

Properties of natural organisms and its use in technological architecture

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Abstract

This research aimed at identifying natural organisms and their properties in the technological samples of contemporary architecture. The main questions were: "Which properties of natural organisms are effective on the technological works of contemporary architecture?" and "How much do they affect?" This descriptive-analytic research was conducted using archival method to access the theoretical literature, and surveying method for collecting the data required. Case studies were selected and analyzed from the internationally famous technological works made from the sixties (Hi-Tech style) till now. The case studies were divided into two periods, 20th and 21st centuries; 8 works each period. The results indicated that properties such as unity, balance, proportion, hierarchy and efficiency have had most used between properties of natural organisms in technological works of contemporary architecture, and properties such as restorability, reproducibility and developability have been neglected.

Keywords: Nature, Properties of natural organisms, Technological architecture.

1. Introduction

1.1. The importance and necessity of the topic

"In animal, plant and mineral climates, there are interesting structures that are undoubtedly

the basis of construction projects, and innovation in architecture" (Senosiain, 2003, 32).

Nature has always been one of the most important inspiring resources of human in life and his products throughout the history. Manifests of nature from the beginning of history on the walls of caves until today in the most advanced industries are proofs of this claim. "Aristotle, the philosopher of archeological eras, was one of the first people who wrote about nature as the giant source of inspiration" (Taghizade, 2006, 75). Conditions of survival in nature have caused the most exploitation gained by spending the minimum amount of energy (Faridani,

1998, 29). Hence any type of development or promotion in the building engineering is possible by the help of nature regulations. There is a kind of inherent simplicity in the nature that by making use of it in architectural designing, we can make the most balanced and beautiful buildings. The inherent regulations within the nature are full of hints that can be used to create varied and endless combinations of structural forms (Margolius, 2007, 6). For example, "snow crystals are fantastic samples of this capability of the nature. Every snow crystal has a six-side, symmetrical and even form and could create unlimited and non-repetitive patterns" (Pears, 1990). A quality in the final product of architecture from different respects is an eternal necessity in architecture. Hence, with regard to cultural changes, increased awareness and growth of the level of human needs, the society needs new and real patterns for promotion and increase of efficiency of architecture. Therefore, referring to nature and natural patterns, as one of the most important inspiration sources of human in life and his products, could be an appropriate strategy for this purpose. Referring to nature has always been one of the important topics in architecture and its traces could be found in the works of architects and writings of authors. In this regard, the first step is studying nature in order to identifying its properties. After that, we study the architecture works containing the desired approaches of research to deal with the amount and the way of exploiting natural organisms.

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1.2. Research goal

The main goal of this research is to identify such concepts as natural organisms, their properties and the way of their manifest in the examples of contemporary architecture works created based on the technology inspired by natural organisms. To realize this goal, natural organisms, their properties and also the reciprocal architectural influence, technology and nature must be analyzed.

1.3. Research questions

Which properties of natural organisms are effective on the technological works of contemporary architecture? How much do they affect?

1.4. Research method

In the present descriptive-analytical research, archival methods have been benefited to access to theoretical literature of the topic and surveying method (objective observation) has been used to gather anatomical information and analyze them (Groat and Wang, 2005).

1.5. Research Process

First, by using the archival methods, the theoretical fundamentals about the importance of the issue of nature and the position of nature in the technology era architecture were studied. Then the properties of natural organisms have been extracted. Surveying methods have been utilized to deal with the analysis of characteristics of case studies. Thereafter, the results of quantitative calculations as well as the qualitative results will be presented.

2. The position of nature in architecture of technology era

2.1. Nature and natural organisms

Natural creatures, wherein form, structure, function and substance have formed in the direction of a unit purpose, fall under two titles of living organisms and non-living organisms. Each of these organisms has subsets. Living organisms can be divided into two plant and animal organisms, and non-living organisms can be divided into three subsets of minerals and non-minerals and by-animal medium. Mineral organisms include all solid non-living organisms, and non-mineral organisms include all fluid non-living organisms. It is worth mentioning that some organisms in the nature exist by mediation. These organisms (e.g. bee nest and birds nest, etc.) are created by animals' inherent intelligence. (Figure 1)

2.2. Properties of natural organisms

In this part properties of natural organisms are defined and described in order to determine its qualities. Properties of natural organisms are correlated; it means if a property happens, other one may happen too. These properties have been obtained by archival studies, objective observation and rational

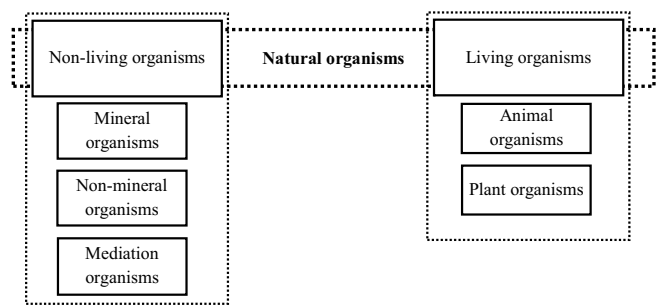


Fig. 1 Classification of natural organisms

analysis of organisms in the nature. It is important to note that all of these properties may not exist in all the natural organisms. Certainly there are other properties in natural organisms that the authors have not achieved them in research process.

2.2.1. Adaptability

It is gradual and permanent deformation of natural organisms to create its comfortable conditions and sustainability that occurs spontaneously. For example, the permanent deformation of a stone that is in the river.

2.2.2. Balance

In physics, a natural organism is in balance state if the resultant of all the external forces and the resultant of all the moments of external forces be zero. But visually, it is a condition that can strengthen the sense of stability in viewer. It should be noted that symmetry is a special case of balance. Symmetry of human body is its sample.

2.2.3. Centralization

The presence of a center can be feel and seen in a lot of natural organisms that the composition and order of them is resulting from this property. For example, the center can be seen in the shell of a snail or cone structure.

2.2.4. Curvature

Antony Gaudi believed that there was no straight line in the nature. He didn't utilize any straight line in design of Casa Mila Building, because he considers himself a naturalist (Ghobadian, 2011). "In nature, the most motion is found in curved lines" (Senosian, 2003, 138). So curvature can be considered as a property of natural organisms.

2.2.5. Developability

It is the ability to grow and change. Developability is generally a property of all components of natural organisms (Faridani, 1998, 21). For example, with the growth of snail, its shell will develop around the central core.

2.2.6. Efficiency

Efficiency of a natural organism is assessed in terms of the weight of the material that must be provided for bearing a given amount of load. If the ratio between resistance and weight be high, efficiency is considered high too (McDonough, 1998, 50). For example, spider's home is a very high efficiency organism.

2.2.7. Extensibility

An extensible organism has a mechanism for adding components to achieve its ultimate goal. For example, the process of flowering and fruiting include this property.

2.2.8. Flexibility

It is the ability to accept changes without occurring major changes in natural organism as much as possible. These changes are suddenly, temporarily, spontaneously and in order to deal with external destructive factors. For example, a tree bending in direction of wind flow in order to deal with its shear force is its flexibility.

2.2.9. Hierarchy

Hierarchy is an important principle in natural organisms. Based on this principle, any components of natural organisms can't be created regardless of higher or lower levels. In a hierarchical system "each component forms its lower orders and follows its higher ones" (Habini, 2011, 104). Food passage through the root to the trunk, branches, leaves and veins include this property of natural organisms.

2.2.10. Parity

Quran in Zariatsura says that everything has been created couples (Zariat, verse 49).

2.2.11. Proportion

It is to be an arithmetic or geometric ratio between the components of a natural organism that make things beautiful. The goal of all theories of proportions is to create sense of order between the components of a visual composition (Ching, 1994). For example, there is a proportion between leaves, branches, trunk and roots of a tree.

2.2.12. Reactability

It is a defensiveness that a natural organism does against internal or external destructive factors. In this case, we can example facing sunflower toward the sun during the day.

2.2.13. Renewable

It is the ability to return to the cycle of the nature completely. For example, animals' body is renewable.

2.2.14. Restorable

It is ability to repair part of a natural organism that is affected by internal or external destructive factors. This process is spontaneously. For example, organism's body can repair its destroyed tissues.

2.2.15. Reproducibility

It is the ability of a natural organism to producing an independent unit of itself massively. For example, by propagating a plant can replicate it in a large number.

2.2.16. Rhythm

It is said to the regular or harmonious repetition of lines, shapes, forms and colors. This manner is seen in many of natural organisms. Besides, rhythm includes the theory of repetition that is a strategy to organize forms and spaces in architecture (Ching, 1994). For example, petals of a flower have rhythm.

2.2.17. Unity

Being an object is not an enough reason of unity in structure; unity is resulted by harmony, integrity and consistency (Golabchi, 2003, 88). A natural organism tends to unity and uniformity, composition and homogeneity in its integrated set. In this integration, whole become a unique identity and presents a special character; regardless of way of combination of its components (Habibi, 2011, 104).

These properties can be divided into two main levels: 1. Physical properties which are recognized from appearance of a natural organism, and 2. Functional properties which are achieved from a function of a natural organism. (Figure 2)

2.3. Technology, architecture and nature

Technology in architecture includes using the techniques to erect a building to confront threatening factors. Jarvis believes that technology is a practical knowledge. Hence, he questions "If the extreme of knowledge and practical wisdom is increased dominance on the nature". Is the entire rational attempt and wisdom of human to dominate the nature and gather knowledge out of it? (Taghizade, 2006, 67). Technology is the mother of nature, i.e. architecture is born from technology (Mozayeni, 1997). Little attempt has so far been done to redirect human's attitude toward the environment in order to restoring the balance that has vanished through the growth of technology. As technology is growing faster and faster each day, some scientists believe that the nature can be the best source for humans to learn from it. They believe that organisms did all the things that humans want to do but without demolishing their environment and future (Vahedi, 2009, 2). Persian traditional architecture has long had a close relationship with its surrounding nature due to cultural and geographical issues that has been in human dignity of his time. In Persian traditional cities, inspiring from the nature and natural organisms has been vernacular and toward completing

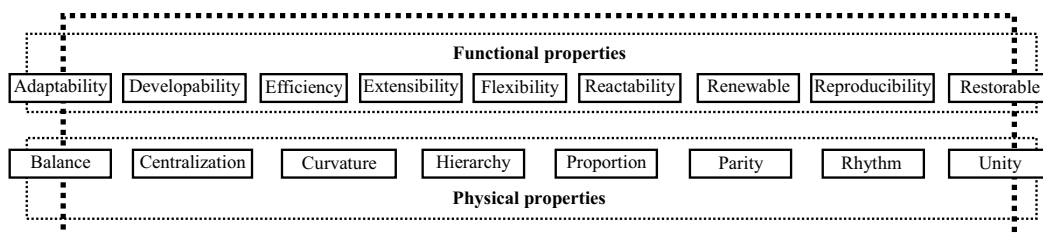


Fig. 2 Properties of natural organisms







the nature. But developments in contemporary architecture was undergoing major changes in Persian architecture occurred with the advent of technology (Feizabadi, 2012). This is an important issue that its investigation is not along with the subject of this article.

In a near future, unifying science, technology and humanism, restoring a balanced relationship with nature, and reducing pressure on natural resources will be desired (Senosiain, 2003, 10). According to Renzo Piano, the process of architecture evolution has changed from High-Tech into Organi-Tech in a slow move because these are the technology and interests seeking that govern the nature and Organic-Tech. Richard Rogers believes that architecture seeks to value the advance of technology and create a human environment adoptable with the environment in accordance with the nature and climate. It seems that throughout the history, technological advances have always been steps that scientists have made one after the other by searching the nature and, in the contemporary period, high ambition ideas of architects with a look at the nature are horizons that make the human be closer to his living environment (Banimasoud, 2010, 350). The ideas of Alvar Alto in architecture should be sought in a special divergence with architectural topics of Organi-Tech. He looked at nature as a source of inspiration that had a living and dynamic organism but what we witness is an abstract nature that has been specifically manifested in his works (Banimasoud, 2010, 257). To current architectures, it is desirable that we move from traditional high-consumption

developing mode to low-consumption and low-pollution developing mode. Bio-architecture is the essential way for such transformation and also an essential trend to the current world's development (Lan, 2011, 1775). Bionic and biomimicry are some of these trends that try to answer these essentials. By integrating the nature, technology and humanity in architecture, we may get a kind of architecture that is not only in harmony with the nature, but also in accordance with the locality, culture, spirit and identity that will, eventually, lead us to a sustainable quality of life (Rachmawati, 2011, 432) that is an Utopia in architecture.

3. Case studies

In this section, we deal with the analysis of case examples of the research. From a lot of the technological works of contemporary architecture created based on natural organisms mentioned in different sources including architects of projects and subsequence reviews, 16 works (due to the limited number of article sheets) were extracted. Since the beginning of the process of using technology in architecture is accompanied by the beginning of High-Tech style, in 1960s, the case samples created from among the technological works in the two time intervals of twentieth and twenty first centuries (8 works each century) and are known in national and international levels, have been chosen and studied in this research.

No.	Building	Designer	Analysis	Image
1	CNIT (Paris)	Nicola Squilla (1958)	This building reminds sea pearls (Taghizadeh, 2007). In this building, the volume and structure conform to each other. Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of sea pearls is seen in this work. Sea pearls is an efficient structure.	 <p>Source: Authors</p>
2	US Pavilion in Expo 67 (Montreal)	Buckminster Fuller (1967)	The geometry of geodesic domes is to great extent similar to the microscopic structure of sea coral (Taghizadeh, 2007). In this building too, the volume and structure conform to each other. Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of sea coral is seen in this work. This dome is renewable like its natural organism.	 <p>Source: www.flickr.com</p>
3	Munich Stadium (Munich)	Frei Otto (1972)	The stadium of Munich is an example that has been constructed with cobweb inspiration and has a high elasticity as simplicity and beauty (Moore, 2008). Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of cobweb is seen in this work. This roof is renewable and extensible.	 <p>Source: www.flickr.com</p>
4	Sydney Opera (Sydney)	Jorn Utzon (1973)	This building enjoys a port scene with blue coral waves and has an unbelievable brilliance under the sun rays (Banimasoud, 2010). The idea of architect was to make a building that mirrors the waves of ocean and a clear-cut symbol of the sea pearls. Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of sea waves and pearls is seen in this work.	 <p>Source: www.flickr.com</p>
5	Lotus Temple (New Delhi)	Fariborz Sahba (1986)	In designing the dome, blue water Lotus flower has been used for inspiration. This beautiful flower is a symbol of purity and worship in India. Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of Lotus is seen in this work.	 <p>Source: www.archdaily.com</p>
6	TGV Train Station (Lion)	Santiago Calatrava (1994)	The symbol designed by Calatrava was a simulation of movement and flying (Jodidio, 2007). The curve of structures in the ceiling and transparency of rays in the sides inspire the sense of moving and flying of the birds' wings. Utilizing such properties as unity, hierarchy, proportion and balance of bird is seen in this work.	 <p>Source: www.arcspace.com</p>

No.	Building	Designer	Analysis	Image
7	The Contemporary Museum of Arts (Rio de Janior)	Oscar Niemeyer (1996)	Regarding his work, Oscar Niemeyer says: " <i>The ground was narrow and surrounded by the sea. The solution was that the beginning point be a central maintainer. Therefore, the architecture was became automatically a flower. The created line from the ground that grew and expanded continuously.</i> " Utilizing such properties as unity, hierarchy, proportion and balance of flower is seen in this work.	 <p>Source: www.flickr.com</p>
8	Orient Station (Lisbon)	Santiago Calatrava (1998)	The structure of this station has been inspired by the mingled branches of trees according to the regional climates and conditions, which make sunshades that while making shade, facilitate the passage of air(Jodidio, 2007). Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of tree is seen in this work. This structure is extensible.	 <p>Source: www.archdaily.com</p>
9	Paul Klee Museum (Bern)	Renzo Piano (2005)	In vicinity of the arched streets of the old city of Bern, a building consisting of three hill-like arches are seen, which like the hills of Alp slopes are part of the topography of this region and no clear border could be seen between it and the surrounding environment(www.rpbw.com). Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of hill is seen in this work. This work is renewable.	 <p>Source: www.rpbw.com</p>
10	Parasol Metropolis (Seville)	Jürgen Mayer (2007)	This project with its big mushroom-like structure has become the symbol of Seville city. The sunshades have a mushroom-like structure and bee nest nets giving the idea of designing to Jürgen Mayer for Parasol metropolis(www.yatzer). Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of mushroom is seen in this work. This work is too extensible and renewable.	 <p>Source: www.yatzer.com</p>
11	Leaf House (Rio de Janiro)	Ivo Mareines& Rafael Patalano (2007)	In this region, many date trees have grown. Hence, the architects have designed a house that its ceiling is like the leaves of a date tree so that when we look at the site from above, it seems as if a bigger date tree has grown in the site. Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of date tree is seen in this work.	 <p>Source: www.yatzer.com</p>
12	National Stadium of Beijing (Beijing)	Herzog & de Meuron (2007)	The internal pattern of this building has been attributed to one of the architectural designers in Beijing and its external architecture to bird nest. Utilizing such properties as unity, proportion and balance of bird nest is seen in this work.	 <p>Source: www.wikipedia.com</p>
13	Water Cube (Beijing)	Joint Designing (2007)	This project is like a simpleand transparent cube and its structure is very much like the society of water molecules, which have been crystalized as a big cube(Zari, 2007). Utilizing such properties as unity, rhythm, proportion and balance of sea pearls is seen in this work. This work is efficient and renewable.	 <p>Source: www.arcspace.com</p>
14	Westfield (London)	Michael Gablini& Kimberly Shepherd (2008)	This building has been inspired by the move of wave and interference of water in the nature, in which water, light and soil are the main elements in creation of plants. Utilizing such properties as unity, hierarchy, rhythm, proportion and balance of water and tree is seen in this work. This work is extensible and renewable.	 <p>Source: www.arcspace.com</p>
15	Mopi School (Rio de Janiro)	Ivo Mareines& Rafael Patalano (2009)	The initial idea and design of this school is attention to the texture of nature and the surrounding forests. The entry façade manifests the trees in jungle due to making the form of trees branches on the entry façade, using the green and white glasses and also using wood for the form of glasses. Utilizing such properties as unity, hierarchy, proportion and balance of tree is seen in this work. This structure is renewable.	 <p>Source: www.inhabitat.com</p>
16	Aqua Tower (Chicago)	Jeanne Gang (2010)	The primary idea of Aqua Tower is the coastal rocks of the region and its wavy bank. This wavy nature is shown in the reflection of light during the day. Utilizing such properties as unity, proportion and balance of its organism is seen in this work.	 <p>Source: www.archdaily.com</p>

4. Conclusion

Based on the analyses we made, and the quantitative results obtained in tables, and considering the research objectives, the following points can be concluded:

50% frequency in utilizing plant organisms and the high difference of this number with that of other types of natural organisms (Animal, Mineral, Non-Mineral and by Mediation) show the importance and capability of this type of natural organism in taking influence by the architect designers.

Unity, proportion and balance (frequency of 100%) are the

laws governing the natural organisms that have always been effective on technological works of contemporary architecture. Frequency of 100% in utilizing curvature of natural organisms in technological works of contemporary architecture indicates the importance of this property in imitating nature. Nature is efficient and 88% usage of this property in case studies represent the efforts of architects to take advantage of this property of natural organisms in design process. "In this process, both the architectural and structural designers attempt to accumulate the architectural and structural considerations by various methods and ideas, which the nature is a manifest

Table 1 Frequency of the types of natural organisms in case studies

Type of organism		CNIT	US Pavilion in Expo 67	Munich Stadium	Sydney Opera	Lotus Temple	TGV Train Station	The Contemporary Museum of Arts	Orient Station	Paul Klee Museum	Parasol Metropolis	Leaf House	National Stadium of Beijing	Water Cube	Westfield	Mopi School	Aqua Tower	Frequency (%)
Living organism	Plant	*				*		*	*		*	*			*	*		50
	Animal	*			*		*											19
Non-living organism	Mineral									*							*	13
	Non-mineral				*									*	*		*	25
Mediation			*										*					13

Table 2 Frequency of the properties of natural organisms in case studies

	Properties of natural organisms																Frequency (%)	
	Adaptability	Balance	Centralization	Curvature	Developability	Efficiency	Extensibility	Flexibility	Hierarchy	Parity	Proportion	Reactivity	Renewable	Reproducibility	Restorable	Rhythm		Unity
CNIT	*	*	*			*			*		*				*	*		47
US Pavilion in Expo 67	*	*	*			*			*		*		*		*	*		53
Munich Stadium	*		*			*	*		*		*		*		*	*		53
Sydney Opera	*		*			*			*		*		*		*	*		41
Lotus Temple	*	*	*			*			*		*		*		*	*		47
TGV Train Station	*		*			*			*		*		*		*	*		41
The Contemporary Museum of Arts	*	*	*			*			*		*		*		*	*		41
Orient Station	*		*			*	*		*		*		*		*	*		53
Paul Klee Museum	*		*			*			*		*		*		*	*		47
Parasol Metropolis	*		*			*	*		*		*		*		*	*		53
Leaf House	*	*	*			*			*		*		*		*	*		53
Beijing National Stadium	*	*	*			*			*		*		*		*	*		35
Water Cube	*		*			*			*		*		*		*	*		35
Westfield	*		*			*	*		*		*		*		*	*		53
Mopi School	*		*			*			*		*		*		*	*		29
Aqua Tower	*		*			*			*		*		*		*	*		24
Frequency (%)	0	100	38	100	0	88	25	0	81	0	100	0	69	0	0	69	100	

and special source for presenting efficient ideas in this regard" (Nikandish, 2010, 27). Hierarchy (frequency of 81%) is another property of nature that has affected on technological works of contemporary architecture very much. frequency of 25% for property of extensibility and frequency of zero for properties such as adaptability, flexibility, restorable, developability, renewable, parity and reactivity emphasize on this point that contemporary technological architecture is not yet benefiting from some laws governing the nature and these laws that can achieve comfortability, convenience, prosperity and sustainability have been neglected; although, we can hear about utilizing these kind of properties of natural organisms and in the near future, we will see their effects on architectural works more and more.

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