shell

Source: Ashkan and Ahmad (2009)

The Taj-al-Mulk dome of the Jameh mosque in Isfahan is the most stunning structure and the best example of Seljuk architecture in Persia; it was the largest masonry dome in the Islamic world at that time, see Figure 5. The square surface of this constructed mosque transforms into octagonal hexagons. These shapes change into sixteen-sided polygons with the aid of "hornets" before creating circles. The dome is incredibly tall, and the distance from its base to its summit is amazing (Yari et al., 2016). Tj-al-Molk constructed a second dome in 1088AD at the other end of the same mosque, with interlacing ribs producing pentagons and five-pointed stars; it is known as the iconic Seljuk dome, and it may have served as a model for later patterns and Il-Khanate period domes. Under the Seljuks, the interiors of domes were increasingly decorated with tile and plain or painted plaster rather than brick (Hejazi et al., 2016; Yari et al., 2016).

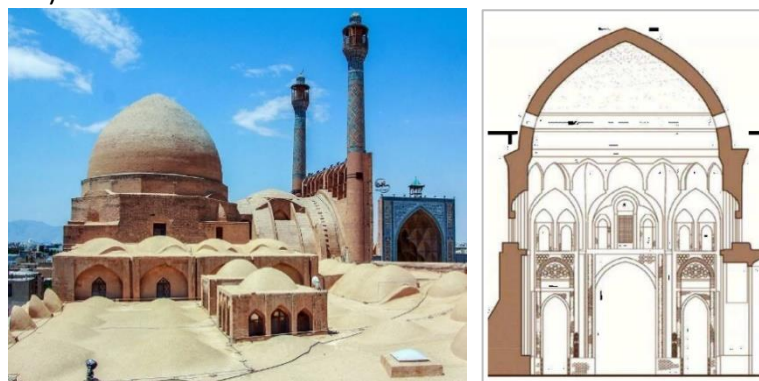


Figure 5 Taj-al-Mulk Friday Mosque in Isfahan

Source: Yari et al (2016)

The Seljuqids architecture has also introduced two methods to resolve certain issues in design by separating the external and internal shells at certain angles from one another. These are arguably their most significant achievements (Yari et al., 2016). Two ample samples for the primary method: First, the dome of the Barsian mosque, one of the oldest Persian mosques, was built in Isfahan city in 1105 AD. Eight brick ribs make up the interior shell of the building. Second, the Ardestan Friday mosque's continuous double-shell dome, built between 1000 and 1100 AD, was added during the early Seljuqids era. The Seljuqids architecture-typical compositions of its squinches tier and internal bearing walls are similar to those of previous

examples, such as the Taj al-Mulk dome in Isfahan (Shadravan and Shadravan, 2019; Ashkan & Ahmad, 2009).

Fourth Period: Ilkhanids and Timurids Era (1256 – 1506 AD): The Ilkhanid continued the Seljuk architectural traditions, while the Timurid dynasty ushered in a period of architectural revival and patronage in Central Asia. The architectural influence of Persia flourished once more with the appearance of the Ilkhanids and Timurids empires, which changed their architectural styles. Its obvious characteristic was a larger scale (Mahmudnejad et al., 2023; Röhrs et al., 2022). Structural elements were doubled, solids were decreased, and open space was enlarged to fulfil various roles. Problems with structures were more successfully resolved. The primary type of discontinuous double-shell domes, in which the shells are completely disconnected, was constructed during these dynasties. Consequently, these structures were distinguished by their resemblance to large discontinuous double-shell domes in this region (Mahmudnejad et al., 2023; Röhrs et al., 2022). The Mausoleum of Öljaitü (1305-13 AD) in Soltaniyeh is an exceptional example of Persian Ilkhanid dome architecture. Hejazi et al. (2015) stated that the 54-meter-high double-shell dome of Öljaitü mausoleum in Soltaniyeh is the largest existing dome in Iran. It has an oval portion and comprises two thin shells separated at a certain angle (Hejazi et al., 2015; Simon and Bagi, 2014). However, in the upper portion, small brick connectors connect its shells at regular intervals. This dome concept stood out completely from the other Persian domes thanks to its oculus (Hejazi et al., 2015; Ashkan and Ahmad, 2009).

Another interesting example of Ilkhanid's architecture is the Soltan Bakht Agha Mausoleum dome built between 1351 and 1352 AD, indicating a significant advancement in Iranian dome design. It is the earliest known example of a double-shell dome with a span of 7.5 meters and a height of 18 meters. The structure comprises radial stiffeners and wooden struts, and the inside and outside shells have very different profiles. This new method for distinguishing between domes' interior spaces and exterior appearances quickly spread throughout Central Asia and the Middle East, paving the way for the later development of the Timurid dome architecture styles (Ashkan and Ahmad, 2009). However, the Sultaniya complex in Cairo, constructed by Sultan Hasan in the 13th century, is the design source of the Sultan Bakht Aqa tomb's inception.

In contrast, the Timurids frequently affixed their domes to madrasas, which served as religious schools, and opted for pairs of domes rather than constructing them atop independent mausoleums and mosques. One famous example of Timurid domes is the shallow pointed dome of the Mir-Chaqmaq Mosque, built in 1437 AS, a well-known dome of Timurid architecture in Iran. It is the most advanced composition of internal stiffeners and wooden struts ever used in Persian dome design (Hejazi et al., 2015). Its enormous semi-circular internal shell was mounted on the large console mini arches as the squinches tier. This pointed discontinuous double-shell dome's most notable feature is its two-tiered circular drum; see Figure 6. Another example is the Bayazid Bistami shrine complex's oldest conical dome, with a span of 8 meters, a height of 20 meters, and a triple shell, demonstrating the Timurid era's advanced dome architecture, see Figure 6. It was created in the pre-early Seljuk period with the addition of a third shell, which resulted in compositional changes during this time. The evolution of Islamic domes in Persian architecture continues its flourishing. As a result, the architectural designs featuring domes underwent swift assimilation and modification into regional aesthetics following the Timurid era. This occurred through the influence of three distinct local dynasties, namely the Safavids in Iran (1501-1732 AD), the

Shaybanids in Central Asia (1503-1800 AD), and the Mongols in India (1525-1858 AD) (Ivashko and Dmytrenko, 2020; Hejazi et al., 2015).

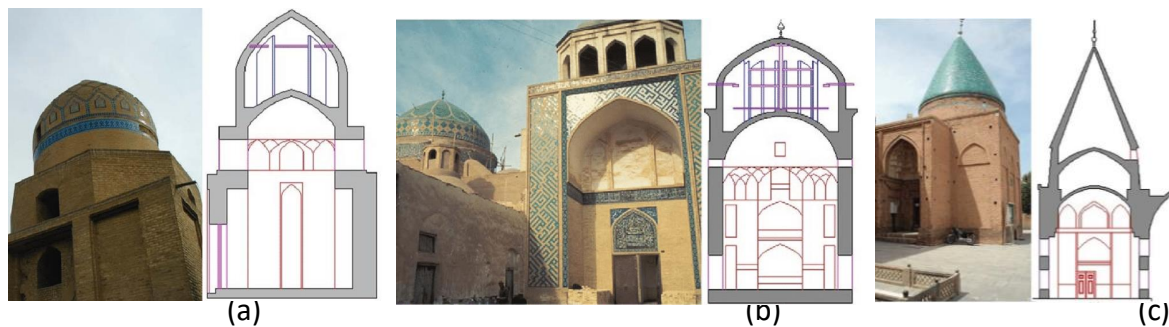


Figure 6 Sample of Persian domes in Ikhanids and Timurids Era. (a) Soltan Bakht Agha mausoleum in Isfahan - Ikhanid era. (b) The Mir chaqmaq mosque in Yazd - Ilkhanid era. (c) Shrine of Hazrat Bayazid Bustami complex in Basstam - Timurids era.

Source: Ashkan et al (2012)

Fifth Period: Safavids and Qajar Era (1256- 1506 AD): The Safavid era in Persia marked a high point in Persian Islamic architecture. The architectural structures of the regions under Safavids were characterised by the proficient utilisation of various building materials, commonly known as vernacular architecture. Well-established construction techniques also distinguished these structures (Askarizad et al., 2022; Hosseini and Ghazizadeh, 2022). Amid the late Islamic era, the significance of incorporating creative ideas in the construction of Islamic domes diminished in the regions of the midst of East and Central Asia (Shadravan and Shadravan, 2019). One of the interesting examples of the double-shell domes of Safavids is shown in the Shah mosque in Iran, which shows the implication of the golden ratio in its design, see Figure 7. Goudarzi et al (2020) stated that the Shah mosque is the most prominent historical mosque in Isfahan, erected on the orders of Shah Abbas I during the Safavid dynasty. It was designed by Ali Akbar Isfahani, one of Iran's greatest architects. This structure is the pinnacle of a thousand years of mosque construction in Iran. This mosque's bulky sections and bulbous double-shell domes are stunning and superbly put together, making it one of the best in the world. They also studied the golden proportions of this mosque. It consisted of the prototype of discontinuous double-shell domes, typically comprising many key components, namely the exterior shell, which holds significant importance as it is the most visible element of the dome, the high drum, the interior shell, and the radial stiffeners within the wooden struts. The latter substance was employed to occupy the voids between shells and facilitate the integration of all the constituent elements (Hosseini and Ghazizadeh, 2022; Shadravan and Shadravan, 2019).

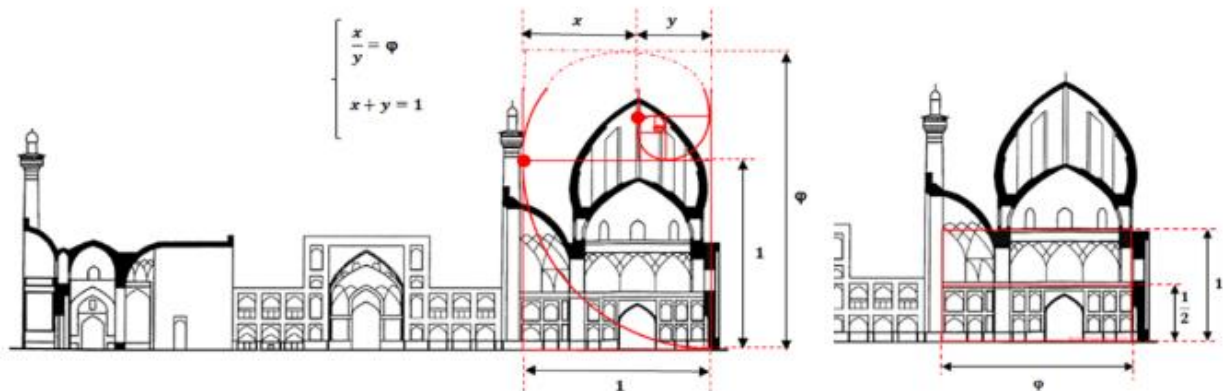


Figure 7 Golden Proportions on Shah Mosque, Isfahan

Source: Goudarzi et al (2020)

However, the creative approaches in dome constructions became less essential in Persian architecture during the Qajar era (1779-1924 AD) with the growth of modern architecture movements (Sarhangi, 2016; Ashkan & Ahmad, 2010, 2009). Yet, the dome architecture in the Qajar Dynasty experienced significant developments and innovations. Shiraz's Nasir al-Mulk Mosque (1876-1888 AD) showcases a magnificent Persian dome with colourful stained glass. The Qajar period was marked by a blend of traditional Persian architectural styles and European influences, resulting in a unique architectural identity. Dome architecture was an integral part of this evolution. The Qajar period saw the introduction of new construction materials, such as steel and glass (Askarizad et al., 2022). These materials allowed for the construction of larger and more innovative dome structures. Domes were constructed atop madrasas, such as the 1848 Imam madrasa, also known as the Sultani school, in Kashan. However, these domes exhibit modest designs and do not incorporate intricate tiled mosaics. The emergence of an ornate variation of the onion dome, characterised by its exaggerated design and placement atop a compact drum, may be observed at the Shah Cheragh (1852-1853) during the Qajar era. The significance of domes persists in contemporary mausoleum architecture. The presence of domed cisterns and icehouses continues to be prevalent in rural areas (Shadravan and Shadravan, 2019; Sarhangi, 2016; Toorabally et al., 2016).

Six Period: Contemporary Period (20th century onwards): Persian dome architecture continues to evolve in modern times, often blending traditional elements with contemporary design. This architecture combines classical dome forms with modern construction techniques (Okuyucu, 2016; Sarhangi, 2016). The progression of this dome design undeniably has contributed to enhancing architectural techniques in various Middle Eastern countries, including well-known ones like Turkey, Saudi Arabia, and Afghanistan, among others. These cutting-edge ideas and structural methods have spread beyond their original locales and across geographic and cultural settings, significantly influencing global architectural trends. Because of this, similar dome designs can be seen adorning buildings on every continent, specifically in Turkey, which is beside Iran. The prevalent aspect is the tendency to imitate architectural styles from previous centuries, which becomes evident in the shared attributes of over seventy thousand mosques built during this era (Okuyucu, 2016).

Classification of Persian Domes in Central Asia and the Middle East

A clear pattern emerges in the realm of Persian dome architecture during the Islamic era. Persian domes can be classified into various categories based on their architectural features, design elements, and historical contexts, see Figure 8. As an architectural feature regarded as the dominant element of Persian domes, the exterior shell can be used to classify their typologies. Consequently, they can be divided into circular or semi-circular, pointed, conical, semi-elliptical, octagonal, and bulbous shapes based on the distinct forms of their shells (external shells in double-shell domes). Circular and semi-circular domes are the most common Persian domes characterized by a circular base. The shallow semi-circular samples were mostly specified during the Seljuk era, whereas the semi-elliptical forms are common characteristics of pre-Islamic domes (Hejazi et al., 2020, 2015).

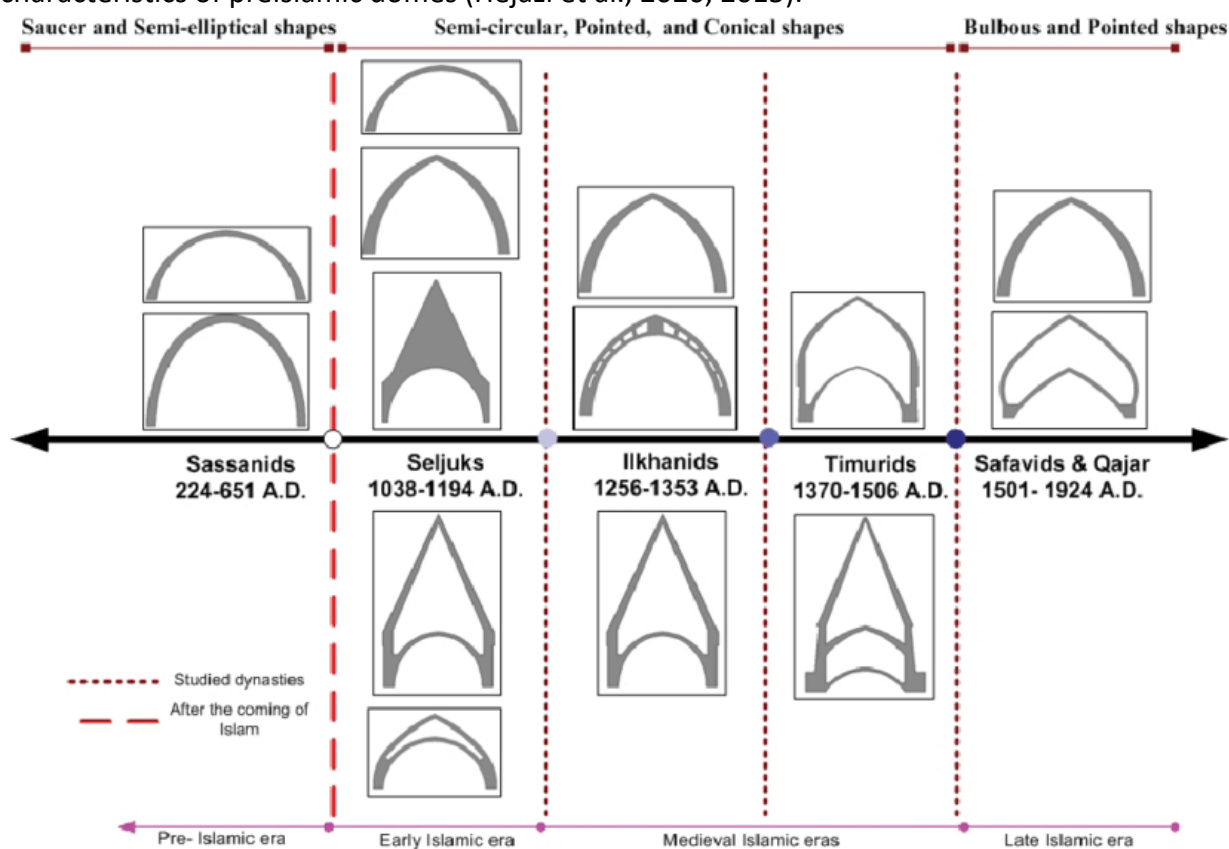


Figure 8 Classification of Persian domes over time

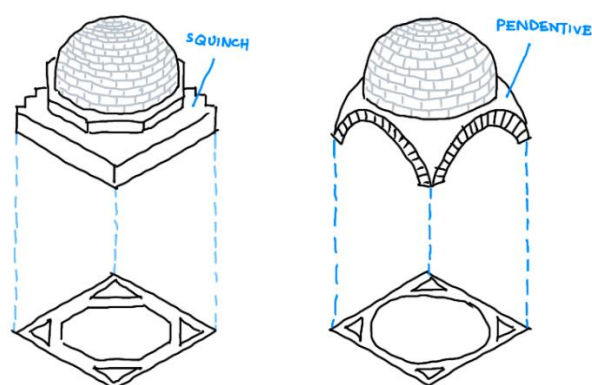
Source: Ashkan and Ahmad (2009)

Figure 8 also shows that most Persian domes built during the Islamic era were of the pointed and conical variety rather than the bulbous variety. The prevalence of pointed and conical designs becomes apparent, supplanting the more conventional bulbous variants. This transformative design shift coincides with the advent of the Qajar era, a juncture marked by the migration from conventional to contemporary architectural motifs. Notably, the bulbous dome style that became prominent during this period represents innovation, embodying the era's spirit until the late Islamic epoch's conclusion (Ashkan and Ahmad, 2009). Referring to the pointed typology in double-shell domes, a tripartite classification, is made based on the variation in external shell heights; these subtypes are shallow, medium, and sharp, whereas the bulbous typology only has two subdivisions: sharp and shallow. These features, which could be pointed or bulbous, were completely in line with the geometrical properties and

shell designs of such domes (Ashkan and Ahmed, 2010). It is crucial to note that these variances in design, whether pointed or bulbous, are underpinned by careful considerations. They stem from a harmonious interplay between geometric precision and architectural intent, describing the morphological evolution of domes throughout the Islamic era (Ashkan et al., 2012).

The number of shells was also used to classify the Persian dome, which varied from one shell (single-shell) and double-shell to triple shells according to dynastic accomplishments. The dome shell constitution, which is characterised by the conical and polyhedral domes, is utilised to categorise the conical and polyhedral domes based on their stylistic attributes. These domes are classified based on the number of shells they possess, namely one-shell, double-shell, and triple-shell (Hejazi et al., 2015). One-shell domes were found more frequently during the Seljuk period than in other historical periods. The tomb towers, characterised by their octagonal solid and hexagonal shells, held a prominent position among other architectural styles. Furthermore, their construction persisted concurrently until the Timurid era in Iran and its neighbouring regions (Hosseini and Ghazizadeh, 2022; Yari et al., 2016). The double-shell dome was the prevalent architectural form during the eras under investigation, particularly in the Ilkhanid era. Nevertheless, a limited number of triple-shell instances can serve as evidence for their evolution from the double-shell prototype. Initially, shells were primarily constructed for ornamental purposes, but they also began to offer structural stability, possibly due to advancements in structural understanding, particularly during the Timurid period (Ashkan et al., 2012).

Structurally speaking, two major types of dome support appeared in Central Asia architecture domes, including squinches (squinch dome), which are arched supports that help transition from a square or rectangular base to a circular dome, see Figure 9. They are a characteristic feature of many Persian domes. The domes in Central Asia and the Middle East were constructed using squinches, a structural element traced back to Persia (Ashkan and Yahya, 2009). In contrast, Western domes were often built using pendentives, a technique originating in Turkey. Pendentive support of the pendentive domes are triangular segments that allow the transition from a square base to a circular dome. Few Persian domes, such as those in the Dome of the Rock in Jerusalem, use pendentives (Ashkan et al., 2012).



(a)

(b)

Figure 9 Type of structural supports of Central Asian and the Middle East domes;(a) Squinch. (b)Pendentive.

Source: *Ashkan et al (2012)*

Therefore, it is clear that there are three types of architectural classification of the domes in Central Asia and the Middle East, including dome shape, type of shell, and type of support. However, a few considerations affect these three dome classifications, such as construction material, historical period and location, and size and scale (Ashkan et al., 2012). Thus, these considerations also affected the design shape, type of shell, of type of support of Central Asia and the Middle East, especially the Persian domes.

Conclusion

The current review focuses on classifying and analysing the Islamic domes' design and how they evolved in Central Asia and the Middle East over time. The culmination of this review study substantiates a profound evolution within the realm of Islamic dome architecture, influenced by the Persian style, tracing its trajectory from ancient epochs to contemporary times. The intricate interplay of forms, functions, and structural constituents that have evolved over centuries have significantly influenced the Islamic dome's dynamic evolution. The dome's historical presence extends across diverse architectural traditions, encompassing Persian, Hellenistic, Roman, and Chinese influences, culminating in its manifestation within Islamic architecture (Hosseini and Ghazizadeh, 2022).

Reflected against the backdrop of the abstract's foundational assertions, the conclusions drawn from the current review cast a radiant light on the persistent legacy of domes in Islamic architecture in Central Asia and the Middle East extended from Persian architecture. Originating in the historical crucible of the Umayyad period, influenced by previous dynasties, the Islamic dome has transcended its origins, becoming an enduring emblem of spiritual and architectural identity. The current review meticulously explores the morphological evolution of historic domes in Islamic architecture. The corpus of findings unveils a remarkable diversity in typologies, component ratios, forms, and aesthetic expressions characterising Islamic domes in Central Asia and the Middle East, each a testament to its distinct journey. The findings of the current review highlighted six periods of time for Islamic domes' evolution in Persia and Central Asia, including the pre-Islam, early Islam, Seljuk era, Ikhaniids and Timurids era, Safavids and Qajar era, and Contemporary period. Each era significantly contributes to the development of the dome design in shape, material, structure, and size. These periods showed the rich diversity and evolution of Persian dome architecture over the centuries. The current review also shows three types of architectural classification of the domes in Central Asia and the Middle East, including dome shape, type of shell, and type of support. A few considerations also affect the three dome classifications: construction material, historical period and location, and size and scale. Most importantly, each type of dome reflects the artistic, cultural, and historical context in which it was created.

The limitation of the study include: the findings developed from a systematic search of journal and conference publications published only in Scopus and ScienceDirect that focus on Islamic domes in Central Asia and the Middle East, especially Persia. In future studies, a further investigation that includes more rejoins and databases is required to develop a new comprehensive understanding of the development of the Islamic dome. Besides, all the studies reviewed were written in English; authors excluded the publications written in other languages. The study's finding catalyze a deeper appreciation for the subtle interplay of form

and function that characterizes the dome's journey through time, amplifying its significance as a living testament to architectural innovation and cultural continuity.

Acknowledgement

This study was supported by the Ministry of Higher Education (MOHE) through 'Fundamental Research Grant Scheme' (FRGS) (FRGS/1/2021/WAB09/ UTHM/03/1) for the research project 'Modenisasi Senibina Melayu Tradisional: Ekplorasi Kerangka Asas Senibina Melayu Modern (SMM) di Malaysia Berteraskan Model Penyelidikan' Research Onion'. The authors also acknowledge the support of the Department of Architecture, Faculty of Design and Architecture, Universiti Putra Malaysia, Serdang Selangor, Malaysia and Department of Architecture, University Tun Hussein Onn Malaysia.

References

- Mohammadi, A., Ebrahimi, N. A., & Shahbazi, Y. (2019). Geometric design of a masonry lattice space dome titled KARBANDI in Persian architecture. *International Journal of Space Structures*, 095605991984563. doi:10.1177/0956059919845631
- Ashkan, M., Ahmad, Y., & Arbi, E. (2012). Pointed Dome Architecture in the Middle East and Central Asia: Evolution, Definitions of Morphology, and Typologies. *International Journal of Architectural Heritage*, 6(1), 46–61. doi:10.1080/15583058.2010.501400
- Ashkan, M., & Ahmad, Y. (2010). Discontinuous Double-shell Domes through Islamic eras in the Middle East and Central Asia: History, Morphology, Typologies, Geometry, and Construction. *Nexus Network Journal*, 12(2), 287–319. doi:10.1007/s00004-010-0013-9
- Ashkan, M., & Ahmad, Y. (2009). Persian Domes: History, Morphology and Typologies. *ArchNet-IJAR: International Journal of Architectural Research*, 3(3). doi:10.26687/archnet-ijar.v3i3.192
- Askarizad, R., He, J., & Ardejani, R. S. (2022). Semiology of Art and Mysticism in Persian Architecture According to Rumi's Mystical Opinions (Case Study: Sheikh Lotf-Allah Mosque, Iran). *Religions*, 13, 1059. <https://doi.org/10.3390/rel13111059>
- Binyaseen, A. M. (2022). Improving thermal performance of existing uninsulated R.C. domes through passive cooling measures using polyurethane foam in double skin layer in hot climate. *Case Studies in Construction Materials*, 16, e00866. <https://doi.org/10.1016/j.cscm.2021.e00866>
- Chen, L., Utaberta, N., Yunos, Y. M., Ismail, N. A., Ismail, S., Ariffin, N. (2015). Evaluating the Potentials of Mosque as a Tourist Attraction Place in Malaysian Urban Context. *Research Journal Of Fisheries And Hydrobiology*. 10. 62-68.
- Goudarzi, M., Bemanian, M., & Leylian, M. (2020). Geometrical analysis of architectural drawings in the Shah-mosque Isfahan. *Curved and Layered Structures*, 7(1), 68-79. <https://doi.org/10.1515/cls-2020-0007>
- Green, B. N., Johnson, C. D., & Adams, A. (2006). Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. *Journal of Chiropractic Medicine*, 5(3), 101–117. doi:10.1016/s0899-3467(07)60142-6
- Hassan, A. S., & Ali, A. (2019). *Typological Study of Domes in Islamic Architecture of North India*. In N. S. Mat Akhir, J. Sulong, M. A. Wan Harun, S. Muhammad, A. L. Wei Lin, N. F. Low Abdullah, & M. Pourya Asl (Eds.), *Role(s) and Relevance of Humanities for Sustainable Development*, vol 68. European Proceedings of Social and Behavioural Sciences (pp. 646-657). Future Academy. <https://doi.org/10.15405/epsbs.2019.09.71>

- Hejazi, M., & Pourabedin, M. (2020). Performance of Persian Brick Masonry Discontinuous Double-Shell Domes against Earthquakes. *Engineering Failure Analysis*, 104994. doi:10.1016/j.engfailanal.2020.104994
- Hejazi, M., Hejazi, B., & Hejazi, S. (2015). EVOLUTION OF PERSIAN TRADITIONAL ARCHITECTURE THROUGH THE HISTORY. *Journal of Architecture and Urbanism*, 39(3), 188–207. doi:10.3846/20297955.2015.1088415
- Hejazi, M., Moayedian, S. M., & Daei, M. (2016). Structural Analysis of Persian Historical Brick Masonry Minarets. *Journal of Performance of Constructed Facilities*, 30(2), 04015009. doi:10.1061/(asce)cf.1943-5509.0000746
- Hejazi, M. M. (1997). *Historical Buildings of Iran: their Architecture and Structure*. Southampton, UK: WIT Press / Computational Mechanics.
- Hosseini, A., & Ghazizadeh, S. (2022). Analysis of the Dome-Chamber's Openness in Persian Historical Mosques. *The Medieval History Journal*, 25(1), 93-126. <https://doi.org/10.1177/09719458209509>
- Ivashko, Y., & Dmytrenko, A. (2020). Historical background and peculiarities of mosque construction in Iran as a basis for their restoration. *Stowarzyszenie Konserwatorów Zabytkow*. 63, 46-53. doi: 10.48234/WK63IRAN
- Koliji, H. (2012). Revisiting the Squinch: From Squaring the Circle to Circling the Square. *Nexus Network Journal*, 14(2), 291–305. doi:10.1007/s00004-012-0113-9
- Koliji, H. (2016). Gazing Geometries: Modes of Design Thinking in Pre-Modern Central Asia and Persian Architecture. *Nexus Network Journal*, 18(1), 105–132. doi:10.1007/s00004-016-0288-6
- Labisi, G. (2019). Squinches and Semi-domes between the Late Sasanian and Early Islamic Periods. *Iran*, 58(2), 236–249. doi:10.1080/05786967.2019.1633241
- Lendering, J. (2010). *Sarvestan*. Livius.org. <https://www.livius.org/articles/place/sarvestan/>
- Mahmudnejad, A., Andaroodi, E., & Saadatseresht, M. (2023). Advanced Clustering of Architectural Geometric Ornaments Using Small Scale Machine Learning, Case Study of Ilkhanid Geometric Patterns. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 10, 417-422. <https://doi.org/10.5194/isprs-annals-X-4-W1-2022-417-2023>
- Moradi, A. (2020). Transition Zone in Seljuq Dome Chambers. *Journal of Islamic Architecture*, 6(1). <https://ejournal.uin-malang.ac.id/index.php/JIA/article/view/7488>
- Peacock, A. C. S. (2004). Ahmad of Nigde's "al-Walad al-Shafiq" and the Seljuk Past. *Anatolian Studies*, 54, 95–107. <http://www.jstor.org/stable/3643041>
- Rohrs, S., Dumazet, A., Kuntz, K., & Franke, U. (2022). Bodies and Glazes of Architectural Ceramics from the Ilkhanid Period at Takht-e Soleyman (North-Western Iran). *Minerals*, 12(2):158. <https://doi.org/10.3390/min12020158>
- Sarhangi, R. (2016). Persian Architectural Elements and Mosaic Designs Both Traditional and Modern. *Nexus Network Journal*, 18(1), 1–5. doi:10.1007/s00004-016-0291-y
- Shadravan, S., & Shadravan, B. (2019). *A structural and architectural review of the ancient Persian domes and arches*. In: AEI 2019: Integrated Building Solutions - The National Agenda - Proceedings of the Architectural Engineering National Conference 2019, pp. 280 - 286. 10.1061/9780784482261.033
- Simon, J., & Bagi, K. (2014). Discrete Element Analysis of the Minimum Thickness of Oval Masonry Domes. *International Journal of Architectural Heritage*, 10(4), 457–475. doi:10.1080/15583058.2014.996921

- Okuyucu, S. E. (2016). Evaluation of spatial fictions, design concepts, aesthetic quests of traditional, modern mosques from past to present and the analysis of mosque samples. *Civil Engineering and Architecture*, 4(2), 54-66. doi:10.13189/cea.2016.040203
- Toorabally, M. F. T., Hoe Sieng, C., Binti Norman, H. F., & Binti Razalli, Z. (2016). Impact of Modern Technologies on Islamic Architecture in Malaysia and Middle East. *Nova Journal of Engineering and Applied Sciences*, 5(1), 1. <https://doi.org/10.20286/nova-jeas-050101>
- Yari, F., Goodarzi, S. S., Amiri, A., & Hoorshenas, R. (2016). The Stability of Dome Structures in the Iranian Traditional Architecture, Case Study: Dome of Taj-al-Molk. *Journal of Architectural Engineering Technology*, 5(2). doi:10.4172/2168-9717.1000164