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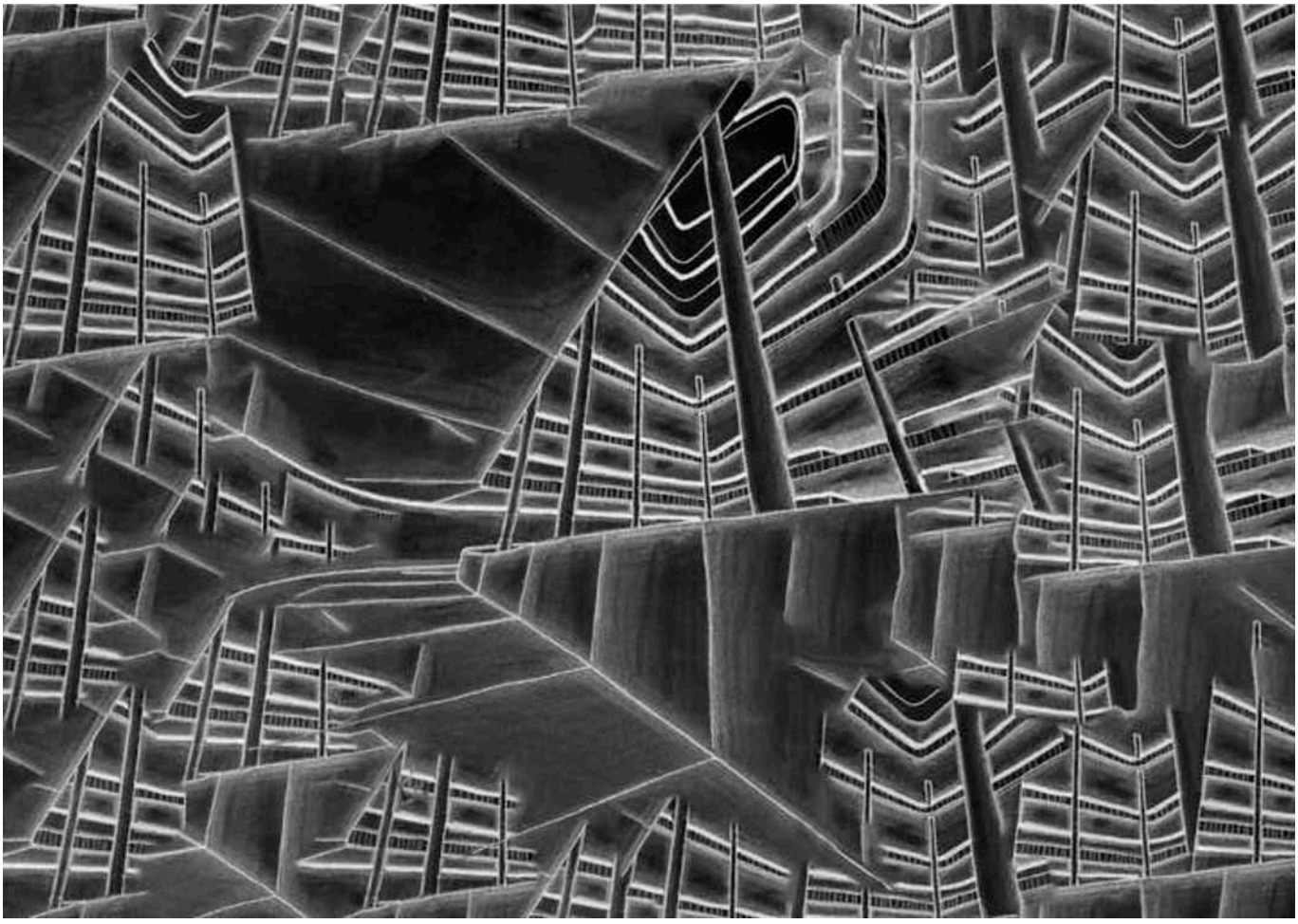

VISUAL & PERFORMING ARTS | RESEARCH ARTICLE

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The experience of movement in the built form and space: A framework for movement evaluation in architecture

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Abstract: "Movement in architecture" is an organized system of various types of movements stimulated by specific architectural elements. This research was conducted through a qualitative-analytical method and empirical and bibliographical research methods with the aim to categorize different types of movements based on the explorer and observer relationships with the built space and form. So far, most of the related studies have focused on a few aspects of movement. In this article, the author tries not only to address circulation in architecture and visual movements but also the physiological psychology of motion, pictorial representation, and natural factors. The physical movement of built form and space is also considered more coherently and comprehensively, along with all stimulus factors and elements. Subsequently, this research presents a taxonomy in the form of an assessment table correlating with various types of movements along with their generator factors and architectural elements. The article conceptions are justified by a comparative analogy between two bridges: Khaju and Tabiat, representing 17th century and contemporary Iranian architecture, respectively.

Mosleh Ahmadi

ABOUT THE AUTHOR

Mosleh Ahmadi is an architecture scholar and researcher who received a B.Arch. and a M.Arch. from Islamic Azad university (Sanandaj branch) in 2015 and 2017. His previous published papers are mainly focused on architectural theory and designing and his main interest is study and research on interdisciplinary subjects of architecture, space architecture, and psychology.

PUBLIC INTEREST STATEMENT

All objects from atoms to the universe contain and represent motion. Architecture, an invented convenience in relation to human and environment, despite its static appearance manifests movement, too. In this sense, architecture comprises even more complex movements including 1. environmental currents (water, wind, and light) and aesthetic motions (sculpture, etc.); 2. the movement embedded or represented in the constitutes of architecture (form and space); and 3. human traverse and promenade consisted of spiritual, physical, and mental movements. These various types of movement are interconnected with the factors (e.g. rhythm, depth, geometry, etc.) and architectural elements (e.g. path, symbol, kinetic element, etc.) of movement in order to be stimulated. The aim of this paper is to explore and investigate these subtle relationships and interconnections in order to create a taxonomy for evaluating movement in buildings. Afterward, two bridges in Iran from deferent periods of time (traditional and contemporary) will be compared using these notions.

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Subjects: Iranian Studies; Environmental Psychology; Visual Perception; Built Environment; Architecture; Theory ofArchitecture; Building and Construction

Keywords: architecture; movement; form; space; Iranian bridge

1. Introduction

Apparently, movement cannot be related to architecture because buildings are static, but there is an analogy between architecture and dance that would enlighten this relation. This analogy can be derived from the research titled "*Placing Space: Architecture, Action, Dimension*" (Eisenbach, 2008), which is based on a collaborative workshop between architecture and dance students. Dancers move their body according to a particular set of rules and their movements are their way of expression. Despite dance, architecture expects the observer to move. This is the observer who must be in motion in order to experience and perceive the architecture. Inferred from *Architecture, Form, Space, and Order* (Ching, 2014), architecture owes its existence to form and space, whose perception owes a great deal to movement. Thereby, movement is a vehicle for understanding form and space. Plummer argues that:

> Ancient art represents the subject accordingly. And now: the experiences of a modern man, walking across the deck of a steamer; 1. His own movement; 2. The movement of the ship which could be in the opposite direction; 3. The direction and the speed of the current; 4. The rotation of the earth; 5. Its orbit; and 6. The orbits of the stars and satellites around it. The result: an organization of movements within the cosmos centered on the man on the steamer. (Plummer, 2016, p. 215)

By an empirical analogy to the Plummer's argument, it can be stated that "movement in architecture" is an organized system of various types of movements stimulated by architectural elements. The types of movements not only include physical movement of a person in space, which is related to physical coordinates, but also other movements that are associated with mental and sensational coordinates of an explorer in the architectural promenade as well as the physical coordinates of the building itself.

Architects have long been trying to employ movement in their works. With the development of new interests and schools in architecture, this tendency has been growing recently more than ever. As a result, many types of relative research have been conducted, whether by studying a specific factor or architectural element or by defining new taxonomies. Two diagrams most relevant to the scope of this research can be extracted from these studies. Architectural movements are categorized in these diagrams (Figure 1).

So far, some other studies have incompletely explored the experience of movement. They do not cover all aspects of movement in architecture: they have addressed just the experience of built space—"through sensation, perception, and association" (Perez de Vega, 2010)—or the role of circulation in buildings and cities to generate architectural form—"such as parallax, sense of space, relative velocity, and rhythm" (Brady Peters, Michael, 2001). Figure 1 and other examples introduced later are also part of these researches. I represent "movement in architecture" more comprehensively here.

The present research studies movement in the relationship between an explorer/spectator and the built form and space. It explores the complex and interconnected architectural movements. Furthermore, with a new approach, it aims to redefine these movements via a taxonomy in which movement interconnections would be depicted in detail. This study divides movement types into three major groups: (1) movement in relation to architectural form and space—where the existence of the explorer is not necessary and architecture involves embedded motion per se; (2) movement of a spectator in relation to the built form; and (3) movement of an explorer in relation to the built space. Making this exploration through an analytical approach, the researcher will

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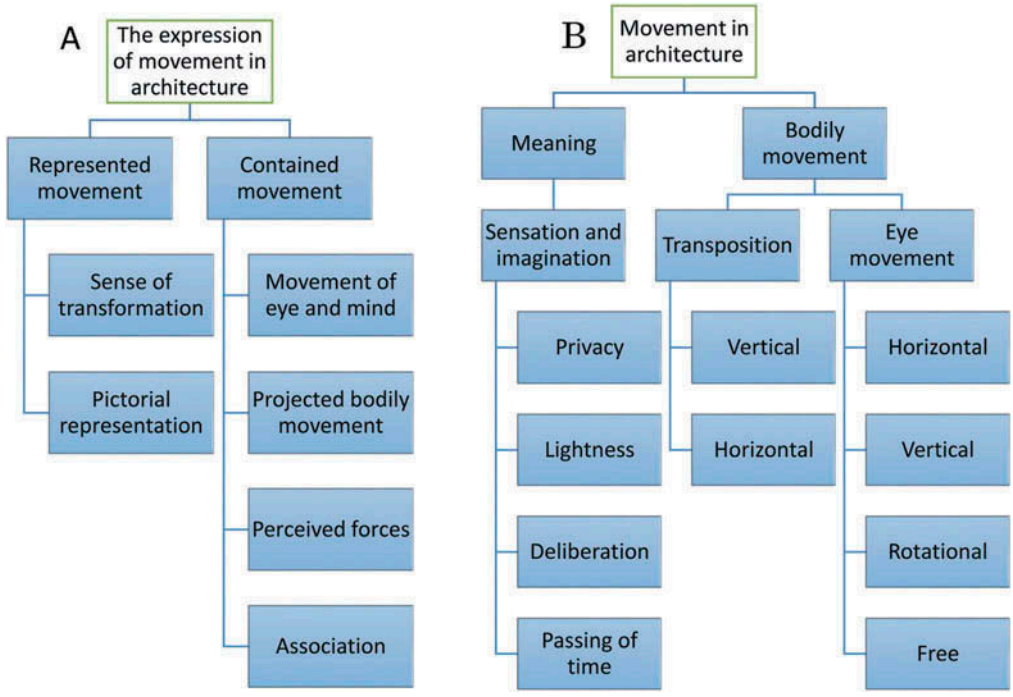

Figure 1. Diagrams of A (Hardy, 2011), and B (Mahdavinejad and Nagahani (1390/2011)) are two antecedent taxonomies based on the subject.

create a table of observations. This table correlates different types of movements to their generating factors and architectural elements.

2. Movement in architecture

Speaking of movement in architecture, the first thing that comes up is the existing movement in architectural form and space that has stemmed from architectural elements in motion. Then, the visual movement of a spectator followed by the physical movement of an explorer attracts the attention. There are other movements derived from the spectator's mind. There are some other movements in architecture that do not need the explorer's presence. It means that architecture involves motion, with or without the explorer. This type of movements is the potential or future movement imagined or kinetic movement embedded in architecture—a simple example of this movement is that of a mill in traditional houses. These movements would also influence architectural form and space, similar to the movement of natural and pictorial elements in architecture. Sculptures and paintings also express an inherent motion.

2.1. Kineticism

Kineticism in architecture has become ubiquitous with the advent of new technologies in the modern period. Architecture is being influenced by technology so that it receives even greater impact from kineticism. When "Revolving Buildings, Skin Unit Systems, Retractable Elements, and Biomechanical Systems" (Ramzy & Fayed, 2011) appeared, movement became enriched more than ever. "Revolving Buildings", which refer to a dynamic architecture in practices of architects like David Fisher (Jewell, 2017), are constructions in which motion is the main concept in their formation. These buildings provide various views to the spectators and residents as they revolve or rotate. Similar to revolving buildings, "Skin Unit Systems" involve movement in themselves, with the difference that movement is not expressed in the main bulk, but through kinetic elements embedded in the form or façade, e.g. "Skin Unit Windows". A "Retractable Element" in architecture is part of a building which can be mechanically retracted or protracted to transform the form due to some functional requirements. Another transformation which leads to movement in the form is caused by "Biomechanical Systems" in which natural forces are transformed into applied movement (e.g. Dynaflex p01 that changes the transparency of its glass strips based on the amount of light that strikes its surface) (Ramzy & Fayed, 2011).

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"Plug-in-City, Blow-out Village, Walking City, and Instant City" (Ching, 2011, p. 778) are some imaginary designs remaining from the modernists. They can be considered as other aspects of kineticism. These types of kinetic buildings are very similar to the abovementioned revolving buildings, with the difference that the movement in kinetic architecture is that of the built form, while movement in these designs occurs in the space. In addition, there is another sort of kineticism referred to as "Space Architecture"—namely Orbital Resort Hotel (Leach, 2014). Another example of this movability can be seen in Jacques Rougerie's design for the floating Marine Research Center (Mafi, 2015). This type of movement can be regarded as movable buildings or as the attribute of movability. As mentioned above, they have either remained as mere schemes or have been practiced limitedly.

2.2. Pictorial representation

As expressed by Hardy, pictorial representation refers to "figurative portrayal of movement (through sculpture, painting, etc.)" (Hardy, 2011). Thus, pictorial representation consists of sculpture, painting, and relief. Sculptures and relieves imply a sense of movement induced whether by proliferating patterns or potential or future movement imagined. In other words, a sculpture contained by space implies an action (Figure 2b). Likewise, particular relieves contain action and in this case, a figure is dominated by form—e.g. the Climbing Stair Soldiers in Persepolis located in Iran (Figure 2c). It would influence the surrounding space (Figure 2b). All objects are in motion. Similar to photography, a painting captures a certain moment of a particular sequence of motions. Therefore, like many other phenomena in nature, the event of movement can be painted. With that said, painting on walls, ceilings, or floors—mainly referred to as composing elements of the form—can be treated as an emanation of motion. Accordingly, sculpture and painting are regarded as types of movements instead of architectural elements of movement. It is because they depict a moment of a series of motions. As Arnheim echoed, "Psychologically, however, a statue is outside time. It does not remain the same or stand still" (Arnheim, 2004, p. 373). On the other hand, similar to sculpture or painting, modern buildings may feature a pictorial representation. Asefi highlights that some buildings are designed as a "Virtually Live Body". He has defined this as "Frozen Transformation" (Asefi, 2012) (Figure 2a). A building, in this sense, has to be seen and perceived in many facets. Despite its exposed structure, Tabiat Bridge provides various scenes from different points of view, similar to a living being.

2.3. The movement of natural factors

In addition to manifesting reviviscent properties in the architecture, the movements of natural elements are also fluid mechanisms. Stavridou refers to this as "Breathing Architecture" (Stavridou, 2015) when defining the role of air circulation. The movement of the main natural light sources is slow in the sky. Albeit, their travel path can be illustrated in the space. Creating certain openings in the form would depict the passage of light through the space.

Water and light have prominent roles in forming architecture, specifically in the traditional Eastern and Iranian architecture. Springs, pools, streams and other water-related architectural elements (Figure 3a) as well as openings and manipulations in the form—which create an altering space dominated by natural light in the space (Figure 3b)—display movement. As a result, they

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Source b: https://www.isna.ir/news/92012810945/
Source c: http://www.mustseepersia.com/sites/persepolis/

Figure 2. Pictorial representation. Frozen transformation in the form of Tabait bridge (a). Sculpture of a lion roaring in Khaju bridge; head of a human is bursting out of the lion's mouth which is the manifestation of its sound (b). Relieves in the stairs of Persepolis (c).

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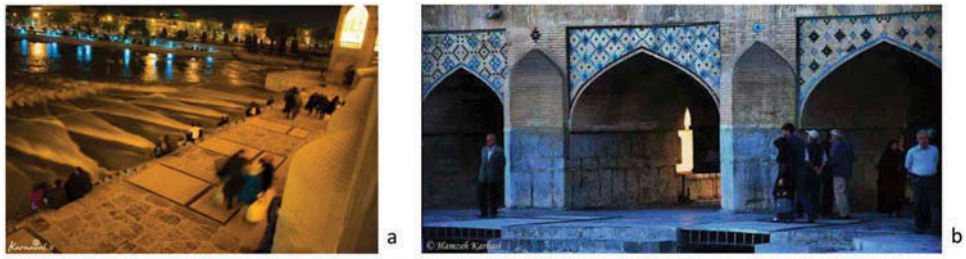

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Figure 3. The movement of natural contributors in Khaju bridge. The intensified stream of water: the pillars of the bridge would intensify the current of water by getting closer and creating narrower spaces between themselves at the exit of the current (a). Metaphoric lightened candles among arches: alternation in space made by beamed light on the form and through space. The candles start to appear at the certain angles of view (b).

decelerate and ultimately stop the circulatory movement of explorers by giving them a sense of peace. Further, they provide a chance to stimulate other types of movement. The circulation of water would also provoke the sense of hearing. In addition, as natural light changes color and direction during the day, it would transform the space and gives the sense of time passage. Salimi et al. have studied the role of light and water in architecture. They explain that:

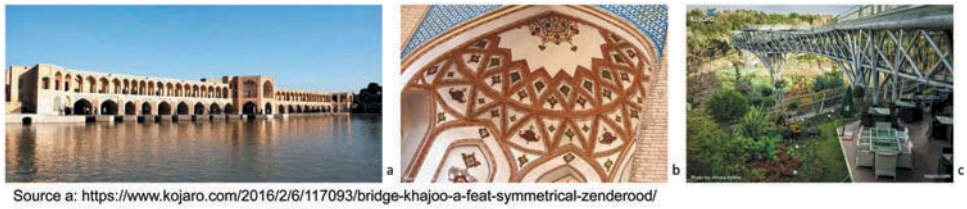
> An architect tries to make an interaction between man and nature in architecture by understanding the dynamic and changing nature of the environment and with awareness of the importance of light and water. (Salimi, et al., 2016)

They later discuss that light and water, in particular, are manifestations of some symbols like "purity" that provoke mental movement.

In addition to these applications of light, water, and wind in architecture, they are also capable of altering buildings—since they have "Contained Energy". This kind of transformation can be observed in primitive shapes which employ natural energies to represent applied movement in their form, e.g. in the mills. This can also be seen in the modern shapes as in biomechanical systems.

2.4. Visual movement

Visual movement is a type of physical movement. "The movement of the ocular muscles" along with "the projection of movement onto objects" are referred to as two ways of motion perception in the modern psychology (Stickells, 2010). Eyes move from one point to another point on the form to perceive the architectural form and its embedded details. With regard to this and according to diagram B in Figure 1, the movements of ocular muscles can be divided into four types. They can be detected in Khaju Bridge (Figure 4a and 4b) where horizontal movement across porches, vertical movement along pillars, rotational movement around ornaments, and free movement of the eye from form to form and through spaces are provoked. Free movement of the eye is the dominant



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Source c: http://cdn.bartarinha.ir/files/fa/news/1396/2/24/1244887_277.jpg

Figure 4. Visual movement. Ocular movement and projected movement (a), rotational movement (Shahneshin of Khaju's ornaments) (b). Free movement of the eye (Tabait bridge) (c).

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type of visual movement in observing Tabiat Bridge due to the proliferating pattern of its structural elements (Figure 4c).

In the opposite side of the real movement of the eye, there is the virtual movement which can be linked to "projected movement". In this regard, eyes are deceived by particular patterns creating an illusion of movement. The visual experience of movement, as explained by Arnheim, occurs because of three factors: "physical movement, optical movement, and perceptual movement". In addition, perceptual movement is defined to be correlated with several factors such as difference in "intensity", "variability" (in size or shape), and "enclosedness" properties of objects (Arnheim, 2004, pp. 379, 380). These differences perceptually make one object to be in motion compared to another object. A perfect example of this movement expressed by ornaments can be observed in the Islamic art. As a concept in the Islamic aesthetics, *Goshayesh* (Goshayesh, 1390/2011, p. 172) implies that movement can be expressed succinctly in some polarities such as shadow and light, complexity and simplicity, as well as curvilinear and linear lines. Hence, the polarity is a factor of movement. Accordingly, manipulations in rhythmic geometry, polarity (e.g. shadow and light), and intensified perspective would create a projected movement in the Khaju Bridge. Sometimes a different factor other than the aforementioned ones causes the projection of movement on the form. "Motion of the field" (Brady Peters, 2001) is a reaction to the movement of the observer (while standing on a kinetic element like an escalator or while the movement of body) that is referred to as "Parallax". Therefore, all of the architectural elements or factors related to transporting the observer's body could also cause parallax. Smooth surfaces can barely generate parallax. Thus, the architect needs to employ the same factors of creating projected movement in order to have the "motion of the field" generated. With that said, parallax and projected movement are totally interconnected.

2.5. Circulation

Circulation is a process that commences instantly by being present in an architectural place, and "whether we are conscious or innocent of this process, our bodies and our movement are in constant dialogue with our buildings" (Ching, 2014, p. 251). Body movement is a component of circulation as a product of the movement of an explorer in relation to the built space. This movement is divided into horizontal and vertical subdivisions. Alongside body movement, there is another movement which is associated with mind in the architectural space. "Projected bodily movement" (Hardy, 2011) is the process of imagining the movement of other creatures in space—whether human, object, or animal—e.g. imagining a body traversing up or down when encountering a spiral staircase. On the one hand, this movement is imaginary and should be sorted out in the mental or visual movement subset. On the other hand, however, this movement occurs in the space—more specifically, in the circulative spaces—and not in the form. Therefore, in this paper, it would be considered as related to the built space and as a corollary to circulation.

When we move through an architectural place, we would interactively affect the space around us and transform it because of circulation. In relation to this interactive relationship, Plummer argues that:

> The kinetic elements of buildings (doors, windows, shutters, and gates) that we are able to directly control and finely adjust with our fingers and hands, and sometimes our entire body, can give us the power to immediately alter the space around us in meaningful and desirable ways. (Plummer, 2016, p. 67)

This relationship is further illustrated in Figure 5, where a dancer appears to transform the space. It has been expressed in this quotation: "movement involves transformation in time" (Eisenbach, 2008) (Figure 5). Therefore, transformation is another by-product of circulation in the built space.

2.6. Mental movement

As thoughtful beings, the movement generated in our mind is much more complicated than that in our eyes and bodies. "Technical, and functional circulation, as well as narrativized aesthetic

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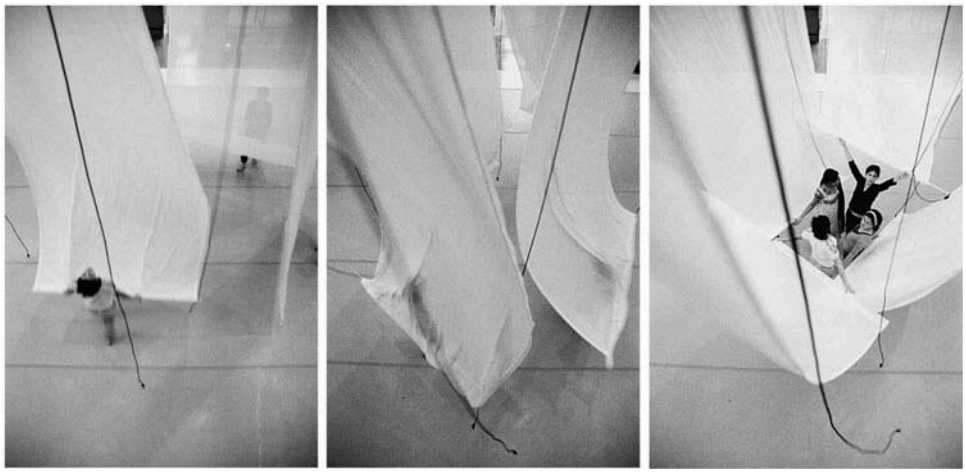
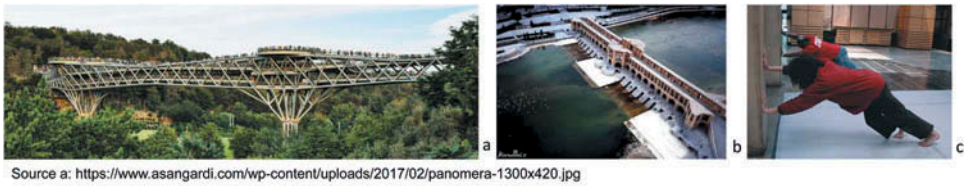


Figure 5. Transformation in space (Photo by Jackie Croussilat) (Eisenbach, 2008).

experience" are described as the attributes of "architectural promenade" (Stickells, 2010). Technical and functional circulations are discussed in the previous sections. What remains to complete this promenade is a narrativized experience.

Lawson describes narrative in architecture as "a kind of real-world theatrical set" (Lawson, 2005, p. 205). Of course, Lawson's expression is about designing tactics for creating a form. In fact, what is obvious is that a narrative originates from the spectators' minds, whether it is the same exact narrative of the architectural design which the designer has intended (Brittain-Catlin, 2016) or it belongs to the self-interpretation of the observer. Narrative is also manifested in Iranian architecture, where Rabi'ie (Rabi'ie, 1393/2014, p. 46) expresses that Iranian-Islamic architecture everywhere and in all times embraces narrative while employing various arrangements and manifestations. Accordingly, "Theatrical Set" could be interpreted as an ideal set of movements in architecture. In this article, the term "Narrativized Aesthetic Experience", which is related to the movement of a spectator in relation to architectural form, is referred to as "Mental Movement". This type of movement includes "Association" and "Perceived Forces".

Wally Shaw summarizes David Hume's arguments about the association of ideas and states that "resemblance, contiguity, as well as cause and effect" are principles of mental association (Shaw, 2008). He later brings some instances of these principles. What is inferred from these examples is that "Resemblance" and "Contiguity" are the two attributes of association through which the mental movement related to architecture can be emanated. If the observer already has knowledge about the event evoked by form, the resemblance and contiguity would be emanated. If not, it leads to "Meaning" in the spectator's mind (Pakzad & Bozorg, 1394/2015, p. 190). Hardy reiterates that "evocation of movement through association" (Hardy, 2011) plays a vital role in perceiving movement in architecture. In this respect, "Resemblance" in architectural movement can be referred to as the elements of architecture which are reminiscent of a particular occurring object or a creature in motion. When observing the configuration of Khaju Bridge from above, it resembles a flying eagle with spread wings (Figure 6b): rhythmic subtractions in the form represent feathers of its wings and a projected form (dais) at the middle of the bridge represents its head. On the



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Source b: https://www.karnaval.ir/khaju-bridge-isfahan-zayanderud

Figure 6. Mental movement in architecture. Imagined forces, and dynamism (Tabiat bridge) (a). Resemblance, and visual forces (Khaju bridge) (b). Depicting the tension of forces (Photo by Mercedes Afshar) (Eisenbach, 2008) (c).

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other hand, an explorer at a particular place might discover a connection between that place and a specific personal memory. It would stimulate the explorer to have a mental time travel. This can be called "Contiguity" in the architectural association. For example, bridges in the Islamic thought implicitly refer to the Sirat Bridge. Therefore, Iranian-Islamic bridges, including Khaju, would have the connotation of the Judgment Day for Muslims. They also give the sense of ascension (tendency to reach the heavens).

Despite physical forces that would cause motion in objects, there are some forces in the built form that are perceived psychologically by the spectator. Psychologists call them "Psychological Forces". In this sense, "Perceived Forces" refer to all psychological forces evoked in the observer's mind. These forces include "Inertia", "Dynamism", "Imagined Forces", and "Visual Forces".

Arnheim counts "Visual Weight" as an attribute which affects the equilibrium of the form (Arnheim, 2004, p. 23). Ching echoes this concept by defining "Visual Inertia" which explains the stability of forms (Ching, 2014, p. 35). Consequently, a low degree of visual stability in form creates a potential movement due to the expected gravitational force (e.g. the reverse pyramidal form of the Museum of Modern Art in Caracas).

"Immobile Motion" is a term expressed by Arnheim (2004, p. 423) which refers to a specific moment of an object in motion captured by an artist. Subsequently, this motion will be resurrected in the spectator's mind. This imagination of motion has been called "Dynamic Spirit" and "Aerodynamic Form" in Mendelsohn's work. It has been defined by such properties as "curvilinear non-Euclidean form, curved windows, and lack of frontality" attributed to Einstein's tower (Hart, 1995). "Dynamism" is a comprehensive feature of such forms.

The current of forces in a structure induces motion in the spectator's mind which is referred to as "Imagined Forces" in this study. To get a better understanding of this motion, Eisenbach has depicted the experience of this tension (Figure 6c). Arnheim has expressed this impression delicately:

> When the dancer lifts his arm, he primarily experiences the tension of raising. A similar tension is visually conveyed to the spectator through the image of the dancer's arm. (Arnheim, 2004, p. 407)

Using an analogy between dancing and architecture, it can be stated that the movement of forces through a structure can be visualized by a spectator—especially through the engineer's vision. It is because the structural elements of buildings can visually show how loads are transmitted to the ground (Ching, 2014, p. 129). Hardy reiterates this notion when he refers to "imagined muscular or mechanical forces, in equilibrium, tension, conflict, etc. (potential or future movement imagined)" (Hardy, 2011) as principles of movement. Regarding these ideas, the high-tech structure exposed in Tabait Bridge has manifested movement in two ways. First, through dynamism, also described as the skeleton of a dragon devouring the parks (Nedaie & Kameli, 1396/2017). Second, by illustrating the current of loads (Figure 6a).

"An observer sees the pushes and pulls in visual patterns" and "perceptually and artistically, they are quite real" (Arnheim, 2004, pp. 16–18). Considering that fact, if they are real, they would perceptually contain motion. Hardy (Hardy, 2011) has also argued that objects that are close to each other would illustrate an interaction repulsion. On the contrary, if they are at a distance from each other, they would show an attraction toward each other. He also attributes Gestalt to visual forces. Likewise, "Subtractive Form"—Subtraction—would fall among this type of movement. These are pieces of evidence of "Visual Forces". Ching brings the house at Stabio as an example. About subtractive forms, he then explains that:

> We search for regularity and continuity in the forms we see within our field of vision. If any of the primary solids is partially hidden from our view, we tend to complete its form and visualize it as if it were whole because the mind fills in what the eyes do not see. (Ching, 2014, p. 58).

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The porous forms of Khaju and Tabiat bridges exemplify this notion (Figure 6a and 6b).

2.7. Sensational movement

This section will deal with the possibility of movement evoked by the human spirit and senses—known as sensational movement. The sense of movement belongs to one of the nine senses of the human body. Taylor has argued that it is "the process by which the movements of different parts of the body relative to one another are perceived" (Taylor, 2009). Based on the notion of movement in architecture, the term "Sensational Movement" in this article refers to the inner experience of our bodies in the built space. Pallasmaa has explained that the forms expressed in architecture would be conceived in a collaborative process through our sensory organs and then would generate imagination and "Sensory Thoughts" (Pallasmaa, 2012, pp. 45-49). In other words, "Sensory Thoughts" are outputs of the presence of an explorer in the architectural space. With that being said, sensation is the movement of a soul in the space. The explorer's body can feel this movement in certain situations created by the built space. In this study, "Arousal", "Time Passage", and "Tendency" are counted as the components of sensational movement.

A subtle example of sensory thought that contains movement is Plummer's metaphor of Gothic churches described as "stone forests":

> … virtual and actual trails weave through and around thousands of slender marble spires, which foliate into screens and filigrees, catching and absorbing our vision, slowing us down but giving us choices on how we might scramble over the rooftops. (Plummer, 2016, p. 224)

As described, being in such spaces would give us a sense of ascension or tendency to reach the heavens (Figure 7a). Therefore, this sense could be infused by being present in a place with heightened vertical space or even by looking at elements which attract our attention to the sky. It is similar to what happens for an explorer in religious places (this is related to the explorer's own beliefs).

Patel explains how in certain conditions our brain receives chemicals from the body which would cause "readiness for action" (Patel, 2015). Architecture can create such conditions wherein an explorer could feel trapped motion in his own body. For example, in a direct inquiry, some explorers on Tabiat Bridge declared that they had a sense of excitement on the elevated bridge (over 40 m high) while passing through ramps placed at the edges of the bridge.

The two obvious parameters of movement are the passage of time and the object in space. Speaking of time, the fourth dimension explained by Einstein first comes to mind. He added the vector of "Time" as the fourth dimension to the three-dimensional space. Based on Bodish's explanations about this vector, in perceiving time, we have only a sense of its presence. Bodish explains that:

> Due to our being stuck in three-dimensional space, we cannot visualize a fourth-dimensional coordinate system, or what an object in the fourth-dimension would look like. (Bodish (2009)

Figure 7. Sensational movements. Sense of ascension encountering heightened spaces (a) (Photo by Jackie Croussilat) (Eisenbach, 2008), sense of tendency created by continuity, axis, and path (b) (Photo by Jackie Croussilat) (Eisenbach, 2008), sense of time passing (c) (Photos by Anita Chen) (Eisenbach, 2008).

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As an artistic attempt to visualize the fourth dimension, Cubism then absorbs our attention. "Construction of all the three-dimensional states of the four-dimensional figure" (Bodish, 2009) is a method of manifesting time in architecture employed by Cubist artists. Therefore, one way of considering time and, thus, movement in architecture is by creating different facets in the form that are in contrast with symmetrical facets of form in the classical architecture. However, this does not mean that classical buildings (old buildings) do not express time. Defining "Patina of Wear", Pallasmaa explains how old buildings would demonstrate the sense of time by the signs of antiquity in their styles, materials, technics, etc. He further calls them "Museums of Time" (Pallasmaa, 2012, pp. 34, 56). By creating particular conditions, the passage of time would also cause people to innovate new movements suitable for those conditions (Eisenbach, 2008) (Figure 7c). Events are the perceptual aspect of architecture (Psarra, 2009, p. 4). Therefore, these innovated movements would create events in architecture. In light of this knowledge, time can be sensed throughout architecture from another perspective, but the degree of its presence varies.

In the research by Shemesh, Bar, and Grobman (2015) exploring human reaction in various spaces, it has been concluded that people have particular feelings for every certain shape in the built space. These feelings evoke psychological tendency or the willingness to move towards that shape or within that space. The behaviorists believe that the built space stimulates our movement (Figure 7b) mostly through sensation and particularly through tendency. For instance, when an explorer is situated in a built space with a low degree of enclosure and with an intensified perspective toward a direction, he would sensually have a tendency to move toward that particular direction—even before starting the body movement.

3. Movement factors and elements in architecture

The aforementioned types of movement are correlated with architectural factors and elements which cause motion. This means that each of them is stimulated because of a certain factor (or an architectural element). Architectural elements are not just the visual elements of architecture. Rather, they are configurations which interact with memory (Pallasmaa, 2012, p. 67), thought, imagination, eye, and body. They are sometimes the manifestations of movement per se.

These elements are the most discussed subjects throughout the related literature. In some references, "continuity, sequence and flow" (Estremadoyro, 2003) as well as transparency are considered as the factors promoting movement. Rabi'ie argues that "sequence, hierarchy, and various private sanctums" (Rabi'ie, 1393/2014, p. 46) are of key factors in the Iranian-Islamic narrative—and thus in movement. More comprehensively, in his book titled *Architecture, Form, Space and Order*, Ching introduces "approach, axis, circulation space, path, the flow of space, elevated planes, hierarchy, rhythm, light, enclosure, opening, asymmetrical curved surfaces or multiple perspectives, as well as linear and radial geometry" (Ching, 2014, pp. 254, 11, 12, 351, 352, 294, 290, 156, 157, 114, 298, 363, 370, 187, 189, 184, 174, 177, 191-193, 44, 218, and 228) as the architectural elements and factors which contain movement or would stimulate it. Plummer would add "Threshold" to this list when he refers to ancient Japanese temples' gateways as "a stimulus to action" (Plummer, 2016, p. 198).

Sometimes a certain sensation compels the explorer to have a particular motion. Sense of "Reverence" is introduced as an attribute of movement behavior, as in Chogha Zanbil ziggurat. Respecting the sense of reverence, pilgrims in this ziggurat had to circle at least twice around the temple to reach the top (Goshayesh, 1390/2011, p. 201). Sense of reverence extended its role in Iranian-Islamic architecture. Prayers inside Sheikh Lotfollah Mosque have to enter the shabestan (main hall) in front of the altar after rounding about it through a hallway (Pirnia, 1392/2013, p. 298). Furthermore, Ching argues that:

> While the act of traversing up a stairway may convey privacy, aloofness, or detachment, the process of going down can imply moving toward secure, protected, or stable ground. (Ching, 2014, p. 298)

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Regarding these notions, senses of "Security" and "Privacy" can be considered as psychological motivations for one moving from one place to another.

Pallasmaa has argued about an architecture of "Sensory Experiences". He instances an architecture in which senses like somatosensation and vision could cause body movement (Pallasmaa, 2012, p. 75). Identically, these senses in addition to olfaction, gustation, and audition are able to compel various types of movements when they are employed by an architect.

Figure 8 illustrates the most frequent factors and architectural elements found in the case studies (Figure 8).

As already noted, various factors and architectural elements might work together to motivate certain type(s) of movement, as in Scala Regia (Vatican staircase) designed by Bernini. Studying ramps, Stickells (Stickells, 2010), on the other hand, clarifies that the role of ramp can be more prominent than being just a mere circulatory element of architecture. Therefore, a single ramp can motivate and manifest various types of movements, as other factors and architectural elements can do the same.

4. Discussion

This study investigated movement in architecture throughout various documents dealing with relationships among space, form, and observer (or explorer). It was shown that different factors are involved in expressing movement in architecture. Also, diverse types, factors, and architectural elements of movement were explained.

The reasons for the presented approach for categorizing movement is as follows: First, mental and visual movements are caused and stimulated by the form while circulatory and sensational movements are motivated by being present in the space. Besides, there are other movements in architecture which are not related to the explorer's presence. It means that architecture involves

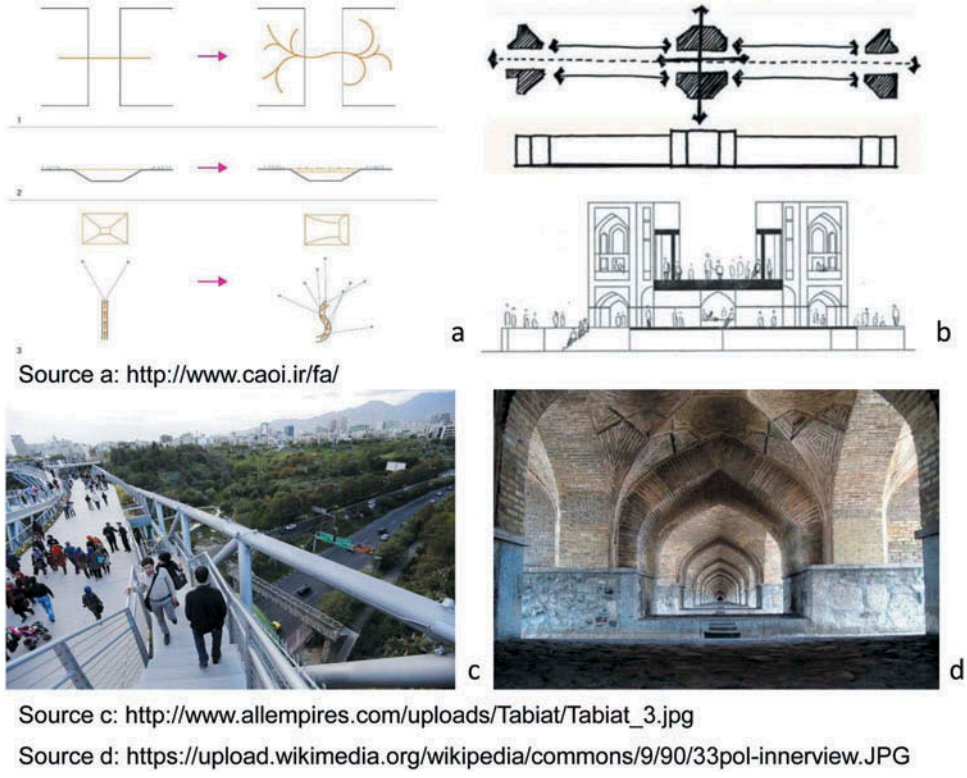

Figure 8. Factors of movement. The main ideas of Tabiat bridge design (curvilinear geometry, elevated planes, and multiple perspective) (a), Division of physical form and axes in Khaju (Source: Moravej-Torbati & Pur-Naderi, 1392/2013) (b), circulatory elements and sense of arousal (Tabait bridge) (c), a passage for circulation (lower passage of Khaju) (d).

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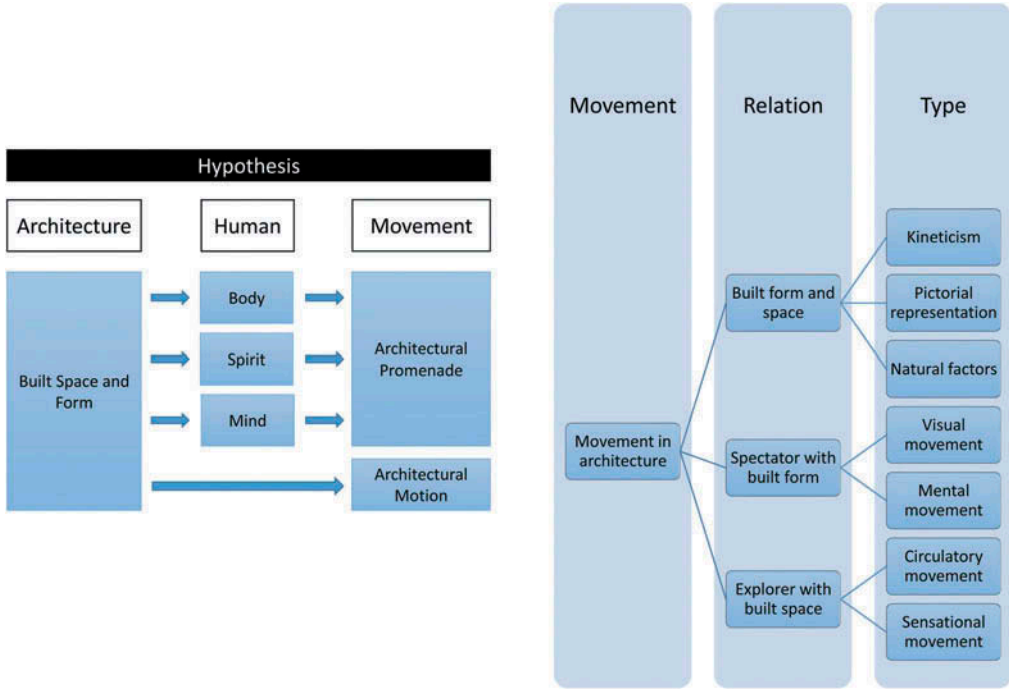

Figure 9. Proposed architectural movement taxonomy.

motion, with or without the explorer. In this sense, architectural promenade includes visual, mental, circulatory, and sensational movements. Meanwhile, kineticism, pictorial representation, and natural factors' motion would compose architectural motion (Figure 9).

It is undeniable that these types of movements were explained in terms of architectural elements and factors: they are provoked when these factors and elements are employed. Therefore, a qualitative-quantitative table is drawn to estimate and assess movement in architecture (Table 1). This table shows the presented taxonomy of movement in this paper and helps to increase the quality of movement in architecture—thus the experience of architecture—by evaluating the movement in any desired built form and space. The table can be used both by dotting or scaling in order to compare the movements manifested in different buildings. It can also be used to estimate which types of movements are more frequently manifested in a certain building.

5. Results

The table assessing the movement for Khaju and Tabiat bridges is presented below (Figures 10, 11). It is clear that the results would be more specific by applying a scale to the table through a questionnaire inquiry—like the Likert scale. However, the tables have been filled through dotting by the author. It thus expresses the researcher's own observations. Every dot placed at each cell represents a certain type of movement (listed at the top of the table) which is stimulated by the corresponded architectural factor or element (listed at the left side of the table). For example, frozen transformation in Tabiat Bridge (column 8 in the table) (Figure 10) appears to be stimulated by curvilinear geometry, weak boundaries, multiple perspectives, and the structure and configuration of the bridge which is a symbol (the structure is reminiscent of a living dragon). Therefore, dots are placed at each one of the correspondent cells. Summing up the number of dots in each row and column gives us particular values of every factor, architectural element, and type of movement. Finally, the last cell at the lower corner of the right side of the table represents the total rate of movement which is the sum of all of the dots on the table.

Diagrams in Figures 12-14 illustrate the varieties between the two bridges using the numerical values extracted from the respective dotted tables. The comparison of the two tables shows that

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Table 1. The table of movement evaluation in architecture

Movement Types / Movement Factors and Architectural Elements			Movement in relation to the built form and space											Movement of the spectator in relation to the built form											Movement of the explorer in relation to the built space							Rate
			Kineticism					Pictorial representation			Natural contributors			Mental movement						Visual movement					Circulatory movement				Sensational movement			
														Association		Perceived forces				Optical				Projected movement/Parallax	Bodily		Projected bodily movement	Transformation				
			Skin unit system	Retractable element	Revolving form	Biomechanical system	Movability	Sculpture/relief	Painting	Frozen transformation	Air	Water	Light	Resemblance	Meaning	Inertia	Imagined forces	Visual forces	Dynamism	Horizontal	Vertical	Rotational	Free		Horizontal	Vertical			Time passage	Arousal	Tendency	
Movement factors	Geometry (of shape, form, etc.)	Linear																														
		Curvilinear																														
		Projection/ Subtraction																														
		Proliferation																														
		Repetition																														
		Weak boundary																														
	Rhythm																															
	Hierarchy																															
	Depth	Multiple perspectives																														
		Intensified perspective																														
	Axis																															
	Enclosedness	Continuity																														
		Transparency																														
	Polarity																															
	Psychologic (Reverence, Privacy, etc.)																															
	Sensational (Audition, Touch, Olfaction)																															
Movement elements	Route (Bridge, Path, etc.)																															
	Outlook (Terrace, etc.)																															
	Elevated planes (Ramp, Stair, etc.)																															
	Symbol																															
	Kinetic element																															
	Ornament																															
	Structural element																															
	Water-related element																															
	Wind-related element																															
	Opening																															
Rate																																

pictorial representation, mental movement, and sensational movement score higher in the Tabiat Bridge comparing to Khaju (Figures 10, 11). However, the score of circulatory movement and the movement of natural factors—not employed in Tabiat Bridge—is higher in the Khaju Bridge. Nevertheless, the two bridges are similar in terms of the total score of kinetic movement: they do not employ kineticism. Also, it is noteworthy that the horizontal movement of the body scores highest in the Khaju, while the highest score in the Tabiat belongs to the free movement of the eye, arousal, and imagined forces all together by the rate of 8 (Figure 12). This explains Khaju's linear repetitive rhythmic form—repetition and rhythm have the highest rate of movement factors in Khaju (Figure 13)—against Tabiat's curvilinear complex from with multiple perspectives—multiple perspective is the dominant factor of movement in the Tabiat (Figure 13). In addition, arousal is the most frequent type of sensational movement in the Tabiat, while it is tendency in the Khaju (Figure 12). Whereas in the Tabiat "imagined forces" and "free movement of eye" are the dominant types of mental and visual movements, respectively (Figure 10), "resemblance" and "horizontal movement of eye" score highest in Khaju in terms of mental and visual movements (Figure 11). From the diagram of movement elements (Figure 14), One can clearly observe that route is the prominent element of movement manifestation in Khaju, while it is a structure in the Tabiat which manifests movement extremely.

The architect of Tabiat Bridge, Leila Araqian, has noted that the bridge is a place for "staying" instead of "passing" (Radoine, 2016) (Figure 9a). This idea becomes more obvious when she tried to create resting and gathering areas like coffee shops and restaurants. A study on this bridge

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Figure 10. Movement assessment of Tabiat bridge.

Movement Types / Movement Factors and Architectural Elements		Movement in relation to the built form and space										Movement of the spectator in relation to the built form											Movement of the explorer in relation to the built space							Rate
		Kineticism					Pictorial representation			Natural contributors			Mental movement						Visual movement					Circulatory movement				Sensational movement			
													Association		Perceived forces				Optical					Bodily							
		Skin unit system	Retractable element	Revolving form	Biomechanical system	Movability	Sculpture/relief	Painting	Frozen transformation	Air	Water	Light	Resemblance	Meaning	Inertia	Imagined forces	Visual forces	Dynamism	Horizontal	Vertical	Rotational	Free	Projected movement/Parallax	Horizontal	Vertical	Projected bodily movement	Transformation	Time passage	Arousal	Tendency	
Movement factors	Geometry (of shape, form,																														
	Linear												•			•			•	•											4
	Curvilinear								•							•		•			•	•								•	6
	Projection/ Subtraction																•														1
	Proliferation												•			•	•					•	•							•	6
	Repetition															•		•													2
	Weak boundary								•						•		•	•				•	•						•		7
	Rhythm															•		•													2
	Hierarchy																														-
	Depth: Multiple perspectives								•									•	•		•	•	•					•	•		8
	Depth: Intensified perspective																												•		1
	Axis																														-
	Enclosedness: Continuity																	•	•			•									3
	Enclosedness: Transparency																					•							•		2
	Polarity															•															1
	Psychologic (Reverence, Privacy, etc.)																												•		1
	Sensational (Audition, Touch, Olfaction)																														-
Movement elements	Route (Bridge, Path, etc.)															•				•				•	•	•		•		•	7
	Outlook (Terrace, etc.)																		•	•		•		•					•		5
	Elevated planes (Ramp, Stair, etc.)																			•	•				•	•			•		5
	Symbol								•																						1
	Kinetic element																														-
	Ornament																•														1
	Structural element								•				•			•		•		•		•	•						•		8
	Water-related element																														-
	Wind-related element																														-
	Opening																														-
	Rate	-	-	-	-	-	-	-	5	-	-	-	3	-	1	8	4	7	4	5	3	8	4	2	2	2	-	2	8	3	71

showed something different from the architect's purpose. In a survey, Yarahmadi, Lotfollahi-Yaqin, and Tashakori (1394/2015) observed that explorers on the bridge would stop most often just for observing Tehran's landscape, or sometimes they sit on benches due to tiredness (Figure 15b). Hence, the bridge has a function of outlook.

Unfortunately, Zayanderud River is now dried off most of the time in the year. A survey about the impact of this phenomenon on the behavior of people on the bridge has shown that over 84% of the statistical population do not want to choose this bridge for their passage anymore (Qalenoei & Hossein-Qolipur, 1395/2016). The result shows that in some buildings, specifically in this bridge, the movement of natural elements can play a prominent role in the whole movement system of the construction.

Overall, the results show that attempts has been made to induce the idea of "a place for staying" in the Tabiat Bridge by reducing the circulation rate through removing the tendency towards moving and the factors stimulating circulation, while this idea has been manifested in the Khaju Bridge despite the factors and architectural elements that extremely induce body movement (Figure 15a). This can be related to the existence of more types of movement in the Khaju Bridge other than circulatory and optical movements, such as the perfect movement of natural elements, the sense of time passage, association, and the impact of water and wind that creates a pleasant place for staying in the hot weather of Isfahan which is beyond the scope of this paper.

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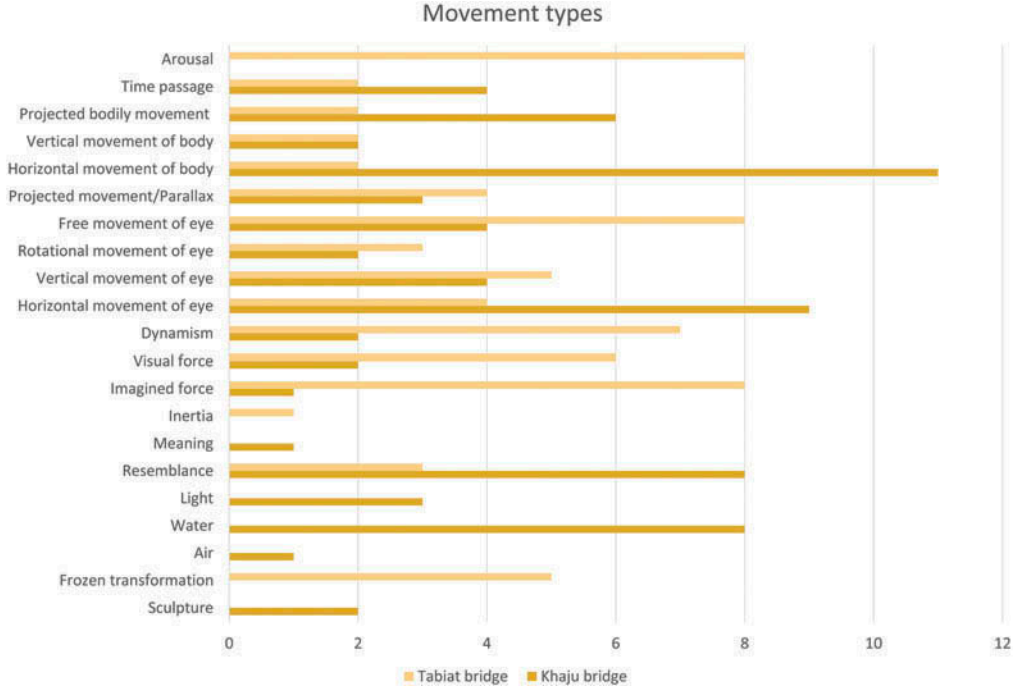
Figure 11. Movement assessment of Khaju bridge.

Movement Types / Movement Factors and Architectural Elements			Movement in relation to the built form and space										Movement of the spectator in relation to the built form											Movement of the explorer in relation to the built space							Rate
			Kineticism					Pictorial representation			Natural contributors			Mental movement						Visual movement					Circulatory movement				Sensational movement			
														Association		Perceived forces				Optical					Bodily							
			Skin unit system	Retractable element	Revolving form	Biomechanical system	Movability	Sculpture/relief	Painting	Frozen transformation	Air	Water	Light	Resemblance	Meaning	Inertia	Imagined forces	Visual forces	Dynamism	Horizontal	Vertical	Rotational	Free	Projected movement/Parallax	Horizontal	Vertical	Projected bodily movement	Transformation	Time passage	Arousal	Tendency	
Movement factors	Geometry (of shape, form,	Linear												•						•					•						•	4
		Curvilinear						•											•				•									3
		Projection/ Subtraction												•				•		•	•											4
		Proliferation																														-
		Repetition										•		•				•		•				•	•							6
		Weak boundary																														-
	Rhythm											•	•							•				•	•		•					6
	Hierarchy											•		•																		2
	Depth	Multiple perspectives											•												•				•			3
		Intensified perspective																							•		•					2
	Axis													•						•					•		•					4
	Enclosedness	Continuity												•									•		•		•				•	5
		Transparency																														-
	Polarity																			•					•		•		•		•	5
	Psychologic (Reverence, Privacy, etc.)																															-
	Sensational (Audition, Olfaction, Touch)											•												•								2
Movement elements	Route (Bridge, Path, etc.)											•		•	•					•					•	•	•		•		•	9
	Outlook (Terrace, etc.)																			•	•	•	•		•							5
	Elevated planes (Ramp, Stair, etc.)																									•						1
	Symbol							•				•	•	•															•			5
	Kinetic element																															-
	Ornament											•							•		•	•	•								•	6
	Structural element																•				•											2
	Water-related element											•																			•	2
	Wind-related element										•																					1
	Opening																			•					•							2
Rate			-	-	-	-	-	2	-	-	1	8	3	8	1	-	1	2	2	9	4	2	4	3	11	2	6	-	4	-	6	79

Figure 12. The rates of movement types.



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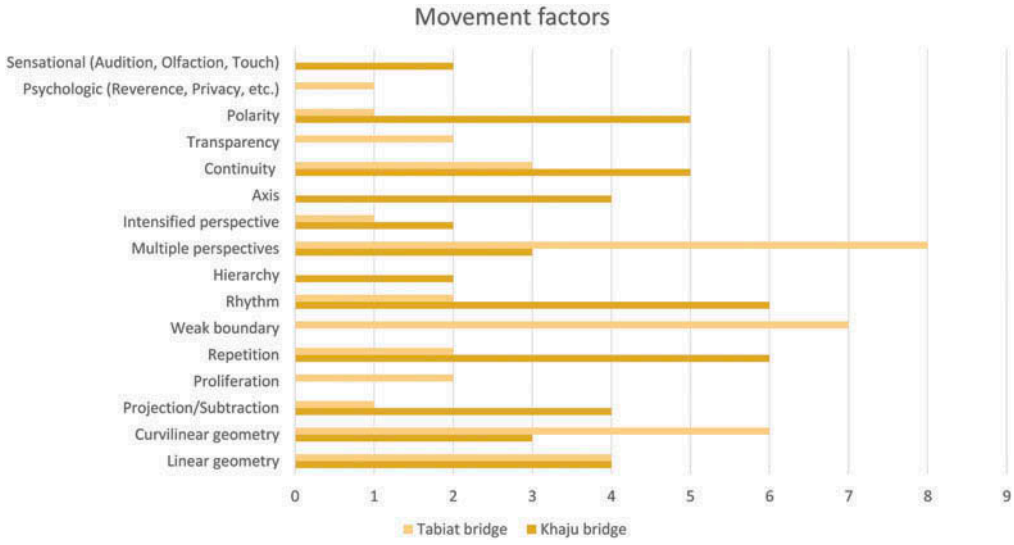

Figure 13. The rates of movement factors.

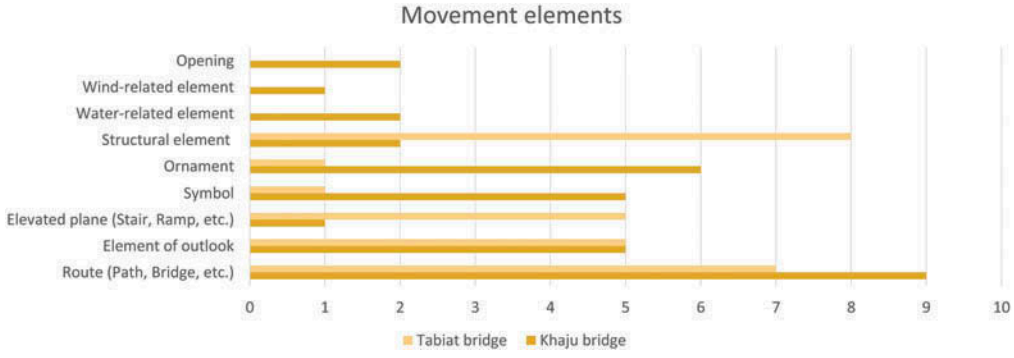

Figure 14. The rates of movement elements.

Source a: https://www.karnaval.ir/khaju-bridge-isfahan-zayanderud

Source b: https://surfiran.com/destination/tehran-city/tehran-tabiat-bridge/

Figure 15. A passage for staying (Lower passage of Khaju bridge) (a), a passage as outlook (Tabait bridge) (b).

6. Conclusion

In this essay, the term "Movement in Architecture" was redefined and a taxonomy was presented regarding not only the movement of body and eye but also the movement of mind, soul, pictorial representation and natural factors, as well as the movement of architecture itself. The taxonomy was developed based on the relationships among form, space, and explorer (or observer). Three types of relationships were defined in this regard: (1) Movement in relation to the built form and space; (2) Movement of the observer in relation to the built form; and (3) Movement of the explorer in relation to the built space.

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The overall goal to create a new taxonomy was achieved in the form of a table of observations (Table 1) depicting the interconnections among different types, factors, and architectural elements of movement. The generated table is also a framework for the qualitative-quantitative assessment of "Movement in Architecture" in any building, whether by employing a scale through a questionnaire or through a descriptive report.

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