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Original Research Article

Historical Analysis of Reflection of Fifteen Principles of Christopher Alexander's Living Structure Theory on the Spatial Organization of "Abwab-al-Berr" Case study: Ghazanieh and Rab'e Rashidi*

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Abstract

Problem statement: One of the physical transformations of the urbanization of Ilkhanid era was the phenomenon of "Abwab-al-Berr", which was unique in diversity, organization, and greatness. It consisted of two general sections, the "central core" and "Shahrestan", both developed with a regular and pre-designed geometric structure. Since Ilkhanid urbanization developed in the direction of the tradition of urbanization in Iran, it is possible to study urban innovation in this era in the same direction. Progress of architecture unfolds by, rather than losing touch with the past, adhering to long-established traditions, principles, and technologies.

Research objective: In *The Nature of Order*, Christopher Alexander describes fifteen properties of a living structure based on the principles of "wholeness". He asserts that fifteen properties can be effective in creating regular, living structures. This study attempts to explore the principles of urban design underlying the spatial organization of "Ghazanieh" and "Rab'e Rashidi" as transcendent examples of "Abwab-al-Berr".

Research question: To what extent are the principles of Alexander's urban design generalizable to the Ilkhanid city of "Abwab-al-Berr"?

Research method: To answer this question and meet the objective of the study, historical-interpretive research was selected. The research process comprises two steps:

In the first step, the focus was on the spatial structure of "Abwab-al-Berr" existing in historical documents. In the second step, the generalizability of the principles of the living structure theory to the spatial organization of Abwab-al-Berr was assessed.

Conclusion: The results of this study show that the spatial structure of Rab'e Rashidi and Ghazanieh are compatible with fifteen principles of the living structural theory, namely levels of scale, strong centers, boundaries, alternating repetition, positive space, good shape, local symmetries, deep interlock and ambiguity, contrast, gradients, roughness, echoes, the void, simplicity and inner calm, and not-separateness. This compatibility can help form an approach for designing and organizing irregular modern-day cities.

Keywords: *Fifteen Principles of Living Structure Theory, Christopher Alexander, Ghazanieh and Rab'e Rashidi, Ilkhanid Abwab-al-Berr.*

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Introduction and problem statement

“Abwab-al-Berr” was a novel phenomenon in urbanization that emerged in the Ilkhanid era. One of the influential factors on urban planning and urbanization in the Ilkhanid era was the interest of the rulers of this dynasty in building more constructions to demonstrate their greatness. Most of the urban complexes in this era were built under the direct command and supervision of the Ilkhanates and their ministers. For instance, Rab’e Rashidi and Ghazanieh complexes, both unmatched in terms of diversity, organization, and greatness (Ali Asl & Yousefifar, 2011), were built under the directives of Rashid ad-Din Hamadani and Ghazan Khan, respectively (Hamadani, 1959, 233- 234). Ghazanieh and Rab’e Rashidi consisted of two general sections, namely “central core” and “Shahrestan”, both developed based on a pre-devised design to form a regular geometric structure. Considered as the transcendent examples of the Ilkhanid utopia of Abwab-al-Berr, they were designed parallel to the Iranian tradition of urban planning, so it seems reasonable that an inspection into the urban design principles of these complexes will help form approaches to be adopted for organizing irregular modern-day cities (and to redesign so-called living ones). Alexander believes that the current plans achieve order at the cost of undermining the living character of cities and fail to create large-scale order. Buildings and spaces have been gradually losing these characters in the last decades as eccentric architectural and design theories of the twentieth century propel architects and designers away from them (Alexander, 2011). Alexander seeks to create living structures in artifacts and buildings as well as in neighborhoods and cities (Alexander, 2004, 50). In his first book, *The Nature of Order*, he describes 15 properties of a living structure, based upon the concept of “wholeness”. The more these fifteen properties are present in space, the more it becomes ‘living’ (Alexander, 2011, 198). In line with the purpose of the research, which is to analyze the principles that have dictated the development of

pre-designed cities of Ilkhanid Abwab-al-Berr, this question arises that how generalizable the principles of urban planning of Christopher Alexander’s living structure theory to the spatial organization of the traditional neighborhoods of Abwab-al-Berr.

Research background

Valuable studies focusing on the spatial organization of Ilkhanid city of Abwab-al-Berr have been conducted, such as Imaginary recreation of Rabe Rashidi based on historical texts (Kaynejad & Belali Oskui, 2011); Spatial Structures of the Ilkhanate Governed Cities Known as the Greatness Pathways (Noghrekar, Kaynejad, & Belali Oskui, 2013); Hypothetical design of Rab and Shahrestan’e Rashidi (Balali Oskuyi et al., 2010); Wagf im Mongolischen Iran.

Rasiduddins Sorge nm Nachruhm und Seelenhide Von (Hoffman, 2000); Islamic art and architecture in Iran and central Asia (Blair, 2003), Findings from the plan of Ghazaniehh, an urban phenomenon of the patriarchal era called Abwab-al-berr (Shekari Nairi, 2005); Recognizing the Architectural Form of “Ghazan’s Tomb” in “Abvab-Albar” collection of “Ghazaniyeh” and its Role in Iranian Urbanization Development (Moradi, Musavi haji, Omrani, 2016); Pajhuheshi dar rab’e rashidi [Research in Rab’e Rashidi] (Saeednia, 2000); A historical approach to urban planning and architectural complexes in the Ilkhanid Tabriz (Ajourloo, 2013); Generalization rate of Christopher Alexander’s living Structure theory Case Study: Charbagh and Isfahan Gardens (Hatefi Shogae, 2015); and Historical analysis of the strategic principles of Ilkhanate ‘Abwab-al-berr’ cities’ structure With an approach of Carmona urban design indicators (Belali Oskoyi, 2019).

In his master thesis, Study and evaluation of somatic and spatial features of ghourtan castle based on christopher alexander theories, Hedayatniya (2013) reported the compatibility of the properties of this castle with fifteen properties described in Alexander’s living structure theory. In their study

entitled as Rooykardi tahlili bar nazariyeh hay tarahi christopher alexander [An analytical approach to design theories of christopher alexander], Mohajeri and Ghomi (2008) concluded that Alexander's theories established a better connection between the various components of design and planning in recent approaches compared to the older ones. In The Concept of Order: Christopher Alexander and the New Science, Hosseini (2017) reported the success of fifteen principles of Alexander's living structure theory in reviving traditional neighborhoods in her thesis entitled "Redesigning Spatial Structure of Traditional Neighborhoods with an Analytical Approach to Christopher Alexander's Design Theories".

However, the principles governing the city of Abwab Al-Berr as a sublime and successful example of urban planning of the Ilkhanid era based on Christopher Alexander's principles of urban design have not been examined so far. What differentiates

the approach of this study from previous ones is that it tries to use the results of previous studies on Rab'e Rashidi and Ghazanieh to extract the spatial structure of the Ilkhanid Abwab-al-Berr and then generalize the principles of the living structure theory to the spatial structure of Abwab-al-Berr to determine their compatibility (Fig. 1).

Theoretical foundations

• Spatial organization of Abwab-al-Berr

The spatial organization of Abwab-al-Berr, based on authentic historical documents, consisted of two general sections, the "central core" and "Shahrestan", which developed based on a pre-designed, regular geometric structure. The central core of Abwab-al-Berr was the tomb of the constructor whose religious aspect was also integrated with the cultural-educational function. Extensive attention was paid to the central core of these cities, which was also well incorporated into

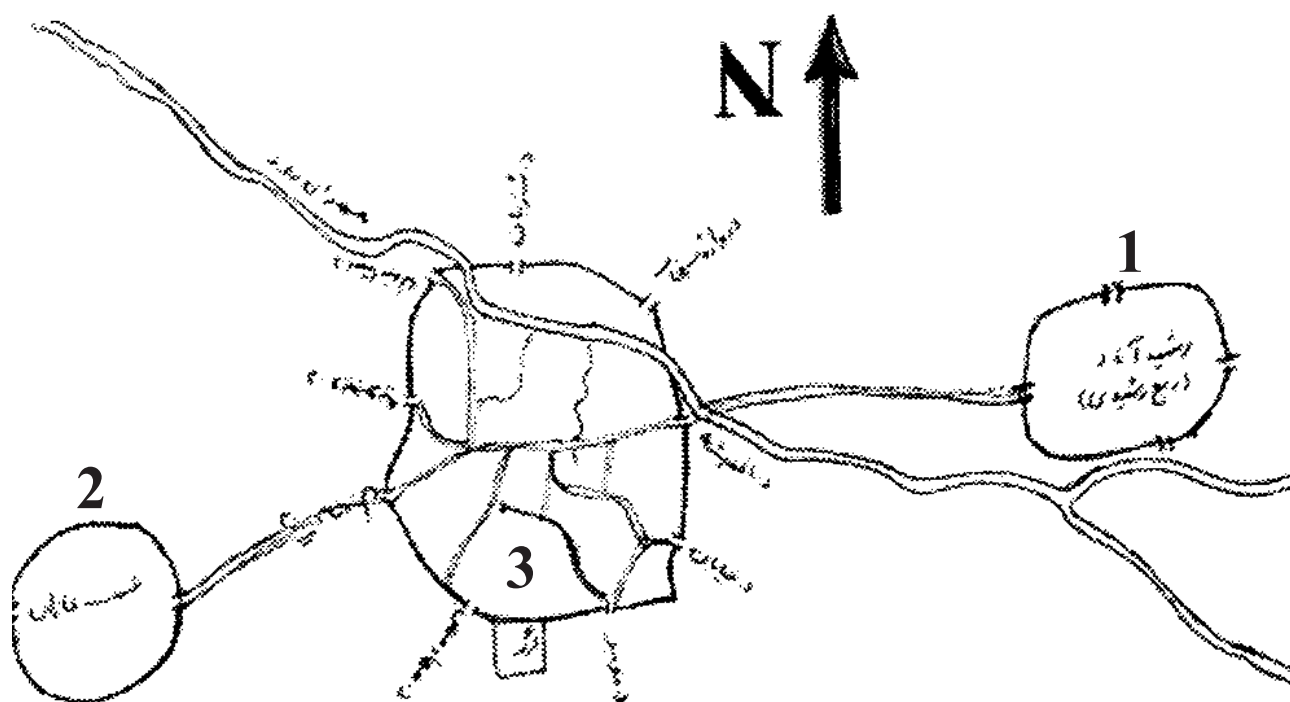


Fig. 1. Location of the studied areas in the research. 1. Rab'e Rashidi, 2. Ghazanieh, 3. The central core of Tabriz. Source: Authors.

the Shahrestan section of the cities. The Shahrestan of these cities consisted of different neighborhoods, where important urban components, such as bazaar, Gheisarieh, baths, mosques, mint, barracks, etc. were located. The texture of these cities had a geometric order and was designed with a checkered texture around two main axes. In terms of spatial design, roads were in a strong connection with the adjacent physical spaces, and their spatial nature was not independent of these spaces. The locations of spaces and activities in cities were dictated by measured order and hierarchy to fulfill the social needs (material and spiritual) of citizens, and all spaces in terms of function often provided a suitable body for a good life. The geometry of Ilkhanid cities, especially important ones, resembled a chessboard, where urban spaces were surrounded by longitudinal and transverse streets perpendicular to each other. Around this network and roads as well as the suburbs, gardens were constructed to shape the outline of the city and to beautify the urban landscape, so roads and gardens were an integral and inevitable component of Ilkhanid cities. In addition to the fortifications of the city, the surrounding gardens turned these cities into urban gardens and enclosed their outer boundaries. The outline of these cities was formed with the axes leading to the gates. The bazaar, which spread from one gate to another along one of the axes, was considered a linear and main axis in the city, tying various neighborhoods, functions, and public urban components, such as caravanserais, etc. (Kaynejad & Belali Oskui, 2011, 60).

• Christopher Alexander's living structure theory

Today, we always compare new forms with traditional ones, wondering why the traditional forms had good compatibility, whereas today's forms are often incompatible? (Alexander, 2011, 12). Alexander compared natural and designed cities and concluded that designed cities do not function as designers intend to. He recognized a complex pattern with a common structure in organically

developed cities (Mohajeri & Ghomi, 2008, 48). When we look at the most beautiful cities of the past, we always get the feeling that these cities are alive. This feeling of "being alive" is not a vague concept, rather an accurate picture of a special structural quality that these old cities have. These cities developed as a "whole" and under the principles of "wholeness", a quality felt not only on a large scale, but also in every detail, including restaurants, sidewalks, houses, shops, markets, roads, parks, gardens, and walls as well as balconies and city ornaments (Alexander, 2004, 27). Based on the concept of The Nature of Order, Christopher Alexander divides all the phenomena of the universe into two categories of "living structures" and "non-living structures" (Alexander, 2011, 7-8).

The Nature of Order was born from Alexander's meticulous observations of the world throughout 30 years, where he presents his living structure theory, focusing on how a group of different phenomena can together form coherent and living structures. These structures are palpable in all phenomena of the universe, including atoms and crystals (micro-organisms) as well as living forms and galaxies (macro-organisms) (Alexander, 2004, 23). In connection with the discovery of geometric responses to the part-whole relation, Alexander arrives at fifteen obscure properties of nature (Mehaffy, 2007, 45).

These fifteen properties, which explain the characteristics of living structures, are not independent of each other and sometimes have commonalities (ibid., 48).

In other words, the centers are not a whole system on their own, rather their commonalities and the relationship with each other through fifteen properties reflect this wholeness. The richer this relationship, the stronger the whole. These centers support each other through the following properties: Support each other: levels of scale, strong centers, boundaries, alternating repetition, positive space, good shape, local symmetries, deep interlock and ambiguity, contrast, gradients, roughness, echoes,

the void, simplicity and inner calm, and not-separateness (Alexander, 2004, 50).

Alexander believes that these fifteen properties appear repeatedly in large buildings and artworks as well as in nature, dictating the nature of living systems (Alexander, 2011, 198-200).

Similar to natural forms developing based on similar processes, the development of neighborhoods and cities should be dictated by these processes. Alexander seeks to create living structures in man-made artifacts. He searches for these structures in buildings and human artifacts alike (ibid.,12).

Theoretical framework of research

As explained earlier, an urban structure is living provided that it reflects the fifteen principles of Alexander's living structure theory, which argues that all living structures must follow these fifteen principles and that these principles are generalizable to organic, natural structures.

Abwab-al-Berr complexes, which were developed according to pre-designed plans in the forms of regular and geometric patterns, are selected to be studied in this research as successful examples of Ilkhanid urban planning to assess the generalizability of fifteen principles of the living structure theory to the spatial organization of Ghazanieh and Rab'e Rashidi of Abwab-al-Berr complexes. The theoretical framework of this research is illustrated in Figure 2.

Research hypothesis

According to Alexander, principles, and patterns creating the so-called living quality have long existed in urban structures. He discovers these principles by studying organic structures and arranges them into fifteen categories. But these principles can also manifest in pre-designed structures, rendering them living. Despite being pre-designed, some structures, such as the ones selected in this study, seem to reflect these properties (fifteen principles of living structure theory) in their design.

Research method

The research method is historical-interpretive, and the research was conducted in two general steps. In the first step, the spatial structure of "Abwab-al-Berr" was examined in historical documents. In the second step, the generalizability of the principles of the living structure theory to the spatial organization of Abwab-al-Berr was assessed in the reconstructed plans. The first step included two stages: The first stage focused on the problem statement and formulating the main question, and the second stage included studying the theoretical foundations, developing the research hypothesis, examining authentic texts of historians of the seventh to ninth centuries AH as well as reconstructing plans and miniatures based on the historical books and documents of this era, such as the history of Mubarak Ghazani, the History of Öljaitü, the Comprehensive history of Rashidi, Rashidi's correspondence, the endowment letter of Rab'e Rashidi, and tourists' accounts on the state of plans and city visage, all of which reveal some parts of Rashidieh and Ghazanieh spaces, partially and indirectly. Furthermore, The Nature of Order written by Christopher Alexander was also studied to extract the fifteen principles of living structure theory. The third stage was the analysis of the data, and in the fourth stage, the results were interpreted and judged (Fig. 3).

Discussion and findings

In this section, we investigate the generalizability of fifteen principles of Alexander's living structure theory to the Ilkhanid complexes of Abwab-al-Berr.

• Strong centers

The most important property of a living structure based on which wholeness is shaped is the existence of strong centers as pillars of wholeness. Centers can be different and symmetric as each center emerges as a square that is beyond a local symmetry point. Strong centers are not necessarily geometric ones (Alexander, 2011). As demonstrated in Figure 4, the spatial organization of Ghazanieh included

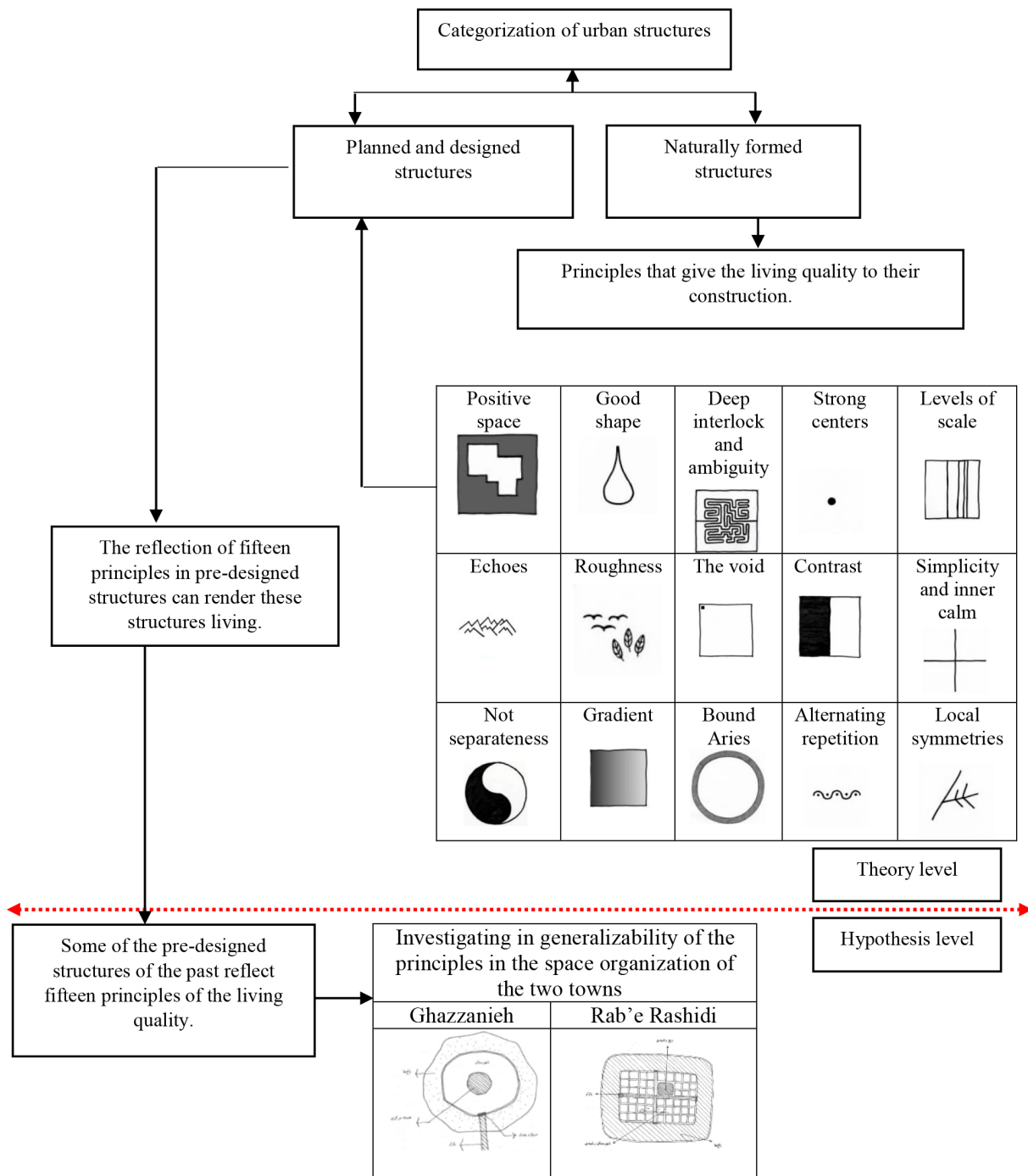


Fig. 2. Diagram of research theoretical framework. Source: Authors.

the central core, Shahrestan, and axis of Ghazani Bazaar, which spread out along the Baghdad gate (Noghrekar et al., 2013, 57) and was considered as the living path of the city (Ibn Battuta, 1980, 28). The importance of squares in the city (Hamadani, 1994, 1996), great emphasis on the

design of entrances (Ibn Battuta, 1980, 253), the location of endowed religious-cultural core in the city center (Hamadani, 1957, 934), the Ghazani dome as the focal point of Ghazanieh town (Kashani, 1969, 179), and the formation of urban spaces of the city around the tomb can reflect the

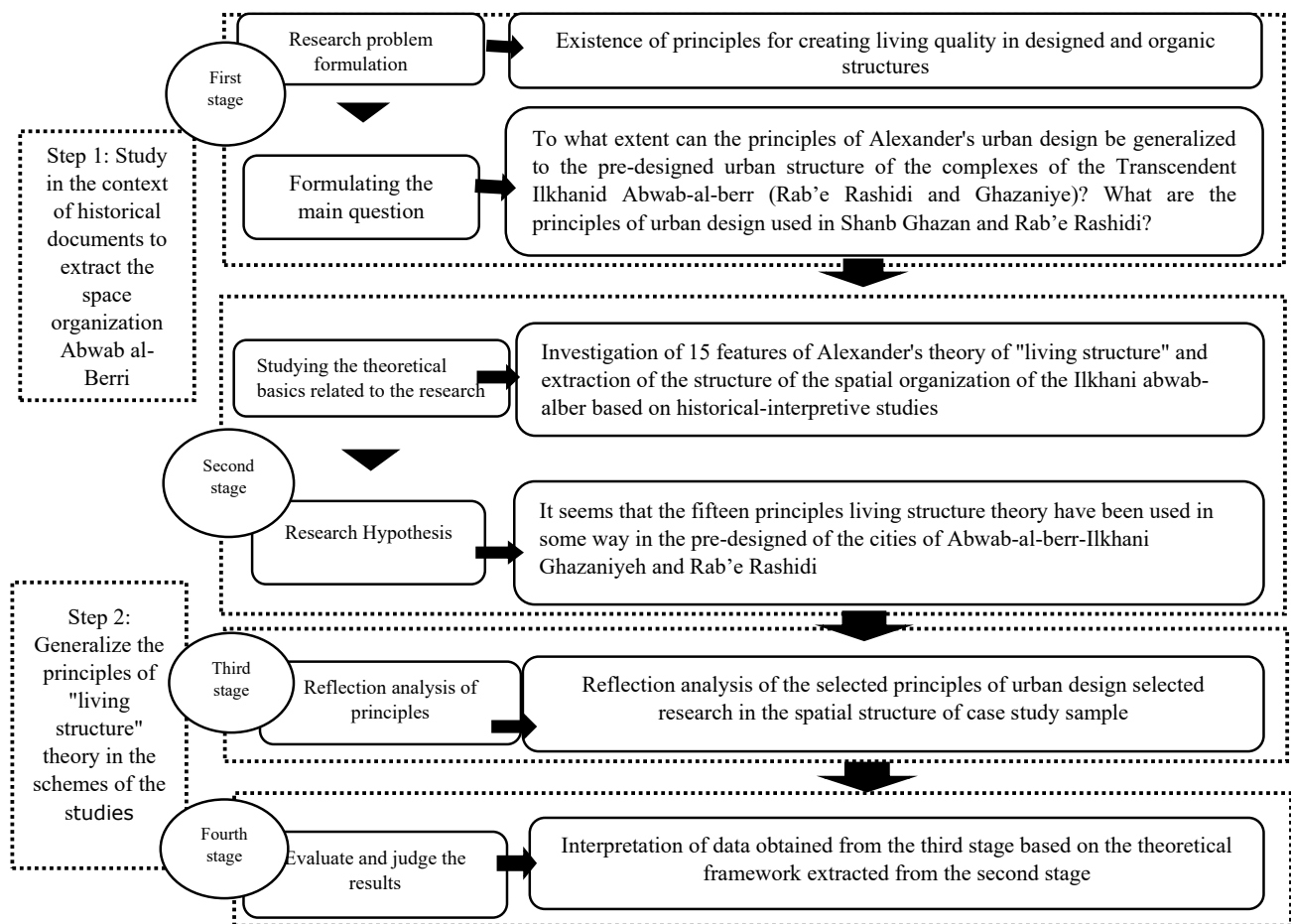


Fig. 3. Diagram of Research Process. Source: authors.

strong centers in the structure of Ghazanieh. As illustrated in [Figure 5](#), Rab'e Rashidi consisted of three sections of the core, Shahrestan, and bazaar ([Noghrekar et al., 2013, 57](#)). Also, Rashidieh town comprised two sections, namely Rab, as the cultural neighborhood, and Shahrestan, as a residential neighborhood. Moreover, the tower-shaped tomb of Khajeh Rashid al-Din Fazlollah, known as the "dome" was located in the middle of the Rab buildings, surrounded by several facilities ([Hamadani, 1934, 42](#)). In short, the urban spaces of these complexes were based on the principle of concentration, and most of the buildings were situated in the central part of the city. Therefore, it is possible to deduce the reflection of the principle of strong centers in the structure of Rab'e Rashidi and Ghazanieh.

• Boundaries

According to Alexander's theory, living centers are shaped by boundaries. Boundaries surrounding centers serve two purposes: separating and connecting. Boundaries first attract attention towards the limited center and then incorporate it into space beyond restricting boundaries ([Alexander, 2011, 127-133](#)). According to historical documents, functions in these complexes were surrounded by green spaces ([Hamadani, 1994, 1995](#)) and Rashidieh was inside the Ghazani fort and had a separate triangular rampart ([Ajourloo, 2013](#)). Also, the Ghazani dome was a tall tower, surrounded by several gardens ([Kashani, 1969, 179](#)). Hence, we can conclude that every urban space in Ghazanieh, including micro-space (houses) as well as macro-space (the city), had its own boundary.

According to historical books focusing on the organization of Rab'e Rashidi, it was surrounded by boundaries (Hamadani, 1977, 211). Rashidieh town comprised two sections, namely Rab, as the cultural neighborhood, and Shahrestan, as the residential neighborhood, both protected by surrounding ramparts (Hamadani, 1934, 42). According to the endowment letter of Rab'e Rashidi and the history of Mubarak Ghazani, functions were bordered with gardens (Kashani, 1969, 116). Also, Rab'e Rashidi had walls and four gates around it (Noghrekar et al., 2013, 54). Taking this information into account, it is possible to deduce the reflection of the principle of boundaries in the design of Ghazanieh and Rab'e Rashidi (Fig. 6).

• Positive space

According to Alexander's theory, the most important property of living structures is positive space, which is the prominence of each particle to the outside. If a center is positive and well-formed, the positive space helps it be more powerful (Alexander, 2011, 141-145). According to the History of Vassaf and Jami' al-tawarikh of Rashidi, the diagram of Ghazanieh and surrounding twelve identical spaces are illustrated in Figure 7. Rashid al-Din used the Mongolian term of 'Kuran', which means rings, to refer to the structure of Ghazanieh, stating that the tomb of Ghazan was the central point of every building constructed under the order of Ghazan, and the other facilities surrounded it. Furthermore, Ibn Battuta described the Ghazanieh complex in 727 AH as comprising a grand mosque, Shafeieh mosque, Hanafieh mosque, monastery, Dar al-Sayadeh, Dar-al-Shafa (hospital), library, reading house, Hozkhane, Beit-al-Ghanun, Beit-al-Motavali, Adeliyeh palace, Ghazanieh dome, Hakimiyeh, garden, several bathhouses, and Ghazani observatory (Hamadani, 1940, 131-173). Figure 7 also depicts an illustration of Ghazanieh based on a miniature of the era of Rashid-al-Din (extracted from the book entitled Gardens and Parks of Azerbaijan). As shown in Figure 6, this complex comprised various elements, and the space

formed from the aggregation of buildings gives the complex a specific shape. According to the recreations of this complex based on historical texts, it is assumed that Ghazanieh Shahrestan was in the form of a dodecagon. Therefore, it is concluded that the design of Ghazanieh reflected the principle of positive space.

Based on the recreated illustration of the spatial organization of Rab'e Rashidi (Fig. 8), the spaces forming the central core of the Abwab-al-Berr were formed around the central point of the builder's tomb. Based on the recreations using historical texts as well as speculations, Rab'e Rashidi consisted geometrical network, resembling a chessboard with an overall shape of a rectangular. Therefore, we can conclude the design of Rab'e Rashidi reflected the principle of positive space.

• Good shape

According to Alexander's theory, the principle of good shape is dependent on centers and the fact that each section must have a well-defined shape (Alexander, 2011, 146-153). According to the reconstructed sketch of Ghazanieh, using historical accounts (Fig. 9), a miniature of the palace, rampart, and dome of the Ghazanieh complex based on the Jami' al-tawarikh of Rashidi, the plan of Ghazan dome reconstructed by Wilber (The Architecture of Islamic Iran, The Ilkhanid Period), and other related texts (Fig. 10), Ghazanieh was a tall tower in the shape of a dodecagon. The construction of this tower in this shape was proposed by Ghazan Khan himself (Ali Asl & Yousefifar, 2011, 73) and its shape and emphasis on centrality immensely influenced the shape of Ghazanieh town (Norzamani, Zahedi, Motaghedi & Mirgholami, 2014, 6). Therefore, it is possible to deduce the reflection of the principle of good shape in the design of Ghazanieh. Based on the reconstructed plan of Rab'e Rashidi (Fig. 11) as well as related texts, in addition to Rab and Shahrestan, Rab'e Rashidi had several villages and a vast garden adjacent to these sections, where a particular group of people of a specific ethnicity lived and worked (Omidiani, 1999). Rashidi Shahrestan

was a garden city as there were numerous gardens inside and around it. These gardens had a great role in the urban system of the Shahrestan as gardens provided food, fuel, water, and the city's existence depended on them (Saeednia, 2000). The concept of the garden city revolves around compatibility with and respect to nature as well as making optimum, favorable use of it. Rab'e Rashidi was adjacent to Rashid Abad garden from the north and Fath Abad garden from the south, both of which were integral parts of the city. These gardens and the city formed a complex in terms of irrigation and water supply systems (ibid.).

According to the endowment letter of Rab'e Rashidi and the history of Mubarak Ghazani, beautiful gardens such as Fath Abad, Mokhtar Abad, Jalal Abad, Hir Abad, Din Abad, and Najm Abad added to the splendor and beauty of summer palaces, houses, and mansions located in the middle of Rashidieh. Abbas Abad was the largest garden of Rashidieh palace (Kashani, 1969, 116). It seems that Rashid al-Din's goal in constructing gardens that encompassed palaces and houses was to create the divine paradise on the Earth (Ajourloo, 2013).

Rashidieh attracted many historians and tourists of the eighth and ninth centuries AH due to its splendor and majesty (ibid.). In Tazkira-e-Shoara-e Samarghandi, the grand mosque of this city is likened to Mount Qaf, whose dome pierces the sky (Dolatshah Samarghandi, 1855). From these facts, we can infer that the design of Rab'e Rashidieh reflects the principle of good shape.

• Local symmetries

According to Alexander's theory, there is a bilateral relationship between local symmetry and a living center. Local and global symmetries supplement each other and create a wholeness; as, on one hand, the most interconnected and coherent patterns have the largest number of local symmetries, and, on the other hand, symmetric sections are necessary to turn a shape into a whole (Alexander, 2011, 154-164). The reflection of the principle of local symmetries by Rab'e Rashidi and Ghazanieh can be

inferred based on a miniature of the palace, rampart, and dome of the Ghazanieh complex (see Fig. 11), the plan of Ghazani dome reconstructed by Wilber (see Fig. 11), plans of dodecagon-shaped spaces of Ghazanieh (see Fig. 11), and accounts stated in historical texts, the land subdivision based on the central core, main aisle (the passage that leads the central core), and bazaar (Hamadani, 1977, Chapter 1 & 2; Hamadani, 1994, Letters of 51 & 53) and the reconstructed scheme of Rab'e Rashidi (Fig. 12).

• Simplicity and inner calm

According to Alexander's theory, the wholeness of a living structure is simple and unostentatious, often emerging in simple and geometric forms; however, this property is achieved through maintaining necessary elements and omitting the rest (Alexander, 2011, 189-192).

The main axes of the city (passages), including the bazaar and aisle, perpendicular to each other, formed the bone structure of the city (Hamadani, 1977, Chapters 1 & 2).

Therefore, the reflection of the principle of simplicity and inner calm by the design of Ghazanieh can be inferred. The city had a geometric order and resembled a chessboard designed around the two main axes. In terms of spatial design, roads were in solid connection with the adjacent physical spaces, and their spatial nature was not disconnected from these spaces (Belali Oskoui et al., 2010, 71). Hence, the design of Rab'e Rashidi reflects the principle of simplicity and inner calm.

• Levels of scale

According to Alexander's theory, structures that encompass elements of various sizes gathered together harmoniously with bordered surfaces create a profound feeling of living surfaces and centers (Alexander, 2011, 112-117). According to the sketch of Ghazanieh, the dome was reconstructed based on historical accounts (Fig. 13) and because the city accommodated elements with different functions, including services, economic, social ones, situated based on the hierarchy and principle of the neighborhood (Hamadani, 1994, 35; Hamadani,

1989, 190; HĀFEẒ-E ABRU, 1972, 231), different components of the city with different scales, including the central core, Shahrestan, the axis of the bazaar, Ghazan tomb, mosque, schools, Dar-al-Sayyadeh, Beit-al-Kotob (library), Beit-al-Ghanun (law house), Beit-al-Motavalli (house of trustees), Hozkhaneh, Garmabeh-e-Sabil (Public Bathroom), palaces, and a garden famous as Adeliyeh, formed the spatial organization of Ghazanieh. Based on this information, it is possible to deduce the reflection of the principle of levels of scale by Ghazanieh.

Regarding Rab'e Rashidi, the schematic plan illustrated in Figure 14 depicts the regular texture of Rashidieh town. Moreover, the endowment letter of Rab'e Rashidi stated that this town was surrounded by various facilities, such as Seyfi mosque, Shatavi mosque, Dar-al-Mushaf, Kotob-al-Hadis, Beit al-Ta'lim, Dar-al-Ziyafeh, Dar-al-Shafa, Beit-al-Kotob, Dar al-Zarb, Dar al-Hojaj, Dar al-Sayadeh, Dar al-Sana'i, monastery, Dar al-Quran, Dar al-Hefaz, schools, a textile workshop, a paper workshop, a caravanserai and a bazaar with more than 1500 rooms. The section of Shahrestan also consisted of Olama alley, Tolab alley, and Moalejan alley, a water storage room, and a laundry house. Other facilities such as gardens and mills and six gardens should be also mentioned (Hamadani, 1934, 42). Therefore, it is possible to deduce the reflection of the principle of levels of scale in the structure of Rab'e Rashidi and Ghazanieh.

• Alternating repetition

One way for the center to support its life is alternating repetition which means a kind of parallel and alternating tone intensified through primary centers' rhythm (Alexander, 2011, 127-133). According to the diagram of Ghazanieh (see Fig. 13), Ghazanieh which accommodated Ghazan tomb, mosque, schools, Dar-al-Sayyadeh, Beit-al-Kotob (library), Beit-al-Ghanun (law house), Beit-al-Motavalli (house of trustees), Hozkhaneh, Garmabeh-e-Sabil (Public Bathroom), palaces, and a garden known as Adeliyeh, reflected the principle of alternating repetition. Figure 14

illustrates the reconstructed plan of Rab'e Rashidi based on historical texts. According to this plan, the repetition of elements in Rab'e Rashidi includes Rab'e Rashidi, Rashid Abad garden, Aslan garden, Fath Abad garden, main aisle, bathhouse, Mosalla, Khaghaz Khane, grand mosque, laundry room, Latif Abad neighborhood, Salehiyeh neighborhood, Upper Rabz, Lower Rabz, Rom Gate, Moghan Gate, Tabriz Gate, and Iraq Gate. As a result, it is possible to reason the reflection of the principle of alternating repetition in the design of Rab'e Rashidi.

• Echoes

According to Alexander's theory, echoes appear when smaller elements and centers which make bigger centers are formally members of a family and this causes their coherence and unity (Alexander, 2011, 218-221). According to the sketch of Ghazanieh, the dome was reconstructed based on historical accounts by Jafar Oglu Ghiyasi (see Fig. 13). as well as other reconstructed plans of Rab'e Rashidi, it is possible to observe the continuity and integrity of the structures of Rab'e Rashidi and Ghazanieh and deduce the reflection of the principle of echoes.

• Deep interlock and ambiguity

According to Alexander's theory, a structure enjoys the principle of deep interlock when centers connect and it is hard to separate them from their respective adjacent centers. Interlock and ambiguity are achieved upon the entanglement of centers with their respective adjacent ones or when important points belong to their centers and the surrounding ones in the space as well (Alexander, 2011, 162-165). According to a miniature of the palace, rampart, and dome of the Ghazanieh complex based on the Jami' al-tawarikh of Rashidi (see Fig. 13) and reconstructed plan of Rab'e Rashidi (Fig. 14), the design of Rashidieh was such that as if there were another city within the city itself (Ajourloo, 2013), and roads were in solid connection with the adjacent physical spaces, and their spatial nature was not disconnected from these spaces.

The location of spaces and activities in the city was

subject to order and hierarchy, and all spaces in terms of function often provided a suitable body for living and being in the environment (Noghrekar et al., 2013, 57). Hence, the reflection of the principle of deep interlock and ambiguity by Rab'e Rashidi and Ghazanieh can be inferred.

• Not -Separateness

According to Alexander's theory, this is the most important property of a living structure. Not-separateness is achieved when a living whole emerges as a part of the world as it is incorporated into the surrounding and not separable from it (Alexander, 2011, 193-197).

Based on the spatial diagram of Ghazanieh (see Fig. 13) (Nurzamani et al., 2014), the elements of Ghazanieh were as follows:

1. Grand dome of Tomb;
2. A void around the tomb;
3. Aliyeh palace, grand mosque, monastery, Shafeiyeh mosque, Hanafieh mosque, monastery, hospital, Beit-al-Ghanun, observatory, library, and Hozkhaneh;
4. Ghazani bazaar;
5. Gardens;
6. Urban facilities, Bath, and caravanserai;
7. Twelve gates of Ghazanieh. Hence, the reflection of not-separateness by the design of Ghazanieh can be reasoned.

Based on the reconstructed plan of Rab'e Rashidi (see Fig. 14) (Oskuyi Balali, 2011), the elements of Rab'e Rashidi included:

1. Rashidi town,
2. Meftah-al-Abwab,
3. Bazaar,
4. Main aisle,
5. Neighborhoods,
6. Mosalla,
7. Rab,
8. Paper factory,
9. Mosque. The city enjoyed unity and coherence as well as spatial and functional diversity (Hamadani, 1977, 41-43).

Also, roads were in solid connection with the

adjacent physical spaces, and their spatial nature was not disconnected from these spaces. The location of spaces and activities in the city was subject to order and hierarchy, and all spaces in terms of function often provided a suitable body for living and being in the environment (Noghrekar et al., 2013, 57).

Rab'e Rashidi, as the religious and scientific core of the city, encompassed numerous elements, such as Bab-al-Abwab, Meftah-al-Abwab, Dar-al-Ziyafeh, Minaret, spatial monastery, spatial shrine, Sabat, Dar-al-Shafa, and Seifi mosque, all of which functioned as the centers with living structures. Similarly, the Shahrestan also encompassed several elements with living structures, including residential neighborhoods, bazaar, mosque, Bath, caravanserai, barracks, Kaghazkhaneh, mint, Dar-al-Masakin, and roads as well as other components of Rab'e Rashidi, including the axis of the bazaar, the axis of aisle, rampart, gardens, city entrance, etc. The relationship between the Rab and its elements with Shahrestan and its elements immensely affected the integrity and not-separateness of the complex. According to historical documents, in Rab'e Rashidi, public and buildings were located next to the main aisle, which played an important role in creating the chessboard-like texture of the city, or in other words, organizing other elements and spaces of the city. This aisle started to spread from one gate to the other one. All spaces in this city enjoyed their own unique characteristics and together created the desired unity and integrity and achieved wholeness. As a consequence, the reflection of the principle of not-separateness in the design of Rab'e Rashidi can be inferred.

• Contrast

According to Alexander's theory, conflict in a living structure, achieved through the coexistence of contrasting qualities, such as the use of black and white as well as full spaces and void, can result in its stability. However, in creating such centers, the integrity and cohesion of the spaces should not be undermined (Alexander, 2011, 200-204).

As illustrated in the spatial diagram of Ghazanieh (Norzmani et al., 2014), (see Fig. 13), there was a void between the full spaces of the tomb and Upper Rabz. The balance of full and vacant spaces (Hamadani, 1977) indicates the reflection of the principle of contrast in the design of Ghazanieh.

Based on the plan illustrating the spaces of Rab'e Rashidi (see Fig. 14) (Kaynejad & Belali Oskui, 2011), the structure of Rab'e Rashidi included closed, open, and semi-open spaces, so we can deduce the reflection of the principle of contrast in the design of Rab'e Rashidi.

• Gradients

According to Alexander's theory, moving through space and hierarchy with a gradual change of distance, size, intensity and features make a proper ground for the creation of strong centers. Hierarchy creates a variety of centers and reveals its internal wholeness (Alexander, 2011, 205-209). Based on the spatial diagram of Ghazanieh and its twelve spaces reconstructed based on the History of Vassaf and Jami' al-tawarikh of Rashidi (see Fig. 13), the elements of Ghazanieh were as follows:

1. Grand dome of Tomb;
2. A void around the tomb;
3. Aliyeh palace, grand mosque, monastery, Shafeiyeh mosque, Hanafieh mosque, monastery, hospital, Beit-al-Ghanun, observatory, library, and Hozkhaneh;
4. Ghazani bazaar;
5. Gardens;
6. Urban facilities, Bath, and caravanserai;
7. Twelve gates of Ghazanieh (Norzamanie et al., 2014). Considering the adherence to hierarchy in passages in the city and its neighborhoods and the fact that the city accommodated elements with different functions, including services, economic, social ones, situated based on the hierarchy and principle of the neighborhood (Hamadani, 1994, 35; Hamadani, 1989, 190; HĀFEZ-E ABRU, 1972, 231), the reflection of the principle of gradients in the design of Ghazanieh can be inferred.

According to the hypothetical scheme of Rab'e

Rashidi (see Fig. 14) and historical texts, Rashidieh neighborhoods and streets were defined and designed based on the location and degrees and activities of different classes of scholars and students (Ajourloo, 2013). The location of spaces and activities in the city was subject to order and hierarchy (Kaynejad & Belali Oskui, 2011). Hence, the reflection of the principle of gradients in the design of Rab'e Rashidi can be inferred.

• Roughness

According to Alexander's theory, roughness is achieved when similar designs are not located in the same place. However, the roughness of a design should not be measured and deliberate in order not to undermine the creation of strong centers (Alexander, 2011, 210-217). According to the descriptions of Khajeh Rashid-ud-Din Hamadani from the architectural spaces of Sham Ghazan based on its endowment letter, several facilities and buildings with various functions were located in this city in addition to the Ghazan tomb (Hamadani, 1994, 988-1002). In Ghazanieh, each urban space had its own unique features and distinguished itself from other spaces. To enhance the unity, various spaces of a city should emit the same feeling, and a balanced distribution of buildings in the main passages -in addition to the city center- indicated this characteristic of them. Therefore, the reflection of the principle of roughness in the design of Ghazanieh can be inferred. Considering the combination of religious practice with cultural, educational, and medical functions in Rab'e Rashidi (Hamadani, 1994, letters 51 & 53), accommodation of elements with different functions, including services, economic, social ones, situated based on the hierarchy and principle of the neighborhood (Hamadani, 1994, 35; Hamadani, 1989, 190; HĀFEZ-E ABRU, 1972, 231), the coexistence of vase green spaces and building (Hamadani, 1989, Letter 51), and the fact that Rashidi Shahrestan was composed of different neighborhoods and important urban elements such as bazaar, Qaisaria, baths, mosques

(Noghrekar et al., 2013, 54), each urban space in Rab'e Rashidi had its own unique features and distinguished itself from other spaces. To enhance the unity, various spaces of a city should emit the same feeling, and a balanced distribution of buildings in the main passages -in addition to the city center- indicated this characteristic of them. Hence, the reflection of the principle of roughness in the design of Rab'e Rshidi can be reasoned.

• The void

According to Alexander's theory, another element effective in the creation of living centers is the void between them. The void creates calm and tranquility absorbs the energy emitted from centers and strengthens and better defines the regular, geometric spaces (Alexander, 2011, 186-188). As illustrated in the spatial diagram of Ghazanieh (see Fig. 13), there was a void around the full spaces of the tomb, and between Upper Rabz (Adelieh palace, grand mosque, monastery, Shefieh and Hanafi schools, hospital, Beit-al-Ghanun, library, observatory, Hozkhaneh) and grand dome-tomb served as a positive space. Therefore, it is possible to deduce the reflection of the principle of the void in the design of Rab'e Rashidi.

According to the reconstructed plan of Rab'e Rashidi (Kaynejad & Belali Oskui, 2011), (see Fig. 14), there was a void between the full spaces. Hence, it is possible to deduce the reflection of the principle of the void in the design of Rab'e Rashidi.

Conclusion

This study assumed that fifteen principles of Christopher Alexander's living structure theory are reflected in the pre-devised design of some Ilkhanid cities of Abwab-al-Berr, namely Ghazanieh and Rab'e Rashidi, and posed this question that how generalizable these principles are to the structure of these cities. We assessed the spatial organization of Abwab-al-Berr in terms of these principles and proved the hypothesis of this study. In other words, the pre-designed structures of Ilkhanid Abwab-

al-Berr (Rab'e Rashidi and Ghazanieh) were compatible with these principles (Table 1-2).

The conclusions of this study can be arranged as follows:

1. The architecture and urban design of Abwab-al-Berr reflected the interaction of these fifteen principles, which assured the order and so-called living quality of the sublime and magnificent architecture of Ilkhanid utopia. Emerging repeatedly in the structure of these cities, these principles, which are not independent of each other and interact and blend harmoniously, are as follows: namely levels of scale, strong centers, boundaries, alternating repetition, positive space, good shape, local symmetries, deep interlock and ambiguity, contrast, gradients, roughness, echoes, the void, simplicity and inner calm, and not-separateness.

2. The compatibility of fifteen principles of Alexander's living structure theory with naturally developed cities have been speculated; however, this study investigates the compatibility of these principles with the spatial organization of two cities of Abwab-al -Berr, namely Rab'e Rashidi and Ghazanieh, both constructed and developed based on pre-designed plans. The concluded compatibility can help form a potentially successful approach for designing modern-day cities, often developed to lack order and living quality.

According to the information on the spatial organization of Rab'e Rashidi collected from historical documents, this city had two powerful centers, namely Rab and Shahrestan, and two axes perpendicular to each other, namely bazaar and main aisle. These two axes defined the rectangular organization of the city. Also, the axes and centrality of the tomb and roads enhanced the symmetry of the complex. Rashidi Shahrestan was under the strong centrality of Rab'e Rashidi, and the Rab itself enjoyed the influence of the shrine and two smaller centers of Dar-al-Shafa (hospital) and Monastery, together surrounded with a rampart with several gates. The shrine included Beit-al-Ta'lim and Dar-al-Kotob as well as two mosques. The repetition

Table 1. Summary and reflection of fifteen principles of Christopher Alexander's living structure theory in the spatial structure of Abwab-al-Berr extracted from historical Sources. Analysis: Authors based on historical documents.


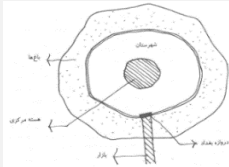
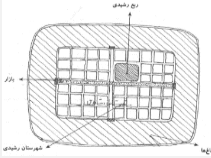

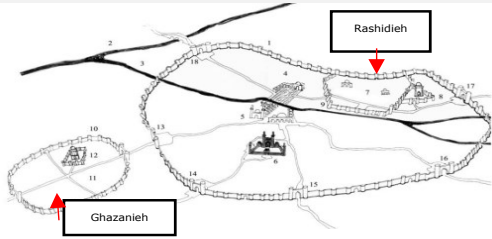

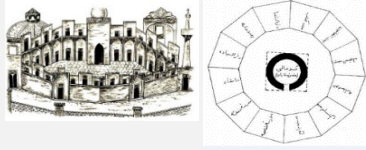
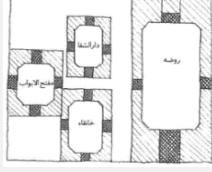




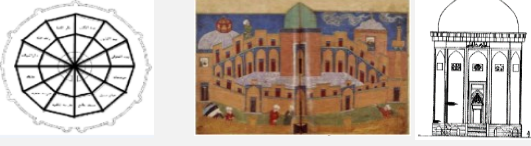
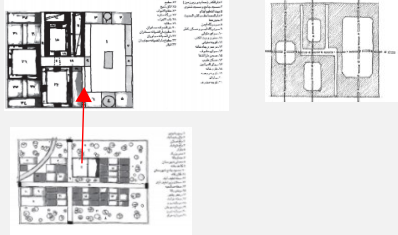

The principle	Ghazanieh	Rab'e Rashidi
1. Strong Centers 	 <p>Fig. 4. Ghazanieh Spatial structure. Source: Noghrekar et al., 2013, 57.</p>	 <p>Fig. 5. Rab'e Rashidi Spatial structure. Source: Noghrekar et al., 2013, 57.</p>
2. Boundaries 	 <p>Fig. 6. Rashidieh and Ghazanieh rampart, structural and military reconstruction of the Ilkhanid capital based on the organized relationship between Tabriz and the two satellite towns of Rashidieh and Ghazanieh, based on historical narrations, Hypothetical design by Jafar Oglu Giyasi. Source: Ajorloo, 2013, 22.</p>	
3. Positive Space 	 <p>Fig. 7. Right: Ghazanieh diagram and the twelve spaces around it based on the Jame-al-Tavarikh Rashidi and Tarikh-al-Vassaf. Left: A design of the Ghazanieh based on a miniature of Rashid al-Din's time (from the book Gardens and Parks of Azerbaijan). Source: Shekari Nairi, 2005.</p>	 <p>Fig. 8. Hypothetical scheme of Rashid Rab reconstruction by Kaynejad & Belali Oskui, 2011.</p>
4. Good Shape 	 <p>Fig. 9. Reconstructed sketch based on historical narrations, Hypothetical design by Jafar Oghlu Giyasi. Source: Ajorloo, 2013, 11.</p>	 <p>Fig. 10. A scheme of the reconstruction of Rab'e Rashidi. Source: Kaynejad & Belali Oskui, 2011.</p>
5. Local Symmetries 	 <p>Fig. 11. Right: the reconstruction scheme of the Ghazanie dome. Source: Wilber, 1986. Middle: A miniature of the pavilion, fence and high dome of the Ghazanieh collection taken from Jami al tavarikh. Source: Ajorloo, 2013, 20. Left: drawings of the twelve spaces of Shanb-e-Ghazan. Source: Source: Shekari Nairi, 2005.</p>	 <p>Fig. 12. Hypothetical scheme of the reconstruction of Rab'e Rashidi above - Rashidi "Rab" design, bottom - Rashidi "Shahrestan" scheme. Source: Kaynejad & Belali Oskui, 2011.</p>
6. Simplicity And Inner Calm 		

Table 2. Summarizing and Reflecting the Fifteen Principles of the Christopher Alexander's Living Structure Theory in the Spatial Organization of Abwab-al-Berr extracted from historical sources Analysis: Authors based on historical documents

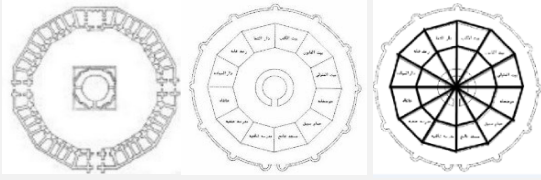
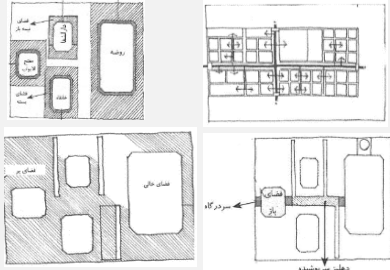


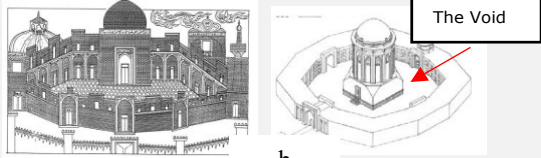
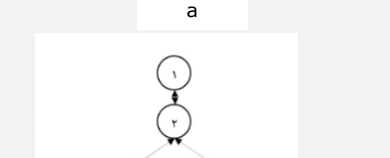
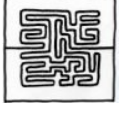
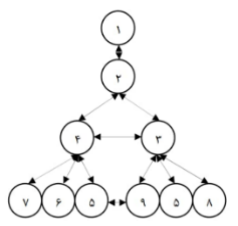

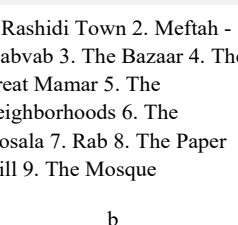

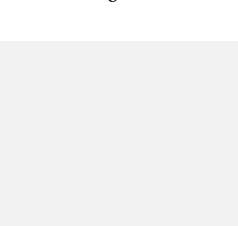

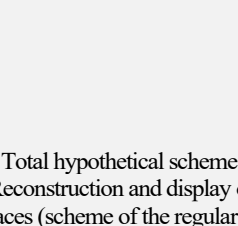

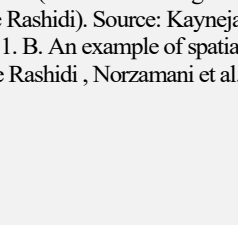

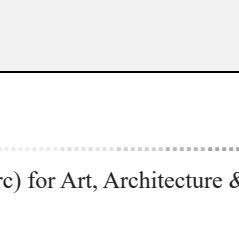
The principle	Ghazanieh	Rab'e Rashidi
7. Levels of Scale		
8. Alternating Repetition		
9. Echoes		
10. Deep Interlock And Ambiguity		
11. Not Separateness		
12. Contrast		
13. Gradients		
14. Roughness		
15. The Void		

Fig. 13. A: Re-reading of Ghazanieh in Tabriz, reconstructed sketch of Ghazanieh dome based on historical narrations.

Source: Shekari Nairi, 2005, 79. B Right: Sketch reconstructed from Ghazanieh dome based on historical narrations based on historical narrations by Jafar Oghlu Giyasi. Source: Ajorloo 2013. B Left: A miniature of the pavilion, rampart and great dome of the Ghazanieh complex, taken from the comprehensive book of Rashidi Chronicles. C: Ghazanieh spatial diagram. Source: Norzamani et al., 2014.

Fig. 14. a. Total hypothetical scheme of Rab'e Rashidi Reconstruction and display of Rab'e Rashidi spaces (scheme of the regular texture of Shahrestane Rashidi). Source: Kaynejad & Belali Oskui, 2011. B. An example of spatial relations of Rab'e Rashidi, Norzamani et al., 2014.

of elements was obvious in these spaces, and there was a correlation between the spaces, roads, and other elements of the complex, which caused unity and not-separateness. The different functions of each element reflected the quality of contrast, and the architecture and ornaments gave the complex quality of roughness. The coexistence of full and vacant spaces in the plans as well as closing/opening and widening/narrowing nature of the spaces defined the contrast developed within the complex. There was a void between the monastery, Dar-al-Shafa, shrine, Moftah-al-Abwab in Rab'e Rashidi. The coexistence of natural and artificial elements, the formation of the complex around the center of Rab, the geometrical shape of the complex, and the symmetry and unity of other elements enhance the quality of good shape as well as simplicity and inner calm of Ghazanieh. The fact that elements with similar shapes but various sizes were repeated in the city created the quality of echoes.

3. According to the data collected from the context of historical documents, Ghazanieh comprised the "central core" and "Shahrestan" as well as the axis of the "Ghazani Bazaar" along the Baghdad Gate. In this complex, in addition to the tomb, there were numerous facilities and buildings with various functions that strengthened and reflected the principle of the strong centers. The centrality of Ghazan tomb, the geometrical shape of the complex, the axis of the bazaar and its roads, and the twelve spaces around the tomb enhance the local symmetry. Other facilities, such as the grand mosque, a monastery for dervishes, a school for Shafis, a school for Hanafies, a hospital, and a palace for administrative affairs and laws made by Ghazan Khan used for archiving documents, a library, an observatory, a Hozkhaneh, bathes, accommodations for Sadat, a palace and a garden called Adelieh, were constructed around the tomb and formed the central core and Upper Rabz. The repetition of these elements with hierarchy and at different levels of scales reflected the qualities of alternating repetition and levels of scales, and the different

functions of these elements created the quality of contrast. The whole complex enjoys integrity and interlock. Considering the gardens around the complex and construction of caravanserais, the bazaar, and a bathhouse in the garden in the suburbs of Ghazanieh, we can conclude that the fact that the elements with similar shapes but various sizes were repeated in the city created the quality of echoes and alternating repetition. There was also a void between the Ghazan tomb and Upper Rabz (see Fig. 13), which can be regarded as a positive space. In general, the Ghazanieh complex enjoyed the qualities of good shape as well as simplicity and inner calm due to the coexistence of artificial and natural elements as well as the centrality of the tomb, the geometrical shape, and symmetry and integrity of other elements.

To conclude, the reflection of the principles of Alexander's living structure theory in the control examples of Ghazanieh and Rab'e Rashidi can be deduced. Furthermore, we can conclude that the Abwab-al-Berr complex of the Ilkhanid era enjoyed some principles in their pre-designed structure that rendered the complex living.

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