Interpreting Architectural History through Mud-brick Modularity and Construction Materials: Spatial Organization in Muzaffarid Domestic Architecture of Yazd, Iran

Bardia Hajirasouliha*[a], Eisa Esfanjary Kenari[b]
[*a & b] Architectural and Urban Conservation Department, Art University of Isfahan, Hakim-Nezami St., P.O. Box: 1744, Isfahan, Iran.
Bardia.hajirasouliha@gmail.com;e.esfanjari@aui.ac.ir

Received	Accepted	Published
28.05.2026	27.07.2026	31.07.2026

https://doi.org/10.61275/ISVSej-2026-13-04-04

Abstract

Muzaffarid houses in Yazd represent one of the earliest surviving traditions of domestic architecture in the Yazd-Ardekan plain. Despite their architectural significance, the role of mud-brick dimensions in shaping their geometric and spatial organization has received little attention. This paper investigates the dimensions of mud-bricks used in eighth-century AH houses and their relationship to the geometric organization of Muzaffarid domestic architecture.

The research adopts a historical-analytical methodology based on field surveys and library research. Mud-brick dimensions were documented in surviving Muzaffarid houses and compared with those of earlier public buildings. Architectural plans and structural configurations were then analyzed to identify recurring dimensional and proportional relationships.

The results indicate that Muzaffarid houses employed a relatively standardized mud-brick module that differed slightly from those used in public buildings constructed during the first half of the eighth century AH. Mud-brick dimensions governed wall thicknesses, courtyard proportions, suffa configurations, and the overall spatial organization of houses, revealing a coherent modular design system. The findings demonstrate that mud-brick functioned not only as a construction material but also as a proportional module that established geometric order and spatial coherence in the domestic architecture of fourteenth-century Yazd.

Keywords: Mud-brick, Muzaffarid architecture, Architectural modularity, Spatial organization, Architectural metrology, Yazd, Iran

Introduction

Construction materials preserve valuable evidence of building technologies, construction knowledge, and architectural development embedded within historic structures (Hejazi et al., 2024). Among these materials, mud-bricks represent one of the principal construction materials of historic earthen architecture and preserve valuable material,

technological, and dimensional information that contributes to the interpretation of architectural history. Consequently, the study of historic building materials has become an important approach to reconstructing technological traditions, interpreting architectural history, and understanding the evolution of construction practices across different historical periods (Moropoulou et al., 2000; Zhao et al., 2019).

Iran preserves one of the world's longest continuous traditions of earthen architecture, extending from prehistoric settlements to the historic cities of the Islamic period (Avrami et al., 2008; Matthews et al. 2010). Within this broader architectural tradition, the historic city of Yazd contains one of the largest concentrations of surviving earthen buildings in Iran, providing an exceptional context for investigating how construction materials influenced architectural development, proportional systems, and building practices (Hejazi & Mehdizadeh Saradj, 2014; Hajirasouliha et al., 2024).

Despite extensive research on the physical fabric and historical development of Iranian architecture, the relationship between construction materials, architectural components, and proportional systems remains insufficiently understood. Because original design drawings, construction manuals, and practical building procedures from the medieval Islamic period have rarely survived, the design logic underlying historic architecture must often be reconstructed from the buildings themselves and the material evidence they preserve. Consequently, it remains unclear how architectural concepts were translated into built form, which dimensional principles governed the design and construction process, and to what extent construction materials functioned as regulating modules in architectural planning and spatial organization. The dimensional analysis of historic mud-bricks therefore provides an opportunity to reconstruct aspects of architectural design that are no longer preserved in documentary sources, contributing to a broader understanding of architectural metrology, proportional design systems, and the transmission of construction knowledge.

During the eighth century AH, the city of Yazd, owing to its relative immunity from the Mongol invasions, experienced favorable conditions for cultural development and architectural expansion. As a result, it attracted numerous artisans, craftsmen, and Sufi masters, a process that continued with the rise of Muzaffarid authority (Khademzadeh, 2008; Bafqi, 2013). According to Natanzi (1957):

> "The region of Yazd, at the beginning of the reign of Ghazan Khan, Sultan Muhammad Öljaitü (703–716 AH), and Sultan Abu Said Bahadur Khan[1] (717–736 AH), remained under the protection of Khwaja Rashid al-Din Fazl-Allah Hamadani[2] and the ministers, to such an extent that, thanks to their protection, it was secured."
>
> Natanzi, 1957: 34

The city's privileged relationship with influential Ilkhanid ministers, including Shams al-Din Taziku, minister of Abaqa Khan, and Khwaja Rashid al-Din, minister of Ghazan Khan and Öljaitü (Rajabzadah, 1998), together with its close association with prominent local families, particularly the Rukniyya family, created favorable conditions for urban growth and architectural prosperity.

During the Atabeg period (ca. 536–719 AH), the deputy of Khwaja Shams al-Din established a dar al-shifa[3] in Yazd in his name, while representatives associated with Khwaja Rashid al-Din founded a madrasa and khanqah adjacent to Maydan-e Waqt al-Sa'at (Kateb,

[1] Abu Said Bahadur Khan (1316–1335 CE) was the ninth and last effective Ilkhanid ruler of Iran; following his death in 1335, the Ilkhanate rapidly disintegrated into competing successor states.

[2] Khwaja Rashid al-Din Fazl-Allah Hamadani (1247–1318 CE) was a Persian statesman, physician, and historian who served as vizier to the Ilkhanid rulers Ghazan Khan, Öljaitü, and Abu Said Bahadur Khan, and is best known as the author of the Jami al-Tawarikh.

[3] The Dar al-Shifa of Yazd was a charitable hospital and medical complex founded during the Muzaffarid period. It functioned as a center for medical treatment, education, and charitable endowments.

1966; Mostawfi Bafqi, 2006). At the same time, local rulers, ministers, and religious scholars established numerous madrasas, tombs, mosques, and khanqahs, including the Rukniyya, Shamsiyya, Abu al-Ma'ali, Kamaliya, and Ziaiyya complexes. Following the collapse of the local Atabeg government in 718 AH, Mubariz al-Din Muhammad of the Muzaffarid family was appointed governor of Yazd by Abu Said Bahadur Khan (717–736 AH). After Abu Said's death in 736 AH, he established the Muzaffarid dynasty as an independent political power (Sotoudeh, 1967). According to Ahmad ibn Kateb:

> "The extent of the city doubled" during this period, and numerous buildings, including mosques, madrasas, tombs, houses, and khanqahs, were constructed throughout Yazd".
>
> Kateb, 1966: 84.

Among these, several madrasas, tombs, and a limited number of residential buildings, commonly referred to as Muzaffarid houses, have survived. These houses represent one of the earliest surviving traditions of domestic architecture on the Central Iranian Plateau and exhibit remarkable consistency in their spatial organization, construction techniques, and architectural decoration while sharing important architectural characteristics with contemporary Ilkhanid monuments in Soltaniyeh[4], Natanz, and Isfahan.

Although previous studies have investigated the history, typology, and spatial characteristics of Muzaffarid houses in Yazd (Khademzadeh, 2008; Zakerameli, 2013; Ashkezari et al., 2016; Emami Meybodi, 2021,2022), the role of mud-brick dimensions in shaping their geometric and spatial organization has not been systematically examined. The present study therefore investigates the dimensions of mud-bricks used in buildings constructed in Yazd from the late Atabeg to the late Muzaffarid period and evaluates whether standardized mud-brick dimensions functioned as regulating modules governing the geometric and spatial organization of Muzaffarid houses. The study poses the following research questions:

- What mud-brick dimensions were used in buildings constructed in Yazd from the late Atabeg period to the late Muzaffarid period?
- What relationship existed between mud-brick dimensions and the geometric and spatial proportions of houses from this period?
- Can mud-brick dimensions be considered a dimensional criterion for analyzing the spatial organization and architectural design of Muzaffarid houses?

The aim of this research is to contribute to a broader understanding of the role of standardized mud-brick dimensions as a regulating dimensional framework in the architectural design and spatial organization of Muzaffarid domestic architecture in Yazd. To achieve this aim, the study pursues the following objectives:

- To identify the characteristic dimensions of mud-bricks used in buildings constructed in Yazd from the late Atabeg to the late Muzaffarid period.
- To analyze the relationship between mud-brick dimensions and the proportional characteristics of Muzaffarid houses.
- To evaluate the role of mud-brick modules in regulating wall thicknesses, spatial organization, and architectural planning.

[4] Soltaniyeh is a historic city in northwestern Iran, founded as the capital of the Ilkhanid dynasty by Öljaitü (r1304–1316 CE). It is renowned for the Dome of Soltaniyeh, one of the largest brick domes in the world and a UNESCO World Heritage Site.

Theoretical Framework:

The concept of a regional Muzaffarid architectural tradition was first articulated by Wilber (1955), who identified a distinct "Yazdi school" of architecture based on the shared structural systems, construction techniques, and decorative vocabulary of fourteenth-century monuments in central Iran. Wilber argued that these common characteristics reflected a coherent regional tradition rather than a series of isolated architectural works. Although later scholars, most notably Holod (1972), questioned the interpretation of Yazd as an isolated stylistic school and instead emphasized the roles of patronage, urban development, local building traditions, and regional exchange, the existence of a distinctive architectural tradition in Muzaffarid central Iran remains a productive theoretical framework for understanding the architecture of the period.

Within this framework, recent scholarship has progressively extended the study of Muzaffarid architecture beyond monumental buildings to include domestic architecture as an essential source for understanding regional building traditions. This shift reflects the premise that domestic architecture preserves local construction knowledge and spatial practices that are often less evident in monumental buildings. Consequently, the Muzaffarid house has emerged as an important analytical category for investigating the formation and continuity of the regional architectural tradition.

The present study adopts this theoretical perspective by examining Muzaffarid domestic architecture through its size and spatial configuration. Rather than treating houses solely as typological or stylistic objects, the study investigates their spatial organisation as an expression of shared design principles and local architectural knowledge. In doing so, it seeks to contribute to a more comprehensive understanding of the regional Muzaffarid architectural tradition and to clarify the spatial characteristics of domestic architecture in fourteenth-century central Iran.

Literature Review

Earthen architecture has attracted increasing scholarly attention over recent decades, reflecting a growing recognition of its architectural, technological, and cultural significance. Early international research on vernacular architecture emphasizes the close relationship between locally available construction materials, building traditions, and environmental adaptation (Rudofsky, 1964; Rapoport, 1969; Oliver, 1997). These investigations establish that construction materials should not be regarded merely as structural components but as fundamental elements influencing architectural form, construction methods, and spatial organization.

During the last two decades, research on earthen architecture has expanded substantially, particularly in the fields of material science, structural engineering, and architectural conservation. Carlos et al. (2022) demonstrate that international scholarship increasingly focuses on material characterization, seismic performance, durability, conservation techniques, and digital documentation of earthen buildings. Although this body of research has significantly improved current understanding of earthen construction technologies, comparatively limited attention has been devoted to examining how the dimensions of earthen construction units influence architectural composition and proportional design.

Within this broader body of international research, Fathy (1973) provides one of the earliest explicit discussions of the relationship between earthen construction materials and architectural design. Earlier archaeological investigations likewise demonstrate that the standardization of mud-brick dimensions contributes to modular planning and architectural regularity in prehistoric settlements, indicating that construction units function not merely as building materials but also as organizing principles of architectural production (Love, 2013; Barański, 2020). Building upon this perspective, Fathy argues that the dimensions and physical characteristics of adobe govern not only structural behavior but also the spatial organization and architectural form of earthen buildings, particularly in vaults, domes, and load-bearing wall systems. Rather than considering adobe solely as a building material, he interprets it as a regulating element capable of organizing architectural design.

In parallel with these international developments, research on Iranian earthen architecture has expanded considerably during the last two decades. Previous investigations have examined a wide range of subjects, including construction technology, material characterization, structural behavior, architectural typology, conservation strategies, and the preservation of historic earthen buildings (Avrami et al., 2008; Hejazi & Mehdizadeh Saradj., 2014; Hejazi et al., 2024; Hajirasouliha et al., 2024). Collectively, these studies have considerably advanced current knowledge of Iranian earthen architecture. Nevertheless, most have addressed construction technology, material performance, and architectural form as separate fields of investigation, while the interaction between construction materials and architectural design has received comparatively less attention.

Within this broader context, in Yazd-Ardekan plain represents one of the best-preserved earthen architectural landscapes in Iran and has consequently become one of the country's principal centres of architectural research. Owing to the exceptional survival of its historic urban fabric, particularly its Ilkhanid and Muzaffarid monuments and domestic architecture, the region has attracted sustained scholarly attention. Earlier investigations have primarily focused on documenting and introducing its architectural heritage (Afshar, 1973; Amirlu, 1995; Khademzadeh, 2008; Ashkezari et al., 2016), while more recent studies have examined the typology, morphology, proportional systems, and historical development of Muzaffarid domestic architecture (Zakerameli and Esfanjary., 2006; Zakerameli, 2013; Zakerameli & Jabal Ameli., 2013; Dormohamadi., 2020; Emami Meybodi., 2022). Together, these investigations establish the principal regional framework within which Muzaffarid architecture has been interpreted.

Following the broader documentation of Muzaffarid architecture, several studies have focused specifically on the dimensions of mud-bricks and the proportional systems governing historic buildings in Yazd-Ardekan plain. Among the most comprehensive investigations is the work of Esfanjary (2017), who reconstructs the long-term chronological development of mud-brick dimensions from the early Islamic period to the twentieth century. His study demonstrates that mud-bricks remain consistently square in form while gradually decreasing in size, from approximately 34 × 34 × 7–8 cm during the early Islamic centuries to about 26 × 26 × 5.5 cm in the Muzaffarid period and approximately 23 × 23 × 5 cm during the Safavid period. Rather than interpreting these dimensional changes as isolated technological variations, Esfanjary argues that they accompany broader transformations in structural systems, construction techniques, and architectural typologies, suggesting that mud-brick dimensions form part of a coherent architectural tradition within the region.

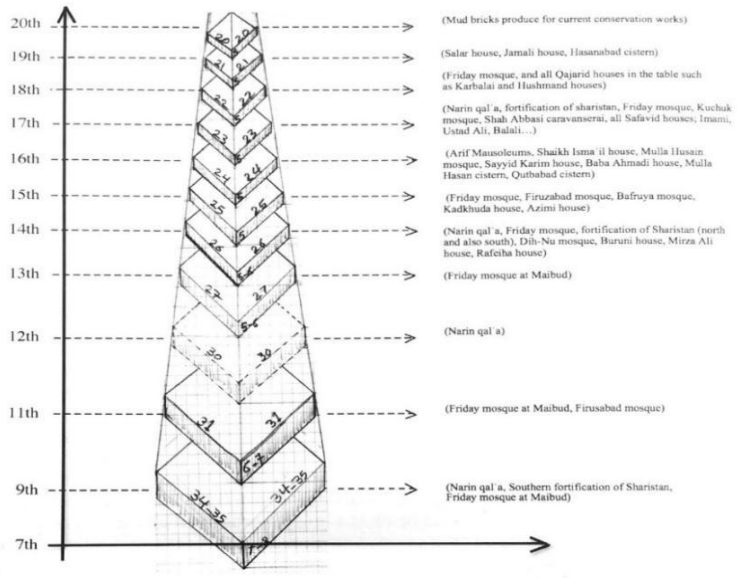

Fig.1: Mud-brick Tie: the chronological development of mud bricks developed in Meybod in the Islamic period, Source: Esfanjary, 2017

Comparable observations have also been reported beyond the Yazd-Ardekan plain. Wilber (1955) identifies a recurring construction module of approximately 26 cm in major Ilkhanid monuments despite minor dimensional variations. Similarly, O'Kane (1987) documents mud-bricks measuring approximately 25–26 cm in Timurid monuments of Khurasan and argues that these buildings were designed using geometric planning systems supported by dimensional grids and pre-construction drawings. Although neither study explicitly interprets mud-brick dimensions as generators of architectural proportion, both demonstrate that standardized construction modules form an integral component of architectural planning and dimensional coordination.

Research has also examined proportional relationships within Muzaffarid domestic architecture itself. Esfanjary and Zakerameli (2006) demonstrate that courtyards, façades, and ṣuffas follow coherent proportional systems throughout domestic layouts. Emami Meybodi (2022) further reports the evolution of courtyard proportions from the Muzaffarid to the Safavid period, while Azizi and Emami Meybodi (2025) analyze the structural proportions and slenderness of iwans in historic buildings of Yazd. Collectively, these investigations demonstrate that Muzaffarid domestic architecture is organized according to well-defined proportional principles. However, the dimensional basis through which these proportional relationships are established remains largely unexplored. Although mud-brick dimensions and wall thicknesses are occasionally reported, they are generally presented as descriptive construction data rather than being interpreted as possible regulating modules within the architectural design process.

This observation is further reinforced by studies documenting individual Muzaffarid buildings. Zakerameli (2013) records the characteristic dimensions of mud-bricks, vaults, and structural piers in Muzaffarid houses, while Nikzad and Ghafouri Barjin (2024) identify mud-bricks measuring approximately 26 × 26 × 6 cm in the earliest construction phase of the Tavana House in Yazd. Although these investigations provide valuable architectural and metrological evidence, they do not examine how the dimensions of mud-bricks influence the proportional organization or spatial composition of the buildings themselves.

Taken together, these studies substantially expand current knowledge of Muzaffarid architecture, historic construction techniques, and proportional systems. Nevertheless, an important aspect of architectural design remains insufficiently understood. Previous research has significantly advanced knowledge of Iranian earthen architecture, particularly regarding construction technology, architectural typology, proportional systems, and the historical evolution of mud-brick dimensions. However, the relationship between mud-brick dimensions and architectural design remains insufficiently understood. Existing research generally treats mud-bricks either as construction materials or as descriptive building components, while architectural proportions are examined independently of the material modules from which buildings are constructed.

This limitation is particularly evident in studies of Muzaffarid houses in Yazd. Although previous investigations document mud-brick dimensions, analyze the proportions of courtyards, façades, and ṣuffas[5], and reconstruct the typological development of domestic architecture, no study systematically investigates whether the standardized mud-brick module functioned as a generative dimensional framework governing architectural proportion and spatial organization. The present study addresses this gap by examining the relationship between mud-brick dimensions and the proportional organization of Muzaffarid houses in Yazd.

[5] Ṣuffas are raised platforms or vaulted recesses in traditional Iranian architecture. In some historical and architectural sources, the term ṣuffa is used interchangeably with iwan to denote a vaulted space open on one side, particularly in medieval Persian architecture.

Research Methods

This research adopts a historical-analytical approach based on a multiple-case study methodology to investigate the relationship between mud-brick modularity and the spatial organization of Muzaffarid domestic architecture in Yazd. The study combines two complementary methods of data collection: (1) documentary research and (2) field surveys. Documentary research was undertaken to identify, date, and classify the selected case studies using historical sources, architectural inscriptions, and previous scholarly investigations. Field surveys were subsequently conducted to document and measure mud-brick dimensions and architectural components. The collected data were then comparatively analyzed to evaluate the relationship between mud-brick dimensions, architectural proportions, and the spatial organization of Muzaffarid houses.

Potential case studies were initially identified through historical documents and previous architectural studies concerning fourteenth-century (eighth century AH) buildings in Yazd. Because only a limited number of buildings from this period have survived, all accessible examples that retained sufficient architectural integrity for reliable investigation were included in the study. Selection was based on three principal criteria: (1) accessibility for field investigation, (2) preservation of original construction fabric suitable for dimensional measurements, and (3) sufficient structural stability to permit accurate architectural documentation. The selected buildings are presented in Table 1.

Documentary research established the historical framework of each case study by identifying available evidence regarding construction dates, patrons, and historical development through surviving inscriptions and documentary sources. The selected case studies were classified into two groups: (1) public buildings, including madrasas and mausoleums, and (2) domestic buildings (houses) (Figure 2).

The first group comprises monumental buildings whose construction dates are securely established through inscriptional evidence. Most belong to the first half of the eighth century AH, corresponding to the reign of the last Ilkhanid ruler, Abu Saʿid Bahadur Khan (718–736 AH), and the transitional period between Atabeg and Muzaffarid rule, while a limited number date to the middle and late Muzaffarid period. These buildings include Madrasa Shah Kamaliya (720 AH), Gunbad-i Hasht (726 AH), Madrasa Sayyed Rukn al-Din (723 AH), the Mausoleum of Shaykh Ahmad Fahadan (725–750 AH), Madrasa Shamsiyya (733–736 AH), Madrasa Ziaiyya (631–705 AH), and Madrasa Taraz (787 AH).

The second group consists of domestic buildings that have been attributed to the Muzaffarid period through previous architectural investigations (Khademzadeh, 2008). Although their precise construction dates remain uncertain because historical documents rarely record domestic architecture, comparative analyses of their spatial configuration, construction techniques, architectural ornamentation, and relationship with contemporary public monuments consistently indicate that they belong to approximately the same historical period. These buildings include the House and Madrasa of Aqa (Seyyed Gol-e Sorkh Quarter), Qariha House (Abu al-Maʿali Quarter), Sarmad House (Abu al-Maʿali Quarter), Najib House (Abu al-Maʿali Quarter), Hassan-abadi House (Bagh-e Gandom Quarter), Tehrani House (Bagh-e Gandom Quarter), Karimi House (Sheikh Dad Quarter), Babaei House (Iranshahr Quarter), together with several comparable examples.

During the field surveys, each selected building was systematically documented and measured. Photographic documentation was first undertaken to record the construction fabric and the locations selected for measurement. Mud-brick dimensions were then measured using a graduated measuring tape and recorded directly during the survey. Measurements were preferentially obtained from interior portions of the buildings, where the original construction fabric had been less affected by weathering and surface erosion, thereby improving the reliability of the recorded dimensions.

For monumental buildings, measurements were taken from the inner and outer walls of the domed chambers and attached iwans. Where access permitted, mud-bricks were also measured in walls, vaults, arches, and other architectural components of domestic buildings to

verify the occurrence of different mud-brick types within individual structures. In total, the original construction materials of twenty-five buildings were documented and measured.

Previous studies have demonstrated that mud-brick dimensions may vary not only between historical periods but also within individual buildings (Hajirasouliha et al., 2024). Similar variations in the dimensions and quality of wall and vault mud-bricks have also been reported for Muzaffarid houses in Meybod (Zakerameli & Esfanjary., 2006). Such differences result primarily from variations in production techniques, mould dimensions, and the physical properties of local soils. Since clay-rich soils experience greater shrinkage during drying than sandier soils, a measurement tolerance of ±0.5 cm was considered acceptable throughout this study (Esfanjary, 2017).

Several factors were considered when interpreting the field measurements. Successive plaster layers applied during different historical periods modify original wall surfaces and may influence measurements of wall thicknesses and pier dimensions. Traditional construction methods also introduce minor dimensional inconsistencies because walls were constructed using string lines and plumb lines rather than modern precision instruments. Furthermore, structural deformations resulting from age, abandonment, differential settlement, and wall displacement have altered portions of the original geometry of several buildings. These factors were considered during the analysis, and minor dimensional inconsistencies were evaluated before reconstructing the underlying mud-brick modular network.

Following completion of the field surveys, the recorded measurements were classified and compared to identify recurring dimensional patterns. The influence of mud-brick dimensions on architectural proportions and spatial organization was then analyzed by recording the principal architectural components of each house, including the courtyard, the principal suffa, the secondary suffas, and the northern suffa, in terms of their length, width, and height. Proportional relationships among these components were subsequently examined to determine whether standardized mud-brick dimensions functioned as a regulating module in the spatial organization of Muzaffarid domestic architecture.

Table 1. List of Ilkhanid and Muzaffarid Buildings in Yazd used for this research

No.	Name of Building	Quarter	Type	Date (AH)	Patron
Madrasas, Tombs					
1	Dar al-Shifa Sahebi / Abu al-Darda Portal	Dar al-Shifa	Dar al-Shifa / Portal	660	Khwaja Shams al-Din Muhammad Taziku
2	Madrasa Ziaiyya	Fahadan	Madrasa	631–705	Mawlana Ziya al-Din Husayn Razi and his son Shams al-Din Ali
3	Madrasa Sayyed Rukn al-Din	Waqt al-Sa‘at	Madrasa-Tomb	725	Sayyed Rukn al-Din Abu al-Makarim Muhammad Qadi Husayni Yazdi
4	Jami‘ Atiq Mosque	Char-suq	Mosque	5th century	Ala al-Dawla Garshasp
5	Madrasa Shah Kamaliya	Shah Abu al-Qasim	Madrasa, Tomb	720–729	Khwaja Kamal al-Din Abu al-Ma‘ali
6	Mausoleum of Shaykh Ahmad Fahadan	Fahadan	Tomb,Khanqah,	725–735–750	Sayyed Mubarak al-Din Muhammad ibn Muzaffar
7	Gunbad-i Hasht	Fahadan	Madrasa-Tomb	726	Sayyed Shams al-Din Husayn

8	Madrasa Shamsiyya	Char-minar	Madrasa-Tomb	733	Sayyed Shams al-Din Muhammad
9	Madrasa Shahab al-Din Qasim Taraz	Shah Abu al-Qasim	Madrasa	787	Khwaja Shahab al-Din Qasim Taraz
10	Mausoleum of Sultan Shaykh Dad	Shaykh Dad	Tomb, Mosque	726	Qazi Shahab al-Din Mas'ud
Houses					
11	Aqa House-Madrasa	Seyyed Gol-e Sorkh	House-Madrasa	7th–8th century	Unspecified
12	Afshar House	Bagh-e Gandom	House	Unspecified	Unspecified
13	Babaei House	Takht-e Ustad	House	Unspecified	Unspecified
14	Tavana House	Shah Abu al-Qasim	House	Unspecified	Unspecified
15	Hassan-Abadi House	Bagh-e Sandal	House	Unspecified	Unspecified
16	Dost-Gol House	Bagh-e Sandal	House	Unspecified	Unspecified
17	Karimi House	Shaykh Dad	House	Unspecified	Unspecified
18	Mumtaz House	Abu al-Ma'ali	House	Unspecified	Unspecified
19	Tehrani House	Bagh-e Gandom	House	Unspecified	Unspecified
20	Najib House	Abu al-Ma'ali	House	730–780 AH	Unspecified
21	Sarmad House	Abu al-Ma'ali	House	730–780 AH	Unspecified
22	Qariha House	Abu al-Ma'ali	House	730–780 AH	Unspecified
23	Muhammad Ali Gol House	Abu al-Ma'ali	House	730–780 AH	Unspecified
24	Khorasani House	Bagh-e Sandal	House	Unspecified	Unspecified
25	House adjacent to Fahadan Shrine	Fahadan	House	725–735–750	Unspecified

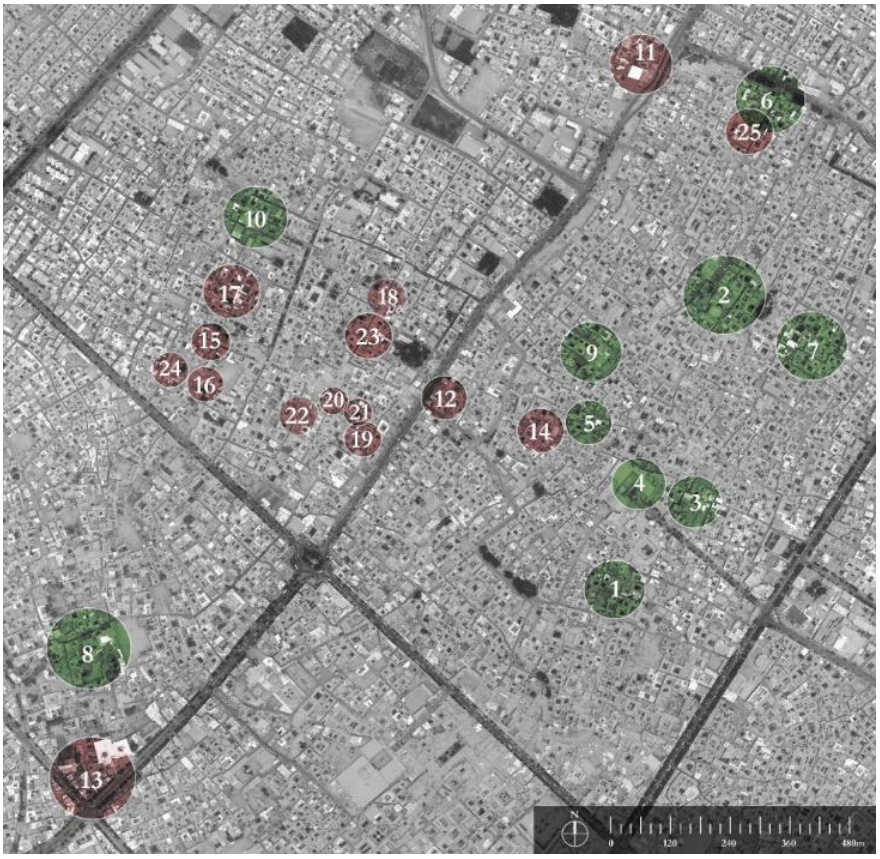

Fig. 2: Locations of the Buildings Studied in an Aerial Image of Yazd (Green color: Madrasas, mosques, and shrines, Red color: Local houses). Source: Authors' field survey (2025).

Introduction to Case Studies

Yazd Madrasas

Following the Mongol invasion, which resulted in the destruction of civilizational infrastructure and the spread of insecurity across Iran, Yazd, owing to the foresight of the Atabegs and its distance from the initial areas of Mongol incursion, attained a prominent position in attracting religious scholars and Sufi masters from the second half of the Ilkhanid period (early eighth century AH) (Bafqi, 2013). To such an extent that by the eighth century AH, approximately one hundred madrasas, two hundred khanqahs, and twelve mosques were established in the city of Yazd (Naini, 1997). This tradition continued the Atabeg practice of madrasa construction, whereby rulers, viziers, and religious scholars each founded a madrasa of their own (Jafari, 1964). The madrasas of Yazd, in addition to serving the teaching and education of scholars, were constructed as the burial place of the madrasa's patron (Khademzadeh, 2008), so that, in addition to functioning as a teaching space and gathering place for a group of disciples, after his death it would serve as his tomb and shrine. Typically, the madrasas of Yazd, in harmony with the pattern of houses and mosques of this period, possess a longitudinal structure in which the main suffa leads to a dome higher than the other three facades (Zakerameli & Esfanjary, 2006; Emami Meybodi, 2022).

Fig. 3: Some of the 8th-century Madrasas: A) Shah Kamaliya, B) Sayyed Rukn al-Din, C) Shamsiyya, D) Aqa, E) Sheykh dad, F) Gunbad-i Hasht, G) Shah Kamaliya, H) Ziaiyya. Source: Authors' field survey (2026).

Muzaffarid Houses

These buildings represent a type of four-suffa domestic architecture in Iran. According to Pirniya, with the enlargement of the four-suffa pattern and the expansion of spaces around the central core, the middle section was transformed into a courtyard (Pirniya, 1999). Like the madrasas of the eighth century AH, Muzaffarid houses also display common architectural characteristics that are expressed through recurring spatial forms and, taken together, define a distinctive architectural tradition. Despite the changes and transformations that have occurred over the centuries, the survival of the principal spaces from the original phase of construction clearly reflects the architectural principles and construction techniques of Ilkhanid-Muzaffarid

domestic architecture (Zakerameli & Esfanjary, 2006). The principal spatial components of Muzaffarid houses in Yazd include the central courtyard, the sarabostan[6] courtyard (Emami Meybodi, 2021), the main (southern) suffa, the secondary suffas, the northern suffa (opposite the main suffa), the tanabi (the room behind the main suffa), corridors, passageways, and the entrance. On the remaining sides of the courtyard are secondary iwans or suffas with symmetrical facades, equal in height to the northern suffa and shorter than the main suffa. These suffas sometimes have equal widths (as in the Hassan-Abadi and Karimi Houses), while in other cases the suffa connected to the entrance passageway and the staircase leading to the rooftop or second floor (secondary suffa 1) is narrower than the opposite suffa (secondary suffa 2) (Emami Meybodi, 2022).

Fig.4: Images of Some of the 8th-century: A & E) Qariha house, B & F) Sarmad house, C & G) Hassan-Abadi house, D) Aqa house, H) Afshar house. Source: Authors' field survey (2026).

Findings

This section presents the findings derived from field investigations, including the measurement, photographic documentation, and recording of mud-brick dimensions in selected historical buildings in Yazd. The obtained measurements are subsequently analyzed to examine the relationship between the mud-brick module and the physical organization of Muzaffarid domestic architecture. Based on these dimensions, the proportional networks of several representative houses are reconstructed and analyzed. In parallel, findings from historical texts, waqf documents, and historical architectural drawings concerning the tradition of architectural representation and proportional systems in Iranian-Islamic architecture are examined to provide a broader interpretive framework for understanding the design principles underlying these buildings.

[6] Sarabestan was a residential garden arrangement in Ilkhanid and Timurid Yazd, referring to houses with either a sunken planted courtyard integrated with the forecourt or a small rear garden (bagh-i khalafi) located behind one of the principal suffas, particularly the main southern iwan.

Dimensions of Mud-bricks

Prior to examining the mud-brick dimensions of buildings from the eighth century AH in Yazd, measurements were taken from surviving mud bricks in the upper portal of the fifth-century AH Old Jami Mosque, located within the western courtyard of the present-day Jami Mosque (dating to the first half of the eighth century AH), as well as from the surviving portal of the Dar al-Shifa complex, known as the Abu al-Darda Portal, dating to around 660 AH. This investigation revealed that the mud-brick used in the surviving vault of the fifth-century AH Old Jami Mosque measures 31 × 31 × 6.5 cm to 30.5 × 30.5 × 6.5 cm, while the mud-brick employed in the walls and vault of the Abu al-Darda complex is identical in dimensions and approximately 3 to 3.5 cm larger than those in the eighth-century AH buildings discussed below (Figure 3).

Examination of the mud-brick dimensions in madrasas and tombs constructed approximately between 700 and 736 AH (late Ilkhanid and Atabeg period and early Muzaffarid rule in Yazd) shows uniform dimensions (Figure 4, Table 2). Specifically, the mud-brick used in the domed chamber walls and iwan of Madrasa Ziaiyya (631–705 AH), Kamaliya (720 AH), Gunbad-i Hasht (726 AH), Shaykh Ahmad Fahadan (750 AH), and Shamsiyya (735 AH) consistently measures 27.5 × 27.5 × 6 cm to 27 × 27 × 5.5 cm. These differ from the mud-brick dimensions in Shahab al-Din Qasem Taraz (25.5 × 25.5 × 5.5 cm), constructed in 787 AH. Among early 8th century AH buildings, the mud-brick in the domed chamber walls of Rukniyya (725 AH) measures 29 × 29 × 6.5 cm to 28.5 × 28.5 × 6.5 cm, which is approximately 1.5 to 2 cm larger than in other madrasas and tombs of the period. This variation may be attributed to an earlier construction phase, or perhaps the larger span of the iwan and domed chamber in Rukniyya.

In the Muzaffarid houses, which exhibit strong structural similarities to the period's prominent buildings, consistent mud-brick dimensions are observed across the sample. Measurements were taken from various points in fourteen buildings. The mud-brick used in walls and vaults of most of these houses measures 25.5 × 25.5 × 5.5 cm to 25 × 25 × 5.5 cm to 24.5 × 24.5 × 5–5.5 cm. For instance, in the Hassan-Abadi House, the mud-brick in vaults, walls, and even the spandrel filled walls of secondary iwans is uniformly 25.5 × 25.5 × 5.5 cm. Similarly, in the Qariha House, mud-brick in various parts including walls and vaults of the main suffa and entrance corridor walls measures 24.5 × 24.5 × 5 cm to 25 × 25 × 5–5.5 cm (Hajirasouliha et al., 2025).

Among the studied examples, Mumtaz House and Karimi House feature smaller mud-brick (23.5 × 23.5 × 5 cm to 23 × 23 × 5 cm) compared to the others. Analysis of the structural patterns in these buildings indicates differences in architectural components from the rest of the sample. For example, variations in arch profiles, iwan slenderness ratios, niche arrangements, courtyard elongation, and iwan decorative elements suggest that these two houses represent a continuation of eighth-century house-building traditions but were constructed in the tenth century AH. Overall, given the minor variations in mud-brick dimensions across most buildings (within a 5 mm range), it is likely that the mould used for producing mud-brick in Muzaffarid houses was square, measuring 26 × 26 × 5.5–6 cm to 25 × 25 × 5.5–6 cm. After removal from the mould, the edges may have shrunk by 1–2 mm, with further reduction of 2–3 mm during drying. Assuming a mould size of 26 cm, this corresponds exactly to one-quarter gaz[7] (Da-irat al-Ma arif-i Buzurg-i Islami, 2001), which was probably the standard gaz unit in this region.

[7] In Iran, a unit known as the gaz was widely used, with a length ranging from 94 to 104 cm.

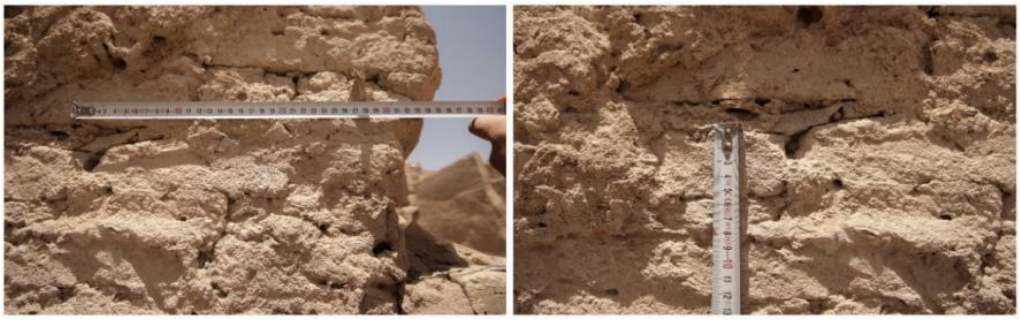

Fig. 5: Measurement of mud-brick in walls in the Dar al-Shifa Complex and Abu al-Darda Portal, dated to 660–669 AH. Source: Authors' field survey (2026).

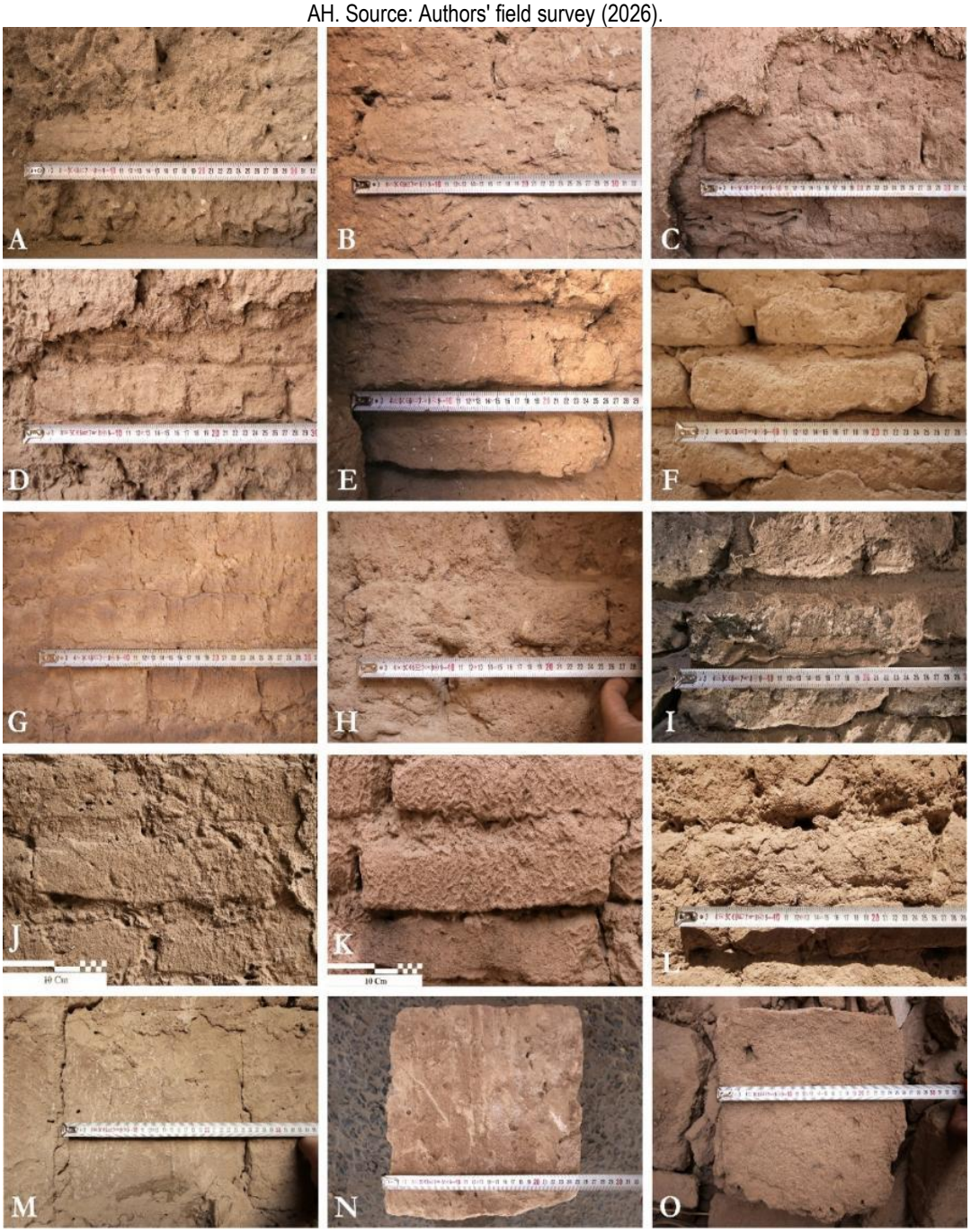

Fig.6: Scaled image of some mud-brick from funerary madrasas of the first half of the 8th century and Muzaffarid houses of Yazd: A) Madrasa Ziaiyya, B) Rukn al-Din, C) Kamaliya, D) Gunbad-i Hasht, E) Shamsiyya, F) Sheykh dad, G) Shahab al-Din Qasim Taraz, H) Sarmad house, I) Qariha house, J) Fahadan house, K) Karimi house, L) Najib house, M) Hassan-Abadi, N) Tavana house, O) Dost-Gol. Source: Authors' field survey (2026).

Table 2. Mud-brick Dimensions of Ilkhanid and Muzaffarid Buildings in Yazd, Measured in This Study

Madrasas, Tombs			
No.	**Name of Building**	**Mud-brick Dimensions (cm)**	**Element**
1	Dar al-Shifa Sahebi / Abu al-Darda Portal	31 × 31 × 5.5 to 30.5 × 30.5 × 5.5	Wall
2	Ziaiyya Madrasa	27.5 × 27.5 × 6	Domed chamber wall
3	Sayyed Rukn al-Din Tomb / Madrasa	29 × 29 × 6.5 to 28.5 × 28.5 × 6.5	Domed chamber wall
4	Jami‘ Atiq Mosque	31 × 31 × 6.5 to 30.5 × 30.5 × 6.5	Vault/wall
5	Kamaliya Madrasa	27.5 × 27.5 × 6 to 27 × 27 × 5.5	Domed chamber wall
6	Fahadan Shrine / Mausoleum	27.5 × 27.5 × 6	Wall/vault
7	Gunbad-i Hasht	27.5 × 27.5 × 6	Wall/vault
8	Shamsiyya Madrasa	27.5 × 27.5 × 6	Wall/vault
9	Taraz Madrasa	25.5 × 25.5 × 5.5	Wall/vault
10	Sultan Shaykh Dad Tomb / Mosque	25 × 25 × 5 to 24.5 × 24.5 × 5	Wall
Houses			
11	Aqa madrasa/house/khanqah	25.5 × 25.5 × 5.5	Main soffe wall
12	Afshar House	25 × 25 × 5.5	Wall
13	Babaei House	25.5 × 25.5 × 5.5	Wall
14	Tavana House	24.5 × 24.5 × 5	Wall/vault
15	Hassan-Abadi House	25.5 × 25.5 × 5.5	Vault/wall/spandrel
16	Dost Gol House	24.5 × 24.5 × 5	Wall/vault
17	Karimi House	23.5 × 23.5 × 5 to 23 × 23 × 5	Wall/vault
18	Mumtaz House	23.5 × 23.5 × 5 to 23 × 23 × 5	Wall/vault
19	Tehrani House	25 × 25 × 5	Wall
20	Najib House	25.5 × 25.5 × 5	Main suffe wall
21	Sarmad House	25 × 25 × 5	Wall/vault
22	Qariha House	24.5 × 24.5 × 5 to 25 × 25 × 5–5.5	Main suffa wall/vault
23	Muhammad Ali Gol House	24.5 × 24.5 × 5	Wall/vault
24	Khorasani House	25 × 25 × 5	Wall
25	House adjacent to Fahadan Shrine	25 × 25 × 5 to 24.5 × 24.5 × 5	Wall

Proportions

Following the examination of mud-brick dimensions in a number of eighth-century AH buildings, six houses that exhibited better conditions in terms of structural integrity and adherence to their original pattern were selected for the proportion analysis. In investigating structural proportions, the relationship between mud-brick dimensions and the thickness of the principal walls that could be confidently attributed to the initial phase of construction and were built of uniformly sized mud bricks was first examined. This analysis focused on the walls flanking the main suffa and the walls separating the secondary suffas. Because of the numerous later additions and alterations made to rooms associated with the northern suffa, the tanabi rooms, and the rooms adjoining the secondary suffas, measurements of these elements were omitted. In this examination, the thickness of each wall was measured and recorded, taking into account the layers of plaster added to the wall surfaces during different historical periods (Table 3). The wall thicknesses were then divided by the dimensions of the mud-brick plus mortar joint employed namely the 26 cm square module and converted into modular units. As noted in the methodology section, several sources of error are encountered at this stage. For this reason, after measurement and division of the thicknesses by the mould dimensions, the resulting figures were corrected. In other words, on the basis of the number of mud-brick units calculated for the wall thickness, the thickness of the plaster layers on both sides of the wall was subtracted in order to obtain the full mud-brick dimension. Likewise, in sections where half mud-brick had been used, it is not precisely clear whether the craftsman divided a full mud-brick exactly in half (equivalent to 13 cm) or slightly more or less. Divisions close to half a mud-brick were therefore also taken into account, with a tolerance of 1 to 2 cm.

This examination showed that the thickness of the piers between the secondary suffas on both the eastern and western sides of the courtyard follow a module ranging from 2 to 2.5 mud-brick units. Of the six samples examined, five have walls equivalent to 2 mud-brick units

(52 cm), while one sample (the Hassan-Abadi House) has walls equivalent to 2.5 mud-brick units (63 cm). In addition, the thickness of the walls flanking the main suffa ranges between 2.5, 3, and 3.5 mud-brick units. Among the six buildings examined, the main suffa walls of the Hassan-Abadi and Tehrani Houses exhibit the greatest thickness at 3.5-3 mud-brick units (91-85 cm); the Sarmad House at 3 mud-brick units (78 cm); and the Qariha, Babaei, and Najib Houses at 2.5 mud-brick units (65-63 cm).

When converting spatial dimensions to the mud-brick module, the width of the main suffa and the width of the courtyard fall within the range of 11 to 15 mud-brick modules, while the length of the main suffa and the length of the courtyard range from 12 to 18 mud-brick modules. A noteworthy point here is that, in most samples, the structural pattern of the suffa follows consistent proportions. However, in some cases the width of the main suffa and the width of the courtyard differ by approximately 1 to 2 mud-brick units. This difference arises because, at the junction of the main suffa facade with the courtyard edges, the flanking walls of the main suffa are set back from the edges of the secondary suffas by about 1 to 0.5 mud-brick unit on each side, thereby creating a continuous frame for the iwan arch, as shown in Figure 4.

Table 3. Measurement of Wall Thicknesses of Main and Secondary Suffas and Conversion to Mud-brick Units

Houses	Centimeter		Mud-brick block unit					
	Thickness		Thickness		Length unit			
	Main Suffa Pier	Secondary Suffa Piers	Main Suffa	Secondary Suffa Pier	Width of Main Suffa	Depth of Main Suffa	Small Courtyad Side	Large Courtyad Side
Qariha	63	52	2.5	2	10	12	11	14
Babaei	63	50	2.5	2	12	15	13	17
Hassan-Abadi	85	63	3.5	2.5	13	17	15	17
Sarmad	78	51	3	2	12	15	14	16
Tehrani	91	52	3.5	2	13	18	15	18
Najib	65	52	2.5	2	13	17	13	16

After measuring and converting pier thicknesses to mud-brick modules, a comparison was made of the dimensions and sizes of each individual space based on the mud-brick mould dimensions. In this context, the dimensions of some of the principal spaces in these houses such as the length and width of the courtyard, the southern and northern suffas, and the eastern and western secondary suffas were first measured. The length-to-width ratios of each component were then calculated for every sample, and the standard deviation of these ratios was determined relative to the overall mean across the six samples. This examination revealed that the length-to-width ratio of courtyards in Muzaffarid houses in Yazd ranges from 1.11 to 1.29, with a mean of 1.22 and a standard deviation of 0.07. Likewise, the length-to-width ratio of the southern suffa ranges from 1.23 to 1.39, with a mean of 1.33 and a standard deviation of 0.08. Examination of the northern suffa proportions shows that this space, which has a lesser depth than the other suffas in all samples except the Hassan-Abadi House (1:3), falls within the range of 2.08 to 3.60, with a mean of 2.14 and a standard deviation of 0.55. The proportions of the secondary suffa connected to the entrance corridor also lie in the range of 1.19 to 2.68, with a mean of 2.14 and a standard deviation of 0.05 (Table 4)

Table 4. Analysis of Physical Proportions of Muzaffarid Houses Studied in This Research

House Physical Proportion	Qariha	Babaei	Hassan -Abadi	Sarmad	Tehrani	Najib	Mean	STD
Width of Court Side (cm)	274	342	380	371	388	340	1.22	0.07
Length of Court Side (cm)	353	438	420	429	474	430		
Courtyard Ratio	1.29	1.28	1.11	1.16	1.22	1.26		
Width of Southern Suffa (cm)	245	324	323	319	344	324	1.29	0.08
Length of Southern Suffa (cm)	303	430	450	391	479	430		
Southern Suffa Ratio	1.24	1.33	1.39	1.23	1.39	1.33		

Width of Northern Suffa (cm)	245	292	314	318	311	324	3.01	0.55
Length of Northern Suffa (cm)	76	94	170	99	101	90		
Northern Suffa Ratio	3.22	3.11	1.85	3.21	3.08	3.60		
Width of Secondary Suffa 1 (cm)	100	133	160	130	200	130	2.14	0.05
Length of Secodnary Suffa 1 (cm)	268	285	190	329	371	317		
Secondary suffa 1 Ratio	2.68	2.14	1.19	2.53	1.86	2.44		
Width Secondary suffa 2 (cm)	175	230	167	210	200	173	1.46	0.3
Length Secondary suffa 2 (cm)	215	281	194	314	362	315		
Secondary suffa 2 Ratio	1.23	1.22	1.16	1.50	1.81	1.82		

After examining each space constituting the physical fabric of Muzaffarid houses individually, the length-to-width ratios of each space in relation to one another were calculated (Table 5). This examination revealed that the ratio of courtyard length to main suffa depth in Muzaffarid houses exhibits a nearly equal proportion, ranging from 0.95 to 1.17 with a mean of 1.05 and a standard deviation of 0.08, with only very slight variation. In the Hassan-Abadi House, which has a larger overall building area and courtyard dimensions than the other samples, the difference between the length of the main suffa and the courtyard ranges from 30 to 50 cm, whereas in the other buildings it is less than 8 cm. Furthermore, the length of the suffas connected to the entrance corridor, relative to the width of the main suffas (excluding the Hassan-Abadi House), exhibits an almost equal ratio ranging from 0.9 to 1.09, with a mean of 0.94 and a standard deviation of 0.19. The transverse ratio of the large secondary suffas connected to the main suffa to the length of the courtyard ranges from 1:2 to 1:2.6, with a mean of 2.25 and a standard deviation of 0.30. Regarding the ratio of the courtyard to the northern iwan, in nearly five samples this ratio is 1:4 (ranging from 4.33 to 4.78), while only in the Hassan-Abadi House has this ratio changed to 2.51. In sum, the figures and proportions obtained indicate that a highly logical relationship exists between the physical components of these buildings including piers and columns and the open spaces such as suffas, courtyards, and small iwans and corridors. This relationship, with only minor differences, is almost uniformly shared across all these buildings.

Table 5. Ratios Between Physical Components of Muzaffarid Houses Studied in This Research

Houses	Length of the courtyard to length of the main suffa	Width of the secondary suffa 1 to width of the main suffa	Length of the secondary suffa 1 to length of the courtyard	Width of the northern suffa to length of the courtyard	Width of the secondary suffa 2 to length of the courtyard	Length of the secondary suffa 2 to width of the courtyard
Qariha	1.17	1.09	0.98	4.64	2.02	1.27
Babaei	1.11	0.88	0.83	4.66	1.90	1.22
Hassan-Abadi	0.95	0.58	0.50	2.51	2.66	2.00
Sarmad	1.09	1.03	0.89	4.33	2.04	1.18
Tehrani	0.99	1.08	0.96	4.69	2.37	1.07
Najib	1.00	0.98	0.93	4.78	2.49	1.08
Mean	1.05	0.94	0.85	4.27	2.25	1.30
STD	0.08	0.19	0.18	0.88	0.30	0.35

Spatial Network Development

Based on the information obtained, a square grid network, aligned with the mud-brick mould dimensions and conforming to the wall thicknesses, was superimposed on the plan of each building. This network was formulated in two variants: the first network, which aligns with the plans of most of these buildings, consists of squares measuring 51 to 53 cm, each comprising two mud-brick units of 25 or 26 cm including a 1 cm mortar joint between them (Figure 7). This network fits five out of the six building samples.

The second network consists of squares based on a module of two and a half mud-brick units, measuring 63 to 65 cm, and was applied only to the Hassan-Abadi House, where the inner courtyard dimensions, suffa dimensions, and flanking piers are larger than in the other buildings (Figure 8). This modular grid approach demonstrates that the standardized mud-brick dimensions served as the fundamental unit for laying out the spatial organization and structural framework of Muzaffarid houses. The predominance of the 51–53 cm grid across the majority of samples underscores the typological consistency and permanence of the design system, while the exceptional 63–65 cm grid in the Hassan-Abadi House illustrates an incremental adaptation within the same modular logic to accommodate greater scale and spatial requirements.

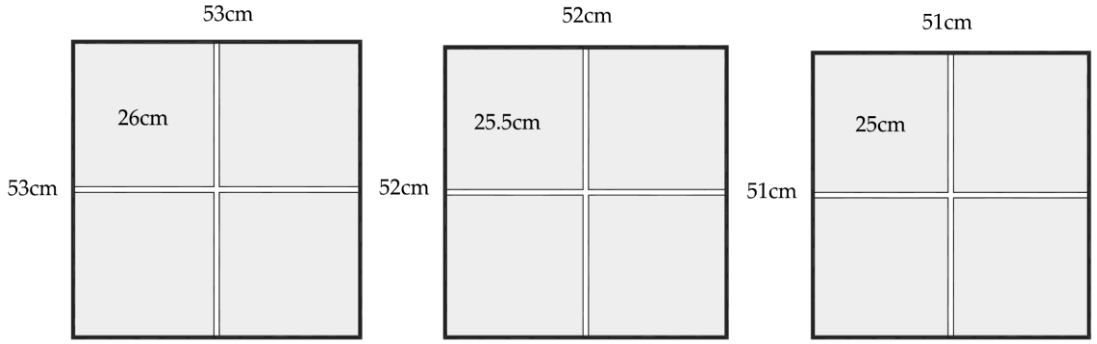

Fig.7: Two and a half mud-brick square grid equivalent to 51-52-53 cm in small scale houses. Source: Authors' field survey (2026).

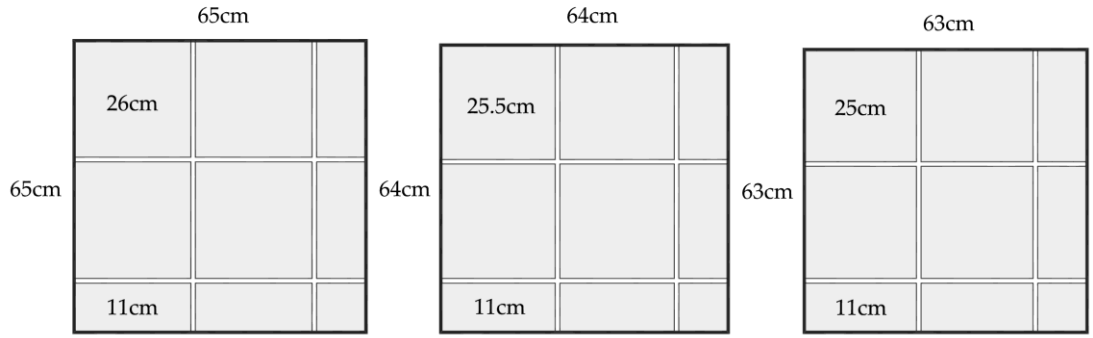

Fig.8: Two and a half mud-brick square grid equivalent to 63–64–65 cm in large scale houses. Source: Authors' field survey (2026).

For the formulation of an underlying grid in the structure of the plans, two essential points must be mentioned. Firstly, the buildings under study, owing to multiple periods of occupation and subsequent changes in their details such as the accumulation of plaster layers and historical strata on walls and floors, the addition of staircases, and the insertion of partition walls alongside the main walls in some cases no longer retain their original dimensions and proportions. Secondly, longitudinal misalignment or lack of right angles in these spaces, resulting from execution errors and the unevenness of the ground beneath the buildings under consideration, introduces errors into the spatial network analysis. Thirdly, the analysis of plan structures, in addition to the reasons already stated, is also subject to errors arising from surveying and manual measurements. For this reason, the proposed grid superimposed on the plans of these buildings is, in some cases, accompanied by an error margin of approximately ±5 cm an error that the authors consider negligible in buildings with an age of 700 to 800 years. Moreover, what appears most significant here is identifying the key to the design system of these buildings, rather than precisely what was executed after the design phase. With these considerations and the acknowledgement of potential errors in certain samples, the proposed grid maintains a very close correspondence with the principal lines of the plans (Figure 9). The examination of the grid aligned with the mud-brick module reveals that the proportions of

the components in the courtyard, southern suffa, northern suffa, and the width of the small and large secondary suffas are almost identical in some of the buildings. These proportions in the Babaei, Najib, Sarmad, and Hassan-Abadi Houses follow similar grids and identical ratios. In this manner, the length-to-width ratios of the courtyard and the main suffa are 6:7 or 6:8. In the meantime, the width of the northern iwan in all samples falls within the range of 1.5 to 2.5 transverse modules and 5 to 6 longitudinal modules, conforming to the courtyard width proportions. The Qariha House, with the smallest area among the Muzaffarid houses, is usually half a module or one module smaller than the common proportions of the other buildings (Table 6). In the secondary side of the courtyard, the width of the small and large iwans ranges from 2 to 4 modules, while their length ranges between 3 and 7 modules. A noteworthy point in the secondary iwan grid is the considerable variation in their length, whereas their width shows limited variation. This indicates that the depth of these iwans varies in each building according to the shape and dimensions of the plot, the number of rooms that can be placed behind the secondary iwans, and the building's position. Consequently, despite the shared proportions in the courtyard and the division of the iwans, the length of the secondary iwans varies according to the characteristics of the land, the building's location, and its adjacent spaces.

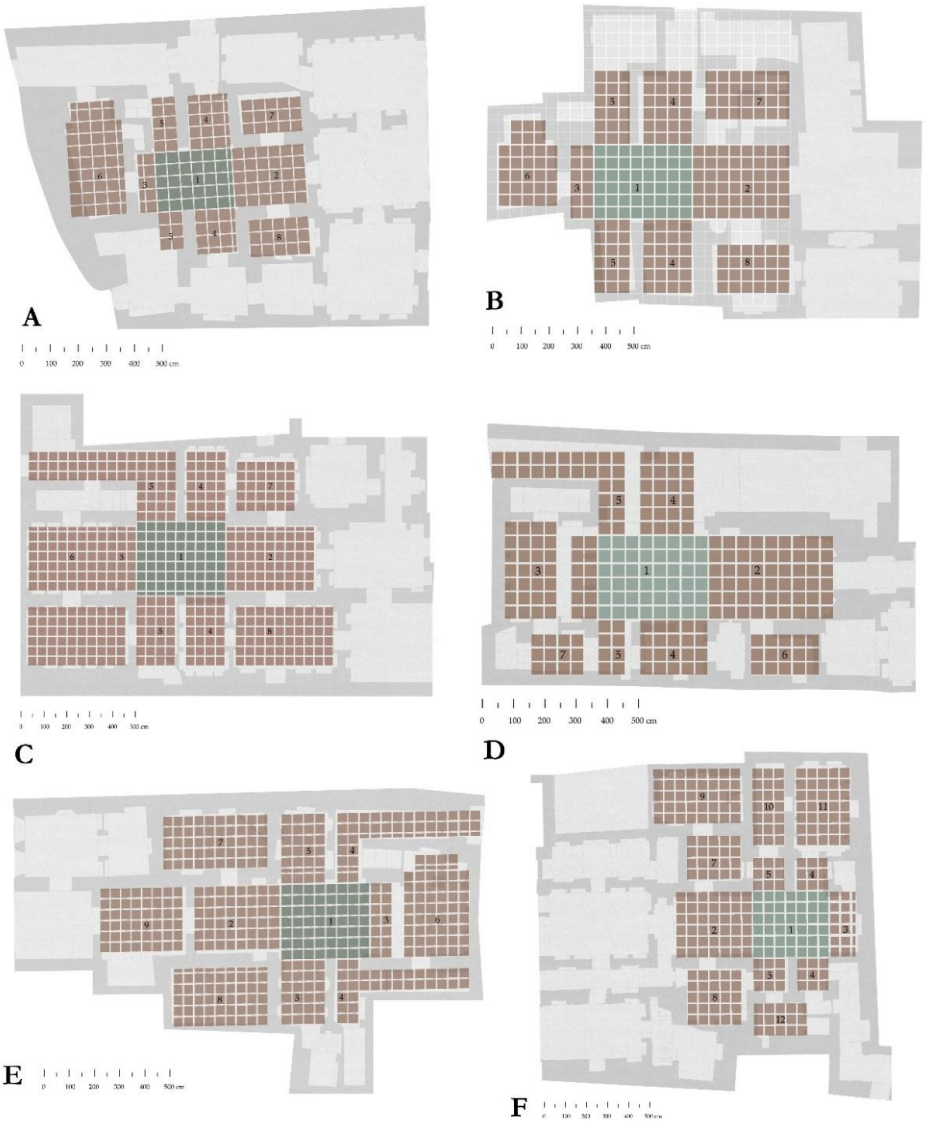

Fig. 9. Development of the underlying spatial grid in the plan structure of Muzaffarid houses based on mud-brick grid modules. A) Qariha, grid: 51 cm; B) Babaei, grid: 51–52 cm; C) Tehrani, grid: 53 cm; D) Najib, grid: 53 cm; E) Sarmad, grid: 51 cm; F) Hassan-Abadi, grid: 62–63 cm. Source: Authors' field survey (2025).

Table 6. Spatial dimensions of the principal architectural elements expressed in mud-brick grid modules

Houses	Court		South Suffa		North Suffa		Small Secondary Suffa		Large Secondary Suffa	
	Lth*	Wth**	Lth	Wth	Lth	Wth	Lth	Wth	Lth	Wth
Babaei	8	6	8	6	6	2	5	3	5	4
Najib	8	6	8	6	6	2	6	2	6	4
Sarmad	8	6_7	8	6	6	2	6	2	6.5	4
Hassan-Abadi	7	6	7	6	6	2.5	3	3	3	3
Tehrani	9	7_7.5	9	6.5	6.5	_	7	4	7	4
Qariha	6.5	5	6	5	5	1.5	5	2	5	3.5
Range	9-7	7-5	9-6	7-5	7-5	2.5-1.5	7-3	4-2	7-3	4-3.5

*Length: Lth **Width: Wth

Historical Documentary Evidence for Architectural Planning

The documentary survey undertaken in this research identified a range of historical, archaeological, and visual sources relating to architectural planning and dimensional coordination during the Ilkhanid and post-Ilkhanid periods. These sources comprise historical chronicles, waqf documents, archaeological discoveries, architectural drawings, and later visual records.

Wilber (1955), based on measurements of major Ilkhanid monuments, identified a recurring dimensional module of approximately 26 cm as a common denominator in the architecture of this period. According to Wilber, although slight positive and negative deviations occasionally occurred, this module appears repeatedly in Ilkhanid monuments. Comparable dimensional variations are also observable in the late Atabeg and early Muzaffarid monuments examined in the present study, where mud-brick dimensions fluctuate within a narrow range of approximately ±0.5–1 cm around the same module.

Wilber (1955) also refers to the now-lost Kitāb al-Iḥyāʾ wa al-Āthār by Khwaja Rashid al-Din Fazl-Allah Hamadani, a treatise reportedly devoted to the principles and regulations governing architectural construction. Although the manuscript itself has not survived, historical references record its existence.

Archaeological evidence includes the earliest surviving architectural drawing attributed to the Ilkhanid period, discovered at Takht-e Soleyman. The drawing consists of a gypsum tablet depicting part of a muqarnas vault and is dated to the reign of Abaqa Khan (Harb, 1978; Blair, 1986).

Historical chronicles of Yazd provide additional documentary evidence. Ahmad ibn Kateb refers on several occasions to the preparation and transmission of architectural drawings between Tabriz and Yazd during the construction of major public buildings in the first half of the eighth century AH, including the Shamsiyya Madrasa, its khanqah, and the Rashidiyya Madrasa[8]. Further documentary evidence is preserved in the waqf-nāma of the Rabʿ-i Rashīdī (709 AH), which explicitly mentions architectural "drawings and designs" (rasmī wa ṭarḥī) prepared on paper (al-Ashʿari, 1953).

[8] Ahmad ibn Husayn ibn ʿAli Katib, describing the construction of the Dar al-Shifa and its associated charitable complex in Yazd, records the transmission of architectural plans from Tabriz to Yazd under the patronage of Khwaja Shams al-Din Muhammad Sahib-Divan: "Know that the Dar al-Shifa of Yazd is among the charitable works of the great minister Khwaja Shams al-Din Muhammad Sahib-Divan. He himself did not see this building, for he was the minister of Abaqa Khan in Tabriz, and his deputy in Yazd was Khwaja Shams al-Din Muhammad Taziku. He sent word that a building should be erected in Yazd for him as a dar al-shifa… Khwaja Shams al-Din Muhammad drew the plan of this building … and sent it to the khwaja in Tabriz …" (Katib, 1966, p. 131).
Katib similarly refers to pre-execution planning in his account of the Shamsiyya Madrasa and Dar al-Siyada complex: "When Amir Shams al-Din Muhammad attained independence in Tabriz, he designed a complex comprising a madrasa, dar al-siyada, four minarets, khanqah, and bazaar, sent it to Yazd, and appointed a group who came to Yazd and constructed the building" (Katib, 1966, p. 129).

Visual evidence for geometric planning methods survives in later architectural documents, including the Topkapı Scroll and the Tashkent Scroll, both of which preserve grid-based design systems[9] (Necipoğlu 1995). Comparable evidence also appears in Timurid miniature painting. In an illustration from the Bāburnāma (988 AH), Zahir al-Din Babur is depicted examining the design of a rectilinear garden while holding a gridded drawing board used for geometric layout (Figure 10). Similar drafting methods are also documented during the Qajar period by Caspar Purdon Clarke (1893), who records the continued use of gridded architectural drawings by Iranian builders during the nineteenth century[10].

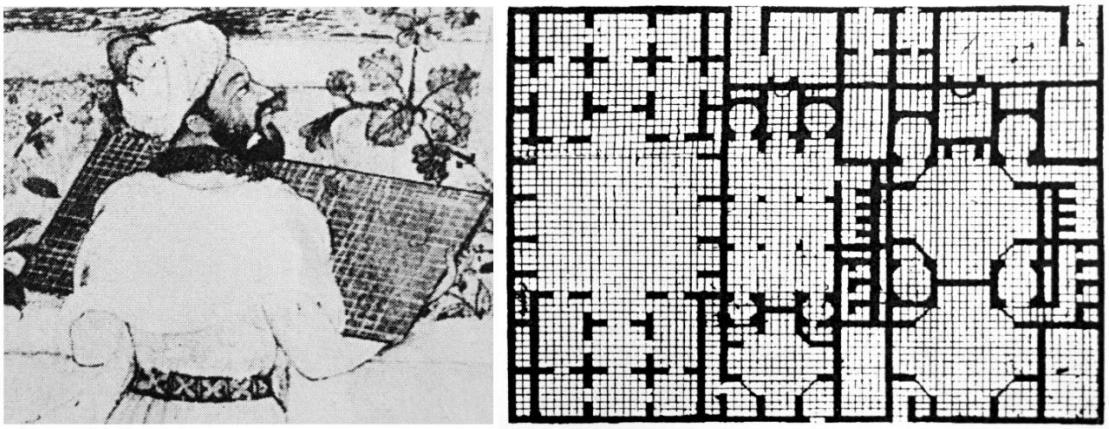

Fig.10: (Left). An image of an individual drafting on a chequered drawing board, from a two page miniature painting in the Baburnama, dated 988 AH. Source: Victoria and Albert Museum, (Right). A map from a scroll attributed to Mirza Akbar, court architect of the Qajar period, dated to the 12th century AH, ink on paper, London, Victoria and Albert Museum (Necipoğlu, 1995).

Discussion

The results of this study indicate that mud-brick dimensions changed during the eighth century AH in Yazd and that this dimensional shift coincided with broader architectural transformations associated with the transition from the late Atabeg and Ilkhanid periods to the Muzaffarid period. Rather than representing an isolated change in construction practice, the reduction in mud-brick size appears to have accompanied the emergence of a distinct architectural typology during the Muzaffarid period. On this basis, mud-brick dimensions may also provide an additional criterion for interpreting the chronology of surviving domestic architecture in Yazd.

This interpretation is consistent with previous research recognizing the importance of mud-brick dimensions in the dimensional coordination of Iranian architecture. Previous research on the historic architecture of Meybod (Esfanjary, 2017) similarly demonstrated that mud-brick dimensions changed through time and that no substantial difference existed between the mud-bricks employed in public monuments and domestic buildings within the same chronological period. Likewise, Wilber (1955) argued that Ilkhanid architecture was based on recurring dimensional modules that exhibited only minor dimensional variations. Together, these studies support the interpretation that relatively standardized mud-brick moulds formed

[9] The Topkapı Scroll, generally dated to the late ninth century AH, preserves evidence of advanced geometric drafting traditions in Iran. Michael Rogers regarded the document as part of the official drawings of a Timurid court architect. The scroll contains geometric knot patterns, muqarnas, half-karbandi, architectural plans, and inverted vault drawings executed on gridded underlays (Necipoğlu, 1995).

[10] Baklankov associated the geometric patterns of the Tashkent Scroll with innovations in Timurid brickwork techniques. According to Baklankov (1944), these drawings were intended for standardized glazed and unglazed bricks arranged according to square modular systems and angular relationships of 45°, 90°, and 135°. Bulatov (1988) likewise argued that the correspondence between architecture and ornament in Timurid architecture derived from shared geometric principles governing both structural and decorative systems.

part of a broader architectural tradition extending across central Iran during the eighth century AH.

The proportional analysis undertaken in this study further suggests that mud-brick dimensions fulfilled a role extending beyond construction technology. The remarkable consistency observed in the spatial organization of Muzaffarid houses indicates that the mud-brick module functioned as a regulating unit within the architectural design process. Such proportional regularity would have been difficult to achieve through purely empirical construction practices and instead suggests that architectural planning followed predetermined modular principles.

The historical documentary evidence presented in the Findings further strengthens this interpretation. Documentary, archaeological, and visual sources collectively demonstrate that architectural drawings, geometric drafting techniques, and the circulation of architectural plans were already established during the Ilkhanid period and continued into later periods. Rather than considering these documents independently, they may be interpreted together as evidence for the existence of an organized tradition of architectural planning within which modular design principles could be transmitted between regions and building types.

This interpretation is also consistent with the architectural relationship observed between Muzaffarid houses and contemporary religious buildings in Yazd. As discussed in relation to the madrasas, the spatial organization of Muzaffarid houses appears to have been strongly influenced by the formal composition of contemporary educational and religious architecture, particularly buildings such as the Aqa, Shamsiyya, and Taraz madrasas. Similarities in longitudinal spatial hierarchy, the sequence leading from the courtyard to the principal covered space, courtyard proportions, arch typologies, and wall articulation suggest that domestic and public architecture were designed according to common proportional principles rather than as independent architectural traditions.

Taken together, the evidence presented in this study supports the interpretation that Muzaffarid architects employed predetermined modular planning systems in which standardized mud-brick dimensions acted as the primary dimensional framework governing architectural proportion and spatial organization. From this perspective, mud-brick dimensions can therefore be understood not only as evidence of construction technology but also as evidence of architectural design methodology.

Conclusions

This study examined the dimensions of mud-bricks used in eighth-century AH buildings in Yazd to investigate their relationship with the physical organisation of Muzaffarid domestic architecture. Through direct measurements of mud-bricks in houses, madrasas, and mausolea, combined with morphological analysis of domestic architectural elements, the research explored how construction materials influenced architectural proportions, spatial organisation, and design in historic earthen architecture. The main conclusions are as follows.

1. In response to the first research question, the findings show that mud-bricks used in houses, madrasas, and mausolea constructed after 736 AH followed a relatively standardized module of approximately 25–26 × 25–26 × 5.5 cm, equivalent to one-quarter of the contemporary *gaz*. These bricks are generally 1–2 cm smaller than those used in public buildings of the early eighth century AH, suggesting that the reduction in size coincided with the transition from the Atabeg and Ilkhanid periods to the Muzaffarid period, consistent with the chronological pattern previously identified at Meybod.
2. In response to the second research question, the proportional analysis demonstrates that Muzaffarid houses were systematically organized through the mud-brick module. Both plan and elevation followed a square-based proportional network derived from repeated units of two mud-bricks (approximately 52–53 cm) and two-and-a-half mud-bricks, governing wall thicknesses, pier dimensions, courtyard proportions, and the height ratios of the principal ṣuffas.

3. In response to the third research question, the study shows that mud-bricks functioned not only as construction materials but also as generative architectural modules that shaped the spatial hierarchy, proportional systems, and structural order of Muzaffarid architecture, linking construction technology with architectural design.

The research objectives were achieved through field measurements of mud-bricks in historic houses, madrasas, and mausolea, together with morphological analysis of Muzaffarid houses. Integrating material and architectural analyses enabled the reconstruction of design principles no longer preserved in historical records.

The principal contribution of this study is demonstrating that mud-brick dimensions provide both technological and architectural evidence. Their analysis offers a reliable basis for reconstructing proportional systems, architectural organization, and design methods, establishing a direct relationship between construction technology and architectural design.

This study has several limitations. Although it examined the principal surviving Muzaffarid houses together with contemporary madrasas and mausolea, access to vaults, domes, and some upper structural elements was limited. Consequently, measurements were obtained mainly from accessible walls and structural components, and future studies with more comprehensive documentation may refine these findings.

Future research should extend this approach both chronologically and geographically. Investigating Safavid, Zand, and Qajar buildings in Yazd, as well as comparable sites elsewhere in Iran, would clarify the evolution of proportional systems and reveal how changes in mud-brick dimensions influenced the development of Iranian architectural design.

Author Contributions

Conceptualization: Eisa Esfanjary Kenari; Methodology: Bardia Hajirasouliha and Eisa Esfanjary Kenari; Formal analysis: Bardia Hajirasouliha; Investigation: Bardia Hajirasouliha; Writing – original draft: Bardia Hajirasouliha; Writing – review & editing: Bardia Hajirasouliha and Eisa Esfanjary Kenari; Resources: Bardia Hajirasouliha and Eisa Esfanjary Kenari; Supervision: Eisa Esfanjary Kenari.

Acknowledgements

The authors would like to express their sincere gratitude to the Art University of Isfahan, particularly the Department of Conservation and Restoration, and to the Cultural Heritage, Handicrafts and Tourism Office of Yazd Province for their valuable support and assistance during the field investigations.

Funding

This research did not receive any external funding.

Statement of Conflict of Interest

The authors declare that there are no conflicts of interest associated with this study.

Ethical Statement

This research followed accepted ethical standards. The study did not involve human participants, personal data, or animal subjects. All field investigations were conducted with the permission of the relevant cultural heritage authorities.

Data Availability

The data generated and analyzed during this study are available from the corresponding author upon reasonable request.

References

Afshar, I. (1973) *Yadgarhaye Yazd: Moarefi-ye Abniye-ye Tarikhi va Asar-e Bastani-ye Shahr-e Yazd*. Vol. 2. Tehran: Anjoman-e Asar-e Melli.

Amirlu, I. A. (1995) Collection of the Martyrs of Fahraj. In: Ayat Allah-zadah Shirazi, B. (ed.) *Proceedings of the Congress on the History of Iranian Architecture and Urbanism*. Vol. 2. Tehran: Cultural Heritage Organization of Iran.

Avrami, E. C., Guillaud, H. & Hardy, M. (eds.) (2008) *Terra Literature Review: An Overview of Research in Earthen Architecture Conservation*. Los Angeles: Getty Conservation Institute.https://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/terra_literature_review.pdf

al-Ashʿari, A. A. (1953) *The Theology of al-Ashʿari: The Arabic Texts of al-Ashʿari's Kitab al-Lumaʿ and Risalat Istiḥsan al-Khawḍ fi ʿIlm al-Kalam*. Edited and translated by R. J. McCarthy. Beirut: Imprimerie Catholique.

Ashkezari, F. M., Zarei, M. E. & Khademzadeh, M. H. (2016) Residential architectural decorations of the Al-Muzaffarid period in the Yazd region and their place in the houses of this period. *Iranian Journal of Architectural Studies*, 5(9),101–122. https://jias.kashanu.ac.ir/article_111761_eb66457388f68208ddb830ee6b9a09de.pdf?lang=en

Azizi Bondarabadi, H. & Emami Meybodi, D. (2025) Evaluating the slenderness of iwan from the Al-Muzaffarid to the Safavid period in the historical buildings of Yazd. *Journal of Architecture in Hot and Dry Climate*, 12(19),21–44. https://doi.org/10.22034/ahdc.2025.21689.1805

Bafqi, A. A. T. (2013) Khanqah Sufism in Yazd in the Ilkhanid and Al-Muzaffarid periods. *Iranian Studies Research*, 2(1), pp. 59–81. https://doi.org/10.22059/jis.2012.35223

Baklanov, N. B. (1944) Arkhitekturnye chertezhi uzbekskogo mastera XVI veka [Architectural drawings of an Uzbek master of the sixteenth century]. *Soobshcheniya Instituta Istorii i Teorii Arkhitektury*, 4,1–21.

Barański, M. Z. (2020) Brick sizes and architectural regularities at Neolithic Çatalhöyük. In: Hodder, I. (ed.) *Consciousness, Creativity, and Self at the Dawn of Settled Life*. Cambridge: Cambridge University Press. 133–150.

Blair, S. S. (1986) *The Ilkhanid Shrine Complex at Natanz, Iran*. Cambridge, MA: Center for Middle Eastern Studies, Harvard University.

Bulatov, M. S. (1988) *Geometric Harmonization in the Architecture of Central Asia from the Ninth to the Fifteenth Century (Historical-Theoretical Research)*. Moscow: Nauka.

Carlos, G., Ribeiro, T., Correia, M., Dipasquale, L., Achenza, M. & others (2022) Literature review on earthen vernacular heritage: Contributions to a referential framework. *Built Heritage*, 6, Article 15. https://doi.org/10.1186/s43238-022-00061-1

Clarke, C. P. & Lewis, T. H. (1880–1881) Persian architecture and construction. *Transactions of the Royal Institute of British Architects*, 3,161–174.

Daʾirat al-Maʿarif-i Buzurg-i Islami (2001) Units of measurement. Vol. 10. Tehran: Centre for the Great Islamic Encyclopaedia,345–348.

Dormohamadi, M. (2020) Typology of historical houses in the Muzaffarid era: Case study of Ardekan city, Yazd, Iran. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLIV-M-1-2020,945–952. https://doi.org/10.5194/isprs-archives-XLIV-M-1-2020-945-2020

Emami Meybodi, D. (2021) Evaluation of Sarabostan (a small garden built next to old houses with a great impact on the climate) space in Yazdi houses of the Muzaffarid period. *Athar*, 41(4),436–453. http://athar.richt.ir/article-2-747-en.html

Emami Meybodi, D. (2022) Courtyard evolution in houses of Yazd from the Muzaffarid to the Safavid era. *Journal of Iranian Architecture Studies*, 21,225–247. https://doi.org/10.22052/jias.2022.245790.0

Emami Meybodi, D. (2022) Researching the Muzaffarid and Timurid schools in Yazd based on historical texts. *Parseh Journal of Archaeological Studies*, 6(21),217–242. https://doi.org/10.30699/PJAS.6.21.217

Esfanjary, E. (2017) *Persian Historic Urban Landscapes: Interpreting and Managing Meybod over 6000 Years*. Edinburgh: Edinburgh University Press.
Fathy, H. (1973) *Architecture for the Poor: An Experiment in Rural Egypt*. Chicago: University of Chicago Press.
Harb, U. (1978) *Ilkhanidische Stalaktitengewölbe: Beiträge zu Entwurf und Bautechnik*. Berlin: Dietrich Reimer Verlag.
Hajirasouliha, B., Dehghani, M. H. & Bakhtiari, S. (2025) Conservation and restoration measures of the historical house of Qariha (a building attributed to the Mozaffarid era in Yazd). *Knowledge of Conservation and Restoration*, 7(4),95–120. http://journal.richt.ir/kcr/article-1-232-fa.html
Hajirasouliha, B., Kiani-Dehkiani, G., Heidari, D. & Emami Meybodi, M. (2024) Analysis of the Effect of Soil Properties on the Mechanical Resistance of Historical Mud-Bricks of Yazd. *Archaeometry Research Journal*, 10(1),145–166. https://doi.org/10.61882/jra.10.1.407
Hejazi, M. & Mehdizadeh Saradj, F. (2014) *Persian Architectural Heritage: Architecture*. Southampton; Boston: WIT Press.
Hejazi, B., Luz, C., Grüner, F., Frick, J. & Garrecht, H. (2024) Characterization of adobe and mud–straw for the restoration and rehabilitation of Persian historical adobe buildings. *Materials*, 17(8), Article 1764. https://doi.org/10.3390/ma17081764
Holod, R. (1972) *The Monument of Yazd, 1300–1450: Architecture, Patronage and Setting*. Unpublished Ph.D. Thesis. Harvard University, Cambridge, MA.
Jafari, J. b. M. Ḥ. (1964) *History of Yazd*. Edited by I. Afshar. Tehran: Institute for Translation and Publication of Books.
Karimi, A. H. (2006) Clay reliefs: A special type of architectural decoration in Meybod. In: Esfanjari Kenari, E. (ed.) *Meybod, the City that Exists*. Meybod: Cultural Heritage and Tourism Organization, 209–238.
Kateb, A. H. (1965) *New History of Yazd*. Tehran: Farhang-i Iran Zamin Publications.
Khademzadeh, M. H. (2008) *Architecture of the Al-Muzaffarid Period of Yazd*. Yazd: Hampa Publishing.
Love, S. (2013) Architecture as material culture: Building form and materiality in the Pre-Pottery Neolithic of Anatolia and the Levant. *Journal of Anthropological Archaeology*, 32(4),746–758. https://doi.org/10.1016/j.jaa.2013.05.002
Matthews, R., Mohammadifar, Y., Matthews, W. & Motarjem, A. (2010) Investigating the Early Neolithic of Western Iran: The Central Zagros Archaeological Project (CZAP). *Antiquity*, 84(323), Project Gallery. https://www.antiquity.ac.uk/projgall/matthews323
Mitchell, W. J. (1990) *The Logic of Architecture: Design, Computation, and Cognition*. Cambridge, MA: MIT Press.
Moropoulou, A., Bakolas, A. & Bisbikou, K. (2000) Investigation of the technology of historic mortars. *Journal of Cultural Heritage*, 1(1),45–58. https://doi.org/10.1016/S1296-2074(99)00118-1
Mostawfi Bafqi, M. M. (2006) *Jāmiʿ-i Mufīdī*. Edited by Ī. Afshār. Vol. 3, Part 1. Tehran: Asāṭīr Publishing.
Natanzi, M. (1957) *Muntakhab al-Tavarikh-i Muini*. Vol. 1. Tehran: Asāṭīr Publishing.
Necipoğlu, G. (1995) *The Topkapı Scroll: Geometry and Ornament in Islamic Architecture*. Santa Monica, CA: Getty Center for the History of Art and the Humanities.
Nikzad, Z. & Ghafouri Barjin, N. (2024) Tavana house in Yazd: Restudy of house architecture in the eighth century Hijri (Al-Muzaffarid period). *Athar*, 44(103), 450–473. https://doi.org/10.22034/44.4.450
Naini, M. A. (1997) *Tadhkirah of Madīnah al-Adab*. Tehran: Library, Museum and Document Centre of the Islamic Consultative Assembly.
Oliver, P. (1997) *Encyclopedia of Vernacular Architecture of the World*. Cambridge: Cambridge University Press.

Pirniya, M. K. (1999) *An Introduction to Iranian Islamic Architecture*. Edited by G. Memarian. Tehran: Iran University of Science and Technology.
Rajabzadah, H. (1998) *Khvajah Rashid al-Din Fazl Allah*. Tehran: Ṭarḥ-i Naw.
Rapoport, A. (1969) *House Form and Culture*. Englewood Cliffs, NJ: Prentice-Hall.
Rudofsky, B. (1964) *Architecture Without Architects: A Short Introduction to Non-Pedigreed Architecture*. New York: Museum of Modern Art.
Sotoudeh, Ḥ. Q. (1967) *History of the Muzaffarids*. Tehran: University of Tehran Press.
Wilber, D. N. (1955) *The Architecture of Islamic Iran: The Il Khanid Period*. Princeton, NJ: Princeton University Press.
Zakerameli, L. (2013) *Historical Typology of Muzaffarid Houses in the Yazd-Ardekan Plain: Influence from Pre-Mongol House-Building Tradition and Its Impact on Safavid House-Building*. Unpublished Ph.D. Thesis. Art University of Isfahan, Isfahan.
Zakerameli, L. & Esfanjari Kenari, E. (2006) Muzaffari houses. In: Esfanjari Kenari, E. (ed.) *Meybod, the City that Exists*. Meybod: Cultural Heritage and Tourism Organization, Meybod Cultural Heritage Research Center,157–208.
Zakerameli, L. & Jabal Ameli, A. (2013) The evolution of the iwan in the houses of the Yazd-Ardekan plain from the Muzaffarid to the Qajar period. *Soffeh*, 62,103–118.
Zhao, C., Zhang, Y., Wang, C.-C., Hou, M. & Li, A. (2019) Recent progress in instrumental techniques for architectural heritage materials. *Heritage Science*, 7, Article 36. https://doi.org/10.1186/s40494-019-0280-z