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Investigation of the exterior skin proportions of urban district buildings with a climatic management approach

R. Mesgaran Kermani[1], S.M. Mofidi Shemirani[1, 2,*], N. Nikghadam[1, 3]

[1] Department of Architecture, Mashhad Branch, Islamic Azad University, Mashhad, Iran

[2] Department of Architecture, Faculty of Architecture and Urban Planning, Iran University of Science and Technology, Tehran, Iran

[3] Department of Architecture, Faculty of Architecture and Urban Planning, South Tehran Branch, Islamic Azad University, Tehran, Iran

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ABSTRACT

BACKGROUND AND OBJECTIVES: Lack of paying attention of contemporary architecture and urban planning to the environment and adaptation to the climate of the region has caused many environmental problems. To solve a part of the problem, the present paper was conducted to achieve the proportions governing the exterior skin of open spaces of urban districts that have unique characteristics to adapt to the climate of their region, since about 2/3 of Iran is covered by arid climate, it was examined. The old texture of Yazd is one of the best architectural models compatible with arid climate of Iran, which its teachings can give suitable guidelines for contemporary architecture and urban planning. In this regard, three districts from the historical texture of Yazd were selected as research samples.

METHODS: This research is of applied in terms of aim and its methodology is descriptive-analytical conducted by library method and field survey. The method of research and data analysis is a combination of quantitative and quantitative, in which the geometric properties of 143 plots were studied first and then, by comparing and analyzing the results, the fit was obtained.

FINDINGS: The results showed that the average height of the exterior skin in the squares was more than that in the passages and entrances; this ratio is 1.22 for the entrances and 1.35 for the passages. The average width of the exterior skin is greater in the squares, followed by the passages and entrances, respectively, with ratios of about 2.3 and 12, respectively. The ratio of height to exterior skin width is 1 to 5.7 in the squares and 1 to 39 in passages, exterior skin width is about 6 times in the squares and 39 times in passages. These proportions are a sign of the influence of the region's climate, the generalization of which in similar climates will increase the harmony with the climate.

CONCLUSION: Results suggest the existence of proportions and relations in the exterior skin that are affected by the climatic characteristics of the arid region of Iran and can be managed in the open spaces of urban districts.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
26	15	10

*Corresponding Author:
Email: *S_m_mofidi@iust.ac.ir*
Phone: +989125116488
ORCID: 0000-0002-2593-1501

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INTRODUCTION

Climatic architecture with the least destructive effects on its environment and paying attention to existing natural resources and saving on the use of non-renewable resources and preserving it for the future and its impact on the surrounding environment is a key step towards sustainable development (Nolson, 2016). The issue of climatic architecture in Iran has a long history. Historical architecture of Iran can be considered as a clear example of climatic architecture. However, in contemporary Iranian architecture, with superficial and slogan-like approaches that result from misunderstanding and fundamental principles and concepts of climate architecture in this area, its position has reduced to ephemeral styles and in they are in contrast to the environment and climate. Thus, planning and design based on climate and following the appropriate patterns of climatic conditions of each region are the requirements for achieving sustainable architecture and subsequently sustainable development (Pordeihimi, 2011). This paper was an attempt to obtain some of these relations and patterns in one of the dominant climates of Iran. Since about 2/3 of Iran is covered by arid climate, this climate was examined to evaluate and achieve the mentioned patterns in the exterior skin of its districts. Iran is a vast country with different climatic zones, and, in the past, traditional builders have presented several logical climatic solutions in order to enhance human comfort (Pakzad and Asadi Khansari, 2018). In fact, this emphasis has been one of the most important and fundamental features of Iranian architecture. To a significant extent, Iranian architecture has been based on climate, geography, available materials, and cultural beliefs. Therefore, traditional Iranian masons and builders had to devise various techniques to enhance architectural sustainability through the use of natural materials, and they had to do so in the absence of modern technologies (Keshtkaran, 2011). Most modern buildings are designed without adequate attention to environmental impacts. The history of architecture exhibits a positive correlation between the environment and traditional buildings, which have been designed with careful attention to climatic requirements and sociocultural contexts (Soflaei *et al*., 2016). Based on one of the theories, some of the reasons for climate change in statistical periods are associated with excessive human activities, particularly industrial activities and greenhouse gases (Samuel *et al*., 2017). During the 20th century, amounts of greenhouse gases such as CO2, CH4 and NO2, have considerably increased in the atmosphere. As much as 5 to 6.2 billion tons of dioxide enters the atmosphere annually. According to the forecasts by the Intergovernmental Panel on Climate Change (IPCC), about the population growth and the increase in the human need for energy, the amount of Carbon Dioxide will increase from 3.1 billion tons in 1985 to 4.7 billion tons in 2025 (Buzasi *et al*., 2021). Successive droughts, severe and sudden floods, cold and hot airwaves are one of the consequences of climate change, which have caused the earth to face various crises. So, recognizing the present and future climate situation is significant for urban planners and designers (Darabi *et al*., 2016). In previous studies, traditional Iranian architecture and urban planning has been recognized as one of the most complete forms of contextualism in the world (Tabarsa *et al*., 2017). Economic and environmental challenges have contributed to intensify, in recent years, national and international efforts to promote sustainable growth. Building sector can help to accelerate progress towards sustainable development through, for example, more sustainable use of natural resources, efficiency in the use of energy and valuation of ecosystem impacts (Ascione *et al*., 2016). A city requires favorable natural conditions, cultural and social relations and economic life to survive. Regarding the natural factors, traditional Iranian cities have adapted to the environment as if they were the environment itself. In fact, Iran is one of the few countries in the world that historically could create a diverse architecture in light of its cultural and geographical characteristics (Mofidi Shemirani and Moztarzadeh, 2015). This diversity can be observed even in the geographical divisions of a limited area. In general, various factors such as topography, climatic characteristics, economic capabilities, and livelihood and water resources in Iran have contributed to the emergence of different physical textures. This special geographical and climatic situation along with the intelligence of the past of this land in using natural energies such as wind and sun, both in arid regions and in humid area of this country, has led to the emergence of this unique architecture (Ziabakhsh *et al*., 2011). Traditional Iranian architecture has a strong background of various aspects of sustainability,

Iranian art and culture and reflects a special value of this art and culture (Hadianpour *et al.,* 2014). Research suggests that the techniques and rules used in Iranian indigenous architecture have all the characteristics of sustainability and clearly have many new concepts in the field of sustainable architecture and can respond to environmental issues appropriately. One of the effective steps taken in the area of optimizing energy consumption in residential buildings is the use of natural energy and climatic design of buildings based on the principles of sustainable architecture in each region. Climatic design has been the main theme of architecture in the past (Hekmatnia and Ansari, 2012). In recent decades, rapid unrestrained increasing of building has strongly affected on disorderly of heterogeneous proximity of bodies, activities and events in overall city (Atarod and Kashi, 2017). In Iran, the useful life of a building is 20 to 25 years. Today's cities are like construction workshops, where a large number of buildings are being built or demolished every day in every alley. A large part of the national capital, energy and environmental resources is wasted every year, resulting in damage to the country and even the world. Moreover, lack of models to achieve adaptation to the climate has left the designer, builder, operator and all construction stakeholders with a kind of ambiguity and confusion. The only official action in Iran in this regard is Article 19 of the National Regulations, which summarizes energy savings only in the form of thermal and acoustic insulation of buildings and presents the same pattern for the whole of Iran, despite its climatic and geographical diversity (Office of National Building Regulations of Iran, 2020). Other steps taken in this regard are objective translations of the experiences of countries that sometimes have no similarity to Iran (Camyabi and Ahmadi, 2013). The occupants decide an acceptable thermal comfort range by adapting to the internal environment of the building. This indirectly minimizes the energy usage and running costs of the building, thus enhancing its economic, environmental and sustainable performance (Albatayneh *et al.,* 2016). Adaptation of the artificial environment to the natural environment, ecosystem and climate is one of the criteria of the city ecosystem (Sharifian Barforosh and Mofidi Shemirani, 2014). Based on the studies conducted so far, some of which were presented in this section, the need to develop completely indigenous models and compatible with Iran's climate is quite clear. Since Iran's past architecture is the best model compatible with climate conditions, its experiences should be used to achieve models that respond to the climatic characteristics of a given region and then use them as a reference for use in areas with similar climates in Iran (Tavasoli,2012). An indigenous view of such research and conducting it based on the climatic characteristics of the Iranian region is the best solution to achieve these principles and models, since the existing and successful models of the world today cannot be effective for other countries, especially developing countries such as Iran. Even if its technical infrastructure is provided to use renewable energy, very important and fundamental issues such as economic issues, maintenance methods, operation, etc., will remain unresolved. Given the spatial value of the historical city of Yazd and its location on the central plateau of Iran with arid climate, and according to previous studies, this city is one of the best examples of climatic architecture that has been registered by UNESCO, so city was selected as a sample of study. The present study was an attempt to examine geometric exterior skin proportions in Yazd districts of arid climate of Iran. Its results help to achieve relations and proportions in design of exterior skin to achieve climatic management in this region. The present study differs from other studies in terms of subject matter and innovation. The present study is the basis of a diverse range of geometric features of the exterior skin of the buildings in the area in 143 plots from three different districts to study the skin proportions and identify the principles that govern their structure. The climatic characteristics of the arid region are unique, based on which a suitable climatic model is included based on the ratios and relationships in the skins. Therefore, the weakness and lack of identification of the principles governing the skin, influenced by climatic characteristics based on the ratios and relationships between them, is evident as one of the shortcomings of theoretical studies in this field. To achieve these up-to-date and innovative objectives, the research survey was conducted in Yazd, Iran in 2019 to 2021.

MATERIALS AND METHODS

Methods

The present study is an attempt to achieve the

proportions governing the exterior skin of urban districts that have unique characteristics to adapt to the climate of their region and climatic management through this skins of districts. The methodology of this research is descriptive-analytical based on qualitative analysis and the research strategy is a combination of descriptive method and case study. Data were collected and analyzed by direct view, drawing as built facades and photography. Then, by using logical, deductive and inductive reasoning, differences and similarities with other examples were obtained. The aim of deductive research is to help explain the research findings in the form of relations, formulas and proportions governing exterior skin similar to climate of the studied area. So, the case study of three districts of Yazd with historical and local value was studied and evaluated, which is the best suitable model for the arid climate of Iran. Then, the results were plotted and analyzed in the form of analytical sketches based on the characteristics affecting the formation of skins in terms of climate, and from their deductive reasoning, models for skins in this climate were presented.

Research variables and indicators

Library studies and field methods were used to collect data. The method of research and data analysis is mixed (a combination of qualitative and quantitative methods) and a comparative causal method was used in this regard. Several cities in arid climate of Iran were considered for study in the present study. According to views of experts and UNESCO, which considered Yazd as the best climatic and historical model, the districts of this city were studied as a case study. The three districts of Shah Abolghasem, Sahl Ibn Ali and Vaqat al-Saat, which are old and inner districts of the historical texture of Yazd city and have valuable buildings, and are historically and strategically important in the passageways, squares and entrances, geometric characteristics of their exterior skin such as length and width and height were selected for the study. By comparing and analyzing the results, the geometric proportions governing the exterior skin in this climate were obtained. Data collection tools in this study included note-taking sheets, tables, detailed maps of districts that were prepared from the cultural heritage of Yazd and passageways and numbered plaques, sketches of facades taken with measuring devices and after matching with the photos taken by the camera, were carefully drawn in the tables. Then, the plaques were drawn in each passageway and the bodies were displayed accurately, and then by examining, comparing and analyzing the skins in the passageways, squares and entrances, the governing geometric proportions of the exterior skin in the districts of this city were obtained. The characteristics and results of the analyses can be generalized to the same climate. In other words, the case study has an external validity.

Geographical scope of research

The study area in the present study is the city of Yazd in Yazd province. This province has an area of about 74493 square kilometers and covers four and a half percent of the total area of Iran. Yazd city is located in the center of Yazd province with an area of 2491 square kilometers. This city is located in the east of Isfahan and in the south of Lut desert in the center of Iran. It is surrounded by mountains on three sides, north, south and east, and has access from the west. Being located in the central part of the Iranian plateau has provided the most unfavorable natural factors governing the central plateau of Iran. Low rainfall with severe evaporation, distance from the sea, proximity to the vast dry and salt desert, low relative humidity with high heat, extreme temperature fluctuations are some of the factors that make Yazd one of the driest regions of Iran (Almutairi *et al*., 2021). The City of Yazd is located in the deserts of Iran close to the Spice and Silk Roads. It is a living testimony to intelligent use of limited available resources in the desert for survival. Water is brought to the city by the qanat system. Each district of the city is built on a qanat and has a communal centre. Buildings are built of earth. The use of earth in buildings includes walls, and roofs by the construction of vaults and domes. Houses are built with courtyards below ground level, serving underground areas. Wind-catchers, courtyards, and thick earthen walls create a pleasant microclimate. Partially covered alleyways together with streets, public squares and courtyards contribute to a pleasant urban quality. The city escaped the modernization trends that destroyed many traditional earthen cities. It survives today with its traditional districts, the qanat system, traditional houses, bazars, hammams, water cisterns, mosques, synagogues, Zoroastrian temples and the historic

garden of Dolat-abad (unesco, 2020). Fig. 1 shows the location of the city of Yazd in the center of Iran.

With its history and indigenous architecture, it has undergone several changes in different periods and accordingly is divided into three parts: 1- The historical part of the city, including the old and inner part, related to before the ninth century AH that has a physically intensive composition. 2- The historical part of the city, including the middle part, which shows the city complex until the establishment of the Pahlavi government in 1920, which is relatively open in terms of physical composition. 3- The new and outer parts of the historical walls of city that their expansion was accelerated in 1958-1968 and during the Islamic Revolution and it has a diverse physical composition (Tavasoli *et al.,* 2007). In the present study, the old and inner historical part of the city was selected due to its spatial values and indigenous architecture. The historical texture of Yazd with 43 districts has been registered by UNESCO. Its three districts were selected and studied due to their different valuable characteristics and their impact on the formation of the old texture of Yazd and having passageways, squares and buildings with historical value. Fig. 2 shows three different districts of the Yazd city and the location of the districts studied in this study.

Finally, it can be said that data analysis in the present study was performed in three steps: In the first step, graphs and tables were obtained by descriptive statistical method of quantitative data. In the second step, using a logical reasoning strategy, the applied research frameworks were explained and the results of these two steps led to the extraction of findings according to Table. 1 to Table.10 and Fig. 3 to Fig. 15 and in the final step, the final interpretation of the findings was performed.

RESULTS AND DISCUSSION

The results show that the exterior skin is suitable for the climate of this region in the open spaces of Yazd as one of the best examples of arid climate architecture in Iran. All images taken and sketches of the exterior skin in this section have been done by the author.

A: Samples of Shah Abolghasem district

In this district, the square and the two main passageways leading to the square were selected. Hosseinieh Shah Abolghasem surrounded the square, and passageway 001, including 16 plaques, 12 residential land uses, one water storage and 3 ruined place, and passageway 002, including 19 plaques, 16 residential land uses, 2 commercial land uses, a tomb, which all of them were taken and drawn according to Figs. 4, 5 and 6. After examining and evaluating their results, the exterior skin proportions of this district were presented in Table 1.

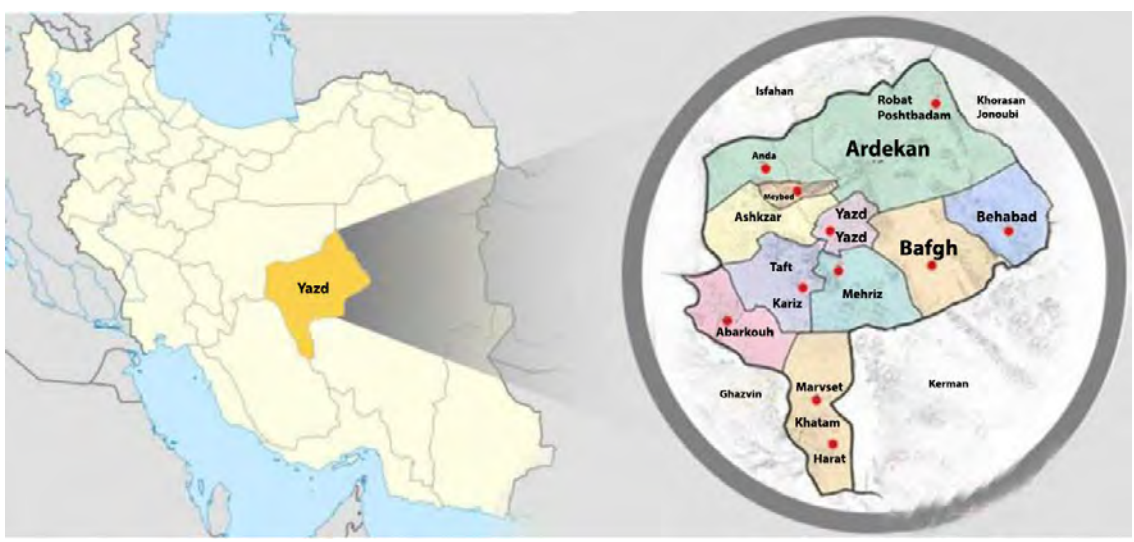


Fig. 1: Location of the study area (Archive of Yazd Cultural Heritage Organization, 2020)

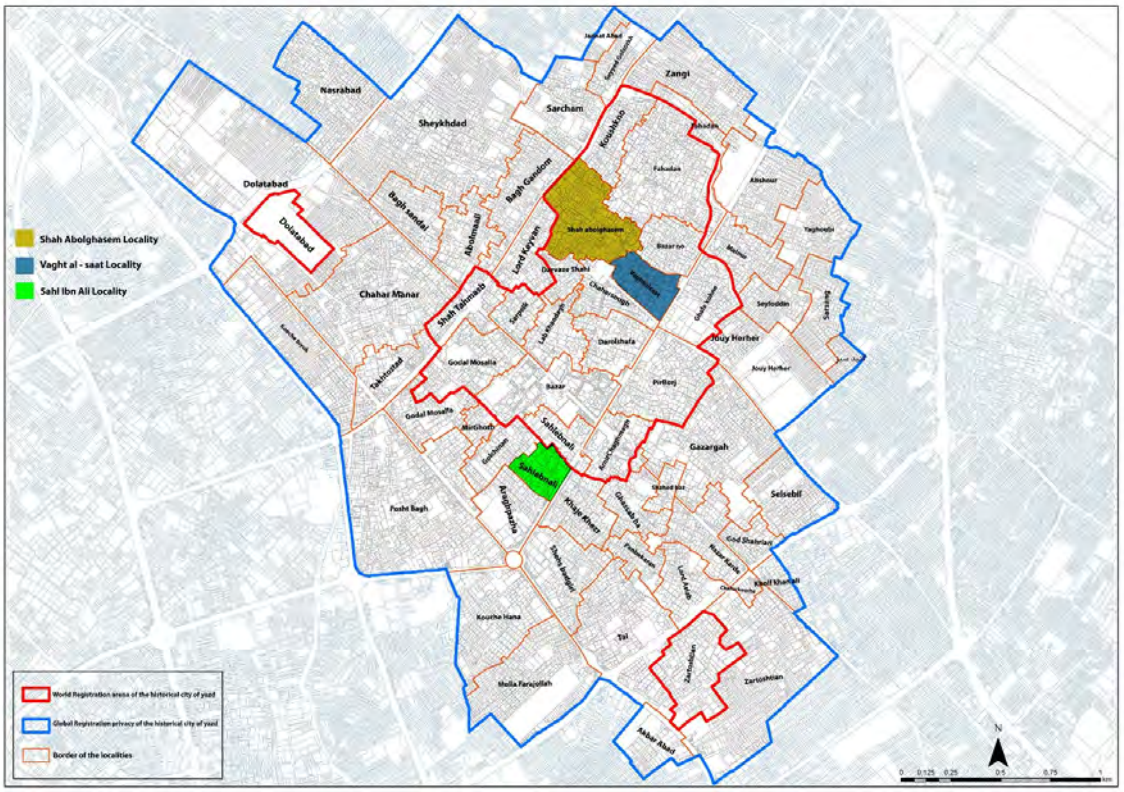
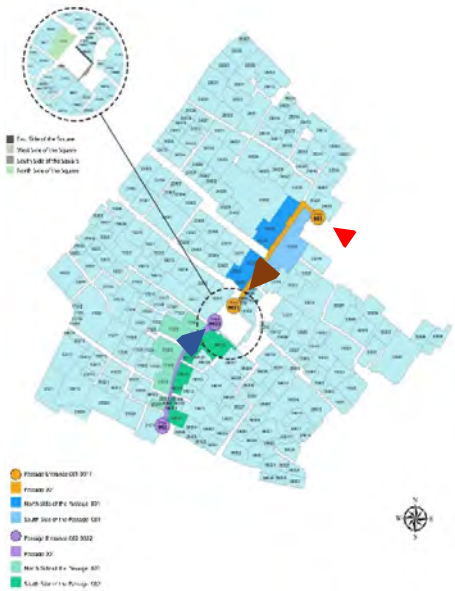


Fig. 2: Area and privacy of the historical texture of Yazd and the location of the three surveyed studied districts (Archive of Yazd Cultural Heritage Organization, 2020)

Sabat Entrance from passage to square



Entrance 001 Shah Abolghasem district

Entrance 0022 from passage 001 to square

Entrance 0011 from passage to square

Fig. 3: Location of the square, passages, and main entrances of Shah Abolghasem district of Yazd

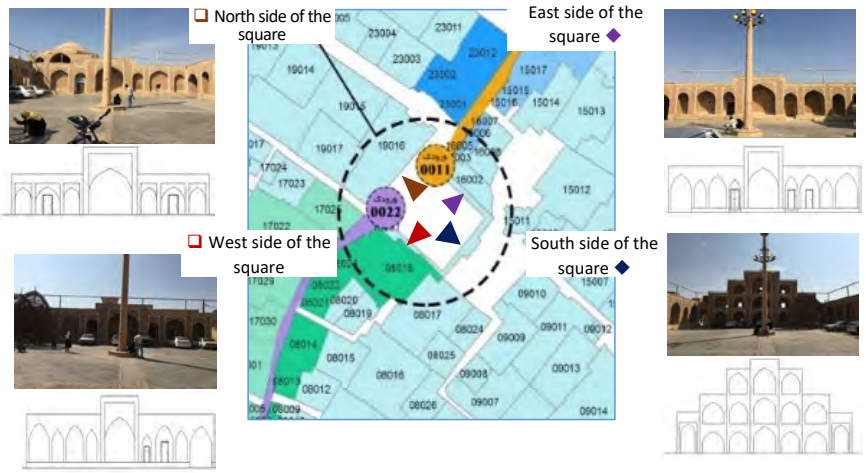
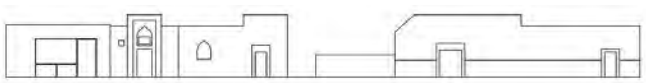
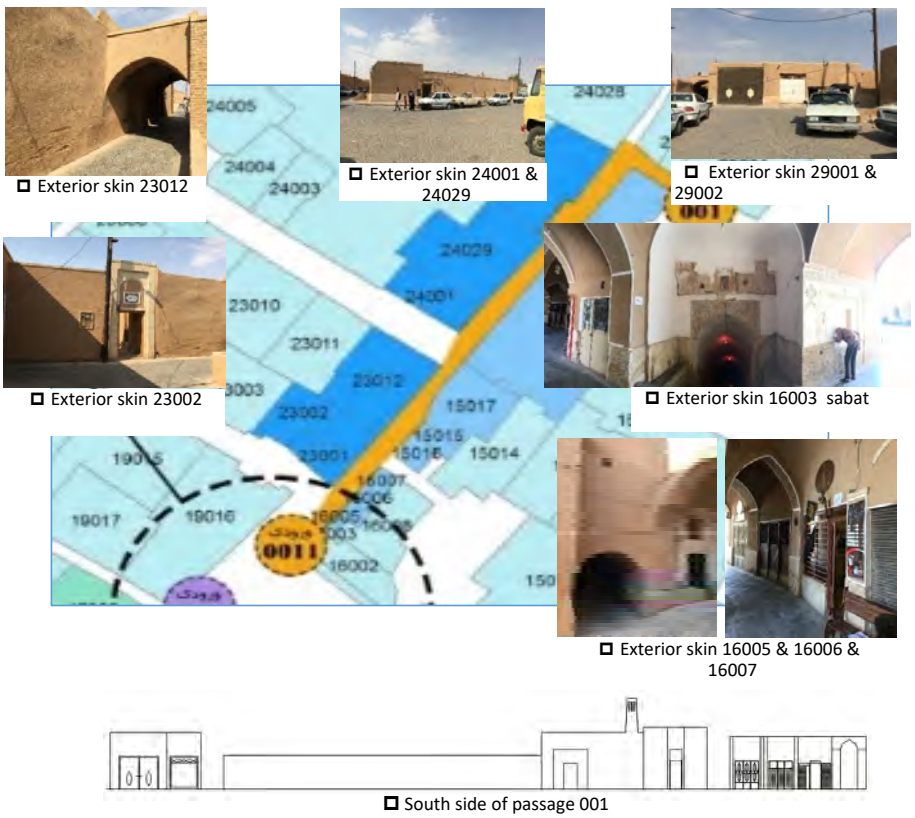


Fig. 4: exterior skin of Shah Abolghasem Square in Yazd



North side of passage 001



South side of passage 001

Fig. 5: Passage exterior skin of 001 Shah Abolghasem district of Yazd

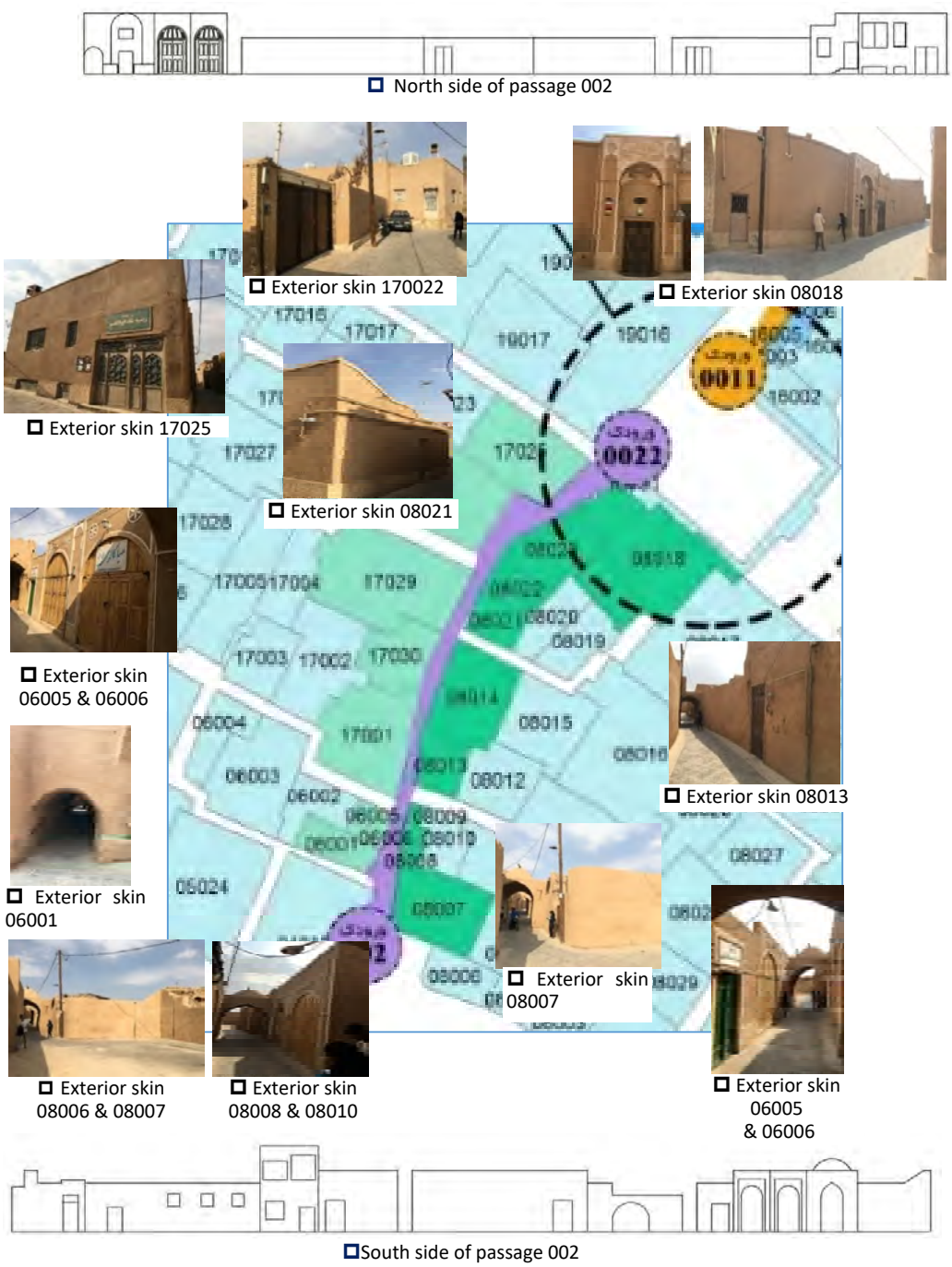


Fig. 6: Passage exterior skin of 002 Shah Abolghasem district of Yazd

Table 1: Summary of the proportions of Shah Abolghasem exterior skin district of Yazd

Average height of square exterior skin (meter)	Average width of square exterior skin (meter)	Average height of district entrance exterior skin (meter)	Average width of district entrance exterior skin (meter)	Average height of passage exterior skin 001 (meter)	Average width of plots passage 001 (meter)	Average height of passage exterior skin 002 (meter)	Average width of plots passage002 (meter)
7 Min: 5/5 Max: 10	23 Min: 22 Max: 25	4/16 Min: 3/51 Max: 5	2/46 Min: 1/74 Max: 3/18	5	6	5	8

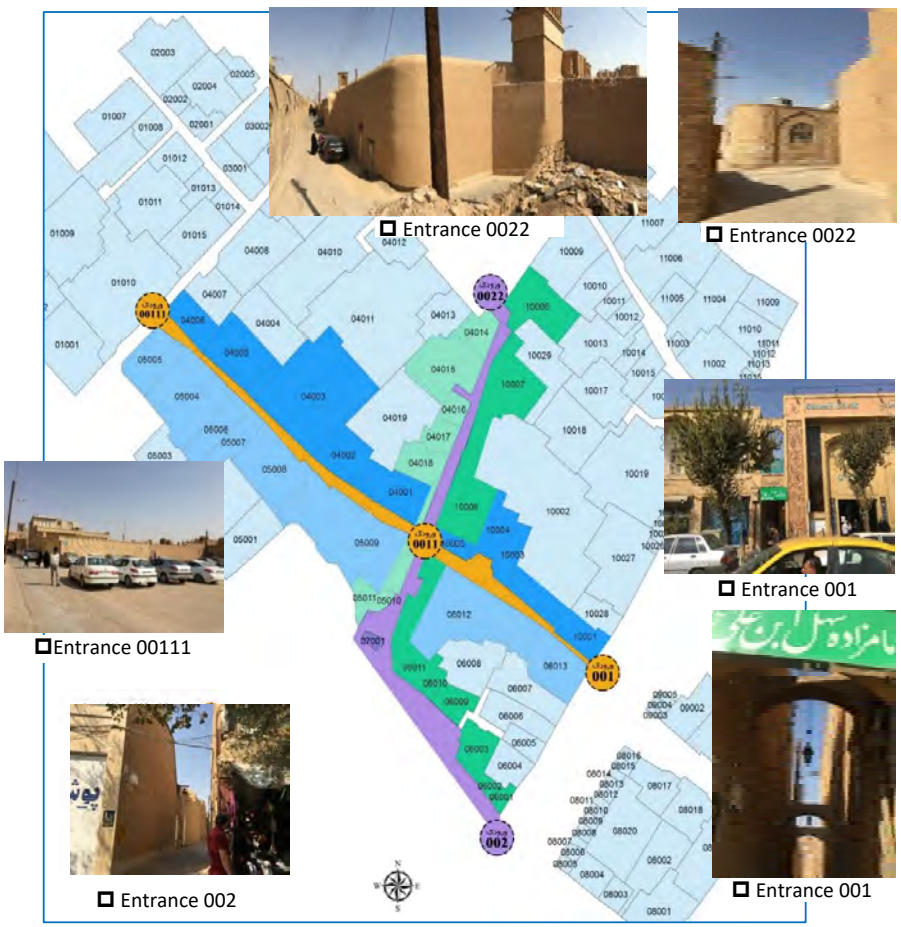
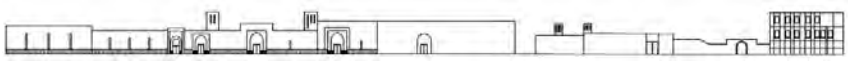


Fig. 7: Location of the passages, and main entrances of Sahl Ibn Ali district of Yazd

B: Samples of Sahl Ibn Ali district

In this district, two passageways that connected this district to the main street and parking lots were selected. Passageway 001 includes 20 plaques, 15 residential land uses, Sheikh Sadoughi House, Pirnia House, Yazd University of Arts, University Library, and Imamzadeh Sahl Ibn Ali building. Passageway 002 includes 20 plaques, 18 residential land uses; Sahl Ibn Ali Mosque and one ruined place, which all of them were taken and drawn according to Figs. 7, 8 and 9. After examining and evaluating their results, the exterior skin proportions of this district were presented in Table 2.



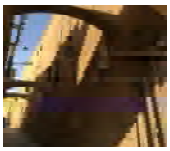
North side of passage 001

Exterior skin 05005

Exterior skin 04002 Pirnia

Exterior skin 04004 uni.

Exterior skin 1002 & 1003

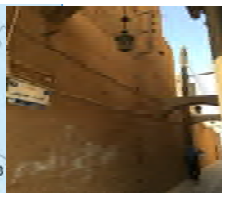


Exterior skin 10001

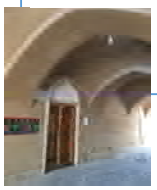
Exterior skin 04003 Lari home(Art Uni.)

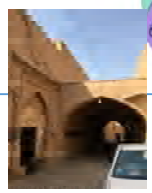
Exterior skin 05007

Exterior skin 04004



Exterior skin 06012 & 06013





Exterior skin 05009 Sheikh Sadoghi home

Exterior skin 06012

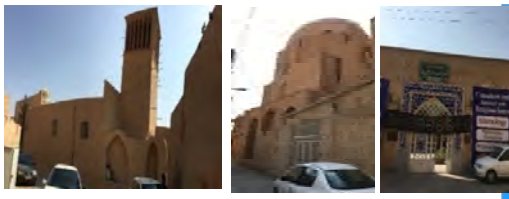
South side of passage 001

Fig. 8: Passage exterior skin of 001 Sahl Ibn Ali district of Yazd

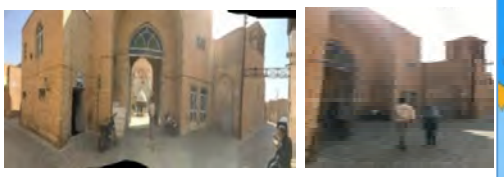
C: Samples of Vaqt al-Saat district

The square and 4 passageways leading to it were selected in this district. Four bodies of the square includes 12 plaques, including 7 buildings with residential land use, 3 buildings with caravanserai land use, one restaurant and one tomb of Sayed Rakneddin. Passageway 001 starts from the boulevard leading to the Grand Mosque Yazd includes 12 plaques, 10 residential land uses, one hotel and one tomb of Sayed Rakneddin. Passageway 002 started from the bazaar includes 11 plaques that of them have residential land uses. Passageway 003 started from the border of Shah Abolghasem and Vaqt al-Saat districts include 4 plaques with residential land uses located under Sabat. Passageway 004 includes 25 plaques that had 18 residential land uses, one hotel, two cafes, one restaurant and 3 ruined places, all of which were taken and drawn according to

East side of passage 002



Exterior skin 06012 Sahl Ibn Ali



Exterior skin 06012 Sahl Ibn Ali

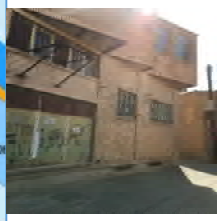
Exterior skin 06012

Exterior skin 06012

Exterior skin 06009

Exterior skin 06001 & 06002

Exterior skin 06012



Exterior skin 06003

West side of passage 002

Fig. 9: Passage exterior skin of 002 Sahl Ibn Ali district of Yazd

Table 2: Summary of the proportions of Sahl Ibn Ali exterior skin district of Yazd

Average height of district entrance exterior skin (meter)	Average width of district entrance exterior skin (meter)	Average height of plots passage 001 (meter)	Average width of plots passage 001 (meter)	Average height of passage exterior skin 002 (meter)	Average width of passage exterior skin 002 (meter)
5/40 Min: 3/20 Max: 7	3 Min: 1/7 Max: 4/7	5/8	17/5	5	21/5

Figs. 10, 11, 12, 13, 14 and 15. After examining and evaluating their results, the exterior skin proportions of this district were presented in Table 3.

D: Analysis obtained from the comparison of the proportions governing the square exterior skin, entrances and passageways of Yazd districts

By examining and comparing the results of the findings in the previous section according to Tables 4, 5 and 6, and analyzing them, the following results and proportions were obtained:

- The minimum and maximum height of the exterior skin in the passageways is more than the squares and are 1.36 times and 1.2 times, respectively.
- The average height of the exterior skin in the squares is more than the passageways and is 1.3 times.
- The minimum and maximum width of the exterior skin in the passageways is more than the squares and are 1.9 times and 6.7 times, respectively.

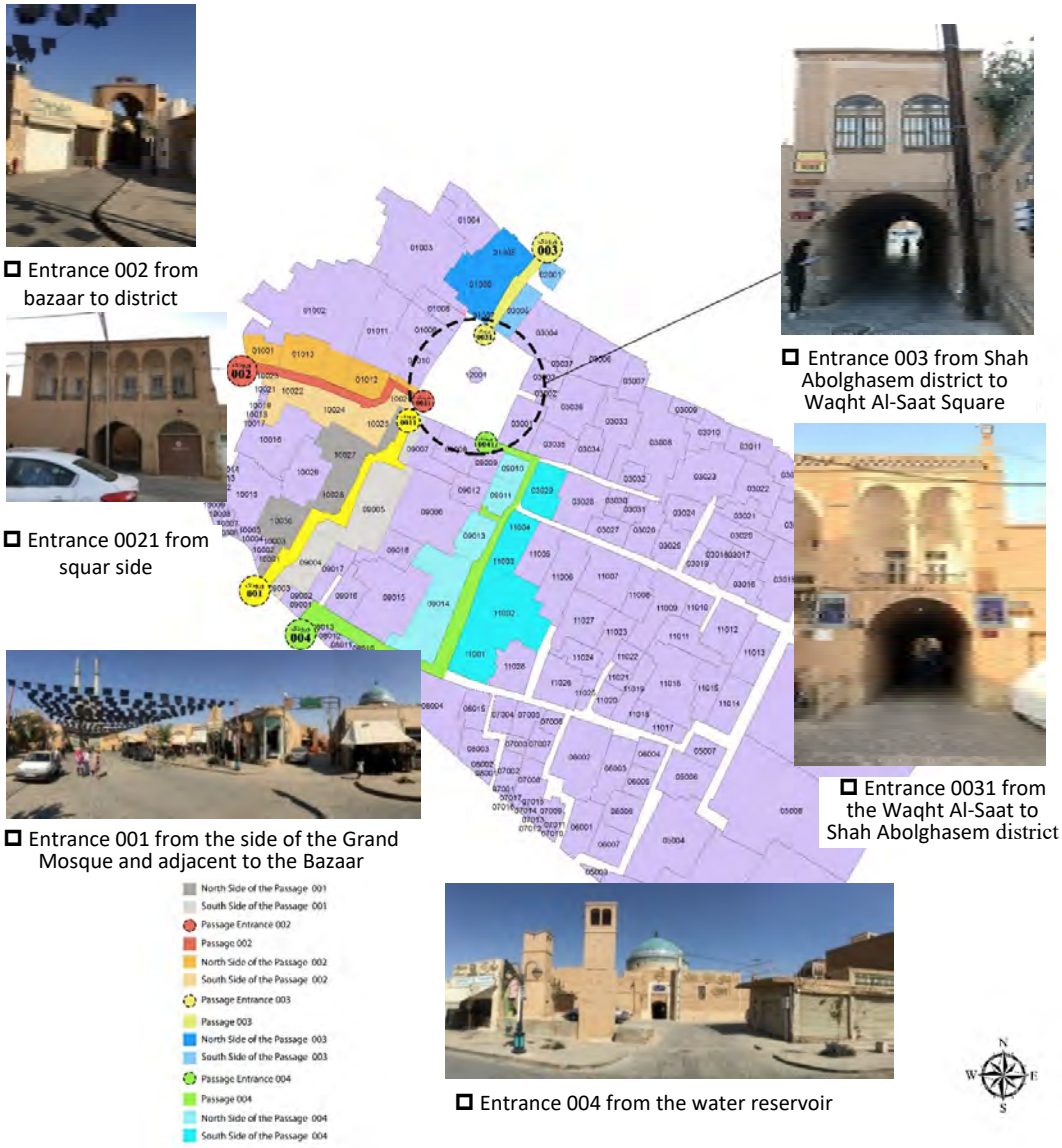


Fig. 10: Location of the square, passages, and main entrances of Waqht al-Saat district of Yazd

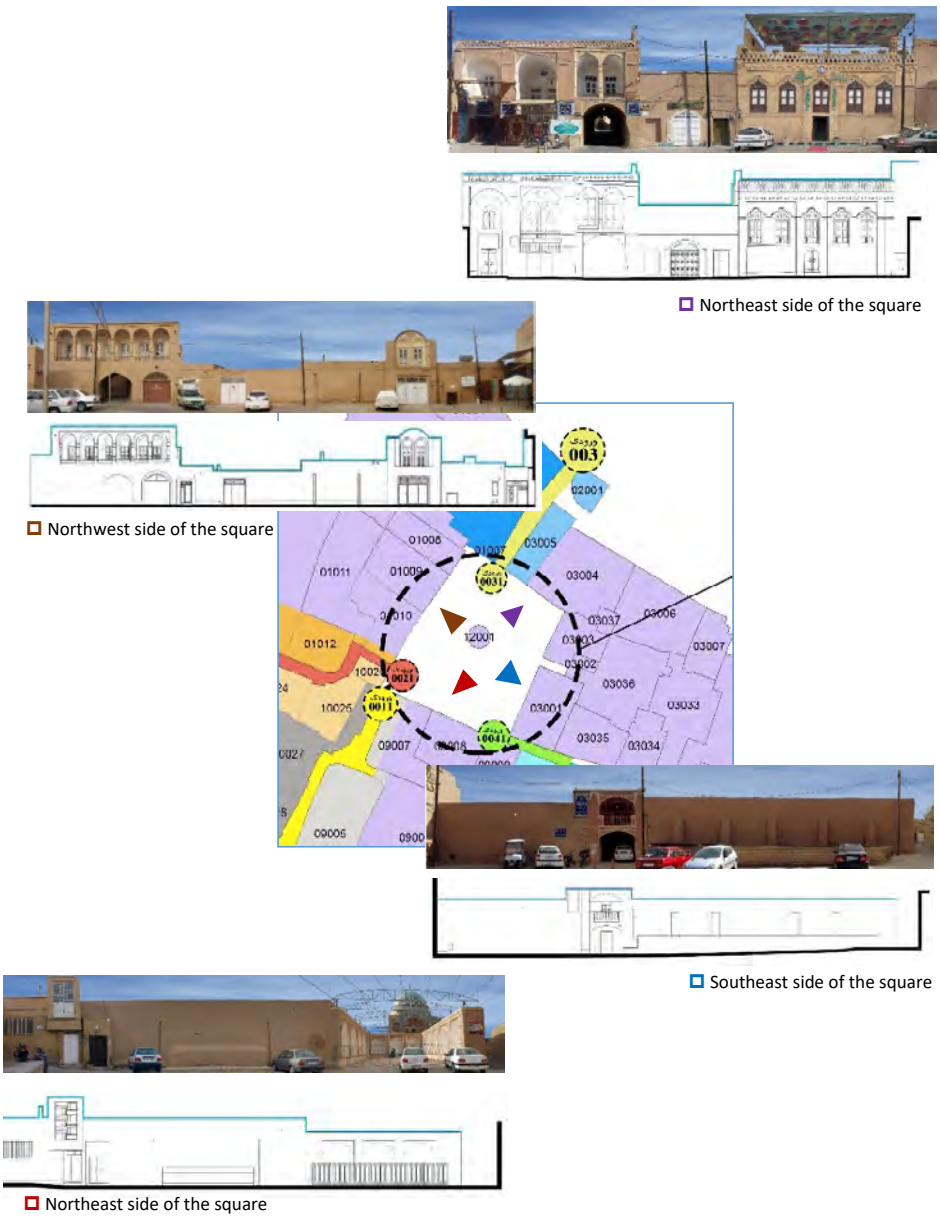


Fig. 11: Exterior skin of Waqht al-Saat Square in Yazd

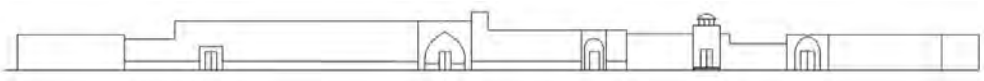
● The average width of the exterior skin in the passageways is more than the squares and is 5.24 times.

● The height to width ratio of exterior skin in squares is 1 to 5.7 and the height to width ratio of passageway is 1 to 39, and the exterior skin width is about 6 times higher than height in squares and 39 times higher than height in passageways.

E: The proportions and relations obtained from the analyses are as follows:

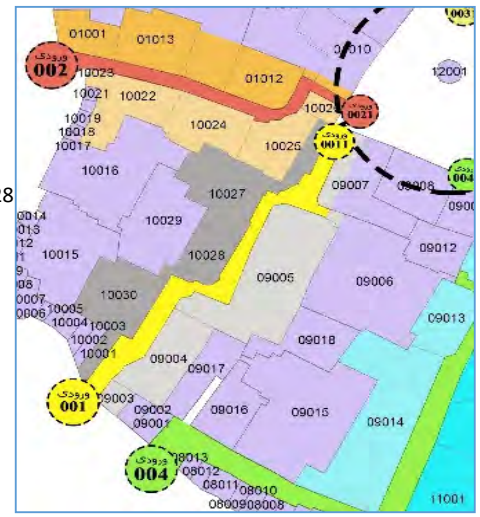
● Average exterior skin height in districts Square **>** Average exterior skin height of districts considered in the passageways and districts entrance of the study

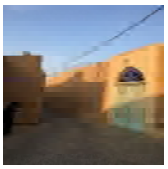
$$1/2= \frac{\text{Average height of the district square exterior skin}}{\text{Average height of the district entrance exterior skin}}$$

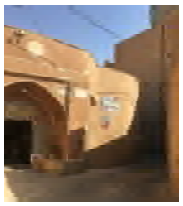


North side of passage 001

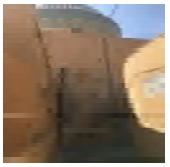
Exterior skin 10028



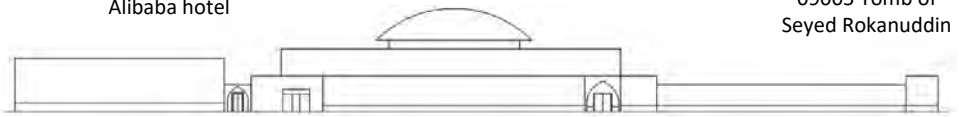




Exterior skin 10028 & 10027 Alibaba hotel

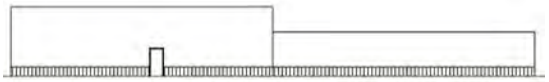


Exterior skin 09005 Tomb of Seyed Rokanuddin



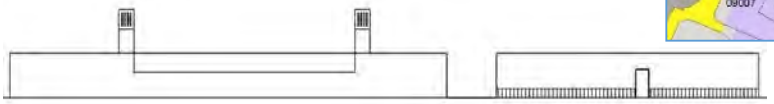
South side of passage 001

Fig. 12: Passage exterior skin of 001 Waqht al-Saat district of Yazd



North side of passage 003

Exterior skin 01005 & 01006 & 03005 & 03001



South side of passage 003

Fig. 13: Passage exterior skin of 003 Waqht al-Saat district of Yazd

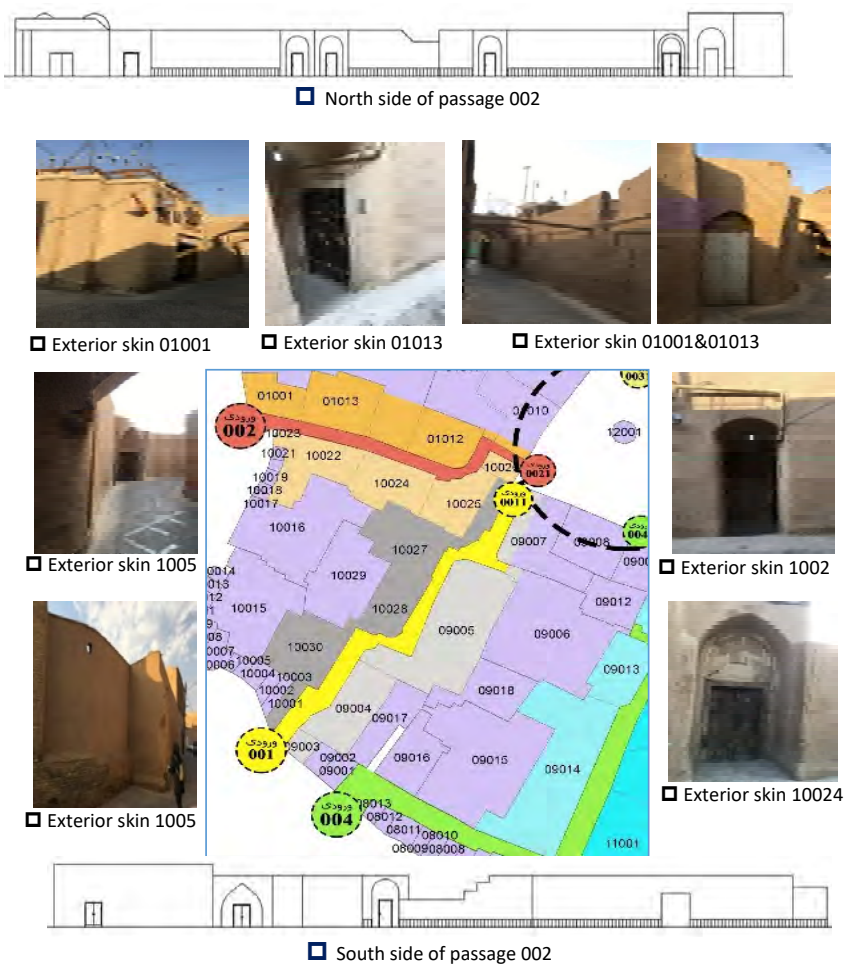


Fig. 14: Passage exterior skin of 002 Waqht al-Saat district of Yazd

$$1/3=\frac{\text{The average height of the district square exterior skin}}{\text{The average height of the district passage exterior skin}}$$

$$2/3=\frac{\text{Average exterior skin width in squares}}{\text{Average exterior skin width in passages}}$$

$$12=\frac{\text{Average exterior skin width in squares}}{\text{Average exterior skin width at entrances}}$$

$$5/2=\frac{\text{Average exterior skin width in passages}}{\text{Average exterior skin width in squares}}$$

● Minimum and maximum exterior skin height in the district passageway > Minimum and maximum exterior skin height in the district square

$$=3/1\ \frac{\text{Minimum passage exterior skin height}}{\text{Minimum square exterior skin height}}$$

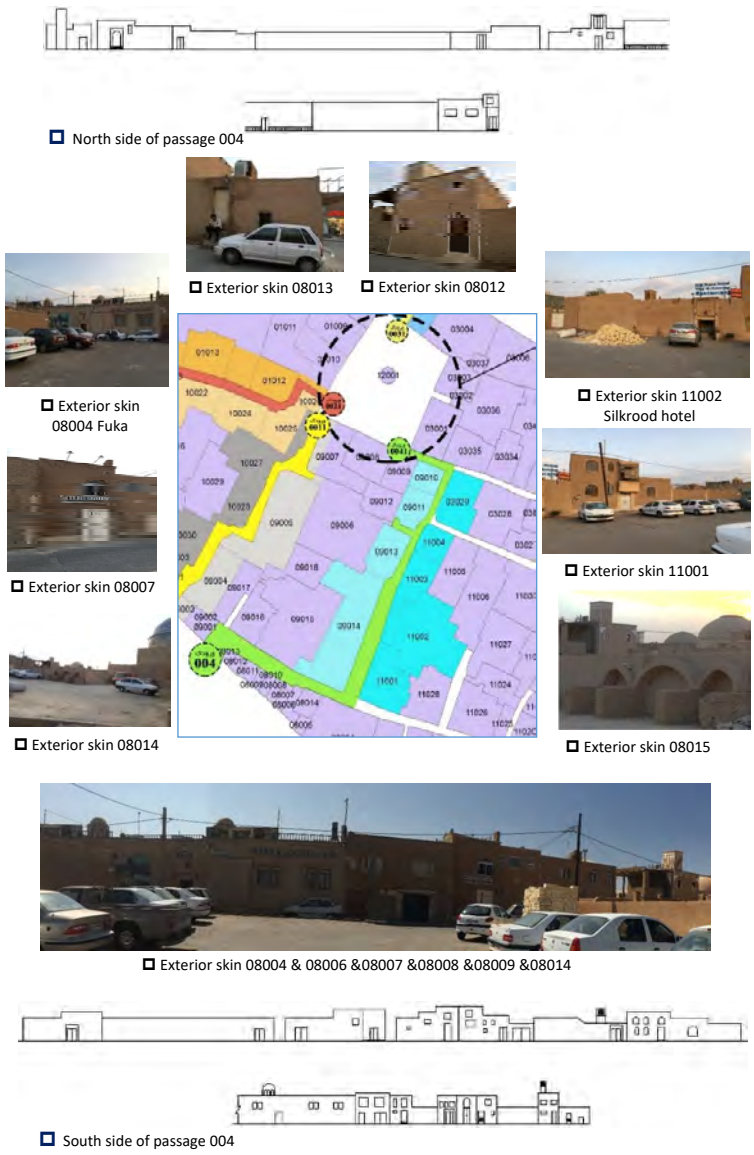


Fig. 15: Passage exterior skin of 004 Waqht al-Saat district of Yazd

$$1/2= \frac{\text{Maximum passage exterior skin height}}{\text{Maximum square exterior skin height}}$$

$$= 9/1 \frac{\text{Minimum passage exterior skin width}}{\text{Minimum square exterior skin width}}$$

● Minimum and maximum exterior skin width in the district passageway > Minimum and maximum exterior skin width in the district square

$$=7/6 \frac{\text{Maximum passage exterior skin width}}{\text{Maximum square exterior skin width}}$$

Table 3: Summary of the proportions of Waqht al-Saat exterior skin district of Yazd

Average height of square exterior skin (meter)	Average width of square exterior skin (meter)	Average height of district entrance exterior skin (meter)	Average width of district entrance exterior skin (meter)	Average height of passage exterior skin 001 (m)	Average width of plots passage 001 (m)	Average height of passage exterior skin 002 (m)	Average width of plots passage 002 (m)	Average height of passage exterior skin 003 (m)	Average width of plots passage 003 (m)	Average height of passage exterior skin 004 (m)	Average width of plots passage 004 (m)
5/20 Min: 20/2 Max: 7	41 Min: 361 Max: 48	5/65 Min: 3 Max: 7	3/60 Min: 2 Max: 6/51	4/84	17/4	4/72	12/3	4/5	24/5	5	12

Table 4: Proportions of Yazd district Square exterior skin

Minimum height(Meter)	Maximum height (Meter)	Medium height(Meter)	Minimum width(Meter)	Maximum width (Meter)	Medium width (Meter)	Height to width exterior skin proportion (meter)
2/20	10	6/10	22	48	35	1 to 5/7

Table 5: Proportions of Yazd district passages exterior skin

Minimum height(Meter)	Maximum height (Meter)	Medium height(Meter)	Minimum width(Meter)	Maximum width (Meter)	Medium width (Meter)	Height to width exterior skin proportion (meter)
3	12	4/70	42	325/2	183/6	1 to 39

Table 6: Comparison of the proportions governing the squares and passages exterior skin of Yazd district

Compared exterior skin	Minimum height (Meter)	Maximum height (Meter)	Medium height (Meter)	Minimum width (Meter)	Maximum width (Meter)	Medium width (Meter)	Height to width exterior skin proportion (meter)
Squares	20/2	10	10/6	22	48	35	1 to 5/7
Passages	3	12	4/70	42	325/2	183/6	1 to 39
Total	In the square less than the passage	In the square less than the passage	In passage less than the square	In the square less than the passage	In the square less than the passage	In passage more than the square	The width of the exterior skin in the square is about 6 times the height and in the passage is 39 times the height

● The ratio of height to exterior skin width in square is 1 to 5.7

$$\frac{1}{7/5} = \frac{\text{Square exterior skin height}}{\text{Square exterior skin width}}$$

Sustainability in ancient urban contexts is a model for new urban planning (Lashkari and Khalaj, 2011).

The argument of this research is based on the proportions and characteristics of the passageways and squares studied in the districts of Yazd city and the patterns obtained from their exterior skin and they are presented in Tables 7, 8, 9 and 10. Accordingly, it is necessary to use patterns and principles of indigenous architecture in arid climates to achieve climatic management.

By controlling the proportions governing the exterior skin of Yazd districts, as one of the best architectural models compatible with arid climate of Iran, and according to the characteristics that exist in the relations between length, width and height of exterior skin, proportions, relations and formulas for arid climate of Iran were obtained in this study that can be generalized to cities with similar climatic characteristics. So far, no similar research has been

Table 7: The pattern of the square exterior skin of Yazd districts

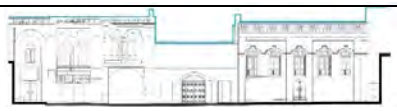
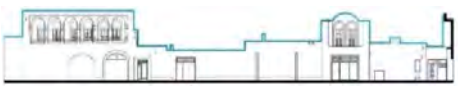
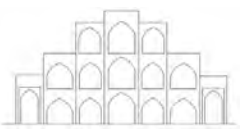
The pattern of the square exterior skin	Waght Al-Saat square exterior skin	The pattern of the square exterior skin	Shah Abolghasem square exterior skin
	North East side		North side
	North West side		South side
	South East side		East side
	South West side		West side

Table 8: The pattern of passageways exterior skin in Shah Abolghasem district of Yazd

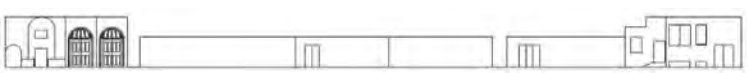
The pattern of the passageways 001 & 002 exterior skin	passageways exterior skin
	North side of passage 001
	South side of passage 001
	North side of passage 002
	South side of passage 002

Table 9: The pattern of passageways exterior skin in Sahl Ibn Ali district of Yazd

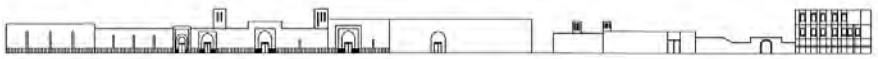
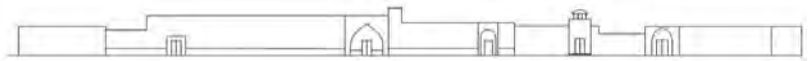
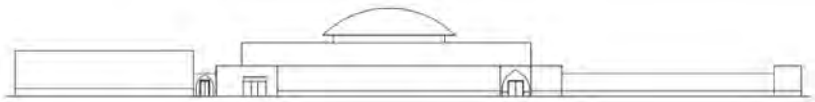
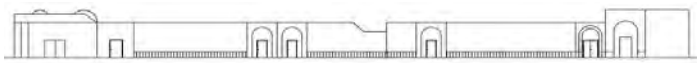
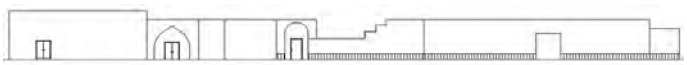
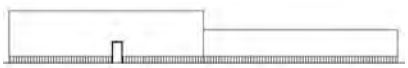
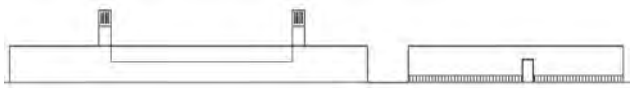
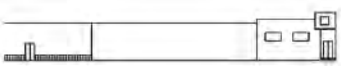
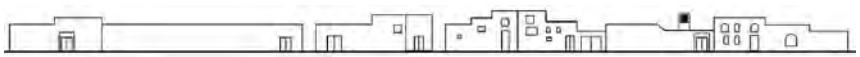
The pattern of the passageways 001 and 002 exterior skin	passageways exterior skin
	North side of passage 001
	South side of passage 001
	East side of passage 002
	West side of passage 002

Table 10: The pattern of passageways exterior skin in Waght Al-Saat district of Yazd

The pattern of the passageways 001, 002, 003 and 004 exterior skin	passageways exterior skin
	North side of passage 001
	South side of passage 001
	North side of passage 002
	South side of passage 002
	North side of passage 003
	South side of passage 003
	North side of passage 004
	South side of passage 004
	
	

published in Iran, and research conducted in other countries cannot be generalized to Iran due to geographical and climatic differences. Therefore, the results of the present study are novel and similar previous articles have not examined this issue. In general, the proportions and relations obtained from the analysis of the characteristics of passageways and squares of the three selected districts of Yazd are classified in the following three characteristics:

1. Average exterior skin height in squares of districts > Average exterior skin height in the passageways and entrances of districts

This characteristic is due to the functional differences between the passageways and the square in the districts of this city. Squares are usually static places and open spaces for holding religious, historical and ritual events, ceremonies and gatherings, and the uses around them were usually public on at least two stories such as hotel, guest house, tomb, Hosseiniyah, etc., but the passageways are dynamic and narrow and the only place for entrance of the mostly residential buildings, placed with an height of one or two stories next to the passageway, and their shadow on the passageways moderated the extreme temperature of the area.

2. Minimum and maximum height of the exterior skin in the passageways of districts > Minimum and maximum height of exterior skin in squares of districts

This characteristic was also due to the uniformity of land use in the passageways, which were mostly residential, compared to the squares that had various land uses, so the minimum and maximum height of the exterior skin of the passages were more than those of the squares.

3. Minimum and maximum width of exterior skin in passageways of districts > Minimum and maximum width of exterior skin in squares of districts

In the squares of the districts, the land uses were diverse with a small width of openings so that they could be next to each other and around the main gathering space of the district, so in the passageways, the exterior skin width of plaques was more.

Based on the results of the present study, a number of formulas were obtained that are listed here and in the previous section.

- *Width square = 5 * square exterior skin height*
- *Passage exterior skin height = 4 * width passage*
- *Passage exterior skin width = 39 * passage exterior skin height*
- *Square exterior skin width = 6 * square exterior skin height*

Considering such patterns and proportions that govern the architecture of the exterior skin of our urban districts in the past and have been quite successful and compatible with the climate of their region, it is appropriate to use these characteristics and patterns in contemporary architecture to form a new approach in architecture appropriate to the type of climate.

CONCLUSION

Designing with climate, and not against it, is nothing new. It is the way in which buildings were constructed for thousands of years. However, in the recent past, architects have been led to ignore the climatic context of buildings, relying on abundant fuel and sophisticated technology when designing for human comfort. Now that the demands on architects are changing the most pressing challenge is to create and adopt an architecture which shelters people in sustainable manner. Achieving climatic architecture and preventing energy wastage in contemporary buildings, patterns that have given the best answers to those climatic conditions should be followed, and by carefully looking at the past architecture of Iran, which corresponds to the climatic characteristics of its region, these patterns can be acquired. Therefore, the current study investigates the proportions of the exterior skin of the ancient districts of Yazd, which is one of the best examples of arid climate architecture. This research started with field surveys and accurate drawings of the samples in Yazd districts and after summarizing, comparing and analyzing them, the results were obtained that indicated the existence of relations and proportions between the length, width and height of the building exterior skin as mentioned. The relations and proportions obtained in this research provided patterns for planning and designing exterior skin of districts that are in accordance with the arid climate of Iran. The results of this current study are novel and have not been addressed in similar prior articles and using these relations and proportions, can help improve the visual and climatic quality of urban skins. Therefore, it is suggested that in the design of urban spaces: the average height of the square skin

more than the average height of the passage skin, the minimum and maximum height of the passage more than the minimum and maximum height of the square, minimum and maximum width of the passage more than the minimum and maximum width of the square, the square width should be considered five times the height of the square skin, the height of the passage skin four times the width of the passage, the width of the passage skin thirty nine times the height of the passage skin and the width of the square skin six times the height of the square skin. Finally, it is recommended that the proportions and patterns of exterior skin to be examined in other climates of Iran, including: hot and humid, temperate and humid and cold and dry, in future research to obtain appropriate patterns of those climates to take effective steps to solve the today's problems of architecture and urban planning.

AUTHOR CONTRIBUTIONS

R. Mesgaran Kermani performed the literature review, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. S. M. Mofidi Shemirani and N. Nikgadam performed the literature review and helped in the analysis and interpretation of the data and manuscript text preparation.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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