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Screening of Criteria Influencing the Spatial Structure of High-Rise Residential Buildings in Tehran with the Emphasis on Fuzzy Delphi

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Research Article

Abstract

Cities' rapid growth has resulted in the creation of undesirable urban phenomena. The necessity to cope with high-rise structures has increased as it has been located and decreased. These structures establish their spatial and physical structure depending on a variety of parameters, each of which plays a critical and crucial part in their construction. The goal of this study is to identify and prioritize useful criteria in the spatial organization of high-rise structures. The research method used in this study is a nested and qualitative-quantitative approach, with systematic review and semi-structured interviews used in the qualitative stage to extract various criteria in the field of spatial structure, and the Delphi system used in the quantitative stage to screen the criteria. In the qualitative stage, Fuzzy uses the Delphi system, while in the quantitative level, it uses MATLAB software. Building height criteria with a value of 0.53 in category M, field criteria with a value of 0.57 in category M, criteria for non-location areas with a value of 0.47 in category L, urban node criteria with a value of 0.61 in category M, Negative criteria with a value of 0.49 in M category, restrictive criteria with a value of 0.44 in M category, index building criteria with a value of 0.19 in VL category, construction criteria for tall buildings with a value of 0.19 It falls under category H with a score of 0.76.

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Keywords: Spatial Structure; High-Rise Buildings; Screening Criteria; Combined Method

1. Introduction

The expansion and development of high-rise structures is seen nowadays in most metropolises and big cities, and it has a variety of beneficial and bad consequences. The pervasive influence of these structures on the body and space of today's cities is obvious, prompting high-rise buildings to be studied by specialists in a variety of professions (Farhoudi and Mohammadi, 2001). High-rise buildings have long been one of the most significant components of today's cities' urban landscapes, and the symbolic, aesthetic, identity, and readability characteristics of the environment are among the factors to examine in their function in the cityscape. While most construction choices in our nation are made without consideration of this (Karimi Consultant, 2010). High-rise building construction is limited to authorized or special areas for high-rise construction in some sub-zones of land use in Tehran, and is subject to permission based on earthquake zoning studies and relevant rules (Kunstler, 2001). In comparison to typical buildings, these structures need unique laws and regulations in terms of design, planning, and construction. High-rise structures of 13 storeys are considered in the American Planning and Urban Standards book. High-rise structures in Iran are often built lavishly, symbolically, and without regard for location. As a result, the research shows that there are major implications and bad impacts for people. One of the most pressing of these challenges is the sense of powerlessness or crisis of identity in cities, particularly in urban areas, which has expanded many aspects of modern life. As a result, a favorable environment has been created for the deterioration of city stability and the decrease in the quality of urban life (Shamaei and Jahani, 2011).

High-rise residential construction issues have long been one of the country's most critical development initiatives for policymakers and planners. Housing production has become a product-oriented process in recent decades, with an emphasis on providing the demand for shelter. Because it is difficult to change the spatial arrangement after construction is complete, and because building codes and regulations control the minimum requirements of designers and contractors in order to comply with urban construction regulations, special attention should be paid to the types of space organization that result from construction criteria. And that is duplicated across Iran's cities, and it is vacant (Armsrong, 2018). Given that construction criteria restrict on the one hand and guide and coordinate the planning objectives for the design phase on the other, measuring and focusing on it by evaluating the impact it has on the body of the high-rise housing organization may pave the way for present criteria to be corrected. This research aims to address the issue of which criteria are more important by extracting the rules and regulations that are successful in defining the spatial structure of high-rise structures (Kropf, 1996). They have a role in influencing the spatial organization of high-rise structures when compared to other factors.

2. Theoretical Foundations

2.1. High-Rise Residential Buildings

The height of a building is a relative term, and numerous definitions for high-rise structures have been presented from diverse perspectives: Tall structures (Amini et al., 2013) are commonly referred to by urban planners and designers, and the attributes of tall buildings are extensively discussed. At least one of its designed façade is known to reflect the number of its various stories

(Shafiei et al., 2013). In other words, an exhibition, factory, or any other high-rise structure does not fall within these criteria (Rahnama and Razzaqian, 2013).

A high-rise building is a multi-story, high-rise structure that commonly houses residential, commercial, or office-residential or multi-use tenants and differs in height from a skyscraper (Rahnama and Razzaqian, 2016). Although there is no universally accepted definition of the minimum height of a high-rise structure, most people agree on a minimum height of 23 meters (Qara Begloo and Khaleghi Moghadam, 2015). A high-rise residential building, according to Nateghi Elahi, is a single tall structure with a height greater than the diameter of the circle that surrounds it (Nateghi Elahi, 1996). While, Bamanyan considers high-rise residential structure with more than 10 stories and a height of around 32 meters. Barney classified high-rise residential structures as those with 15 to 16 stories, and extremely high-rise residential buildings as those with 30 to 40 stories in 2003. Towers are high-rise residences with more than ten stories, according to Saidnia (Barney, 2003).

High-rise buildings and super-high-rise buildings are not the same as high-rise structures. Structures higher than 150 meters in skyscrapers and buildings taller than 300 meters above the earth are referred to as High-rise buildings in the United States, according to a not-so-common tradition (Seyed Sadr, 2007: 119). Even shorter structures may be classified as skyscrapers if they are much higher than the surrounding structures (Einifar and Agha Latifi, 2011: 19-20).

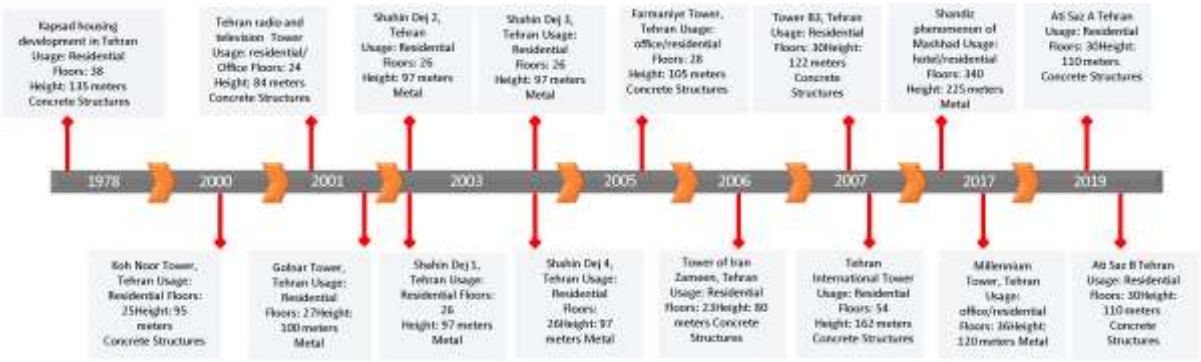

Fig 1 The evolution of tall buildings (Source: Authors)

According to the Emporis standard, a high-rise structure is "a multi-story structure with a height of 35 to 100 meters or a 12- to 39-story structure with an undetermined height" (Remook, 2002). According to India's Heidar Baba Code, a high-rise residential building is defined as one with four or more storeys or one with a height of at least fifteen meters (Adeli and Sardeh, 2017).

Massachusetts General Law defines a high-rise residential building as one that is greater than 70 feet (21 meters) in height (Consultant's Final Study Document, 2010); The Oxford English Dictionary defines a high-rise residential building as "a structure with multiple floors"; and many building engineers, supervisors, architects, and other building-related professionals consider a building to be a high-rise if it is at least 75 feet (23 meters) in height (Niu, 2003).

Table 1 Comparison of different periods of urban planning after the Islamic Revolution in Iran and the characteristics and buildings of high-rise residential index (Rahnama and Razaghian, 2016).

Motivations and construction characteristics of high-rise residential buildings	Construction place	Name of the complex or apartment	Course
Due to the beginning of the Islamic Revolution during this time period, development of high-rise residential structures was halted for ten years, and only partially built residential complexes were completed. The majority of these structures were finished and are still in use by government organizations and institutions.	Tehran	Shahid Fakuri Complex, Vanak Park, Ekbatan, Apadana, West Town Apartments	**1978-1989**
This period began with the conclusion of the Iraq-Iran war, which corresponded with the emergence of a new wave of high-rise building development, particularly in Tehran. Another concern is the city of Tehran's uncontrolled horizontal development during these years, which prompted a broad trend for high-rise construction. The task of finishing the half-completed complexes that began before to the revolution sometimes reached this era. The early 1970s are synonymous with the height of high-rise building. This time is marked by unchecked urbanization and a rush of peasants and inhabitants of small towns migrating to major cities. In the late 1970's, as the height of tall buildings increased, a new kind of high-rise construction emerged. During this time period, the look of great cities was transformed by the use of high-rise building methods, and tower development was very lucrative, while the price of urban land continued to grow.	Tehran and most of Iran's metropolises and provincial capitals	Countless	**1989-2001**
During this time, new technology were used into the construction of tall buildings to a greater extent than ever before, and the construction of tall structures for different residential, office, commercial, and mixed-use purposes grew increasingly popular in Tehran and other cities. Additionally, throughout this time period, an endeavor was made to progressively catch up with newer structures across the globe, with particular care given to the materials and consumables used within the building. The buildings of this time are defined by their unique internal design, progression toward luxury structures, and modeling of successful outside examples. Other difficulties that have been identified in this structure include safety, attractiveness, and durability, as well as appropriate use of sunshine and sunlight. Residential towers evolved into luxury towers during this time period, with spaces such as complete sports amenities, fitness clubs and water complexes, cinemas, kindergartens, car washes, hair salons, multipurpose reception halls, green roofs, and even hypermarkets incorporated into these high-rises. The facilities provided by five-star hotels for a pleasant and affluent living transformed these towers into luxury structures costing three to four times as much per square meter as the surrounding structures.	Tehran and most of Iran's metropolises and provincial capitals	Countless	**2001 until now**

2.2. Spatial Structure of Residential Buildings

The term structure comes from the Latin word Stractura and the verb Stuere, which means to create or construct (Kunstler, 2001). Structure is a collection of interactions in which pieces may change but the total must remain stable (Armsrong, 2018). The relationships between the components are more significant than the elements themselves in structuralism (Habibi et al., 1997). Expertise (Misra, 1974) spatial structure is the order and organization of phenomena on the ground surface that result from physical effort and human activities (Seif al-Dini, 2006: 119). From a systemic perspective, it is the primary unit of any system and the fundamental linkages between it. (Salehi, 2013) The system structure is referred to as; it is regarded as the system's ossification and infrastructure and plays a critical role in the construction of other system components and their behavior and function (Dadashpour, 2009).

The spatial organization of the home is determined by the interaction between public, semi-public, and private sections; public and private space are inextricably linked; although each keeps its uniqueness and significance, it is apparent that the housing unit must operate (Nateghi Elahi, 1996). While it is obvious that working in residential units is necessary, just working does not satisfy the inhabitants. To transform a residential unit into a home, people must build a relationship with it and be able to adjust it to their own preferences, requirements, and desires (von Mays, 2007).

Housing space organization, which is sometimes referred to as structure in studies of housing design, is one of the most difficult notions to employ for an extended period of time (Samsami Hosseini, 2001). In terms of its structure and definition, we may point to numerous that have been referenced in the past. Military space organization, according to the definition, refers to behavioral systems that control the components of architectural space in line with behavioral systems and in order to suit human requirements (Barney, 2015).

Soltani characterizes structure as "deep, concealed, and difficult to perceive," and thinks that when recognized, it may provide light on the entire. When determining the spatial structure of housing, the integrity of the system's communications is referred to as construction or organization (Karimi Consultant, 2010). Additionally, space organization has been characterized as a broad model that outlines a community's use of space and the arrangement of space components in such a manner that their interaction and complementarity are conceivable (Karimi Consulting et al., 2010). Structure is a collection of regular components next to one another that, while remaining autonomous, are connected to one another, complement one another, and constitute a unit. An organization is composed of a number of components, each of which is responsible for a specific duty that benefits the others. It is a place for the components to communicate (both objectively and psychologically). Bacon refers to this as ossification (Tavassoli, 1990).

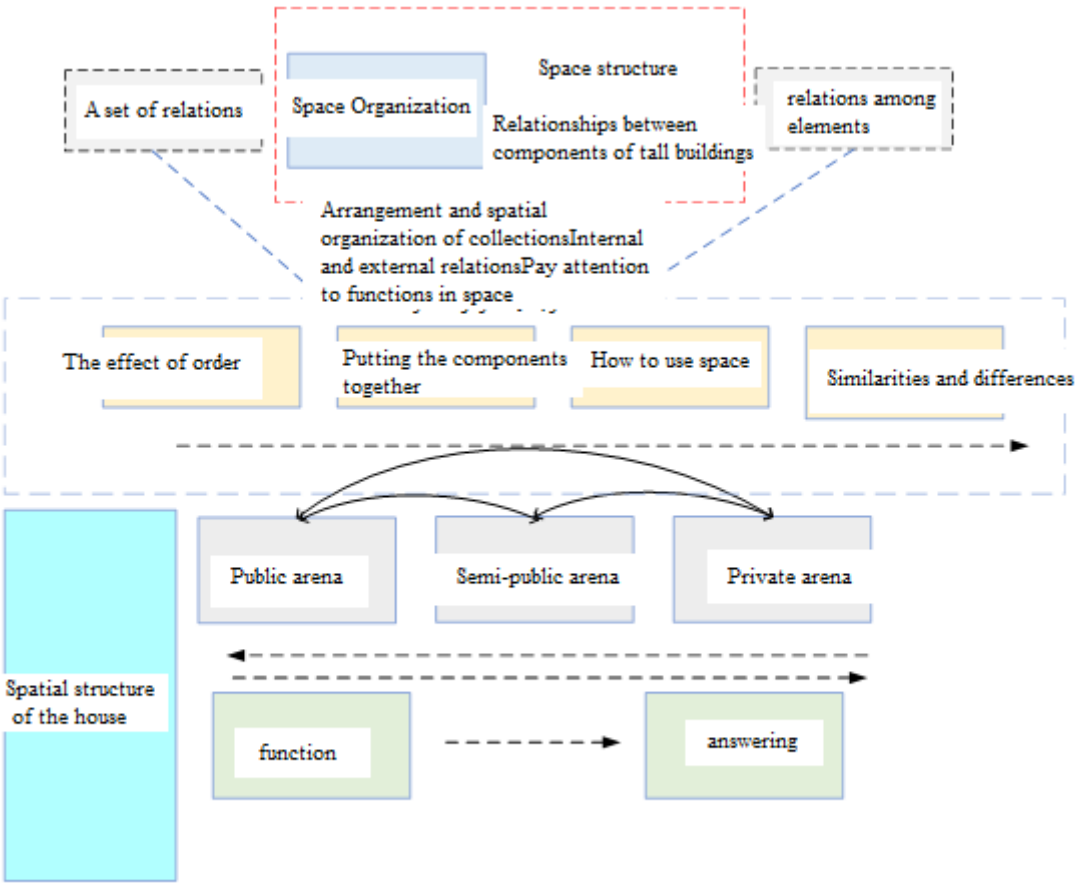

Fig 2 Interpretations of the spatial structure of residential buildings (Source: Authors)

2.3. High Ranking Criteria

According to the Supreme Council of Urban Planning and Architecture of Iran's decision on the general criteria for high-rise construction, the esteemed head of the country's Organization of Municipalities and Villages, the esteemed governors of all provinces, the Supreme Council of Urban Planning and Architecture in its meeting dated 10/80/2018 (Technical Committee No. 4)

The consultant on "General criteria for high-rise construction" approved the following: Next month, the report presented to Iran's Supreme Council of Urban Planning and Architecture. From the date of notice of this order, no permit for the construction of high-rise structures will be issued in the nation unless it complies with the terms of this decree.

Thus, while communicating the general criteria for the establishment of tall buildings in the cities of Iran, the general principles and rulings on it are emphasized as follows:

1- Beginning with the date of notification of this decree, permits for the construction of high-rise buildings in the country's cities will be issued, but only in cities with a population of more than 200,000 and in areas designated by the Supreme Council of Urban Planning and Architecture as authorized areas for high-rise buildings in accordance with the rules and regulations.

2. In cities with a population of 200,000 or more, where high-rise zones are not included in authorized urban development plans, if the city requires them and there is an initial demand, the

municipality should accept a report explaining the necessity for a high-rise structure with council approval. Islamshahr should be prepared and, after approval by the Five Commission and the Provincial Planning and Development Council, presented for ultimate approval to Iran's Supreme Council of Urban Planning and Architecture.

3- If the High Council approves the requirement of constructing a high-rise building, a proposal linked to defining the necessary areas, rules, and regulations in accordance with the terms of this resolution and utilizing its guide shall be issued by the High Council's Secretariat.

General rules:

Criteria that, in the event that the Supreme Council of Urban Planning and Architecture of Iran approves the need for a high-rise building, a proposal to define the areas, rules, and regulations in accordance with the provisions of this resolution and using the guidance provided by the Supreme Council of Urban Planning and Architecture of Iran will be notified, prepared, and, following the legal process, approved by the Supreme Council of Urban Planning and Architecture of Iran.

Table 2 Spatial structure criteria for high-rise residential buildings (Source: Authors)

The average vertical distance from the building's highest and lowest points of junction with the ground (excluding trusses and roof extensions) to the level of the tallest roof is the building's height.	**Building height criteria**
High-rise area: Areas suitable for the construction of high-rise structures with a minimum allotted size of one urban block. The area's high-rise buildings may be divided into residential and commercial purposes, or into mixed residential and commercial usage. A group of structures near to a route or geographical feature is referred to as an elevated edge. Tall buildings are truly linearly linked, and their primary characteristic is that they may only be allocated to non-residential purposes. It is a single structure that is much higher and more unique than the surrounding structures. The primary characteristic of high sites is their function as an urban landmark.	**Arena rules**
It is a kind of area determination in which, in addition to the authorized zoning, criteria are applied to sections of the city with particular characteristics. According to this perspective, the high-rise arena, as a layered arena, adds layers to the allowed uses.	**Criteria for overlapping areas**
It is a sort of field determination in which spatial attributes are determined rather than a precise location is specified. This approach is used to ascertain the location's negative and positive qualities and indications. This strategy is only applicable to high-rise structures.	**Criteria for vacant areas**
The Nodes are special points which are located at the intersection of important urban axes or obtain access to a large area of the city.	**Urban node criteria**
Criteria based on which the possibility of building high-rise buildings in some parts of the city is strictly prevented.	**Negative criteria**
Criteria based on which the maximum utilization of the possibility of constructing a high-rise building in permitted areas is subject to certain situations.	**Restrictive criteria**
Effective buildings have a positive impact on the look and landscape surrounding them due to their form, body, purpose, audience type, location, social, cultural, and quality features.	**Index building**
Criteria that must be followed in addition to established rules when tall structures are constructed.	**Criteria for construction of tall buildings**
A collection of rules designed to safeguard the safety and comfort of users and customers of tall buildings while they are in operation.	**Operating criteria**

2.4. Criteria for the Spatial Structure of High-Rise Residential Buildings

Each residential unit shall have a minimum space of 70 square meters. In developments designed to provide affordable housing, the amount of infrastructure for each residential unit may be adjusted to accommodate the permitted consumption pattern, but should never be less than 40 square meters. The ground floor occupancy level of high-rise structures should not exceed 40% of the plot area. The position of the structure should not exceed 75% of its length. This indicates that if the ground length is 100 meters and the amount of retreat is 10 meters, the structure cannot exceed 65 meters in length, or in other words, the yard's depth should be at least 20 meters (Tehran City Center for Studies and Planning, 2013). To achieve a proportional and coordinated skyline next to the roadway, the buildings should be parallel to one another; in other words, the structures should be specified and decided for each street (Road, Housing and Urban Development Research Center, 2016).

To protect building occupants from noise, traffic pollution, and other urban activities, structures should withdraw by one-quarter the length of the sidewalk (or the ground). This area is utilized for the front and usage of public, commercial, and office buildings. It is not permitted to use it as a parking lot, security guard, or any other kind of structure and the development of any type of structure is also forbidden. Certain of these sites may be utilized in exceptional circumstances with the approval of municipalities and in line with authorized plans for sidewalk expansion or the creation of city-needed services. The basement of a tall structure should not exceed 70% of the total floor area. A maximum of 5% of the land area and 70% of the basement space may be utilized for stairs and ramps (Supreme Council of Urban Planning and Architecture, 2016). At least 25% of the land should be planted with plants. The bottom floor and first floor of high-rise structures used for commercial, office, mixed, commercial-office, and mixed residential-commercial purposes may occupy the property without retreating from the land's sides, or up to the neighboring land's boundaries. The occupancy level on the ground floor to the fourth floor of high-rise structures is equivalent to the occupancy level specified in the preceding criterion. Additionally, to the preceding decrease, infrastructure is suggested (Abdollahi et al., 2013). For instance, the maximum occupancy level in high-density regions is 30%, which should be decreased to 30% from 30% to 12th and 20% from 12th to 20% (Deputy for Study and Planning of Infrastructure and Master Plan, 2013).

Table 3 Spatial structure criteria for high-rise residential buildings (Source: Author)

Apartment complexes and high-rise buildings, as well as multi-family and single-family structures, are zoned differently, and apartment complexes are not permitted in a substantial portion of the city that is mostly single-family and predominantly multi-family. (Project Management for Urban Development, Assistant to the Director of Urban Planning and Architecture) (2015).		**Spatial constraint criteria**
The most often used occupancy rate in urban planning is 60%; however, this indicator is occasionally split 50-50 between open and developed space. The occupancy rate of high-rise residential buildings may be lowered by 20% to 40%. (Center for Research on Transportation, Housing, and Urban Development, 2016).	**Occupancy level**	**Physical criteria**
At least 50 residential buildings (250 habitable rooms) (Deputy for Study and Planning of Infrastructure and Master Plan, 2013)	**Number of houses or units**	
The unit sizes vary depending to the occupants' income and location, but the typical net market rate is as follows: One-bedroom homes	**Extent of units**	

range in size from 75 to 55 square meters; two-bedroom units' range in size from 110 to 85 square meters; and three-bedroom units' range in size from 140 to 100 square meters. (Consulting urban planners and architects, 2001).	
The tower design provides for more outside light into the units (a greater proportion of units get light from both sides) and also allows for more freedom in the placement of dedicated units than the slab plan. The Supreme Council of Urban Planning and Architecture (Supreme Council of Urban Planning and Architecture, 2016). Low occupancy levels in proportion to volume (particularly in tower designs) and the need for surrounding space (to offer light, ventilation, and landscapes to all apartments) (Deputy for Study and Planning of Infrastructure and Master Plan, 2013)	**Plan**
Any structure that exceeds 23 meters in height (the vertical distance between the highest habitation floor and the lowest level accessible to a fire engine). (Organization for Country Management and Planning, 2015).	
The height of these structures is unrestricted, but they must adhere to the permissible density and nearby building rights (Tehran Studies and Planning Center, 2013)	**Elevation restriction criteria**
According to a report issued on 10/08/2018 by the Supreme Council of Urban Planning and Architecture's Technical Committee of Rules and Regulations, buildings with a height of two meters or more, or with a number of floors including eight or more, or with a height greater than the height of the highest floor, may be used more. A building is deemed tall if it rises more than two meters above the average ground level. (2016) (Supreme Council for Architecture and Urban Planning).	
Tall structure (height from the bottom floor to the floor level of the top floor is 23 meters or more, and also if the ground floor has eight stories). A wet system (fire box), a fire extinguisher, sprinklers installed throughout the structure, and a dry riser are required. For residential usage in high-rise structures, seamless black pipe with standard welding connections should be utilized for wet and dry lines (approvals of the Deputy of Urban Planning and Architecture, 2021).	**Fire extinguishing rules**
Approximately 40-35 square meters per car (Road, Housing and Urban Development Research Center, 2016).	**Criteria for placing cars**
Located within a maximum radius of 500 meters from urban public transport stations (Road, Housing and Urban Development Research Center, 2016).	**Criteria for stops**
The distance between the exit steps and the end of the hallway is limited to six meters (by building authorities and international law enforcement, or BOCA) or fifteen meters (by the same building standards, or UBC) (Road, Housing and Urban Development Research Center, 2016).	**Access criteria and exit route**
Door and window seals must be properly sealed between the door and its frame. The seam between the aperture and the frame must be removed in windows. (National Building Regulations, Iranian Engineering System topic 19). It made use of springs to automatically shut the door. These springs act as a seal around the door, preventing heat loss. (Iranian Engineering System, 2020, topic 19 of the National Building Regulations). Around door and window frames, air conditioner ducts and their surrounds, around floor	**Criteria for energy consumption and saving**

coverings (in villas), around water and gas and sewage pipes, around water and gas coolers installed on walls or windows, between walls and non-structural components such as wooden roof components, etc. are all places where the possibility of cracks and holes is very high; therefore, plaster can be used to fill these cracks and holes. Silicone sealants are available on the market and may be utilized in areas where they come into direct contact with the open air or where the plaster adheres poorly. (National Building Regulations, topic 19 of the Iranian Engineering System, 2020). Electricity consumption index in residential buildings (apartment complex of 12 floors and above) is 64.5 $\frac{KWh}{m^2}$ and thermal energy consumption index in residential buildings (apartment complex of 12 floors and above) is 1510$\frac{KWh}{m^2}$. (National Building Regulations, topic 19 of the Iranian Engineering System, 2020).	
Terraces in the rear with large glass doors or partitions, a balcony, moonlight, and a useable roof (Project management, Deputy of Urban Planning and Architecture) (2015).	**Pre-emergence criteria**
Residential apartments are configured in high-rise residential buildings around a central elevator core that connects to either the lobby on each level or a circular hallway that surrounds the elevator core. Around the center, two escape steps with accompanying doors are spaced as far apart as feasible. (Iranian Engineering System, topic 15 of the National Building Regulations, 2013).	**Criteria for electrical installations and elevators**
Due to the importance of natural light from the outside, rooms should be oriented in the direction of their smallest size in relation to the window wall. (Center for Research on Transportation, Housing, and Urban Development, 2016). The design of high-rise residential buildings provides for more external illumination for the units (a greater proportion of units get lighting from both sides) and also allows for more freedom in the layout of private apartments than the slab plan. However, since each story has fewer units (typically eight), the efficiency of the tower is lower than that of the slab. (Project Management for Urban Development, Assistant to the Director of Urban Planning and Architecture) (2015).	**Criteria for ventilation and lighting**
In all structures, the shading height includes the roof shelter, stairs, and building installations. (National Building Regulations and Iranian Engineering System topic 4). The distance between the completed floor and the shelter of terraces, balconies, and any other protrusions on the floors of buildings shall be at least 1/20 meter. (National Building Regulations and Iranian Engineering System topic 4). The height of the building's roof is used to determine the building's permissible height. (National Building Regulations and Iranian Engineering System topic 4).	**Criteria for protection and shelter**
High-rise structures should have a façade on all four sides and be detached from the urban fabric on each of the land's four sides (National Building Regulations, topic 19 of the Iranian Engineering System). Selection of appropriate facade materials in accordance with climatic and environmental conditions (national building codes and regulations, topic 19).	**Facade design criteria**
The average energy in a week (especially high-rise residential buildings) is L_{PA} to dB and $L_{Aeq(30)}$ to dB (National Building Regulations, topic 18 of the Iranian Engineering System).	**Acoustic criteria of spaces**

The Figure 3 is generally used to answer the questions; (Fig 3)

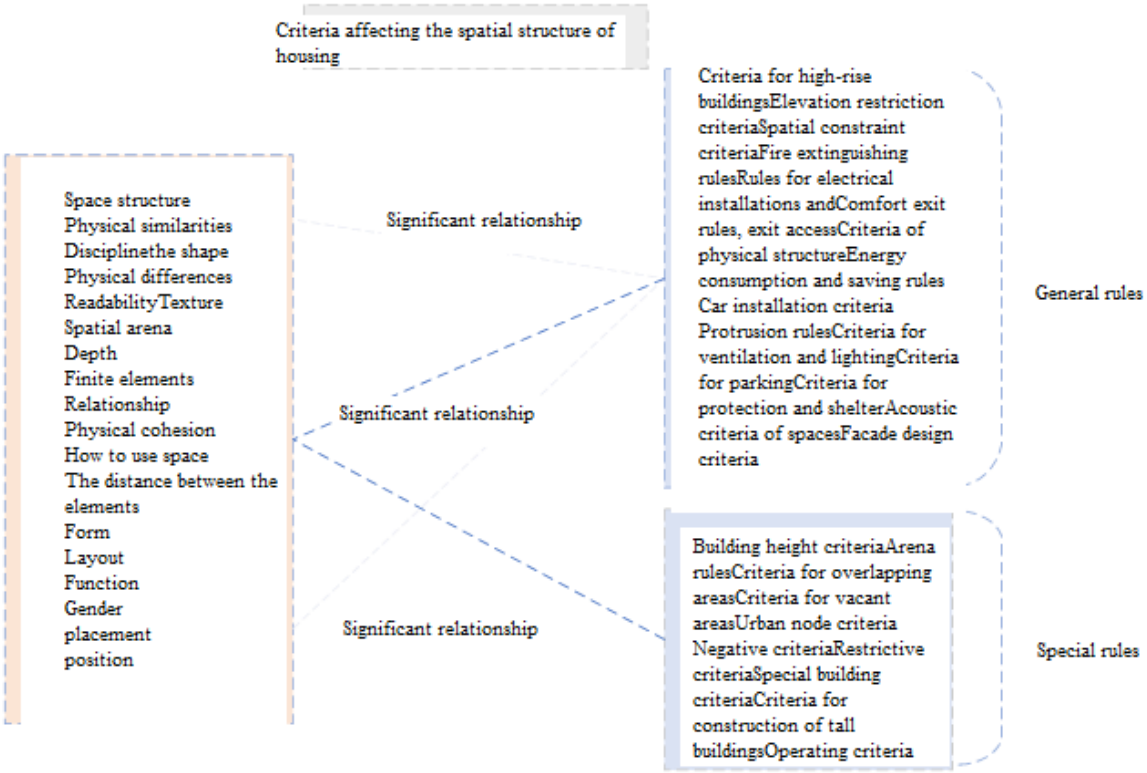

Fig 3 Conceptual framework

3. Methodology

This study is a qualitatively coupled approach in quantitative nesting, and it has an applied-developmental objective. This step begins with a qualitative assessment of the documents and the extraction of effective criteria for the spatial organization of high-rise structures. After lowering the data to the level of description and interpretation, the extracted codes are inserted into fuzzy Delphi as measurement variables. After brainstorming, restriction, and selection, Matlab software is used to quantify the influence of the variables (generic and particular criteria) on the dependent variable (dependent) and to screen using the Delphi system. The questionnaires are distributed randomly among 384 individuals (the upper limit of Morgan table).

3.1. Fuzzy Delphi Method

Fuzzy logic is a well-known mathematical theory that is used to represent the complexity of nonstructural situations. A fuzzy set is a function that may describe as a degree of membership the various values of a set number between two zeroes and one. In general, the evaluation process of fuzzy inference consists of three stages: 1. Construction with fuzziness, 2. Concluding, 3. Constructed in a non-fuzzy manner (Amini, 2005: 45). The goal of this research is to ascertain the most trustworthy group agreement of experts on a certain issue via the use of a questionnaire and opinion polls, based on their response. Indeed, this approach is a comprehensive examination of expert perspectives, with three primary characteristics: unbiased responses to questions, receipt of

expert input, and statistical analysis of expert opinions. Answering questions utilizing the Delphi technique, analyzing the mental data of experts Statistics devolve into almost objective facts. This strategy results in decision-making consensus. The Delphi technique has been used in a variety of domains, including forecasting, decision making, and screening (Azar and Faraji, 2002). It is used for a variety of purposes, including technology forecasting, service analysis, and factor screening. Asgharpour, 2003) Subjects in the world around us cannot be classified into two or more categories, such as white or black, but rather each topic falls within a spectrum (Neige et al., 2001). When used to tasks like as prediction and classification, using definite numbers produces unrealistic results. Utilize this strategy to reach agreement on topics when the objectives and criteria are not well defined. Thus, intellectuals express their hypotheses with the fewest feasible details, the highest probability of validity, and the greatest one (triangular fuzzy).

3.2. Fuzzy

The first need for developing a fuzzy system is that membership functions for linguistic variables be chosen. The effect's importance was determined by the linguistic values (very low VL, low L, medium M, high H and very high VH). For exterior screening of residential complex variables, those classified as low or very low will be eliminated from the list of effective elements contributing to a feeling of place.

Table 4 Membership functions related to the profile and the importance of the work to obtain membership status

Function type	Membership function
Very low	$\mu_{VL} = \begin{bmatrix} 1 & 0 \le x \le 0.2 \\ -6.25\,x+2.25 & 0.2 \le x \le 0.36 \end{bmatrix}$
low	$\mu_{L} = \begin{bmatrix} 6.25x-1.25 & 0.2 \le x \le 0.36 \\ -6.25\,x+2.25 & 0.36 \le x \le 0.52 \end{bmatrix}$
average	$\mu_{M} = \begin{bmatrix} 6.25x-2.25 & 0.36 \le x \le 0.52 \\ -6.25\,x+4.25 & 0.52 \le x \le 0.68 \end{bmatrix}$
high	$\mu_{H} = \begin{bmatrix} 6.25x-3.25 & 0.52 \le x \le 0.68 \\ -6.25\,x+5.25 & 0.68 \le x \le 0.84 \end{bmatrix}$
Very high	$\mu_{VH} = \begin{bmatrix} 6.25x-4.25 & 0.68 \le x \le 0.84 \\ 1 & 0.84 \le x \le 1 \end{bmatrix}$

The most critical aspect of the fuzzy inference approach is the establishment of a law basis. The objective of these rules is to specify the numerous propositions that result from the combination of the various situations described for each profile (base and supplement) (Patience, 2008: 149; Pourghassemi et al., 2008).

3.3. Non-Fuzzy Making (Definitive)

A non-fuzzy creating unit is a function that converts a fuzzy set to a definite value. The final decisive value achieved in this investigation was, in fact, the center under the curved surface in the final fuzzy sets (Amini Ternoodi, 2005: 39-45). The definitive value of output is computed using the following relationship, in which y is the output value of (y) the output membership degree of y, and $\bar{Y}$ is the actual value of output.

$$\bar{Y} = \frac{\int y\mu(y)dy}{\mu(y)dy}$$

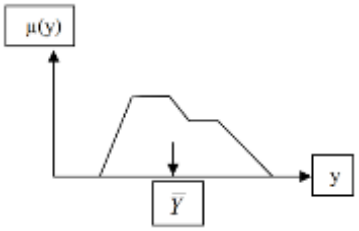

Fig 4 The Method of Penetrating the Center of Gravity (Source: Monem et al., 2007)

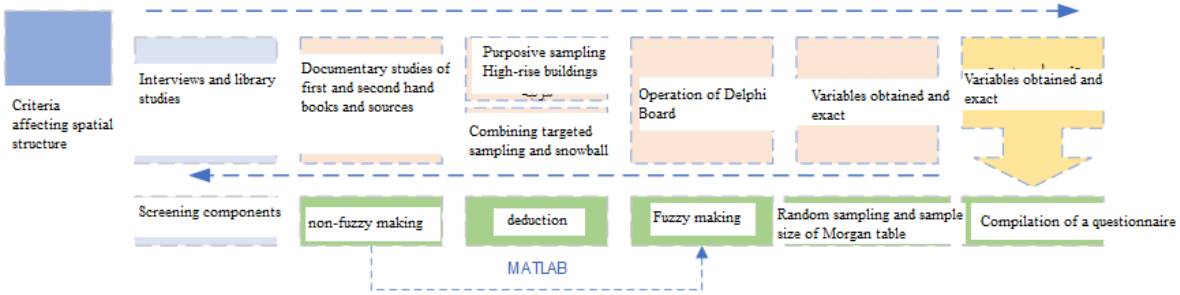

Fig 5 Research Trend Chart

4. Findings

In this research, the importance of the criteria influencing the spatial structure of tall residential buildings was calculated applying Matlab software and classified due to the membership grade, which the findings of above-mentioned method are listed in the form of the figure below (Fig. 6).

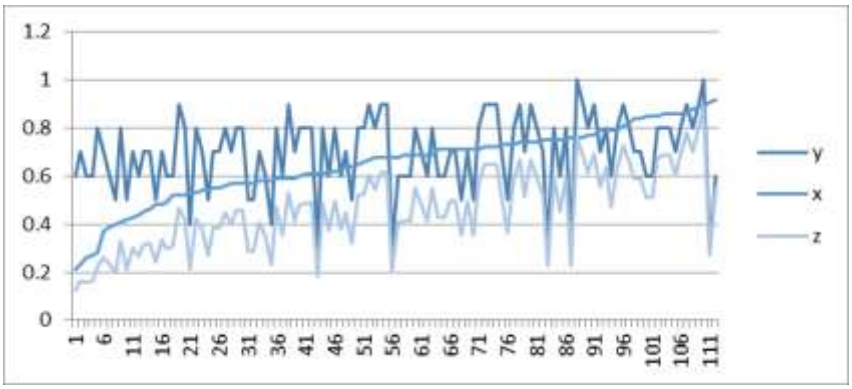

Fig 6 Classification of the importance of each linguistic variable

According to the preceding chart, the significance of each language variable's influence is listed in the Table 4. To assess the fuzzy model, the spatial structure and characteristics criteria, the

quality of which was evaluated by experts based on the required quality index, were generated using software and utilized as the fuzzy model's output. In fuzzy logic, an effect is classified as belonging to one of two membership functions, each of which has a different degree of membership. Finally, the degree of membership indicates the significance of the influence of a particular linguistic variable type. When the variable x is increased, the effect's value changes and grows from a very tiny attribute (a very small linguistic variable) to a very big attribute, as indicated in the Table 4; That is, as we increase the variable x, the value of the language variable increases in each class, which is represented by a class in the matrix's output. For example, if the variable x = 0.53 belongs to the middle class, and if the variable x = 0.67 still belongs to the middle class, despite the fact that it has increased significantly. This issue is solved using the fuzzy Delphi technique of this fuzzy logic, and its result makes sense in terms of membership degree. For instance, if the fuzzy logic output is Y=0.67, the fuzzy logic calculates the degree of membership for the two membership functions, so slowing down and increasing uncertainty.

Examination and outputs obtained from MATLAB software revealed that the general criteria; The criteria for high-rise buildings in the H category by a value of 0.87, height limitation criteria in M group with a value of 0.55, spatial constraint criteria with a value of 0.53 in M category, fire extinguishing criteria with a value of 0.71 in H category, electrical installation and comfort criteria with amount 0.69 in category H, exit and access criteria with value 0.49 in category L, vehicle placement criteria with value 0.49 in group M, overtaking criteria with value 0.79 in category H, ventilation and lighting criteria with value 0.31, the criteria for stops with a value of 0.51 in the M group, acoustic criteria for space with a value of 0.69 in the H category, facade design criteria with a value of 0.58 in the M category.

In particular, building height criteria with a value of 0.53 in category M, area criteria with a value of 0.57 in category M, criteria of non-location areas with a value of 0.47 in category L, urban node criteria with a value of 0.61 in category M, negative criteria with a value of 49 / 0 in category M, restrictive criteria with a value of 0.44 in category M, index building criteria with a value of 0.19 in category VL, tall building construction criteria with a It belongs to the H category.

Table 5 Membership grade and final class of agents (criteria affecting spatial structure)

Fuzzy Logic					
Factor	Degree of membership	Floor	Factor	Degree of membership	Final floor
Building height criteria	0.53	M	Criteria for high-rise buildings	0.87	H
Arena rules	0.57	M	Elevation restriction criteria	0.55	M
Criteria for overlapping areas	0.16	VL	Spatial constraint criteria	0.53	M
Criteria for vacant areas	0.47	L	Fire extinguishing rules	0.71	H
Urban node criteria	0.61	M	Rules for electrical installations and comfort	0.69	H
Negative criteria	0.49	M	Exit route criteria, exit access	0.49	L
Restrictive criteria	0.44	M	Criteria of physical structure	0.88	VH
Index building criteria	0.19	VL	Energy consumption and saving rules	0.27	L

Criteria for construction of tall buildings	0.44	L	Car installation criteria	0.49	M
Operating criteria	0.76	H	Advance criteria	0.79	H
Acoustic criteria of spaces	0.69	H	Criteria for ventilation and lighting	0.31	L
Facade design criteria	0.58	M	Criteria for parking	0.51	M
			Criteria for protection and shelter	0.60	M

5. Discussion

The criteria that fall into the L and VL categories are omitted from the impact procedure, according to the findings. Firefighting, electrical installations and comfort requirements, acoustic criteria, and operation criteria were shown to be the most essential factors that may have a significant influence on the spatial layout of high-rise structures. Contrary to common opinion, general criteria have a bigger part of the influence on the creation of spatial structure, although overlapping area criteria, index building criteria, tall building construction criteria, lighting and lighting criteria, criterion The exit route, access, has little or no influence, and they may be termed ineffectual in terms of spatial structure, as shown by the ineffectiveness of the secondary criterion. A component has never been prioritized in respect to the criteria defining the spatial organization, and the efficacy of each has never been evaluated in previous studies.

6. Conclusion

Cities' vertical rise has been extensively researched in recent decades, and buildings function as a single complex that serves and receives. High-rise buildings have been utilized to exploit downtown real estate and to develop and monitor the urban economy. The requirements have led certain portions to stay stiff and inattention to other parts in the design of the spatial structure due to a lack of localization and a simple concentrate on specific features of the spatial structure. The influence of distinct sets of criteria on the components of the spatial structure has not been examined or evaluated in numerous studies. To regulate the spatial structure, all forces in each building must be controlled, which necessitates the recognition of the spatial structure's elements and components. It has not, however, been explained or evaluated. According to the results, the spatial structure of high-rise residential structures is influenced by the distance between elements, communications, and unit components. Understanding the meaning of communication requires knowledge of terms like component, whole, link, and interaction. The term "interaction" refers to a degree of connectivity between components. In other ways, interaction refers to the idea of a sum of parts or a link of parts. Interaction, on the other hand, entails viewing and perceiving components in a unified flow rather than independently. The spatial structure is formed by the components and how they interact in this process. The primary goal of communication is to determine the traits and features of components and constituents. The distance between the components is the second factor.

Due to a lack of coordination between the structural aspects of the space, the following solutions are recommended to enhance the spatial structure and regulate destructive maps:

- The creation of standards for managing forms, enhancing order, texture, and readability in order to enhance the physical and spatial structure
- Providing ideal solutions for combining areas with varied functions and improving spatial structure components

- Creation of indigenous gender, layout, and spatial zoning requirements in line with Iranian-Islamic culture

- To enhance the spatial structure, develop standards for managing forms, enhancing order, texture, and readability.

References

Abdullahi, D., Rabbani, R., & Varesi, H. R. (2013). The Relationship between the Architecture of Urban Residential Complexes and the Social Capital of Residents (Case Study of Ardabil Urban Complexes). *Quarterly Journal of the Iranian Association for Cultural Studies and Communication, 31*, 105-132.

Adeli, Z., & Sardeh, A. A. (2011). *Location of high-rise residential buildings in Qazvin using the hierarchical process*. The third conference on urban planning and management, 1-10.

Amini, S., Hosseini, S. B., & Nowruzian Maleki, S. (2013). A comparative study of residents' satisfaction between two samples of Medium-Range and High-Level residential complexes: Case Samples: Shahid Mahallati and Sobhan Residential Complexes. *Armanshahr Journal of Architecture and Urban Planning, 6*(11), 1-13.

Armstrong, P. J., & Mir, M. A. (2018). Overview of Sustainable Design Factors in High-Rise Buildings, *CTBUH 8th world congress*, 1-10.

Barney, G. C. (2015). *Vertical Transportation in Tall Buildings, Elevator World. Consultant`s Final Study Document, (2010)*. Chapter Five: Regulation for Tall Building Design, Toronto.

Dadashpour, H. (2009). *Textbook of Master's Degree, Basics of Regional Planning*, Urban and Regional Planning, Tarbiat Modares University.

Einifar, A., & Ghazizadeh, S. N. (2006). Typology of Tehran residential complexes with open space criteria. *Armanshahr Scientific Research Journal, 5*, 35-45.

Einifar, A., & Agha Latifi, A. (2011). The concept of territory in residentioal complexes. *Honarhaye ziba journal, 3*(47), 17-28.

Fini, R., Grimaldi, R., & Sobrero, M. (2009). Factors Fostering Academics to Start Up New Ventures: An Assessment of Italian Founders'incentives. *Journal of Technology Transfer, 34*(4), 380-402.

Farhoudi, R., & Mohammadi, A. (2001). The Effect of High-Rise Buildings on Urban Land Uses in Regions 1, 2 and 3 of Tehran. *Geographical Research Quarterly*, (41), 1-19.

Ghafoorian, M., Pay Sokhan, M., & Hesseri, E. (2017). Typology of space organization and entry hierarchy in Iranian houses with emphasis on confidentiality. *Scientific-Research Journal of Development Planning, 2*(3), 129-144.

Habibi, S. M., Hamidi, M., & Salimi, J. (1997). *Osteoporosis of Tehran*. Tehran: Technical and Engineering Consulting Organization of Tehran.

Hok Architects Corporation, & City of Toronto. (2006). Design Criteria for the Review of Tall Building Proposal.

Karimi Moshaver, M. (2010). *The role of high-rise construction in the urban landscape*. Doctorate thesis, University of Tehran.

Karimi Moshaver, M., Mansouri, A., & Adibi, A. A. (2010). Relationship between high-rise buildings and urban landscape. *Bagh-e Nazar journal, 7*(13), 89-99.

Kropf, K. (1996). Urban Tissue and the Character of Towns. *Urban Design International, 1*(3), 247-263.

Kunstler, J., & Salingaros, N. A. (2001). The End of Tall Buildings. *Planetizen.com, 17*.

Misra, R. P., & Maboganj, A. (1989). *Regional development: new methods* (Mokhber, A. Trans.). Tehran: Program and Budget Organization.

Mohajer Milani, A., & Einifar, A. (2018). Recognition of Tehran Conventional Housing Space Organization. *Journal of Fine Arts-Architecture and Urban Planning, 24*(1), 45-56.

Nateghi Elahi, F. (1996). *Behavior and design of tall buildings, Ministry of Culture and Higher Education*. International Institute of Seismology and Earthquake Engineering, Tehran.

National building rules and regulations, (2016). *Topic 4 of Iran's engineering system (General building requirements)*. 19th edition, 3rd edition.

National building rules and regulations, (2013). *Topic 15 of Iran's engineering system (elevators and escalators)*. Third Edition.

National building rules and regulations, (2011). *Topic 18 of Iran's engineering system (Insulation and Sound Regulation)*. First Edition.

National building rules and regulations, (2020). *Topic 19 of Iran's engineering system (Energy Saving)*. Fourth Edition.

Niu, J. (2003). Some Significant Environmental Issues in High-rise Residential Building Design in Urban Areas. *Energy and Building, 36*, 1259-1263.

Powell, N. (2003). Single-minded, compelling, and unique: visual communications, landscape, and the calculated aesthetic of place branding. *Environmental Communication: A Journal of Nature and Culture, 7*(2), 231–254.

Qarabagloo, M., & Khaleghi Moghaddam, N. (2015). Typology of residential complexes, an effective step in designing the quality of contemporary residential complexes (case study: Residential complexes of Tabriz city). *Journal of Architecture and Urban Planning, 7*(14), 117-139.

Rahnama, M. R., & Razzaqian, F. (2013). Location of high-rise buildings with emphasis on the theory of smart urban growth in District 9 of Mashhad Municipality. *Quarterly Journal of Golestan University, 3*(9), 45-63.

Rahnama, M. R., & Razzaqian, F. (2016). *Analysis of high-rise residential buildings with emphasis on the theory of ecological city in the southwestern part of Mashhad metropolis*. Faculty of Literature and Humanities, Ferdowsi University of Mashhad.

Ramkisson, H., Smith, L. D. G., & Weiler, B. (2013). Relationships between place attachment, place satisfaction and pro-environmental behavior in an Australian national park. *Journal of Sustainable Tourism, 21*(3), 434–457.

Remok, M. (2002). Complications and location of tall buildings in Tehran. *Quarterly Journal of Urban Management*, 11-12.

Management and Planning Organization of the country, (2015).

Road, Housing and Urban Development Research Center, (2016). Tehran, Iran.

Salehi, N. (2013). *The place of high-rise construction criteria in shaping the desired urban landscape*. Master Thesis in Architecture, Azad University of Mashhad.

Seif al-Dini, F. (2006). *Specialized losses of urban planning*. Third edition, Tehran: Aij Publishing.

Seyed Sadr, S. A. (2007). *High-rise construction in modern buildings*. Second edition, Andisheh Works Publishing, Tehran.

Shafiee, M., Fayyaz, R., & Heidari, S. (2013). Appropriate form of tall building to receive radiant energy in Tehran. *Iran Journal, 16*(4), 47-60.

Shamai, A., & Jahani, R. (2013). Investigating the vertical development of the city on neighborhood identity; Case Study: Tehran Region 4. *Iranian-Islamic City Studies Quarterly*, Tehran.

Shukri, F., & Shahri, K. (2015). Transformation of the Spatial Organization of Traditional Houses in the Contemporary Housing Model (Case Study of Ilam City). *National Conference on Civil Architecture, Urban Planning and Tourism, Sustainable Urban Development*, 1-11.

Samsami Hosseini, A. (2001). Necessity of construction, criteria and effects of tall buildings, *Proceedings of the Second International Conference on Tall Buildings, Iran University of Science and Technology, Tehran.*

Tavassoli, M. (1990). *Structure and body* (Kiani, M. Y. Trans.). Iranian architecture of the Islamic period, Tenth edition, Tehran, Samt.

Tehran Studies and Planning Center, (2013). *Development plan and regulations for the construction of high-rise buildings, analysis studies and presentation of proposed criteria*. Part Consulting Engineers.

Von Mayes, P. (2007). *A Look at the Basics of Architecture from Form to Location* (Ayvazian, S. Trans.). Tehran, University of Tehran Press.