ISSN: 2008-5079 / EISSN: 2538-2365
DOI: 10.22034/AAUD.2024.402903.2796

Research Paper

Investigating the Evolution of Tehran City's Spatial Structure and the Influence of the Pedestrian Street Development Plan on It; Using the Space Syntax Technique; Case Study: 17th Shahrivar Pedestrian Street Development Plan

Leila Moghimi[a*]- Pirouz Hanachi[b]- Somayeh Fadaei Nezhad Bahramjerdi[c]

[a] Assistant Professor of Architecture, Faculty of Architecture and Urbanism, Soore International University, Tehran, Iran (Corresponding Author).

[b] Professor of Restoration and Revitalization of Historic Buildings and Fabrics, School of Architecture, College of Fine Arts, University of Tehran, Tehran, Iran.

[c] Associate Professor of Restoration and Revitalization of Historic Buildings and Fabrics, School of Architecture, College of Fine Arts, University of Tehran, Tehran, Iran.

Received 18 June 2023; Revised 21 October 2023; Accepted 06 January 2024; Available Online 20 December 2024

ABSTRACT

The spatial structure of Tehran City has evolved over time due to various factors, including spatial, temporal, and socioeconomic ones. To understand how changes in the city's spatial structure and new development plans, such as pedestrian street projects, have affected its historical areas, it is essential to know the city's history and its physical evolution. This study examines the evolution of Tehran's spatial structure throughout different historical periods by analyzing the degree of integrity using the Space Syntax technique. Assessing the integrity of streets at both neighborhood and supra-neighborhood scales within the historical area is crucial for their valuation and prioritization in accepting pedestrian street development plans. The study argues that implementing these plans can effectively enhance the integration and connectivity of the city's historical structure while acknowledging that the formation of specific streets before their conversion into pedestrian streets influences their walkability. Therefore, the present study categorizes them. This research is applied, focusing on the physical and structural evolutions of Tehran City through an interpretive-historical approach. The data are analyzed through simulation and content analysis. The findings reveal that pedestrianizing 17th Shahrivar Street, as a case study, fails to preserve the integrity and coherence of the city's historical center, and undermines accessibility and integrity indicators at both neighborhood and supra-neighborhood levels.

Keywords: City Structure, Pedestrian Street Development Plan, Integrity, Space Syntax.

* E_mail: l.moghimi@soore.ac.ir

1. INTRODUCTION

Achieving goals such as protecting historic urban centers, implementing sustainable transportation, etc. requires the existence of pedestrian-oriented streets since they improve mobility, reduce negative environmental influences, strengthen the economy, and enhance social interactions and sustainability. Pedestrian-oriented streets play a crucial role in revitalizing city centers and encouraging people to voluntarily attend urban spaces. In the late 1940s, pedestrian streets were first introduced in European cities after World War II, during the rebuilding of war-damaged areas and renovation of historic urban centers. This is when the idea of pedestrian/vehicle segregation emerged. The cities of Rotterdam and Stockholm witnessed the initial experimental experiences of creating traffic-free zones in the late 1950s. Due to the threat of traffic to the historic centers of European cities and the resulting destruction of valuable urban fabrics, private cars were driven out of the central and historic areas of these cities, resulting in the restricted entry of cars in almost all important historical cities in Europe by 1975 and the formation of pedestrianized historical-commercial axes in them (Pakzad 2005). Creating pedestrian-specific centers can ensure the continuity of life, the prosperity of activities, and the sustainability of historical urban centers. Pedestrianization is the most powerful and effective street redesign movement. It is one of the solutions applied to reduce the presence of cars and their negative consequences, and to enhance the vitality of cities and urban cores. Historical fabrics and urban centers can be organized in such a way that walking and enhancing pedestrian orientation are considered suitable options for protecting these areas and their structures. For this purpose, it is required to examine the walkability of the passages located in them. Many historical cities in Iran have witnessed efforts to sustain and protect urban centers during their physical development, without sufficient attention to their historical shape and structure. For instance, one can refer to the pedestrian-oriented street development plans which were implemented without categorizing and prioritizing them, resulting in the emergence of problems for historic centers, such as inadaptability to new physical changes, inappropriate connections with the existing structure, and spatial isolation, and thereby the failure of these plans. Previous studies have used various variables and methods to perform the prioritization abovementioned. This research seeks to fill a methodological gap in this field, which is largely the result of applying the personalized opinions of researchers and professionals to carry out this prioritization or their weaknesses in the use of selected variables. Therefore, the present study seeks to answer the following question: Are all streets located in the historical areas suitable for converting to walkable ones? How do pedestrian street development plans influence the spatial structure of Tehran? To answer the research question, first, the background of the method used, theoretical foundations relevant to city structure, pedestrianization, and underlying indicators related to street prioritization in terms of suitability for pedestrianization are presented. Next, the research method is presented per the research question considering the limitations, and is then applied in the analysis section. Finally, the streets forming the historical structure of Tehran are categorized, analyzed, and prioritized in terms of suitability for pedestrianization.

1.1. Research Background: Prioritizing Streets for the Implementation of Pedestrianization Projects

Regarding the studies in Iran, one can refer to some studies examining changes in the spatial structure of several cities using the Space Syntax technique. However, the highest presence of people and natural movement within the historical structure of the city and its surrounding streets were considered in a few studies. Moreover, there is limited research on the outcomes of pedestrian street development plans implemented in the streets within the historical structure of the city and their influences on the historical centers considering the principles of Space Syntax. Rikhtehgaran et al. (2020) introduced the priority of creating pedestrian axes in Gaz City considering three underlying components: "space syntax", "access to a mix of leisure uses", and "access to a mix of uses related to daily or work needs". In their study entitled "Analyzing the Impact of Physical Changes on the Spatial Structure of the Historical District in Urmia City by Space Syntax and Gis", Abedini et al. (2019) acknowledged that the average integrity of most historical rastehs (in English, rows of shops) is higher than the average total integrity in all four periods studied, indicating the spatial importance of these axes in the structure of Urmia City. Among the international studies, one can refer to the study on the sustainable development of Shichahai District, a historical and cultural district in Beijing, in which the changing street texture of Shichahai District during the Yuan, Ming, Qing, and current periods was traced using the space syntax technique[1]. This study indicated that the main street texture in the Shichahai District is relatively stable. However, the increasing automobile dependency in Beijing has reduced the vitality of the streets in general (Zhang et al. 2018). Another paper critically evaluated urban conservation and revitalization of areas under the banner of “heritage” and revealed that Suzhou has experience examined two critical and dialectical phases: the period of growth and incremental change during the imperial period, and the pressure for change and development during the 20th century, which have caused irreparable damage to the historic streets (Xie and Heath 2017). Van Nes and De Rooij (2015) examined how people use streets in three neighborhoods in the city of Notre

Dame and understood the role of the structure of the streets in strengthening street life. Moreover, they argued that the high integrity of the street network on the global scale and the connection with the urban network encourage the attendance of diverse people in the streets. Joo and Kwon (2022) evaluated the consequences of supergrid development in relation to the modernization and conservation of Seoul's historic street patterns using the Space Syntax technique. The results regarding its conservation revealed the disruption of historic streets. In their study entitled "Natural Movement: A space syntax theory linking urban form and function with walking for transport", Koohsari et al. (2019) related urban forms and functions to the approach to pedestrian-oriented development. The results of a study on the walkability assessment of Iglesias City introduced Space Syntax as a useful tool for assessing walkability in cities. Also, it can help mayors and urban planners make better decisions regarding pedestrian network improvement and enhancement of accessibility to urban services (Garau, Annunziata, and Yamu 2024). In a study most similar to the subject of the present research, Space Syntax was used as a tool to assess the changes in the spatial structure of city centers. The results indicated that implementing pedestrian axes can significantly improve the urban space and enhance citizens' quality of life. Furthermore, it was found that implementing a pedestrian axis in the city center can promote commercial and recreational activities in the area and improve the regional economy (Mohamed Tahoon 2023). Research on the environmental quality assessment of streets shows their much greater volume than the studies on prioritizing urban streets for creating pedestrian-oriented streets. However, there is an important difference between these two issues, which is the research goal. The first group seeks to assess the environmental quality of urban streets to measure the level of walkability of the streets. While, the second group, which includes the present study aims to identify those streets that need to improve the qualities related to walkability, due to having special conditions. Research in this field indicates that providing special conditions for streets to make them suitable for walking requires considering desirable indicators, which are categorized into two groups: indicators related to the history and formation of the particular street during the development of the city structure and space syntax indicators.

2. THEORETICAL FOUNDATIONS

The theoretical framework and research method of the present study indicate that it is possible to classify indicators effective in prioritizing streets located in the historical structure of the city to create pedestrian-oriented axes based on the analysis of the research background and existing knowledge in this field. This classification is as follows: 1. underlying indicators; these are essential for determining the priority of urban streets in pedestrianization and also define the flow of pedestrian movement in cities. These indicators are related to the space syntax indicators. 2. superstructure indicators; which can enhance the environmental qualities of the street as a pedestrian-oriented axis. Using this theoretical framework and research method, the present research examines Category 1, including indicators effective in prioritizing urban streets in pedestrianization for creating pedestrian-oriented axes. To examine how pedestrian street development plans influence the historical structure of the city and the pedestrian orientation of the streets, issues related to the evolution of the city's physical structure are investigated. For this purpose, concepts such as spatial structure, pedestrian orientation, and indicators related to space syntax-related indicators are first presented.

2.1. The Concept of the Spatial Structure of the City

In Iranian culture, two words refer to the concept of "structure": "sakhtar" and "sakht" (Ashuri 1976). Structure, as the framework of everything, represents a system in which all components of a complex are interconnected and form the entirety of the work in accordance with a coordinated function (Seifzadeh 2012). The city structure includes components such as open spaces and facilities, streets, and public buildings (Crane 1960), and its symbolic foundation is built by symbolic places and the connections between them (Ahari 2015). As a metabolism, the city structure is the main skeleton of the city with long durability, and neighborhoods, blocks, and houses, like body cells and tissues, are less durable (Pakzad 2007, 57). The main structure of the city is relatively stable and creates its citizens' mental image, i.e. an image that, according to Lynch, provides a coherent entirety by linking places (Lynch 1997, 170). Spatial organization is a network whose elements are urban centers (mixed commercial, administrative, cultural centers, etc. on the scales of the entire city and its districts and areas), important connecting axes (primary streets and metro lines), important functional axes and major uses (on the scales of the city and its districts and areas) (Behzadfar 2015). The adaptation of the spatial organization of the city to the physical environment is called spatial structure. The spatial structure of a city is a composite complex consisting of a single backbone and a connected network of different urban uses and elements (Hamidi 1997). The spatial structure of a city is the product of historical processes and changing socioeconomic and political conditions (Roshani and Saghefiasl 2013). Analyzing the characteristics of the spatial structure of cities through a variety of basic city forms and their structures indicates the unique growth and expansion characteristics of each of them (Zebardast and Shad Zaviyeh 2012), which influence the way the

historical city expands and the decisions of experts and specialists in this field regarding development plans such as pedestrianization of a specific axis.

2.2. The Concept of Pedestrianization

Pedestrianization is one of the solutions effective in revitalizing urban centers and strengthening social solidarity and interactions by increasing citizens' attendance in public places. In fact, pedestrian zones of the city are parts of the urban space that are closed to vehicle traffic during some or all hours of the day, due to their special capacities and are completely dedicated to pedestrian traffic (Cratan 2008). Walking is the oldest and most natural manifestation of human movement in the environment and is considered an important opportunity to observe places, feel passion and vitality during activities, and discover values in the urban environment. This phenomenon has undeniable significance as it contributes to the perception of identity, the creation of a sense of belonging to space, and the perception of beauty (Pakzad 2007). It is also effective in conserving historical urban structures. Researchers such as Behzadfar and his colleagues examined the role of the Strøget axis in Copenhagen, one of the most important pedestrian streets in the world. They analyzed the factors affecting the efficiency of this pedestrian street and pointed out the many advantages and benefits of using the idea of walkway construction in the renovation and improvement of historical contexts by citing the research results (Habibi, Behzadfar, and Jaberi 2011). Also, Ghorbani and Jame Kasra (2011), in their study entitled "Pedestrianization as A New Approach to Renewal of Urban Centers," examined and identified the spatial and temporal origins of the emergence of pedestrian axes. The results indicate that organizing these axes in the central fabric of the city has complied with the historical fabric renewal policies and has helped to promote commercial places and related uses after being implemented. It is essential to note the difference between pedestrianization and walkway construction. "Pedestrianization" means reducing vehicle traffic and increasing freedom of movement for pedestrians, while "walkway construction" means eliminating cars and completely separating pedestrians from vehicle traffic. In other words, special conditions are required for the construction of walkways (Etesam and Nouri 2018), and many experiences of walkway construction projects show that complete vehicle/pedestrian segregation to improve the status of pedestrians has not been always successful and is not feasible in many urban areas. Therefore, the pedestrianization approach has been chosen as an alternative to walkway construction. This research examines the underlying factors affecting the prioritization of streets within the historical structure of the city to create pedestrian-oriented axes.

2.3. Space Syntax-Related Indicators

Pedestrian movement and pedestrianization play a crucial role in the structure of cities and the layout of urban spaces. These two elements are directly related, as shown in the articles by (Akbarzadeh, Ahmadi, and Azadeh 2016) and other experts. In general, research in the relationship between pedestrian movement and space syntax, as a theory and method, seeks to provide a suitable explanation of the skeleton of the city and the flow of pedestrian movement. This research focuses on the indicators that express space syntax and are related to pedestrianization. Regarding the identification of streets with high priority in pedestrianization, many domestic and foreign studies have used space syntax indicators to identify streets suitable for pedestrianization (Özer and Kubat 2014). For example, the integrity index used in the articles by Abbaszadegan and Azari shows that the higher this index, the higher the priority for creating pedestrian streets, and vice versa (Abbaszadegan and Azari 2012). Therefore, in the present study, streets classified as suitable for pedestrianization should meet indicators related to the history and formation of that particular street during the city structure development and space syntax.

3. THE SPATIAL STRUCTURE EVOLUTION OF TEHRAN CITY

This section provides a historical-interpretive study to reread the evolution of the spatial organization of Tehran in the Qajar and Pahlavi periods. This study is carried out using simulation and analysis of changes in the integrity value during the formation of Tehran's streets relative to the historical center at the metropolitan scale and in the Qajar and Pahlavi periods. Then, it examines how the 17th Shahrivar pedestrian street development plan, as a case study, influences the historical structure of Tehran City.

3.1. Rereading the Spatial Structure Evolution of the Historical Center of Tehran from the Qajar Period to the Present

Urban changes in the Qajar period can be categorized into two sub-periods: Qajar I and Qajar II. In the Qajar I era- from 1164 to 1229 AH - Iranian cities, including Tehran, were a perfect symbol of traditional cities. These cities were on a human scale, had a traditional integrated fabric, were surrounded by a high wall, had a government citadel with a higher wall than the city wall that separated the rulers from the public, and the mainly narrow passages of the cities extended in an indirect direction (Ghobadian 2013). The primary streets started from the main gate and ended at the government citadel, with shops on both sides of the streets (Fig. 1).

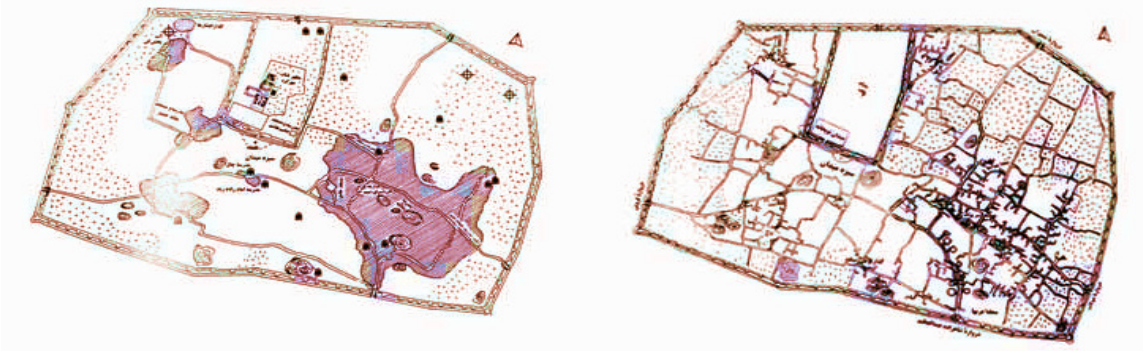


Fig. 1. Right- Tehran, the Reign of Agha Mohammad Khan Qajar; Left - Tehran, the Reign of Afghans
(Motamedi 2002)

In the Qajar II era- from 1229-1260 AH - despite the preserved historical fabric of Iranian cities, the historical fabric of Tehran experienced some changes. According to Seyyed Mohsen Habibi[2], the Tehran style emerged in this period. Until the beginning of the reign of Nasser al-Din Shah Qajar, Tehran was a completely enclosed city and, in the special sense of the word, it was a traditional city belonging to the Eastern world (Ibid 2013). In addition to the government citadel, Tehran had four neighborhoods and two squares, Arg and Sabzeh Maidan, both of which were located south of the government citadel. During the reign of Nasser al-Din Shah Qajar, three maps were prepared for Tehran. The first map was prepared by Barzin in 1232 AH. About six years later, the second map (known as the Dar-al-Khalafa-ye Nasseri Map) was drawn by August Karel Kriz. Due to their closeness in time, these two maps are almost physically consistent with each other. According to Vahid Ghobadian, the only difference between them is the reduced area of the gardens on the outskirts of Tehran city and the conversion of parts of them into residential areas. In both maps, the main structure of the city is the same as that built during the Safavid government and by the order of Shah Tahmasp I (Rafieian, Alizade, and Taghvaei 2016).

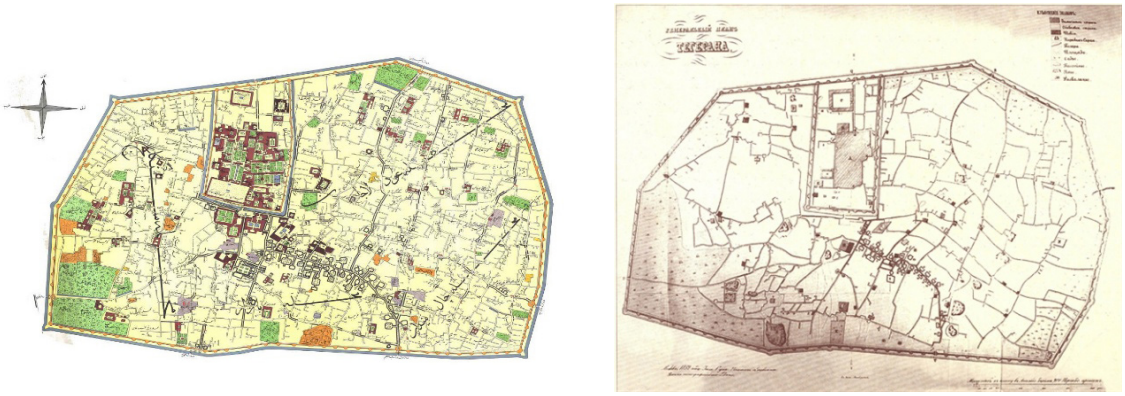


Fig. 2. Right- Tehran in the Qajar Era (the Map drawn by Kriz); Left - Tehran in the Qajar Era (the Map drawn by Barzin)
(Shirazian 2012)

Fig. 3. Tehran in the Qajar Period (the Map drawn by Abdul Ghaffar)
(Shirazian 2012)

Developing the third map of Tehran caused the initial development of Tehran outside the Safavid (Tahmasp) wall. The drawing of this map was started in 1247 by Abdul Ghaffar Khan Najm al-Molk and completed by 1270 AH. As this map shows, the Tahmasp wall was demolished, the Nasseri wall was built outside it, and the city expanded. The order of Tehran's new wall, with its specific geometry, did not significantly influence the internal fabric of the old city, and the old city was connected to the new gates by constructing new streets (Habibi 2003). The new center of gravity at this time was the Mobarakeh Toopkhaneh Square on the northern side of the Citadel, and all the important roads of the city were connected to it. The word "passage (gozar in Persian)" on the maps drawn by Barzin and Kriz changed to the word "street (khiaban in Persian) on the map by Abdul Ghaffar, and the old wall within the area of the Nasseri wall became a horse-drawn railway, leaving the old fabric almost unmanipulated.

From Pahlavi Period to the present: The modernist movement reached its peak during the Pahlavi period, dramatically reshaping the structure of Iranian cities. This transformation has not only persisted but has also led to the isolation of historical urban centers—a trend that we continue to witness. New streets were constructed based on a gridiron plan, cutting through the historical fabric, while additional roads emerged outside these traditional areas. The most integrated streets now encircle these historical zones (Fig. 4), and this pattern of development continues to this day.

Fig. 4. Tehran during the Pahlavi Period; Street Construction Map

3.2. Analyzing the Changes in the Value of Integrity during the Spatial Structure Evolution of the Historical Center of Tehran from the Qajar Period to the Present

The most important changes in the structure of Tehran City have occurred at its historical center. So, to analyze the spatial structure of old Tehran and how it has changed over time, first, three axial maps[3] were developed according to the maps of Tehran drawn before and after the development of the city in the Qajar period and the street construction map of Tehran drawn in the Pahlavi period with the feature of integrated lines. Next, the integrity index was analyzed (for the Qajar period (before and after the development of the city), the Pahlavi period (for the time at which the construction of new streets started), and the present era (District 12). This section examined the integrity value at the global level in the study area (the historical center of Tehran). The analysis used a color spectrum including red, orange, yellow, green, and blue, expressing the highest to lowest levels of integrity value. Lines in cooler colors have lower integrity, so the integrity value index determines spatial potential. Examining the integrity map of Tehran city during the Qajar period based on the maps drawn by Barzin and Kriz (the area within the Tahmasp wall) shows the high integrity of historical routes such as the bazaar, which defined the main skeleton of the city. Furthermore, one can see that these routes have maintained their integrity and coherence with other parts of the city, in addition to their internal structure, and connected the city's main gates, the government citadel, the square, and the neighborhoods. It should be noted that the historical fabric of Tehran, like many cities in Iran, is valuable and has been formed organically and logically because one can see the observance of the spatial hierarchy principle. Figure 5 shows gradual changes in colors from warm to cold (spatial hierarchy of changes from main to secondary ones) without sudden jumps. Finally, the analyses of the axial maps of Tehran City in the Qajar period based on the maps drawn by Barzin and Kriz (the area within the Tahmasp wall) indicate a coherent and coordinated structure.

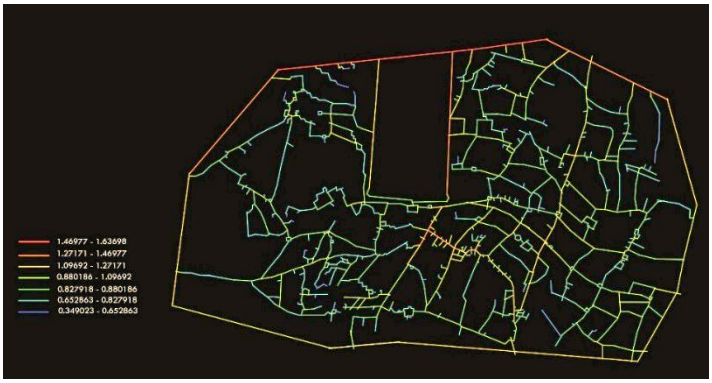


Fig. 5. The Axial Map used for Analyzing the Integrity Parameter using Depthmap Software; The Limits of Tehran City in the Qajar Period, based on the Maps drawn by Barzin and Kriz

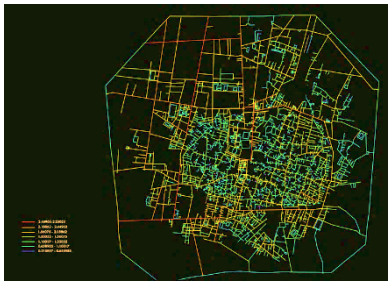
Fig. 6. The Axial Map used for Analyzing the Integrity Parameter using Depthmap Software; The Limits of Tehran City in the Qajar Period (Nasseri Wall), based on the Map drawn by Abdul Ghaffar

Fig. 7. The Axial Map used for Analyzing the Integrity Parameter using Depthmap Software; The Limits of Tehran City in the Pahlavi Period, based on the Street Construction Map

Although, in the late Qajar period, the main goal was the expansion and development of Tehran, planners and designers never decided to build a completely separate city outside the old city. Thus, the old city was connected to the new one through the bazaar and its new form, namely the streets constructed on the north of the citadel to connect the new center of gravity (Mobarakeh Toopkhaneh Square) to the new gates, and the spatial coherence of the old and new cities was still maintained desirably. According to urbanism scholars, including Seyyed Mohsen Habibi, the Tehran style in the Qajar period can be considered the continuity and exaltation of the Isfahan school. In this style, the urban spaces created are connected to the ancient urban spaces, explaining continuity. The birth of the Tehran style (during the development of the city and the creation of the Nasseri Wall) shows its place in the historical continuity of the change from Shar to Shahr, which is proven by analyzing the standard deviation of the integrity value. The lower the standard deviation of the integrity value, the greater the integrity in the area under study in different periods (during the physical changes). Space Syntax analyses show a slight increase in the average value of total integrity in the Qajar period from 0.078983718 before the development of the city (the map drawn by Barzin) to 0.155638672 after the development of the city (the map drawn by Abdul Ghaffar). The same increase is observed in the standard deviation according to Table 2. This increase was insignificant, and one can still observe the spatial hierarchy and gradual changes in colors from warm to cold (spatial hierarchy of changes from main to secondary spaces) without sudden jumps in Figure 6 (axial map for analyzing the integrity value based on the map drawn by Abdul Ghaffar). Despite new developments on the north of the city, the old city has maintained its structure and the bazaar remained the most integrated element between the old squares (Arg and Sabzeh Maidan) and the new ones (Mobarakeh Toopkhaneh), indicating the maintained coherence and coordination of the whole spatial organization of Tehran City and the routes within its limits.

The Space Syntax analysis of the historical area of Tehran City during the Pahlavi period indicates that the new street network has disrupted the spatial coherence of these areas, ignoring the hierarchy of increases in the integrity value of old streets. In the new street network, the new streets had higher integrity than the old street network (Fig. 7). The construction of new streets in the gridiron form has resulted in the disappearance of the old structure and the reduced integrity values of the squares and old streets. According to Abbaszadegan, the paradigm of clarity is perceived as poor in Iran's historical fabrics, so intervention in the form of street construction, such as what happened during the Pahlavi period under the influence of global conditions, can increase this clarity, however, such an increase in clarity is in conflict with what is defined in the logic of the formation of these fabrics.

Table 1. Comparison of Characteristics and Average Integrity Value in Different Periods

Period	Characteristics	Maps	The Axial Map used for Analyzing the Integrity Parameter using Depthmap Software	Average Global Integrity Value (Rn)
Qajar (within the Tahmasp Wall)	- the reduced area of the gardens on the outskirts of Tehran city and the conversion of parts of them into residential areas. - The passages (mostly narrow and extended in an indirect direction) started from the main gate and ended at the government citadel.			0.379707
Qajar (within the Nasseri Wall)	- The Tahmasp wall was destroyed and the Nasseri wall was built outside it. - The old city was connected to the new city's gates by constructing new streets. - The new center of gravity at this time was the Mobarakeh Toopkhaneh Square on the northern side of the Citadel.			0.581503
Pahlavi (after Street Construction)	The modernist movement reached its peak during this period with the construction of gridiron streets in the historical fabric			3.450337

Analyzing the changes in the structure of the historical core of cities in different periods is of great importance because the main skeleton of cities plays a crucial role in the development and sustainability of cities in different periods and in the maintenance of the coherence and integrity of the city structure over time. This issue is important in the case of historical cities of Iran, highlighting the use of standard deviation since it is an indicator for measuring the degree of spatial dispersion and coherence. Therefore, analyzing the standard deviation of the integrity value is a good option for analyzing the changes in the city's physical structure. The lower the standard deviation of the integrity value, the greater the integrity in the area under study in different periods (during physical changes). What distinguishes the present study from the previous one is the comparison of the integrity value of streets located in the historical context at neighborhood and supra-neighborhood scales to accept the pedestrian street development plan within the historical structure of the city. According to Table 2, the average integrity value has increased significantly from the Qajar period to the Pahlavi period. However, it has not enhanced the coherence of the urban structure, which can be understood from the increase in the standard deviation of the studied index in Figure 8 and Table 2, implying that the structure has become incoherent and lost its integrity. The gridiron streets constructed in the historical fabric during the Pahlavi period have increased the average integrity value in the Pahlavi period, which is not considered desirable because they have caused primary axes in the old fabric to lose their major role and coherence. This can be understood from the significant increase in the standard deviation from the Qajar period to the Pahlavi period.

Table 2. Global Integrity Value in the Study Area

		Qajar (within the Tahmasp Wall)	Qajar (within the Nasseri Wall)	Pahlavi (after Street Construction)
Global Integrity Value (Rn)	Average Integrity Value	0.379707	0.581503	3.450337
	STDEV	0.078984	0.155639	0.833766

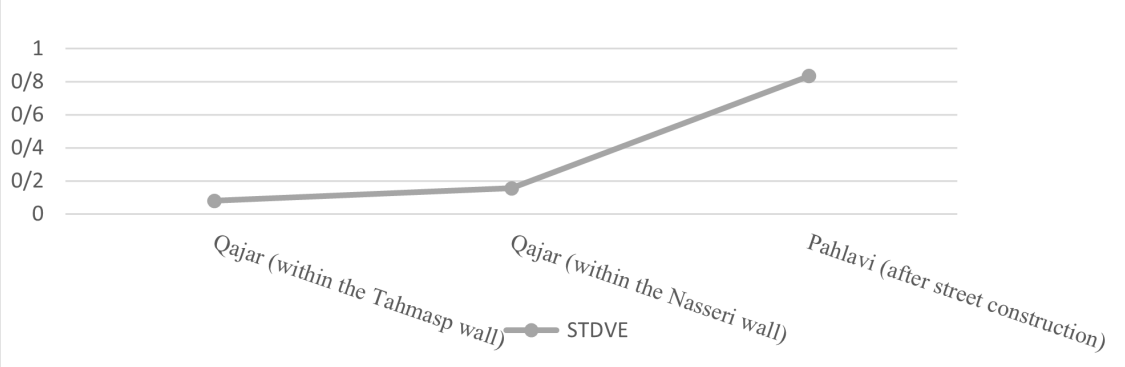


Fig. 8. Standard Deviation Changes in Macro-Coherence Value

the paradigm of clarity is perceived as poor in Iran's historical fabrics, so intervention in the form of street construction, such as what happened during the Pahlavi period under the influence of global conditions, can increase this clarity, however, such an increase in clarity is in conflict with what is defined in the logic of the formation of these fabrics (Ibid 2002). New street constructions compete with historical passages and reduce their value, resulting in the reduced value of the historical fabric and provision of the grounds for its isolation. As mentioned earlier, the development of Tehran in the late Qajar period and the emergence of streets in that period, with the characteristic function of connecting squares together and the main gates to the Mobarakeh Toopkhaneh Square, have introduced a new concept that not only didn't decrease the value of historical passages but also administered the "city" concept to Tehran and caused the new part to form in harmony with the old part of the city. The standard deviation index has increased slightly in this period according to Figure 8, indicating the maintenance of coherence. Moreover, with the construction of the Nasseri wall, a horse-drawn railway was created within the Tahmasp wall, causing the old area to be conserved with minimal changes and access to it and other parts of the city to be facilitated. In contrast, Figure 8 shows a significant increase in the standard deviation index in the Pahlavi period compared to the previous period, indicating the disruption of the city's cohesion and integrity, which resulted in the isolation of old areas and the deterioration of the new structure. Of course, it should be emphasized that the skeleton of the old city was formed based on strong structural logic and has still maintained its structure to an acceptable extent in the present time despite numerous developments. Therefore, the results of implementing any new plan and change, such as the pedestrian street development plan in the city, must be predicted before its implementation so that it helps to strengthen the integration of the historical structure. Furthermore, understanding the spatial structure of the city to categorize streets in the historical area before implementing pedestrian street development plans enhances the success of such plans.

3.3. Analyzing How the 17th Shahrivar Pedestrian Street Development Plan Influences the Spatial Structure of Tehran

In the metropolises of Iran, constructing pedestrian streets in a modern and contemporary style is completely new and emerging. The present study aims to evaluate the impact of the pedestrian street development plan on the streets within the historical structure of Tehran. Considering studies by other researchers and other tools used for analyzing pedestrian street development plans, the present study attempts to investigate whether these plans are successful using underlying indicators and the Space Syntax technique. With a broad view, it considers the results of implementing such plans to be influential on the integrity and coherence of the city's historical structure, on the one hand, and it considers a role for the formation of this particular street before becoming a pedestrian axis in the desirability of its walkability, on the other hand. That is why, according to the classification provided by the authors, three types of streets, that were converted to pedestrian axes, are discussed here: Type 1. gridiron streets, which were extended throughout the city regardless of the fabric and structure of the old city, such as the 15th Khordad Pedestrian Street; Type 2. the streets constructed outside the structure of the old city, that were

developed by destroying parts of the Nasseri Wall and filling in the ditches, such as the 17th Shahrivar Pedestrian Street; and Type 3. the streets existing in the city structure, such as the Sepahsalar (Saf) Pedestrian Street. Figure 9 presents this classification. Implementing pedestrian street development plans including the streets of Type 1 (the streets that crossed the old structure), such as the 15th Khordad Pedestrian Street in Tehran has been a successful experience (Ebrahimzadeh and Esfandyarimehni 2018; Mohammadpourzarandi and Aminian 2015) because these streets are located in the historical fabric and considering numerous factors and attractions close to it, pedestrianization seems desirable due to its companionship with the main structure (although the initial design of the disintegration of the historical fabric by the new streets leads to the isolation of some parts of it). Also, the pedestrian street development plans including the streets of Type 3 (the existing streets in the old structure) such as Saf Pedestrian Street have shown desirable experiences, due to the placement of these streets in the main structure and other factors and indicators mentioned in the studies by other researchers (Hosseini et al. 2021; Pourahmad and Abbasi 2016; Ranjbar and Rais Esmaili 2010).

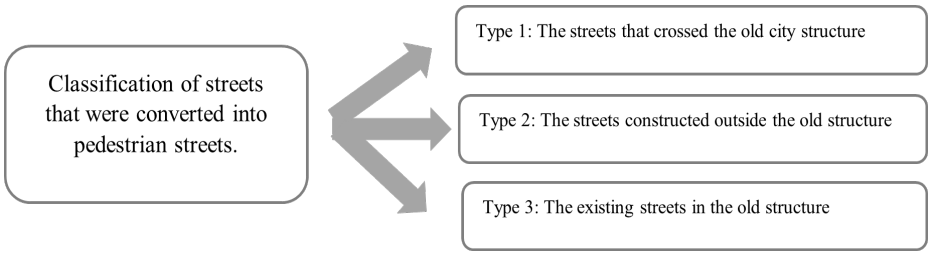


Fig. 9. Classification of Streets converted into Pedestrian Axes

Currently, urban development plans, including pedestrian street development plans, are implemented using traffic engineering methods and artistic designs, and no outcome prediction techniques are applied. For example, one can refer to the 17th Shahrivar Pedestrian Street development plan, which is placed in the Type 2 (the streets constructed outside the old structure) category according to the classification made by the authors. This plan seems to have failed, as confirmed by many researchers and experts (Ojagh, Haraeeni, and Imani 2017; Kheyroddin, Haghbayan, and Shokouhi Bidhendi 2020; Etesam and Nouri 2018). For this reason, the present study analyzed this plan as a case study using the Space Syntax technique, in which the theory of natural movement, and the integrity index are addressed.

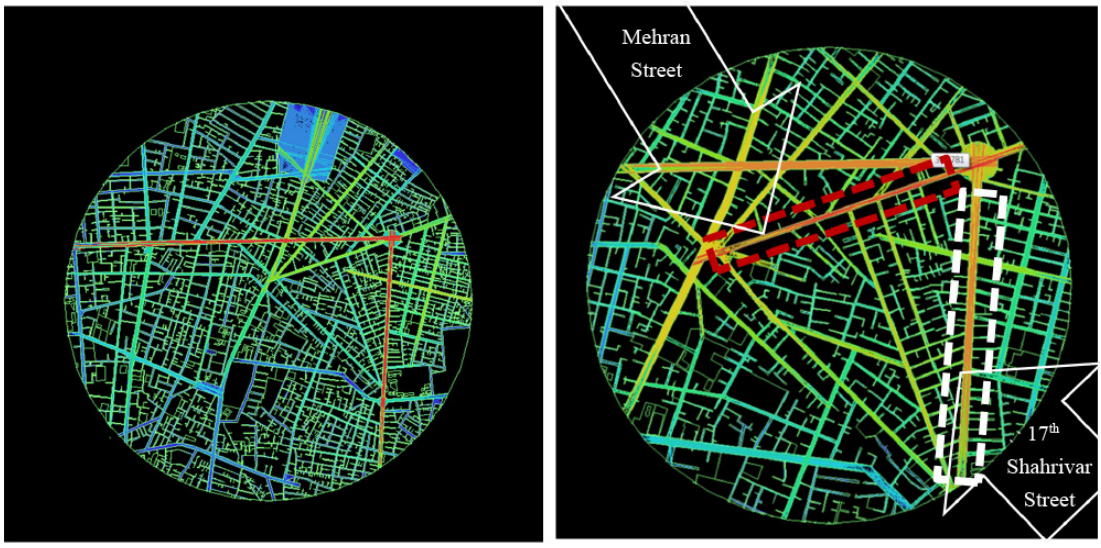


Fig. 10. Analysis of the Area of 17th Shahrivar Pedestrian Street, Right: Local Scale; Left: Global (Supra-Neighborhood) Scale using Depthmap Software

On a supra-neighborhood (global) scale, the 17th Shahrivar Pedestrian Street has high integrity according to the output (axial map) of the software as these streets attract the integrity value of other historical spaces within the fabric. This is one of the city development characteristics resulting from the

construction of new streets. These streets compete with the old streets in the historical structure and reduce the integrity value of the structure. Therefore, it is required to define the integrity radius at the local scale[4] for the constructed streets of Type 2 and the walkability of the street limit at the local scale should be measured. The results of Space Syntax analyses, as depicted in Figure 10, introduce Mehran Street (red in the right figure) as the most integrated axis with higher walkability and connectivity at the local scale. The full implementation of the 17th Shahrivar Pedestrian Street has weakened access to the main historical structure on a global scale and disrupted local access. Here, one can conclude that pedestrian street development plans including streets of Type 2, such as 17th Shahrivar Street, on a global scale don't help maintain the main structure of the city and access to it, in addition to weakening the accessibility and integrity indicators on the local scale.

The results reveal that examining the evolution of the cities' main structures (to maintain its integration and coherence) and paying attention to pedestrian street development plans on the neighborhood and supra-neighborhood (relative to the city structure) scales enhance the success and desirability of such plans.

4. CONCLUSION

Considering the theoretical framework and research method, the present study classified indicators effective in prioritizing streets located in the historical structure of the city to create pedestrian-oriented axes into two categories: 1. underlying indicators that are used to determine the priority of urban streets in pedestrian orientation and are related to the flow of pedestrian and the space syntax indicators; and 2. superstructure indicators; which can enhance the environmental qualities of the pedestrian-oriented street. The latter category was not addressed in this article because the authors believe that the underlying indicators are necessary conditions for addressing superstructure ones. Since urban spaces in old Tehran were formed on a structural logic basis before the urban developments in the Pahlavi period and had spatial hierarchies, any change in spatial layout leads to a change in their spatial structure. So, urban development plans, including pedestrian-oriented development plans within the city's historical structure, should first be evaluated based on underlying factors and, if desirable, then based on superstructure indicators before decision-making on their implementation. Therefore, the streets located within the city's historical structure should be assessed in terms of being suitable for being walkable, and then prioritized and valued based on the logic of their formation in the city's structure and underlying indicators such as space syntax indicators. Furthermore, the integrity of the streets should be measured relative to the city's main historical structure and analyzed on both local and global scales. Otherwise, pedestrian street development plans would not help preserve the city's main historical structure, in addition to weakening the accessibility and integrity indicators on local and global scales. The present study used underlying indicators related to pedestrian movement flow and space syntax indicators to determine the priorities of streets in pedestrianization plans. This study examined whether these plans have been successful while investigating the evolution of the structure of Tehran. Therefore, the streets were divided into three categories relative to the historical structure of the city: Type 1. gridiron streets, which were constructed regardless of the fabric and structure of the old city, such as the 15th Khordad Pedestrian Street; Type 2. the streets constructed outside the structure of the old city by destroying parts of the Nasseri Wall and filling in the ditches, such as the 17th Shahrivar Pedestrian Street; and Type 3. the streets existing in the city structure, such as the Saf Pedestrian Street. Regarding Types 1 and 3, evidence shows the success of pedestrian street development plans, because their walkability is assessed as desirable in companionship with the main structure and considering various underlying factors. Regarding Type 2, pedestrian street development plans show unsuccessful experiences, as confirmed by other researchers. The present study applied the Space Syntax technique, the theory of natural movement, and the integrity index, which are among the underlying factors, to analyze the 17th Shahrivar pedestrian street plan. In this way, it has proved the theoretical and qualitative issues raised by other researchers. The results show that implementing the 17th Shahrivar pedestrian street plan has led to poor access to the main historical structure on the supra-neighborhood scale and also disrupted local access. Pedestrian-oriented development on streets of type II, such as 17th Shahrivar, does not help maintain the city structure and access to it on the global scale, in addition to weakening the accessibility and integrity indicators on the local scale. The results show that examining the evolution of the city's main structure to maintain its integration and coherence and paying attention to pedestrian street development plans on the local and global scales will enhance the success and desirability of these plans.

ACKNOWLEDGMENTS

This article wasn't supported by any financial or spiritual sponsors.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

MORAL APPROVAL

The authors commit to observe all the ethical principles of the publication of the scientific work based on the ethical principles of COPE. In case of any violation of the ethical principles, even after the publication of the article, they give the journal the right to delete the article and follow up on the matter.

PARTICIPATION PERCENTAGE

The authors state that they have directly participated in the stages of conducting research and writing the article.

ENDNOTE

1. Space syntax refers to a set of theories and techniques concerned with understanding spatial configuration through a logical organization and enables us to analyze it. Space syntax expresses the inherent characteristics of space quantitatively and tangibly by studying space quantitatively.
2. Seyyed Mohsen Habibi, born on August 18, 1947 - died on September 27, 2020, was a full professor in the field of urban planning at the College of Fine Arts, University of Tehran. He is often referred to as the "Father of Iranian Urban Planning" in various publications.
3. An axial map is composed of axial lines. The axial line is the longest visual-motion channel through which humans perceive movement and the city. Therefore, an axial map includes a structure of urban open spaces drawn with axial lines.
4. According to the basis of the space syntax technique

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HOW TO CITE THIS ARTICLE

Moghimi, Leila, Pirouz Hanachi, and Somayeh Fadaei Nezhad Bahramjerdi. 2024. Investigating the Evolution of Tehran City's Spatial Structure and the Influence of the Pedestrian Street Development Plan on It; Using the Space Syntax Technique; Case Study: 17th Shahrivar Pedestrian Street Development Plan. *Armanshahr Architecture & Urban Development Journal* 17(48): 113-129.

DOI: 10.22034/AAUD.2024.402903.2796
URL: https://www.armanshahrjournal.com/article_188636.html