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Original Research Article

Decoding Architectural Design Elements Through Shape Grammar (Typology of 64 traditional houses of Kashan, Yazd, and Isfahan)

Seyed Amir Hosseini[1], Shahaboddin Fathi[2**], Mohamadreza Bemanian[3], Mohammadjavad Mahdavinejad[4]

1. Ph.D. in Architecture, Department of Architecture, Faculty of Art and Architecture, Tarbiat Modares University, Tehran, Iran.
2. M.A. in Architecture, Department of Architecture, Faculty of Art and Architecture, Tarbiat Modares University, Tehran, Iran.
3. Professor in Architecture, Faculty of Art and Architecture, Tarbiat Modares University, Tehran, Iran.
4. Professor in Architecture, Faculty of Art and Architecture, Tarbiat Modares University, Tehran, Iran.

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Abstract

Problem statement: Typology provides a simple and diagrammatic description of a group of phenomena and establishes a degree of connection or affinity between those phenomena. Many studies have addressed the typology of spaces of historical houses, but most of these studies have focused on one or more limited spaces, which reveal the absence of structural connection between different spaces and the lack of a specific method or framework that can be used to typify all spaces and explain the structural connection between them.

Research objective: This study aims to establish a connection between different spaces in introverted historical houses located in the Central Iranian Plateau Iran and identify the formal-structural connection between the findings from previous studies on the typology of spaces of historical houses in Iranian architecture.

Research method: Using the shape grammar, the present study performed a typological analysis of micro-spaces of 64 historical houses from Kashan, Yazd, and Isfahan. This study also developed the initial typology of micro-spaces and established a coherent system of relationships between formal typologies in the historical houses located in these three cities.

Conclusion: Based on the findings from this study, a two-stage grammar was first developed for generating the formal structure and then establishing spatial relationships between components of the houses. With the help of this grammar, a triple structure was developed using a range of formal structures and spatial relationships identified in the studied samples. The developed typology can account for the structural relationships between different forms. In addition, it can pinpoint the differences between different typologies in other cities. Accordingly, the typological model developed in this study establishes a structural-form relationship between different spaces in introverted historical houses located in the Central Iranian Plateau.

Keywords: *Typology, Shape grammar, Kashan, Yazd, Isfahan.*

* This article extracted from Ph.D. thesis of "Seyed Amir Hosseini" entitled "Recognition of spatial organization of Iranian architecture" that under supervision of Dr. "Mohamadreza Bemanian" and in consultation of Dr. "Mohammadjavad Mahdavinejad"which has been done at Tarbiat Modares University, Faculty of Art and Architecture, Tehran, Iran in 2023.

**Corresponding author: +989125872159 , Shahaboddin.fathi@modares.ac.ir

Introduction

Typological analysis in the history of architecture dates back to Vitruvius, Alberti, and Ghiyāth al-Dīn Jamshīd Masʿūd al-Kāshī, but it has become widespread in architecture and archaeology since the mid-18th century and has been practiced in Iran for nearly 4 decades. Gholamhossein Memarian and Mohammad Ali Tabarsa (2013) consider type to be "a representative of a group of objects with common features," but they consider the term "features" as a controversial issue that may change depending on its interpretation (ibid.). These common characteristics can include function, plan shape, having common building elements or space, form, structure, lived experiences, meaning, and shape (Memarian & Dehghani Tafti, 2018).

In general, the two traditions of Southern and Northern Europe have developed two perspectives on typology. The first perspective has a historical-evolutionary interpretation of species influenced by biology and Darwinian theory of evolution and focuses mainly on form and the evolution of typologies in history, and the second perspective, using a social interpretation, ultimately leads to spatial typology (ibid.). Memarian & Dehghani Tafti (ibid.), In their article "Seeking to Find a Novel Concept to Type and Typology in Architecture (Case study: Vernacular Houses in Taft, Type of Tallardar)", seeks a comprehensive definition of typology fitting the Iranian architectural tradition. While pointing out the contradictions and shortcomings of the definition of typology from a Western perspective, he introduces the concept of an "architectural system." The architectural system of a typology is a multidimensional schema that consists of physical organs and non-physical schemas (ibid.) (Fig. 1).

Concerning the definitions of typology, Khademzadeh et al. (2022) suggested that "first, in typology, there is a kind of hierarchy that can be based on precedence - not necessarily chronological order. Second, typology can be carried out from different aspects. Third, a degree of connection and affinity is necessary while requiring differences to carry out typology; and fourth, a simplified (diagrammatic) description of the subjects in question can be considered a very efficient method for carrying out typology" (ibid.). Typology is an essential aspect of analyzing the components of historical Iranian architecture. Moreover, houses and residential space as fundamental components of Iranian architecture, require further attention and emphasis. Typology is a strategy for recognizing and understanding the architecture of the past. A review of the literature on the typology of spaces in historic houses reveals several shortcomings:

First, there is no formal-structural connection between spatial patterns or types. For example, except for one case (Parsi, 2011), no rule or law shows how a spatial cross pattern is related to a cross-shaped space.

There is no coherent model or specific pattern that shows the difference between spatial patterns in different cities. There is only one study on four-faced spaces in Boshruyeh, Yazd, Sabzevar, and Zavareh (Gholami & Kavian, 2017), which has partly addressed this issue in only one spatial pattern.

Literature Review

• Formal typologies

Some studies have addressed special patterns in Iranian architecture. However, a majority of these studies have focused only on one or two spatial patterns. Most of these studies have addressed the typology of spatial patterns. For example, a study examined the typology of the four-arched pattern

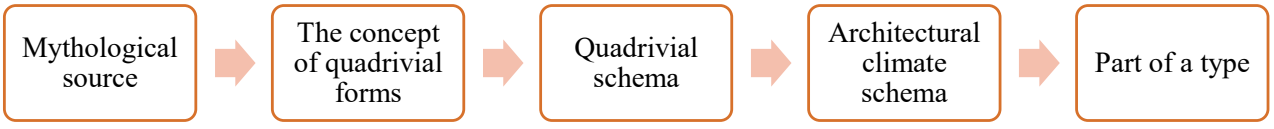


Fig. 1. The development and impact of a schema on architectural typologies and the architect's artifacts. Source: Auhtors.

in Iranian architecture and its evolution. The authors attributed the prevalence of four-arched structures, in addition to climatic considerations and other physical characteristics fitting the four-arched pattern, to a kind of ancient worldview. They have also studied pre-Islamic and post-Islamic architectural patterns and have divided four-arched patterns into two general categories, one with a central yard and the other without a central yard. "The first group has remained stable in a specific standard from the beginning of its formation until recent centuries in plans called four porches and the second group itself is divided into two specific types; In one model, the general plan is divided into five patterns, and in another model, the physical structure of the building is divided into nine parts, which are in contrast to the "nine introverted domes" model (Jodaki Azizi et al., 2015).

Jodaki Azizi & Mousavi (2016) claim that the names of some architectural models are different from their original and initial names. They have studied the nine-part model by comparative analysis of literary texts from the fourth to tenth centuries AH and architectural works, which are mainly palaces and pavilions. The first type of nine domes in the Achaemenid Apadana was an example of the nine heavens, which later became known as the "eight heavens" in the Islamic era. These two researchers have made a distinction between the four-faced and nine-dome models (ibid.).

Gholami & Kavian (2017) also examined the four-arched pattern. They focused on houses in Boshruyeh, Tabas, Zavareh, and several other cities. The four-arched pattern is the oldest Iranian architectural pattern that is also important from a mythological and semantic perspective, as this pattern has also been widely used in architectural decorations. They introduced examples of the use of this pattern in three types of residential houses. First, the houses located in Boshruyeh and Tabas, in which the four-arched pattern appears more purely and comprehensively in the role of a small central courtyard with four porches. Second, the houses located in Zavareh, in which the four-arched pattern is a covered central space, and finally, the presence of the four-arched pattern as a secondary space such as the pond in the courtyard houses located in the Central Iranian Plateau (ibid.) (Fig. 2).

This study seeks to address the evolution and diversity of the applications of the four-arched pattern in houses in different cities. Accordingly, Rahravi Poodeh et al. (2019) suggested that "the formal characteristics of the four-arched houses have played an effective role in the micro and macro structure of historical introverted houses". They examined the typology of the components of the four-arched houses and their emergence in houses located in Isfahan. There are two general types of four-arched houses based on the shape of the middle space and roof covering: The houses located in Zavareh with a koleno-arched roof and the houses located in Boshroyeh with an uncovered center. The authors have also introduced a third type of house with a pavilion located between two open spaces, and the middle four-arched space is also covered. They also suggest that spaces such as the hall, living room, autumn and spring-dwelling rooms, and the ponds in the houses located in Isfahan are inspired by the formal characteristics of the four-

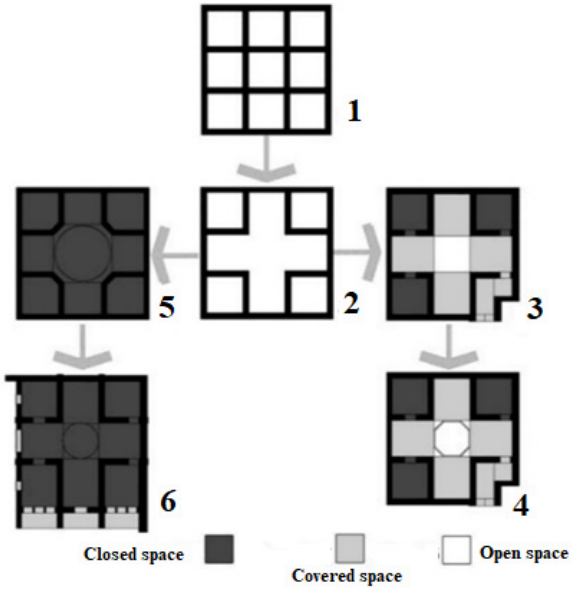


Fig. 2. The geometric plan of four-arched houses in Boshruyeh (3 and 4), Yazd and Sabzevar (5), and Zavareh (6). Source: Gholami & Kavian, 2017.

arched pattern (ibid.). Another study examined the introverted houses located in Isfahan and other spatial patterns and addressed the physical typology of the main spaces in the multi-sided houses built in Isfahan (Rahravi Poodeh et al., 2018).

Shakouri & Seyyed-Khamoushi (2017) studied the cross-shaped pattern and introduced two cross-shaped patterns as examples of flexibility in Iranian architecture. They also introduced the different functions and possible lifestyles in this spatial.

Tabatabaie Zavareh et al. (2018) studied the traditional four-arched and pond-shaped houses located in the city of Zavareh. To compare the structural similarities and differences between these two types of buildings, they have specified indicators including geometry, numerical proportions, and plan changes. Another study examined and typified the use of visual documents and oral history of architecture in the representation of micro-spaces and 3D modeling of the historical house of Razavi Nawab in Yazd (Valibeig & Karimi, 2018).

Madahi et al. (2017) specifically focused on four-arched houses located in Boshruyeh and introduced the elements of the houses located in this historical city and detailed the spatial patterns of these houses using a model proposed by Haeri Mazandarani. They also analyzed the cultural, climatic, economic, and other factors in the use of these spatial patterns (ibid.). In a more coherent study, Parsi (2011) examined the design method in historical Iranian architecture and described the general organization of a house. First, he introduced different spatial patterns and then explained how these patterns are placed together to create a coherent whole. The author also addressed the formal relationship between the cross and arched-shaped patterns.

• The application of shape grammar in the study and design of traditional architecture

The application of shape grammar in the analysis and design of traditional or historical architecture dates back to the first studies using the shape grammar method, and many doctoral dissertations and articles have been conducted in this field, as detailed below:

A study of Mongolian gardens (Stiny, 1977; Stiny & Mitchell, 1980; Knight, 1981), traditional courtyard houses in Bosnia and the use of grammar to produce new houses (Colakoglu, 2000; 2000), and Sudanese houses (AbdulRaheem & Rayis, 2016) have all focused on the analysis of house plans, the overall structure of the plan, and the building volume. A study on Chinese architecture (Li, 2015) and a study of the architecture of traditional houses in Taiwan (Chiou & Krishnamurti, 1995) have examined the cross-section or facade of the building. Studies of Mamluk schools (Eilouti & Al-Jokhadar, 2007a; 2007b) and traditional Turkish houses (Çağdaş, 1996; Torus, 2011; Guzelci, 2014) have emphasized the plan of houses and schools in the Middle East. The production of traditional Malaysian roofs, concerning the section, the connection to the ground, and also the structure are other subjects that have been addressed by some researchers (Said & Embi, 2008). A grammar based on Alberti's treatise (Figueiredo et al., 2013a; Figueiredo et al. 2013b; Duarte et al., 2011) is one of the examples close to the present study, in which the emphasis is on the formal structure of the plan, as well as first creating general outlines and then increasing the details step by step as the grammar continues. In addition, several studies using the shape grammar method have examined Iranian architecture, including the form of the courtyard and its associated spaces in houses located in Kashan (Hassani et al., 2017), the grammar and semantic dimensions in Qajar complex houses in Tabriz and Tehran (Hasani & Nourouzborazjani, 2018), and the analysis of morphological patterns in the city of Kashan (Darabi, 2016).

Research Hypothesis

This study hypothesizes that there is a formal and structural relationship between the different spaces of the introverted historical houses located in the Central Iranian Plateau. Accordingly, a coherent model can be developed with the help of shape grammar to come up with a typology of these spaces. To this end, the present study conducted a typological analysis of the spaces of 64 historical houses from Kashan, Yazd, and Isfahan to find a coherent relationship between the types of spaces in these houses.

Theorical Foundation

• Shape grammar

Shape grammar was invented by George Stiny (Stiny, 1976), turning into an analytical tool for studying architectural styles and also some traditional and historical architectural styles in the 1980s to the 1990s. Following Terry Knight's (1999) study, which introduced shape grammar as a tool for simultaneous and combinatorial analysis and design, shape grammar has also been widely used for generative design in architecture, and there is the possibility that specialized grammar can be developed in different subjects.

Shape grammar generally involves basic shapes, rules, and rule-guided labels. In some specialized forms, other components may be added to this grammar. But the main structure of shape grammar consists of these three parts. Most of the rules are expressed algebraically. This helps to make the grammar processable and computable.

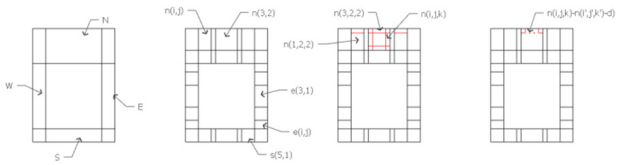
One of the problems with shape grammar is the range of options it produces. Two solutions have been proposed to fix this problem: One is to limit the initial dimensions and size that we give to the grammar (Eilouti & Hamamieh Al Shaar, 2012), and the other solution could be to impose restrictions on the spatial syntax (Eloy & Duarte, 2015).

The houses in question in this study were analyzed using the shape grammar developed by Hosseini & Bemanian (2022) for houses located in Kashan. In this study, this grammar and the resulting typology were applied to houses in three cities of Kashan, Yazd, and Isfahan and were revised the grammar to fit the research sample.

This grammar, which was developed for houses located in Kashan, consists of 4 main stages. In the first stage, the initial plan of the building is divided into different fronts, and a courtyard is formed. In the second stage, the different fronts are divided into different states based on the statistical findings of the researchers, and the outcome is a grid of lines that contain different spaces inside. In the third stage, relying on the formal typology, the overall formal structure of the spaces is produced within the cells resulting from the grid in the previous stage. This formal structure is developed based on the typology of the spaces of the historical houses located in Kashan. In the last stage, the overall formal structure of each space is converted into a plan in different states. That is, the connection between spaces is produced at this stage (Fig. 3). Accordingly, we have also studied the historical houses located in the three cities of Kashan, Yazd, and Isfahan, based on this initial grammar and maintaining its 4-stage structure. For this purpose, an attempt has been made to analyze the historical houses located in the other two cities in the proposed structure for Kashan and to measure the validity and reliability of the Kashan grammar for these two cities as well. In cases where there were discrepancies, an attempt has been made to develop the grammar fitting the houses located in all three cities by changing the initial rules and instructions.

• Samples

The population in this study consisted of houses located in the cities of Kashan, Yazd, and Isfahan1. These three cities were selected because their historical houses have been well analyzed and documented compared to other cities located in the Central Iranian Plateau. In addition, due to their geographical distribution, these houses efficiently



1	$RA(intial\ shape: n, e, w, s)$ $n, s \in \{5, 10, 13, 3, 8, 11, 4, 7\}$ $e, w \in \{1, 2, 3, 4, 5\}$	$intial\ shape \rightarrow N, E, W, S$
2	$rb(i,j) = \sum RB(ra: b_x, b_y)$ $rb \in \{N, E, W, S\}$ $b_x \in \{210, 211, 212, 213, 214, 215, 216\}$ $b_y \in \{220, 221, 222, 223, 224, 225\ 226, 227, 228, 229\}$	$N, E, W, S \rightarrow rb(i,j)$
3	$rc(i,j,p) = RC(rb(i,j)): c * c')$ $rb \in \{N, E, W, S\}$ $i, j \in \mathbb{N}$ $c\ and\ c's \in \{311, 322, 332, 342, 352, 353, 362, 363, 372, 373, 382\}$	$rb(i,j) \rightarrow rc(i,j,p)$
4	$RD(rb(i,j,p), rb(i', j', p')): d)$ $p\ and\ p' \in \{1, 2, 3, \dots, (c\%10 * c'\%10)\}$ $rb\epsilon\{N, E, W, S\}$ $i, j \in \mathbb{N}$ $d \in \{1,2,3,4\}$	

Fig. 3. The grammar developed for the houses located in Kashan and its algebraic expression. Source: Hosseini & Bemanian, 2022.

represent the vast geographical spread of this region. Almost all of the historical houses in these three cities have been constructed during the Qajar and Safavid periods, with a handful of houses from the Safavid and earlier periods. Thus, the scope of this study is limited to the Qajar period. The low number of historical houses in some cities, such as Kashan, from earlier periods is the earthquake that occurred or similar events that happened during the Qajar period. In any case, the historical houses in these three cities mainly belong to the Qajar period. Some of the valuable historical houses in these three cities are documented in the Ganjnameh stone inscriptions. A total of 64 houses including 19 houses from Kashan, 24 houses from Yazd, and 21 houses from Isfahan were examined (Haji Ghasemi et al. 1996, 1998, 2004). Fig. 4 shows Al-e Yasin House in Kashan. On the left, there is a tree diagram of the micro-spaces in historical houses in the three cities, which was constantly reviewed and revised while studying the house plans in the cities, until a sufficiently comprehensive and concise tree diagram of the typology of spaces was developed.

Findings

- **Typology based on formal structure**

Following the grammar of houses located in Kashan and simultaneous comparison and revision of the typology of micro-spaces of the houses located in Kashan (Hosseini & Bemanian, 2022) with the houses located in the two cities of Yazd and Isfahan, the initial typology of the houses was developed. As mentioned, in a back-and-forth process, the tree diagram of the spaces in the houses was designed based on their formal structure (Fig. 5).

As stated earlier, Hosseini & Bemanian (ibid.) had previously developed a grammar on houses located in Kashan and presented a typology based on it. As displayed in the figure below, we developed a shape grammar to account for houses located in the three cities as shown in Fig. 5. As can be seen, the formal structure of the main residential spaces in the historical houses located in the three cities has been typified and the relationship between them has been demonstrated.

The spaces in the houses have 5 transverse modules. In the figures displayed, the lower sides of each adjacent side represent the courtyard. As can be seen in the figure below, for example, Fig. 6, 521a shows a cross-shaped structure with the alcove being located at the end. However, in Fig. 6, 521d, there is a similar structure but with two shoe stands adjacent to the courtyard leading to a cross-shaped structure with the alcove adjacent to the courtyard.

- **Typology based on spatial relationships**

Fig. 7 displays the spatial relationships between the

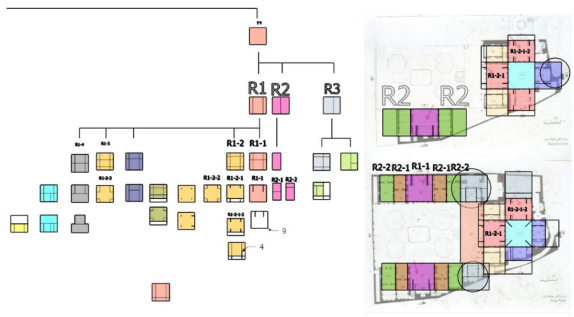


Fig. 4. Simultaneous comparison and revision of the typology of micro-spaces of historical houses in Kashan with the historical houses in Yazd and Isfahan and its development. Source: Authors.

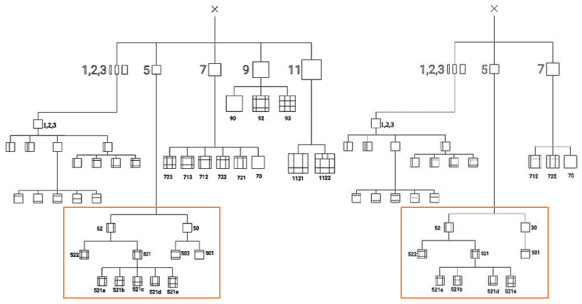


Fig. 5. Right: Initial typology of the micro-spaces in historical houses in Kashan (Hosseini & Bemanian, 2022), Left: Typology developed for historical houses in all three cities. Source: Authors.

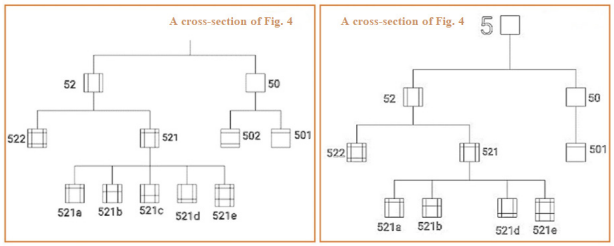


Fig. 6. Right: The typology of the 5-module pattern in the historical houses located in Kashan. Source: Hosseini & Bemanian, 2022/ Left: The typology of the 5-module pattern in the houses located in the three cities revised based on the Kashan typology. Source: Authors.

internal components of the different formal structures of the houses located in the three cities. As can be seen in Fig. 7, a space with a formal structure of 522 in the houses studied can have 5 states, depending on how its internal micro-spaces are connected.

• Typology based on formal structure and spatial relationships

When we interpose the data in Fig. 5 with the data in Fig. 7, the Fig. 8 is obtained. In Fig. 8, each column represents a formal structure and each row represents a spatial pattern.

By enlarging a part of the diagram/table above, the patterns starting with 5 can be analyzed in Fig. 9.

Discussion

This study aimed to specify the relationship between the types and formal-spatial architectural patterns of historical houses and develop a coherent model to account for this relationship. The data in this study revealed that the identified typologies, in addition to covering a wide range of spaces, also have a well-defined structural and formal relationship between them. The tree diagrams presented in this study display different typologies next to each other and demonstrate modular categories. Although Rahravi Poodeh et al. (2019) The second objective of this study was to establish a connection between the typologies of spaces in historical houses in different cities. A coherent model was proposed that can easily study the distribution of the typologies of the houses located in all three cities. Fig. 10 shows the differences between the historical houses located in the three cities in terms of use, repetition, and frequency of use of some patterns. For example, as can be seen in Fig. 10, the houses located in Isfahan and Kashan are distinguished from the houses located in Yazd in the use of pattern 521 (cross-shaped pattern), and the houses located in Isfahan are distinguished from the houses located in the other two cities in the use of pattern 721 (extended hall known as the dining room). Similarly, Gholami & Kavian (2017) have addressed the differences in a spatial pattern or formal typologies in different cities. However, they focused only on one spatial pattern and

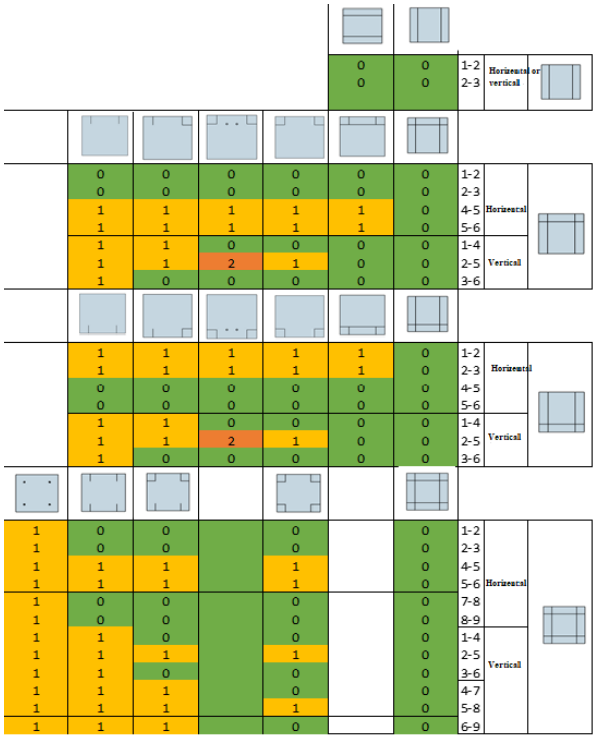


Fig. 7. The formal-spatial typology of the 5-module pattern in the houses located in the three cities. Source: Hosseini & Bemanian, 2022.

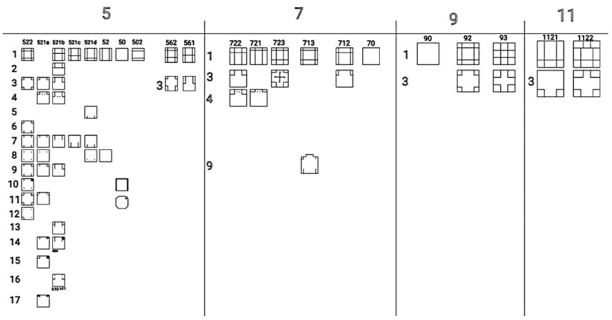


Fig. 8. A summary of the formal and spatial patterns and typology of all spaces in the houses located in the three cities. Source: Authors.

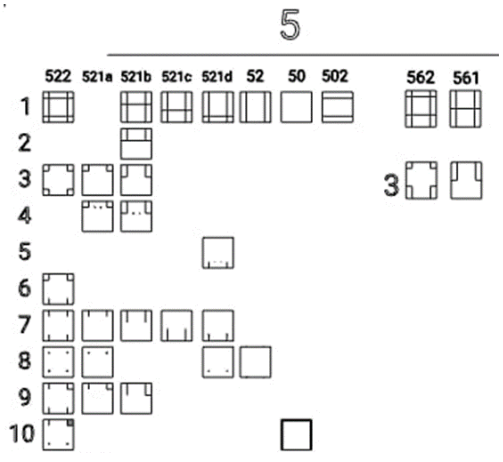


Fig. 9. Formal typology (the horizontal axis and columns) and spatial typology (the vertical axis and rows) of the 5-module spaces in the houses located in the three cities. Source: Authors.

identified a structural and formal relationship between different typologies.

A comparison of the data for the three cities in Fig. 10 indicates that spatial patterns 3 and 4 are the most frequent elements among the internal components of the shape patterns of the houses located in the three cities. The houses located in Yazd and Kashan have 5-module shape patterns with many internal spatial relationships of type 3, while in Isfahan we often see this spatial relationship between the internal components of the 7-shaped and 9-module patterns (Table 1).

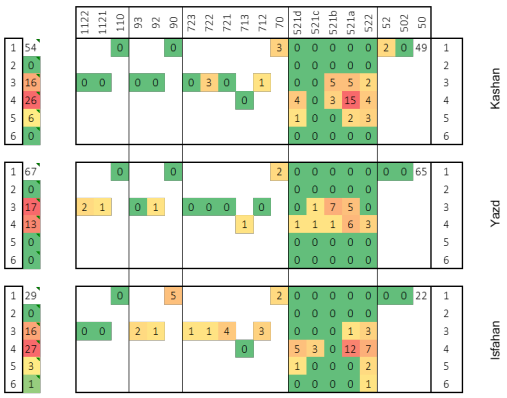


Fig. 10. The distribution of the formal pattern-spatial relationships between each pattern in houses located in three cities. Source: Authors.

Conclusion

A look at the data in Fig. 9 shows some differences in the frequency of the shape patterns of the houses located in all three cities. Although pattern 50 (can be a hall or a porch) is frequent in the houses located in all three cities (the most frequent among all shape patterns), it is mostly frequent in the houses located in Yazd. Most of the houses in Yazd have $3x^5$ halls and most of the deep porches are $5x^5$ and 5x7. Pattern 70, although less frequent in total, is found in all three cities. Another common shape pattern is 521a. According to some criteria, this shape pattern is seen more frequently in the houses located in Kashan. In terms of spatial features inside houses, pattern 521a in Isfahan follows spatial pattern 4. This pattern is half 3 and half 4 in Yazd and is mostly 4, one-third 3, and slightly 2 in Kashan. Thus, it can be argued that 521a is a common shape pattern in the houses located in all three cities, but in Kashan, it is both more frequent and more diverse in terms of internal spatial relationships. Moreover, 521b is a common shape pattern in the houses located in Kashan and Yazd. Spatial pattern 521d is also a common feature of the houses located in Kashan and Isfahan and is often seen as a shape pattern 4. The shape pattern 722 with spatial relations 3 is a special feature of the houses located in Kashan, and the shape pattern 11 with spatial relations of type 3 is rare but found only in Yazd,

The shape pattern 90 (often seen as an extended hall 3 by 9) is most frequent but only found in Isfahan, and patterns 92 and 93 (rare but only seen in Isfahan) are special features of the historical houses in Isfahan. Although these spatial patterns are less frequent, they are only seen in the aforementioned cities. Pattern 522 is also more common in Isfahan and its type 4 is seen more frequently, although type 3 is also found. Moreover, 521d is a spatial pattern of type 4 which is more often seen in Isfahan in terms of the number of houses but it has fewer spaces (Fig. 12) (Table 1).

Concerning the third objective of this study, it should be noted that one of the advantages of using shape grammar is the development of a coherent and unified model that, in addition to accounting for the relationship between types and patterns, it can also predict historically extinct or possible future types. It seems that using shape grammar can be a reliable and efficient method for typological analyses in Iranian architecture. The use of shape grammar in Iranian architecture is not unprecedented (Darabi, 2016; Hassani et al., 2017), but in the present study, an attempt was made to examine all the micro-spaces of the historical houses located in the three cities of Isfahan, Yazd, and Kashan. In addition, shape grammar, as a model, could capture the structural relationships between types of spaces well. Another contribution of the study is that by relying on this grammar and its shape-spatial typology, it accounted for the similarities and differences in the micro-spaces of the houses located in the three cities.

This study conducted a typological analysis of the

Table 1. Common and specific shapes and spatial patterns in the houses located in the three selected cities (adopted from Figs. 6, 7 & 8). Source: Authors.

Cities	Yazd	Kashan	Isfahan
Specific patterns in each city	11 type 3 patterns that are less frequent but found only in Yazd 50 common but recurring subscribers in Yazd	722 type 3 patterns 521a patterns (slightly frequent)	522 type 3 and 4 patterns 521C type 4 patterns 90 patterns frequent but only found in Isfahan Patterns 92 and 93 are less frequent but only seen in Isfahan
Shared shape and spatial patterns	Shared patterns 50 most frequent but only found in Yazd Shared patterns 521a but more frequent in Kashan based on some criteria Patterns 70 less frequent but often found in all three cities		
Patterns shared between two cities	521b type 3 patterns in Yazd and type 3 and 4 in Kashan	Pattern 521d mostly type 4	

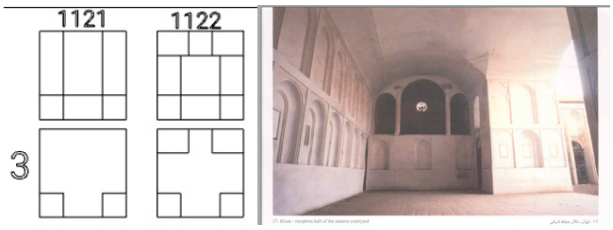


Fig. 11. The spatial relationship of the porch to the elongated hall at the back and the extension to each other, Ardakanian House, Yazd, Y02. Source: Haji Ghasemi et al., 2004.

Fig. 12. Right: The dining room of the southern facade of the A'lam House in Isfahan, a long hall of 9 modules in length IS07, Left: The 9-module hall of the northern facade of the Chermi House in Isfahan, IS02. Source: Haji Ghasemi et al., 1998.

spaces of historical introverted houses in the Central Iranian Plateau. This study examined 64 houses from three cities, all of which belonged to the Qajar period. The study also aimed to propose a coherent model of their formal structure through typology and with the help of shape grammar. In addition to the typology of these spaces, the shape grammar of these spaces has also been presented separately for the houses located in the three cities. This type of grammar can be used to identify the local architectural language and dialects of the houses located in these three cities.

Shape grammar can be an effective tool for typological studies on introverted houses constructed based on Iranian architecture. With the help of coherent grammar, structural connections between different types and forms-spatial patterns can be captured and the relationships between them can be explained to come up with a proper understanding and comprehension of how these spaces were formed. Ancient Iranian architecture, with its rich identity and history, contains patterns that follow specific rules, and this has led to the coherence and permanence of these patterns. One of the most important applications of shape grammar is the reproduction and reconstruction of past patterns, which can be achieved and new patterns can be created after decoding and finding the way these patterns are formed. Shape grammar can well respond to one of the concerns of modern man, which is the identity crisis.

Finally, it seems that the shape grammar developed in the present study of the historical houses in question, along with a typological analysis of the spaces inside the houses, has been able to connect the multiple and fragmented findings from other previous studies in the form of a coherent model. This study can also be replicated for other uses of Iranian architecture and analyze schools, mosques, caravanserais, and other buildings. Shape grammar can also be used to study and typify decorations, roof forms, details, and other constructional elements.

Endnotes

1.The houses analyzed in this study; Kashan: Al-Yasin House, Isfahanian House, Ba Kuchi House, Boroujerdi House, Bani Kazemi House, Tahami House, Jahanarai House, Khairieh House, Dasmalchi House, Reza Hosseini House, Sajjadi House, Sharifian House, Saleh House, Tabatabai House, Abbasian House, Attar House, Alaqband House, Chi Factory House, Mortazavi House/ Yazd: Akhavan Sigari House, Ardakanian House, Tehranian House, Rasoulian House, Rohanian House, Rismanian House, Samsar House, Shafipour House, Arab House (Bibi Roghieh), Arab House (Alireza), Arab House, Kermani, Arab House, Ulumiya House, Fatehi House, Farhani and Mozaffari House, Karaoghli House, Gerami House, Golshan House, Lariha House, Mortaz House, Mister Vay House, Constitutional House, Meshkian House, Malek House/ Isfahan: Angoorestan Malek House, Charmi House, Haj Hassan Ghafoori House, Haj Rasouliha House, Haj Musawer al-Malki House, David House, Doktara'alem House, Dehdashti House, Zovlian House, Sartibii House, Sukiasian House, Sheikh al-Islam House, Sheikh Harandi House, Akafzadeh and Sharif House, Qodsiyeh House, Karimi House, Gakhankhan House, Labaf House ,Martha Peters House, Vasiq Ansari House, Yadolahi House.

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