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Evaluation of the correlation between the orientation and sides in Qajar houses of kashan[1]

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ABSTRACT

Climatically, the orientation of the courtyard effectively controls the receipt of renewable energy from wind and radiation. Thus, the type of activity on each side of the courtyard can be affected by the house's orientation. This study aimed to investigate the correlation between the orientation of the courtyard and the number and position of sides in K houses. The study area was the old fabric of Kashan, and its statistical population was Qajar houses in the area of Jalali fortification. The type of research is applied, and the research method is historical. In this study, 20 Qajar houses from the Kashan Cultural Heritage Organization were chosen, each with a distinct orientation, the number of sides, and elongation. Each research variable was investigated through field visits and written sources, and SPSS outputs based on Pearson correlation. This study is innovative in terms of subject matter. The results showed no significant correlation between gradual change of orientation and change in the number or position of sides or elongation, but there are relationships; all cases have a north and south side. In the southwest and southeast orientation, most cases had an east side.

Keywords: *Kashan, orientation, house, Qajar*

1. Introduction

The courtyard is a common and traditional architectural concept in Middle Eastern countries, especially Iran [1]. Courtyard means yard in Dehkhoda dictionary; every place is limited by walls and houses [2]. "In a desert climate, the courtyard is the main space in the house, and other spaces are organized around the courtyard" [3]. In the environmental conditions of a large part of the central desert of Iran, creating a place for human comfort is possible only by creating an enclosed and isolated space that creates a micro-climate of a house [4].

Despite its proximity to the central desert, Kashan's proximity to the Karkas Mountains has resulted in creating groundwater and numerous canals (Ghanat). Many gardens and farms are located around it, and most houses have large ponds. On the one hand, the amount of humidity caused by these cases, and on the other hand, cold winds from Karkas Mountain, improve the comfort in severe heat conditions. So, while Kashan buildings follow the principles of desert houses in general, the quantity and quality of components differ from other desert types, affecting the courtyard's character and performance. The geometry of the building, courtyard, surrounding areas, orientation, wind direction, sun position, shadow function, and absorption of solar radiation has a significant impact on the environmental conditions of the courtyard and the height of the enclosed walls of

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the courtyard [5]. The architectural typology of houses in Kashan reveals that they are constructed using a combination of three patterns of open, semi-open (covered), and closed spaces, either individually or in a complex. The presence of nature is directly or indirectly evident in all three space patterns. Open space was considered the main place of nature in the residential area and allowed residents to enjoy nature [6]. The houses of Kashan are not older than the Qajar period due to the earthquakes of the Zandieh period, which led to the destruction of the city. After the earthquake of 1191 (Ah), all the houses in Kashan were destroyed. The ruler of the time contributed significantly to the reconstruction and restoration of houses and the construction of new buildings. He built and restored several beautiful houses, each with its distinct character [7] and the multiplicity of these houses has made Kashan famous as a "City of houses".

From a climatic point of view, the orientation and elongation of the courtyard are effective in receiving and channeling the type of wind, shading and the amount of solar energy received, so the placement of the building in a certain orientation can affect the possible activities on each side of courtyard especially east and west.

This study seeks to answer this question:

What is the relationship between the orientation of the courtyard and the number and position of the sides of the courtyard? And whether they are correlated?

This study aimed to identify and investigate the correlation between the orientation, the extent of the courtyard and the number and location of living sides in the courtyard.

2. Theoretical Framework

2.1. Courtyard

As one of the native, ancient, and architectural identity patterns, the courtyard is seen in the physical and spatial composition and organization of most traditional houses in the hot and dry climate of Iranian cities [8].

"The courtyard is referred to as a" mezzanine "which implicitly refers to centralism and introversion" [9]. The courtyard is the center of events [10]. The courtyard is located in the center of spatial relations in hot and dry areas and will form all structures [11]. "The courtyard in the house creates a centrist force. Centrality connects the various components of the house "[12]. In these houses, the courtyard is at the center of cohesive relations of the house.

2.2. Dimensions

The geometry of the courtyard plays an important role in its bioclimatic performance. The ratio of height to length and width, shape, geometry, size, area, orientation, and use of natural elements for shading are among the factors that greatly impact the optimal design of the courtyard [13]. Courtyards with elongated and deep forms reduce energy consumption, and courtyards with shallower depths are mainly used in cold weather because they absorb more solar radiation and reduce thermal energy consumption in winter [14]. Courtyard design elements such as shape, size, proportions, details, and surrounding walls are different due to climatic characteristics and function. These differences are due to cultural, economic, social, and environmental factors [15].

2.3. Elongation

The elongation of the courtyard is obtained by dividing its length by its width. Stretching affects three issues: First, the percentage of shading and sunbathing in the courtyard. The second is to create a channel for optimal wind and reduce the effect of unfavorable wind and passing wind on the pond and through the trees. And third, the quality of lighting in the rooms on the east and west sides. The courtyards of Kashan houses, whether with a little depth or in the G type, "in most cases are square or rectangular, and they are rarely octagonal. As the length increases, so does the width and this ratio varies between 1 and 1.6" [16]. The physical shape of the courtyards is usually rectangular with a movement axis along its length; the proportions of this rectangle are about 2.3. The quadrangle of the courtyards creates concentration and calm [11].

2.4. Orientation

It seems that factors such as way, belief, and nature have effectively shaped the orientation of Iranian architecture [17]. The ratio of sunny walls to walls in the shade and the flow of favorable wind is determined by the courtyard orientation, which is one of the core elements used by architects to control energy in traditional houses. In winter, the angle of the sun is inclined, so vertical surfaces are more efficient at receiving energy, and in summer, because the sunshine is almost vertical, the roof receives more energy. In a study on the optimal orientation of Kashan houses, Karbalaei Deri and Hejazizadeh found that the south orientation, which receives 53.6 % of sun energy in cold weather and 41.7 % in hot weather, as well as the orientations of + 165 and -165, which get 51.7 % in cold weather and 43.8 % in hot weather, are effective orientations [18].

2.5. Sides

In Kashan, large houses and complexes have four sides or, in other words, four seasons house, and smaller houses have fewer sides depending on the size and width of the land. "Each side is designated to a season and an hour; the winter section is on the sunny side (north), the summer section is on the back front to the sun (south), and the western section is for hours of cold winter days." [19]. "The best design mode for heat load control is to build houses in four seasons." [20]. "There is always a balance between the summer section and the winter section during the year, and the minimum energy received by the summer section is equal to the maximum energy received in the winter section." [21]. Different house spaces are located on one to four sides of the courtyard as needed [22]. Unfavorable winds with soil and sand blow from the east, which are very hot in summer, and on the other hand, in spring and summer, a cool breeze blows from the mountains (northwest) to the city of Kashan [23], [24]. According to these issues, the western side is not recommended for continuous activities, and the eastern side is suitable for three doors (Se Dari) and is recommended for sleeping and studying spaces.

3. Literature review

Lashkari and Pourkhadem (2005), in the article "Optimization of the orientation of open spaces in Ardabil based on climatic conditions," used meteorological data and concluded that the optimal orientation of the courtyard in Ardabil is southeast and its axis East-West. By examining thirty-five historical houses in the article "Recognition of physical features and natural elements of courtyards in historical houses," [25]. Niazimotlagh Jonaghani and Akbari (2019) concluded that 65% of the courtyards' orientations are southeast (2 to 20 degrees) and southwest (2 to 20 degrees) and the elongation of the courtyards is 1.25 to 1.5 [8]. In the article "Optimization of the orientation of buildings in the Ahvaz based on climatic conditions of natural geography," Lashkari et al. (2011) concluded that the optimal orientation of the building is 45 degrees and acceptable orientations are 30 degrees and 15 degrees from the south [26]. In the article "Typology of traditional courtyard houses in Tabriz based on physical criteria affecting the climatic performance of the courtyard" for 64 houses Moradi et al. (2018) examined the multiplicity of quantitative variables, they concluded that the optimal orientation of the courtyard is -10 to +20 from the south [27]. Nedjadebrahimi and Taamoli (2018) examined the factors affecting building orientation in six categories (climate, balance, neighborhood, religion, view, landscape, slope, and shading) in their article "Orientation in Architecture and its Role in the Formation of Historic Houses in Tabriz" [17]. In their article "Design criteria in the structure of the courtyard and summer hall of Qajar houses in Yazd," Yazdi et al., (2019) examined the design criteria, courtyard patterns, proportions and spatial communication of eight houses, and concluded that the courtyard and the summer hall have similar proportions and similar physical patterns [28]. In the article "Analysis of the morphological characteristics of four-sided houses and its influence on the morphology of introverted houses in Isfahan," RahraviPoudeh et al. (2019) examined the morphological characteristics of these houses on a small scale and large scale, including house sides and direction [29].

A literature review shows that some studies focus on building orientation while others focus on form and proportions, but there is no research on the relationship between orientation and building form. Most studies have considered the variables of sun and wind to affect the orientation. They also state that the components of Qajar houses are proportional, and the elongation of the courtyards is between 1 and 1.5.

4. Methodology

This research is about Qajar houses in Kashan and investigates the effect of house orientation on the number of sides of the courtyard. The independent variable is the direction of the yard, and the dependent variables are the sides (number and position of the sides) and the elongation of the courtyard. The type of applied research and research method is historical and Qajar period. A sample of 20 houses from the Cultural Heritage Organization (with different orientations, number of sides, and elongations) was chosen. Data was gathered via a survey method as well as textual sources. Pearson correlation was utilized because the number of variables was minimal and definite, and SPSS software was employed. The study population of Qajar houses is located in the old fabric of Kashan, which is surrounded by a Jalali fence. The research is implemented in four steps: 1- Obtaining information by field research and referring to written sources and maps. 2- Investigating the quiddity of variables from the point of view of experts 3- Examining the correlation between independent and dependent.

4.1. Study Range

According to the country's divisions, Kashan is located northeast of Isfahan province, with 4408 s

quare kilometers. (Map No. 1) Kashan is located 244 km south of Tehran at 51 degrees, 27 minutes east and 33 degrees and 59 minutes north latitude of the Greenwich meridian [30]. Archaeological studies in Silk Hill show that the history of living in this area dates back to 4200 BC. [31]. There is a scarcity of water in this city, and the plains and foothills have distinct temperatures. Summer temperatures can reach 47 degrees, while winter temperatures can drop to -10 degrees, with an average rainfall of 150 millimeters. Summers that are hot and dry, frigid winters, and scorching winter winds make for a harsh climate in the city [32].

Map 1. Location of Kashan in the country and province [33]

4.2. Samples

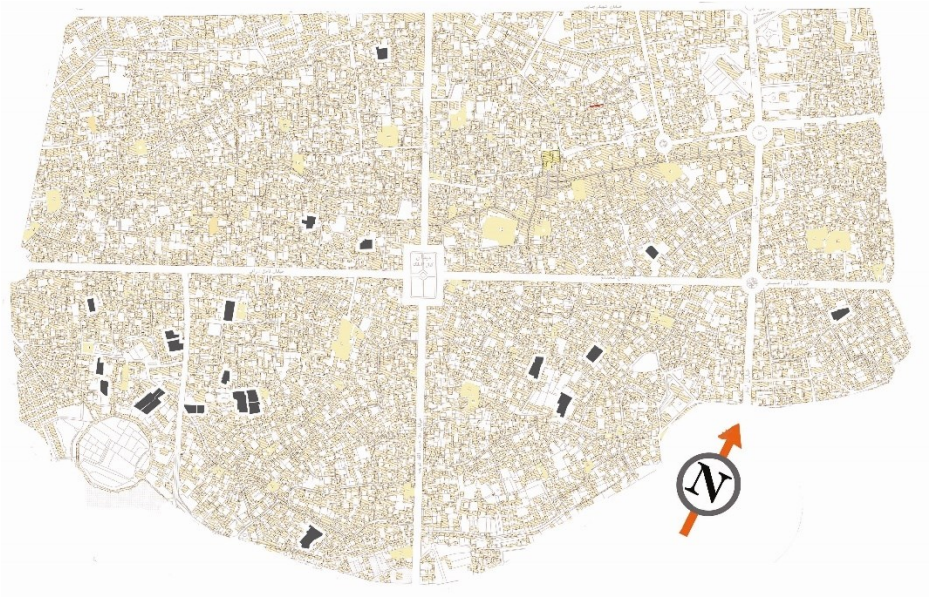
To study the correlation between the direction and sides, twenty samples from the Qajar houses of the Cultural Heritage Organization have been selected. The samples are shown in Table 1, and their location in the old city fabric is determined in Map 2.

Table 1. Introduction of sample Qajar houses, Source: Author and [34]

Al Yasin house 	Imam St., Darband Agha Alley, Posht-e-Mashhad Neighborhood Built in: Middle Qajar	**Raheb house** 	Fazel Naraghi St., Farhang Alley, Drb-e-bagh, Neighborhood Built in: Late Qajar
Isfahanian house 	Mullah Sharif St., Domasjedoon Neighborhood, Built in: Late Qajar	**Sharifian house** 	Mullah Fathullah St., Sadra neighborhood Built in: Middle Qajar
Balakhanechi house 	Fazel Naraghi St., Drb-e-bagh Neighborhood Built in: Late Qajar	**Saleh house** 	Jamshid Kashani St., Sarsang neighborhood Built in: Late Qajar
Bakoochi house	Alavi Street	**Tabatabaee house**	Alavi Street

	Sultan Amirahmad neighborhood. Built in: Early Qajar		Sultan Amirahmad neighborhood. Built in: Late Qajar
Borujerdiha house 	Alavi Street, Sultan Amirahmad neighborhood. Built in: Late Qajar	**Abbasian house** 	Alavi Street Sultan Amirahmad neighborhood. Built in: Middle Qajar
Banikazemi house 	Alavi Street, Kushk Safi neighborhood. Built in: Early Qajar	**Atarha house** 	Baba Afzal St. Old Square neighborhood. Built in: Early Qajar
Tahami house 	Alavi Street, Haghighi Alley Kushk Safi neighborhood. Built in: Early Qajar	**Masoudi far house** 	Alavi Street Sultan Amirahmad neighborhood. Built in: Middle Qajar
Hosseini House 	Alavi St., Khanzad Alley, Kushk Safi neighborhood. Built in: Early Qajar	**Manouchehri House** 	Mohtasham Kashani St. Mir Sign neighborhood. Built in: Early Qajar
Handkerchief House 	Mohtasham Street, Yalan Door Neighborhood Built in: The end of Qajar	**Hashemian House** 	Fazel Naraghi St. Crying neighborhood. Built in: Middle Qajar
Roin Ton House 	Fazel Naraghi St. Suri Jan neighborhood. Built in: Late Qajar	**Yousefi House** 	Alavi Street, Kushk Safi neighborhood. Built in: Early Qajar

Map 2. Location of samples in the old part of Kashan (Map source: Kashan Cultural Heritage Organization)



5. Finding

5.1. Dimensions

The length of the courtyards is between 14 and 35 meters, with an average of 23/8 meters, and the width is between 12 and 26 meters, with an average of 17/5 meters, according to the findings as shown in Table 2.

Table 2. Length and width of courtyard

Length	Width	Houses	Length	Width	Houses
27	18/5	Al Yasin	18/5	15/5	Raheb
24	17	Isfahanian	29	20	Sharifian
26/5	13/5	Balakhanechi	30/5	18/5	Saleh
15	13/5	Bakoochi	33	26	Tabatabaee
30	20	Borujerdiha	19	12/5	Abbasian
35	26	Banikazemi	22	15	Atarha
20	14/5	Tahami	14	12	Masoudi far
26	21	Hosseini	24	17	Manouchehri
20	17	Dastmalchi	27	23	Hashemian
15	12/5	Roeen Tan	24/5	17/5	Yousefi
23/8	17/5	Average			

5.2. Elongation

According to the findings of the studied samples in Table 3, the elongation of the courtyards is between 1 and 2, with an average of 1.38

5.3. Orientation

Based on the studied samples listed in Table 3, the courtyard's orientation to the north ranges from 135 to 225 degrees (range 90 degrees), with an average of about 168 degrees.

Table 3. Elongation and orientation of courtyard

elongation	orientation	Houses	elongation	orientation	Houses
1/29	220	Al Yasin	1/21	151	Raheb
1/33	165	Isfahanian	1/46	189	Sharifian
1/96	149	Balakhanechi	1/66	165	Saleh
1/06	151	Bakoochi	1/24	154	Tabatabaee
1/55	195	Borujerdiha	1/47	224	Abbasian
1/33	142	Banikazemi	1/43	144	Atarha
1/43	158	Tahami	1/39	140	Masoudi far
1/33	140	Hosseini	1/28	186	Manouchehri
1/20	195	Dastmalchi	1/28	156	Hashemian

1/27	135	Roeen Tan	1/44	205	Yousefi
1/38	168/2	Average			

5.4. Sides and directions of sides

According to the findings of the studied samples shown in Table 4, 25% of the courtyards are four-sided, 55% three-sided, and 20% two-sided. North and south are the side directions in 100 % of the samples, east in 70 %, and west in 35%.%

Table 4. Number of sides and directions of sides

W	E	S	N	Sides	Houses	W	E	S	N	Sides	Houses
	*	*	*	3	Al Yasin		*	*	*	3	Raheb
		*	*	2	Isfahanian	*		*	*	3	Sharifian
		*	*	2	Balakhanechi			*	*	2	Saleh
		*	*	2	Bakoochi	*	*	*	*	4	Tabatabaee
	*	*	*	3	Borujerdiha	*	*	*	*	4	Abbasian
	*	*	*	3	Banikazemi		*	*	*	3	Atarha
	*	*	*	3	Tahami	*	*	*	*	4	Masoudi far
*	*	*	*	4	Hosseini		*	*	*	3	Manouchehri
*		*	*	3	Dastmalchi	*	*	*	*	4	Hashemian
	*	*	*	3	Roeen Tan		*	*	*	3	Yousefi
7	14	20	20	3	Average						

6. Discussion

A study was conducted to assess the alignment between the independent and dependent variables from two perspectives: first, the existence of a common trend between them (correlation), and second, the existence of a limited link between them.

6.1. Correlation

To understand a common trend between a gradual change of orientation with the number of sides or elongation, the correlation calculation was used by the software SPSS (Table No.4). The significance in both cases is greater than 0.05; therefore, there is no significant correlation between the variables.

Table 5. Correlation

		Orientation	Elongation
Number of courtyard sides	P	-0/59	-0/279
	S	0/805	0/233
	N	20	20

P=Pearson Correlation S=Sig. N=Number of samples

6.2. Relationship

Each subject was classified into ranges to understand the relationship between orientation with sides and elongation. According to the literature review, the orientation of the courtyard (according to the literature review) was divided into a range of 30 degrees: south, southeast and southwest, along with information about the sides and elongation were collected in Table 5. Then, the relationship between orientation and two-sided, three-sided, and four-sided houses were presented in Table 6. Also, the elongation of the courtyards was divided into three groups (1-1.33, 1.34-1.66, 1.67-2), and the relationship between orientation and elongation was presented in Table 7.

Table 5. Sort And Grading the Orientation

Sides				Elongation	Orientation	Houses	Direction
N	S		E	1.27	135	Roeen Tan	**Southeast**
N	S	W	E	1.39	140	Masoudi far	
N	S	W	E	1.33	140	Hosseini	
N	S		E	1.33	142	Banikazemi	
N	S		E	1.43	144	Atarha	
N	S			1.96	149	Balakhanechi	

N	S		E	1.21	151	Raheb	
N	S			1.06	151	Bakoochi	
N	S	W	E	1.24	154	Tabatabaee	
N	S	W	E	1.28	156	Hashemian	
N	S		E	1.43	158	Tahami	
N	S			1.66	165	Saleh	**East**
N	S			1.33	165	Isfahanian	
N	S		E	1.28	186	Manouchehri	
N	S	W		1.46	189	Sharifian	
N	S		E	1.55	195	Borujerdiha	
N	S	W		1.2	195	Dastmalchi	
N	S		E	1.44	205	Yousefi	**Southwest**
N	S		E	1.29	220	Al Yasin	
N	S	W	E	1.47	224	Abbasian	

Table 6. Statistical study of the relationship between orientation and sides

significan	Relationship (present)	Sides	Direction
**	%100	North	**Southeast** 165-135 degree
*	%81.8	East	
**	%100	South	
	%36.4	West	
**	%100	North	**East** 195-165 degree
	%33.3	East	
**	%100	South	
	%33.3	West	
**	%100	North	**Southwest** 225-195 degree
**	%100	East	
**	%100	South	
	%33.3	West	

Table 7. Statistical study of the relationship between orientation and elongation

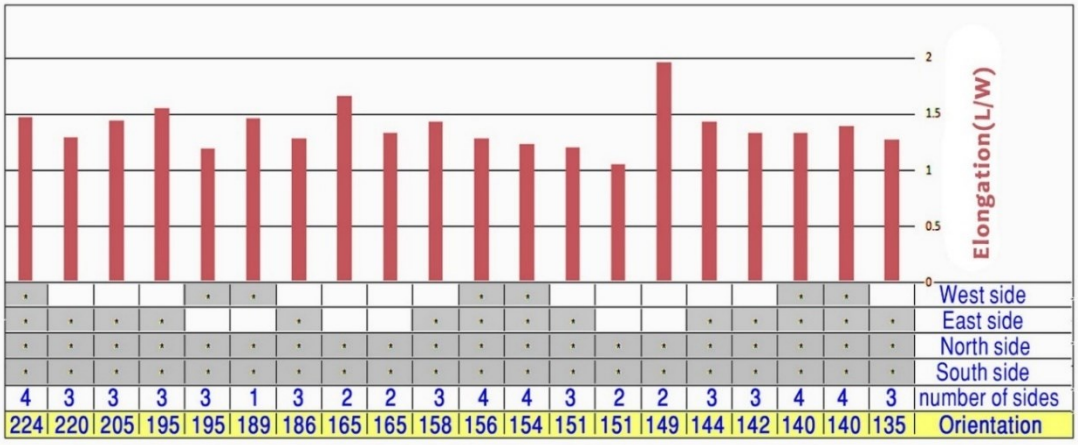
significan	Relationship (present)	Elongation (Range)	Direction
*	%63.6	1.33-1	**Southeast** 165-135 degree
	%27.3	1.34-1.66	
	%9.1	2-1.67	
	%50	1.33-1	**East** 195-165 degree
	%50	1.34-1.66	
**	%0	2-1.67	
	%33.3	1.33-1	**Southwest** 225-195 degree
*	%66.7	1.34-1.66	
**	%0	2-1.67	

6.2.1. Statistical review

According to Tables 6, 7, and Figure 1, the following can be deduced:

- All cases have a north side.
- All cases have a south side.
- In the southwest direction, all cases have an east side.
- In the southeast direction, most cases have an eastern side.
- There are two sides, three sides, and four sides in the south with an equal ratio. In the south orientation, there is no sample of 1.67-2 elongation
- In the southwest direction, there is no sample of a 1.67-2 elongation
- In the southeast direction, most samples have a length of 1-1.33
- In the south orientation, most samples have an elongation of 1.67-2
- In the southwest direction, most samples have an elongation of 1.34-1.66
- Elongation of all four-sided samples is between 1/2 and 1/5.
- Samples with an elongation greater than 1/6 have two sides.

Diagram 1. Elongation, orientation, number of sides, and directions of sides



7. Conclusion and recommendations

7.1. Conclusion

This study aimed to investigate the effect of house orientation on the sides and elongation of the courtyard of Kashan houses. The variables were studied in terms of content and statistics, and their correlation was controlled. This study shows that there is no significant correlation between gradual change of orientation and change in the number or position of sides or elongation, but there are important relationships.

The samples have three sides: north, south, and east, with a length ranging from 1 up to 1.33. Orientation to the south gets the least shading. The number of sides does not differ significantly, and the elongation of the courtyard is less than 1.67.

The smallest number of samples are found in the southwest orientation. The specimens have north, south, and east sides, and the elongation of the courtyard is less than 1.5.

7.2. Recommendations

Because the main climatic problem of K is the heat of summer and its east wind is hot and with soil, and the northwest wind that blows from the mountains is cool in summer, the best orientation is southeast, and the most suitable sides are north-south and east, and in this direction, elongation less than 1.33 is sufficient.

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