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Analysis the Physical Proportions of Main Courts in Azeri Style Mosques

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ABSTRACT

This article is an attempt to assessing the physical proportions and orders of main courts in Azeri style mosques. Azeri style consists of two main periods, Illkhanid period (12 and 13th century), and Timurid period (14 and 15th century). Thus, 10 case studies from the Illkhanid and Timurid dynasty have been selected for this approach. Orders and proportions of these case studies have been derivate. Five parameters have been mentioned in this paper are: length to width ratio, length to height ratio, area of the main court, area of the main complex, and area of the court to area of the main complex ratio. The paper applied statistic methods to analysis these parameters. Case studies have been categorized in to two periods, and then all of data of these two periods have been compared and analyzed with Independent T-test with 0.95 percent confidence intervals ($P_{value}<0.05$) to find out significant level of the parameters by SPSS Statistic 17.0 software. Analysis indicates that the Length to Height ratio and Area of the Courts variations has significant level with 0.95 confidence level, and variations between other parameters are not significant. In addition, statistical analysis with means and standard deviation indicated that, climate is not the main variable of built in these periods. Also, in 0.80 percent of mosques, the Court symmetry line are parallel with the Chamber domed roof symmetry line, and 0.90 percent of Court symmetry line is parallel with the main entrance symmetry line, in both periods.

***Keywords*: Courts, Azeri style, Illkhanid dynasty, Timurid dynasty, Independent T-test, SPSS statistic**

1. Introduction

Many scholars have categorized styles of Iranian traditional architecture, which most of them are foreign archeologist. Arthur Pope has divided Iranian Architecture to four eras; Achaemenian era, the Sassanid era, The Seljuk era and The Safavid era. This categorization is extensional, based on historical prominent reigns, and because of that, cannot cover diverse features and details of Iranian architecture (Pourjafar, 2009:94). Pirnia (1993), Iranian architecture researcher has provided a different classification of the history of the Iranian architecture. He divided Persian architecture to Pre-Islamic era and Islamic era, which The Parsi (Mādai and Achaemenian dynasties), and Parti (Parthians and Sassanid dynasties) styles are Pre-Islamic era, and Khorasani, Razi, Azeri and Isfahan styles are in Islamic era of Iran

architecture. This division based on architectural details and historical governments both (21-25). This paper is based on this categorization, which Pirnia discussed. The scope of this research is Azeri style. The Azeri style is fifth style of architecture when categorizing Iranian architecture development in history. Landmarks of this style span from the late 13th century in Illkhanid and Timurid Dynasty to the appearance of the Safavid Dynasty in the 16th century. Mosques and religion monuments are most permanent buildings in this era. First buildings of this style have been made in East Azerbaijan of Iran, in Illkhanid dynasty, so it has been called Azeri style. The Azeri styles consist of two main periods. The first period begun from throne of Hulaku-Khan, in Illkhanid Dynasty in Maraque[1] and the second one is Kingdome of Timur in Samarqand[2]. The main characterizations of Azeri style are, increasing of height, attention to geometrical sciences, using Peymun[3] stucco and ceramic ornaments, building giant monuments, sophisticated plans and etc (Pirnia, 2009: p.214). Build of Court in mosques begun from Razi style, in Seljuk Dynasty, and after That, Courts and Courtyards became one of the main elements of masque's structure.

Court in the history of Islamic architecture, and Iranian architecture then, experienced many forms and features. The main and first form of the Court was used in Medina Mosque in the early years of Islam rising. This form was a one-way Court. Then in Razi style, central-Court and Extended-Court enclosed by four porticos (Aminzade, 1997: p.28). This was an ideal form to increasing Centralization of place in mosques and built after Razi style to Azeri and Isfahan Styles. The Four-Portico form is originally an Iranian form, which has used before this period, in Achaemenian palaces (Kiani, 1992: p.43).

As stated, Azeri style, consist of two main periods, Illkhanid and Timurid dynasties. Ilkhanid dynasty begins from 1256 to 1335, opened a new era in art and architecture in Iran, which Far East art had a large impact on it (Sherato and grope, 1376: p.10). Most of remaining buildings from this period are mosques, schools, and chambers. In addition, most materials used are brick, stone, wood, and iron (Wilber, 1365: p.35). Characteristics of Illkhanid architecture are building stone foundations, pay attention to building height, attention to ornaments and Length to Width ratio increasing against Seljuk architecture. Timurid dynasty begins from 1370 to 1507, Indebted Ilkhanid architecture because of using Iranian architects and artisan and sending them to Samarqand (sherato and grope, 1376: 37). One Outstanding feature of this era was brilliant ornaments and decorations. Advanced classification standards and criteria of professional knowledge of architectural drawings were proliferated using a single scale for buildings in Timurid architecture, was another one (bller and bllum, 1381: 94). These exploitations are an introduction to investigating courts in Iranian architecture, as one of the most important spaces in Islamic architecture. Regarding to the lack of scientific investigations in assessing elements of Iranian architecture, this paper is an attempt to introduce hidden features of this architecture through a statistical approach.

2. Methods and Materials

This article is a Retrospective Study, which used statistical methods and analyzing case studies to assessment the orders and proportions of Courts in Azeri style mosques. Azeri style consists of two main periods as stated. Thus, 10 case studies from the Illkhanid and Timurid dynasty have been selected for this approach. 5 case studies selected from Illkhanid dynasty, first period of Azeri style. Case studies are: Friday mosque of Varamin, Friday mosque of Yazd, Friday mosque of Natanz in Isfahan province, Semmnan mosque and Friday mosque of Froimud in Isfahan province. Four mosques of above list have been rehabilitated but Froimud

[1] A city near Tabriz, East Azerbaijan, Iran
[2] A city in Afghanistan
[3] A kind of module in designing

mosques have not been repaired completely yet. Also 5 masques of Timurid dynasty have been selected. Case studies of second period of Azeri styles are: Mir-Chaqmaq mosque in Yazd, Gawhar-Shad mosque in Mashhad, Bibi khanum mosque or Timur mosque in Samarqand, Kalian masque in Bokhara, Maidan mosque in Kashan in Isfahan province. Orders and proportions of these case studies have been derivate. Parameters have been mentioned in this paper are: length to width ratio, length to height ratio, area of the main court, area of the main complex, area of the court to area of the main complex ratio and climate concerning. Case studies have been categorized in to two periods, and then all of data of these two periods have been compared and analyzed. We have applied statistic methods to analysis these parameters. The Independent T-test with 95 percent of Confidence intervals (P_{value}<0.05) has been applied to analysis the Significance level of the parameters relationships. We have used SPSS Statistic 17.0 to perform this analysis. Also for analyzing the role of variable climate in the design process of Illkhnid and Timurid architecture, Mean and standard Deviation- the relationships below- has been used.

$$M=\frac{\sum xi}{N}$$

$$\partial^2=\frac{\sum(xi-M)^2}{N} \quad \rightarrow \quad SD=\sqrt{\partial}$$

Researches around the subject of Courts are divided to two major fields: First, itineraries from tourists and geographers like Shardon, Abne-Batote, Istakhri etc, who described the sense of place and give us some details about the year of build and circulation of mosque and architect of monuments. Second, analysis of contemporary archeologists and architects about this space, which none of them attended to proportions and orders of Court separately. This article is an approach to comparing the orders of Court in Azeri style and assessment of evolution of this space in this period.

3. Case Studies

3.1 Varamin Friday Mosque

This monument is located in Varamin, in forty-two kilometers from south of Tehran. This mosque by the order of Abo-Sa'eid Bahador Khan, substitute of Illkhanid king Oljeitu, has been built in 1301 (Wilber, 1886: 170). Author of this monument is Mohammad –Bin-Mansur Al-Ghohedi, which first mentioned by Etimad-Al Saltane, Iranian History researcher in 17th. The mosque has been once repaired in Timurid era (17th), and then in 19th up to now. In the central part of mosque, the non-covering court with four porticos is parading. One of the most famous features of the mosque is its brilliant ornaments which have been made by native materials like ceramic and bricks (24*24*5) (Sheibani, 1986: 29). The court surrounded on its 4 sides by a one-story arcade covered with pointed barrel vaults. It includes to the south, a 10 meter per side domed chamber with its portico overlooking the court, and the main portal portico is on the north side of the court. In addition to the main portal, two lateral entrances were formerly located on the east and west (Grabar, 1953: 591). The area of the mosque is about 2838 m^2, and courtyard is a quadrangular with 24 m length.

3.2 Yazd Friday Mosque

Located adjacent to the center of the city of Yazd, the complex of Friday mosque of Yazd was founded in 1324 in Illkhanid Dynasty, and later augmented in 1365 under Muzaffarids and then by Timurid Dynasty (Wilber, 1886: 172). The court surrounded on all four sides by one story arcades of Pointed-Arch vaults on massive square piers. The monument's main portal portico is located on east side of the court, with a 12 by 12 meters domed chamber that

located on southern side of the court The portico has galleries on the second level, which permit to access to arcades roof. (Pirnia, 2009: 234). The area of the complex measures about 46 by 54 meters, which is approximately 2500 square meters. The mosque encloses a rectangular open court, which is 18 by 46 meters.

3.3 Natanz Friday Mosque

The Natanz masque is located in Natanz city, Isfahan Province, Iran. The base structure of mosque comes back to Illkhanid, and Azeri style as Pirnia (2009) stated. The portal on the western end of the façade is the only remains of an early fourteenth century Qanaqah[4] that was destroyed and replaced by a mosque in the 1930s. The center of the façade is composed as a triple arcade, behind the central arch of which there is a minaret with an inscription dated 1324-25. Another portal on the eastern end of the façade provides entry to the complex by way of a sunken narrow corridor. An inscription on this portal reveals that the building is a mosque built by Zain-al-Din Mastari in 1304-5 (Blair, 1986:70-3). The square courtyard mosque is faced by two stories of rooms that link four porticos of varying depths. Construction is of baked brick, with a coat of white plaster. Muqarnas[5] vaults are found in the north and south portico. Two bays at the rear of the south portico flank the Mihrab, leading to the domed octagonal sanctuary, which abuts the main façade (Wilber, 1886: 145).

3.4 Semnan Mosque

This mosque located in Semnan city and built in 1354 in Illkhanid dynasty. Semnan mosque is a giant monument which includes many different ornaments and attachments. The Minirate of the mosque with 31 meters height has been built in Seljuk Dynasty and main Shabistans, Court and Domed roof has been built in Illkhanid dynasty (Wilber, 1986: 197). The monument has been built in arqun-Khan imperial. There is an epigraph by the date of 1354 in the southern portico (Wilber, 1886: 198). Godard has surveyed the mosque plan. The area of the court measures about $675m^2$, with 25 widths and about 27 lengths.

3.5 Froimud Mosque in Sabzivar

This mosque is placed in 120 km of the Sabzivar city in Khorasan Razavi province. The oldest part of mosque comes back to the Seljuk dynasty, but most of the features and the new shape, which is standing, belong to the Illkhanid (Wilber, 1986: 168). Godard stated that the base pattern of mosque belongs to Khorasani styles, which Wilber do not accept this. The Court of the mosque is a small square form with a long height. The length to height ratio in this mosque is small (Wilber, 1886: 169). The monument has brick ornaments and is too simple in forms and in geometry.

3.6 Gawhar Shad Mosque

This monument is located in Mashhad, Iran. It is part of Imam Reza shrine which consist of 4 different mosques. Construction of this monument ended in 1400 AD, by the order of Timurid Dynasty king's wife Gawhar shad-Aqa, in the southern part of Imam Reza Harem in Mashhad (Pirnia, 2009: 248). The architect of this monument is Ghavan-Adin Shirazi, who is

[4] A hostel for Sufis or dervishes
[5] Vaults that carries the stress of the domed roofs

one of the greatest traditional architects in his era (Pirnia, 2009: 249). This mosque is famous for its brilliant ornaments with ceramic, and is a 4-porticos mosque. On a high base of marble revetment, panels of enamel brick and tile work are arranged in two stories that run around the courtyard, capped by a band of calligraphy designed by Gawhar Shad's son Baysunghur. It is clear that energetic floral patterns in tile and geometric schemes in brick are used in alternation, emphasizing the strong rhythm around the courtyard (Byron, 1977: 1123-5). The mosque is built of mud brick (Pope, 1966: 234). The area of masque is 9400 m^2, and area of its court is approximately 2800m^2.

3.7 Amir-Chaq-Maq Mosque

This monument is founded in larger institutional complex consisting of a Schools, Qanaqah, Caravanserai[6], Qanat[7], Public baths, Square and etc in the Dehkok quarter, which has since transformed from a suburban garden to a dense residential and commercial district. This mosque is famous for its excellence decorative artisanship on its Mihrab[8] and its mosaic panels (Golombek, 1988: 421-2). Construction of the mosque was begun by order of Jalal Al-din Chaq-maq Shami, the governor of Yazd under Timurid ruler Shah Rukh in 1436-7, and was completed some years later, with a number of subsidiary structures through the active patronage of Bibi Fatima Khatun, wife of Mir Chaq-maq. The mosque is built of mud brick finished with white washed with plaster, along the traditional Iranian 1- portico structure around a square courtyard with no minarets (Pirnia, 2009: 255-6). The mosque today is identified with a later nineteenth century addition to the complex, the Takieh-ye Mir Chaq-maq. The area of masque measures approximately 1500 m^2 and the court area is about 200 m^2.

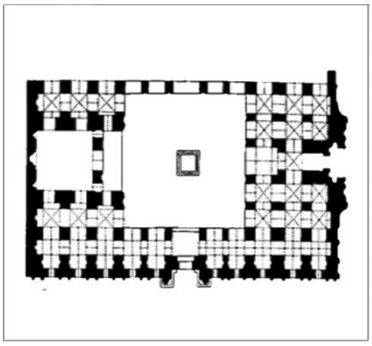


Fig.1 Varamin mosque

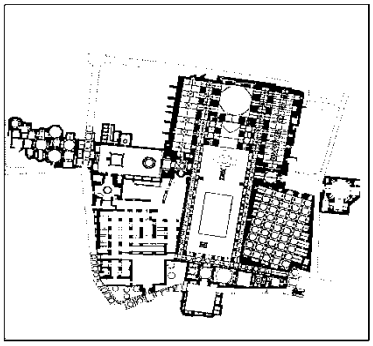


Fig.2 Yazd Friday mosque

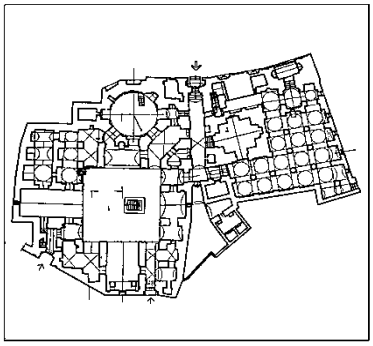


Fig.3 Natanz Friday mosque

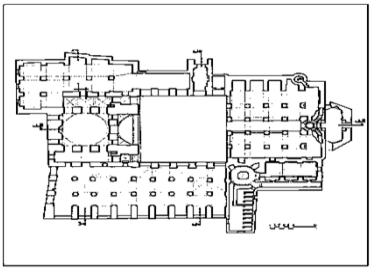


Fig.4 Semnan mosque plan

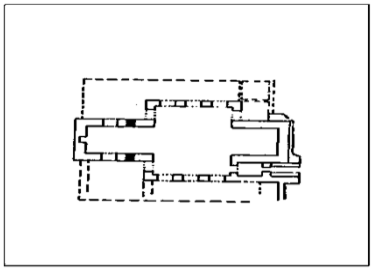


Fig.5 Froimud mosque plan

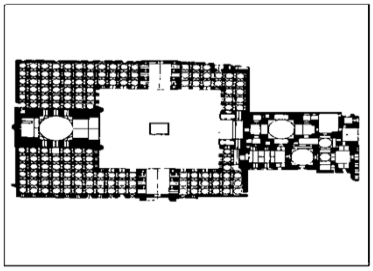


Fig.6 Goharshad mosque plan

[6] Travelers inn

[7] Subterranean canal dinged for water

3.8 The Timur Mosque (Bibi-Khanum mosque)

This mosque is located in Samarqand, Uzbekistan, built in 1387 (Pirnia, 2009: 261). By victory of Timur in India battle, building of this monument has begun. Located near the Iron Gate, the mosque faced a School, no longer extant, that would later the mausoleum constructed for Saray Mulk Khanum, now in a ruinous state. A covered bazaar connected the massive mosque to Registan Square (Blair, 1994: 40). The four fragments mark the four central points of the courtyard mosque: on the east-west axis, the monumental entrance portal with minarets, and the immense domed sanctuary with a portico flanked by minarets; on the north-south axis, two smaller porticos and domed chambers that punctuated the long sides of the courtyard (Golombek, 1988: 346-346). The area of mosque is about 18203 m^2, and the court measures about 8426.28m^2.

3.9 Kalian Mosque

This immense four-portico mosque occupies the site of an earlier congregational mosque commissioned by Qarakhanid ruler Arslan Khan, in about 1430 to 1514, of which only the minaret remains (Golombek, 1998: 302). This mosque is a huge four-portico which measures about 78 meters in 127 meters. A single story arcade of blind arches forms the main exterior façade, from the center of which projects a tall pishtaq with a semi-octagonal portico (Golombek, 1988: 303). Behind this is situated a vestibule. A single story arcade lines the courtyard, porticos fronted by pishtaqs marking the center of each façade. Hazarbaf brickwork predominates, with hexagonal haft-rangi floral tiles in the spandrels (Michell, 1995: 259). The area of the mosque is about 9050.22 m^2 and the area of the Court is approximately 2747.3 m^2.

3.10 Maidan Mosque in Kashan

The Maidan mosque located in the east part of the huge bazar in Kashan city in Isfahan province is a Azeri style mosque built in 14th century. The first built of mosque came back to saljuk dynasty, but nothing remained from that era and the whole complex rebuilt in 1400 to 1462 (Golombek, 1988: 553-4). The mosque is a four-portico monument, which has a doomed roof chamber room, portal, Courts and etc. The form of the Court is a square in the middle of main complex. Also the symmetry line of the Court is parallel with the symmetry line of the chamber room and main entrance (Golombek, 1988: 555). The area of the main complex is about 2070 m^2 and area of the Court is approximately 552 m^2.

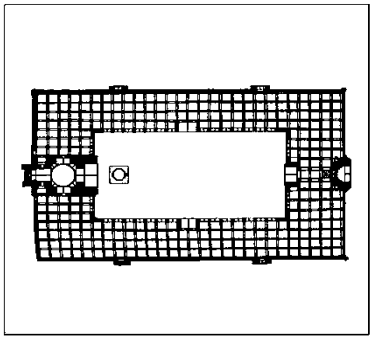


Fig.7 Bibi khanum mosque plan

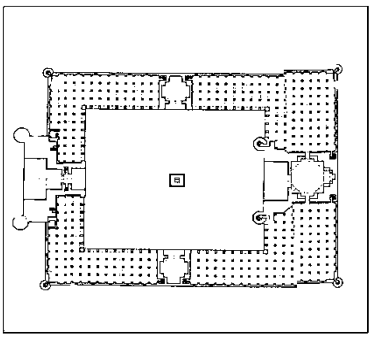


Fig.8 Kalian mosque plan

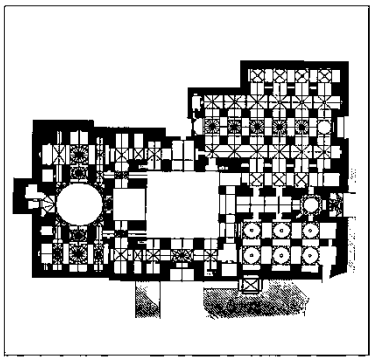


Fig.9 Mir chaqmaq mosque

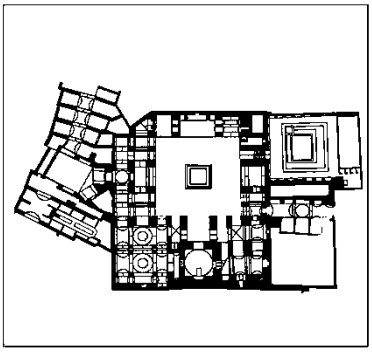
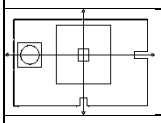
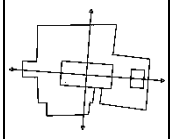
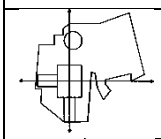
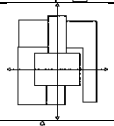
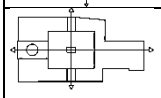
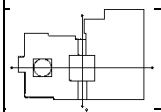
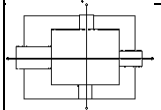
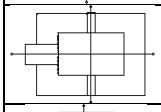
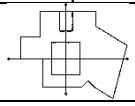


Fig.10 Maidan mosque plan

4. Analysis and Discussion

First step of the research, was measuring the dimensions of Courts in mosques in two periods of Azeri style. Ten different mosques, which described above, have been chosen. The primly data of the dimensions is gathered in table1. This data used to analyzing the variations between two periods of Azeri style through T-test. For approaching an accurate analysis of numerical data of the proportions and orders of Courts in Azeri style, 10 mosques from two main periods of this era have been selected. The statistical analysis from Independent T-test of the Length to Width ratio in the first period opposite to the second period, with 0.95 confidence intervals, in spite of a decrease in this ratio, from Illkhanid period to Timurid period, does not show a significant relationship. Also, statistical test of the area of the mosques in the first period of Azeri style to the second one, with 0.95 confidence intervals does not show a significant relationship. Of course in primary observations we can find a clear distance in the mean of areas in first period (3887.6 m) opposite to the second period (8876.644 m). Analysis of Length to Height ratio with 0.95 confidence intervals indicates a significant relationship (sig= 0.007). It indicates that this ratio has increased through Timurid dynasty, which can be interpreted in two ways. First, the length of courts in Timurid era has increased, so the extent of courts has increased too. And in Timurid architecture the height of court did not increased and in some cases decreased even. Most of the Timurid mosques are one-story façade, and the cases which are two-story courts, the length and width of the place are wide. Totally exact explanations need more investigation in future.

Table 1: Case studies characteristic

Geometric plan of court	Symmetry line of court		Length to Height	Length to width ratio	Area of Court to Complex ratio	Area of complex	Area of court	Case Study	Period	Row
	Coincidence on chamber symmetry line	Coincidence on chamber symmetry line								
	+	+	2.72	1	0.20	2838	576	Varamin	1st	1
	-	+	6.16	2.65	0.10	10000	1060	Yazd	1st	2
	+	-	1.66	1	0.18	2150	400	Natanz	1st	3
	+	-	2.83	1.70	0.34	500	174	Semnan	1st	4
	+	+	3	1.08	0.17	3950	675	Froymud	1st	5
	+	+	2.80	1.09	0.30	9410	2850	Goharshad	2nd	6
	+	+	1.34	1	0.03	5650	213.16	Mir chaqmaq	2nd	7
	+	+	12.25	1.15	0.46	18203	8426.28	Bibi qanum	2nd	8
	+	+	10.19	2.03	0.30	9906	2747.3	Kalian	2nd	9
	+	+	3.69	1.04	0.26	2070	552	Maidan	2nd	10

[Authors]

The analysis of area of courts, with 0.95 confidence intervals shows a significant variation in the area of the Courts of first period to the second period (sig=0.048). This significant relationship indicates increasing of extent in the second period of Azeri style. Also with exact analyzing of mosques of first period, we can find that most of the Illkhanid mosques, except Friday masque of Yazd or Ali-shah masque of Tabriz, are smaller than ones in the second. This may happened because of numerous requires of built in Illkhanid dynasty,

which occurred because of destruction of moguls war against Iran. Totally we can say that area of the Courts has been increased in second period of Azeri style, of course more valid interpretations needs further investigations. Finally analysis of ratio of whole complex area to the area of the Court, in first period to second period, with 0.95 percent of confidence intervals do not show a significant relation. Although this ratio has decreased in the second period, but statistically this difference is not significant. The table 3 shows the Means and Standard Deviations of parameters of research, and table 4 shows the final t-test which performed in SPSS statistics software.

Table 2: Means and Standard Deviation of the main parameters

Group Statistics					
	periods	N	Mean	Std. Deviation	Std. Error Mean
Acourt	First	5	577.0000	330.39068	147.75520
	second	5	2472.4600	2315.97377	1035.73496
LtoH	First	5	3.2740	1.69655	.75872
	second	5	6.0540	4.84499	2.16675
AtoA	First	5	.3120	.25440	.11377
	second	5	.2660	.13849	.06194
LtoW	First	5	1.4860	.71378	.31921
	second	5	1.2620	.43298	.19363
Acomplex	First	5	3887.6000	3638.75237	1627.29953
	second	5	8876.6440	6000.77386	2683.62765

Table 3: Independent T-test final result of main parameters in SPSS statistics software

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Acourt	Equal variances assumed	5.422	.048	-1.812	8	.108	-1895.46000	1046.22106	-4308.05009	517.13009
	Equal variances not assumed			-1.812	4.163	.141	-1895.46000	1046.22106	-4755.99237	965.07237
LtoH	Equal variances assumed	13.294	.007	-1.211	8	.260	-2.78000	2.29574	-8.07400	2.51400
	Equal variances not assumed			-1.211	4.966	.280	-2.78000	2.29574	-8.69343	3.13343
AtoA	Equal variances assumed	1.053	.335	.355	8	.732	.04600	.12954	-.25271	.34471
	Equal variances not assumed			.355	6.179	.734	.04600	.12954	-.26875	.36075

LtoW	Equal variances assumed	1.494	.256	.600	8	.565	.22400	.37335	-.63695	1.08495
	Equal variances not assumed			.600	6.593	.569	.22400	.37335	-.67001	1.11801
Acomplex	Equal variances assumed	.554	.478	-1.590	8	.151	-4989.04400	3138.46477	-12226.35675	2248.26875
	Equal variances not assumed			-1.590	6.591	.159	-4989.04400	3138.46477	-12504.65940	2526.57140

The assessment of the role of climatic aspects in design process in both period of Illkhanid and Timurid architecture with 0.95 confidence intervals do not shows any significant variation (Table 5). Table 5, is showing the area of court and the length to width ratio of courts in the order of climate. As it is clear, the area of court in hot-arid climate is more than one in temperate climate. While the characteristic of hot and arid architecture demands more massive buildings. Also, the length to width ratio in hot-arid masques is more than one in temperate climate too. This fact indicates that the Variable of climate is not the main characteristic of masques in Azeri architecture, but any Speculation about this fact demands more investigation around the subject.

Table 4: Proportion of courts in the order of climate (M±2SD)

	Temperate climate	Hot-Arid climate
Length to Width	0.52±1.18	0.80±1.2
Area of court	1948.6±930.3	6075±2604.5

The data from the main plan of the Courts shows that 0.80 percent of masques, the symmetry line of the Courts are parallel with the symmetry line of the Chamber domed roof. And also 0.90 percent of symmetry line in Courts is parallel with the symmetry line of main entrance.

5. Conclusions

The Azeri style is one of the brilliant eras in the architecture of Iran. As stated, this style has divided to two different periods, of course with some equivalent features. The statistical analysis of the main parameters and geometrical design with 0.95 percent of confidence intervals ($P_{value} \leq 0.05$) shows that, the ratio of Length to Height, and Area of Courts, in the second period of Azeri style (in Timurid Dynasty) has increased opposite of first period (Illkhanid Dynasty), which indicates a significant relationship. The analysis of the Length to Width ratio, Area of the whole complex, area of the Court to the Area of the whole complex ratio, with 0.95 percent of confidence intervals was not significant. The statistical assessment indicated that climate was not the main variable for architecture design of masque and courts. Also by studying of Azeri architecture, we can find that it is based on the geometrical design. It means that in the Azeri style, 0.80 percent of masques, the symmetry line of the Courts is parallel with the symmetry line of the Chamber domed roof. And also 0.90 percent of symmetry line in Courts is parallel with the symmetry line of main entrance. Totally, results indicate that in Timurid dynasty, concerning about grandeur masques and Courts has increased opposites to the Illkhanid era, otherwise authors suggests further investigations to clarify the dimensions of subjects.

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