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ROLE OF NATURE IN THE FORMATION OF ORGANIK ARCHITECTURE

ABSTRACT

Nature is the creation of God, the greatest architect of all, and has been a superb inspiration for most architects. Historically, humans have looked at natural elements as vital structural factors since they began building shelters, residences, workplaces, or any other constructed space. In fact, architecture has intentionally covered two concepts of form and function during this historical era. Utilizing natural forms in architecture is a clue to human's tendency toward the creation and its impacts. In other words, nature's forms were of reverence and sanctity in different cultures and among different people both functionally and aesthetically. For instance, animals and birds possessed a particular sacredness due to the cultural background they had in different societies and different creeds. Being related to nature is among the most essential conditions of being an artist. Artist is a human and human in nature. The human is part of nature and is in nature.

Nature affects almost all the strategies aiming to reach architectural creativity. Nature is omnipresent, unclassifiable and an indispensable tool for inspiration. Nature is indeed present in metaphors, mimicry formability, and even in architectural materials. The present paper attempts to highlight the romantic, tangible, and intangible aspects of nature and elaborates on the concept through views prominent designers and architects have on dealing with nature. The paper in fact intends to emphasize tangible aspects and mimicry teachings of nature along with the need for getting accustomed to experiencing diverse natural environments and nature-based drawing drills. The paper also attempts to investigate and express the geometry of elements in nature and the order among them through scrutinizing objective samples in nature. To get a better understanding of the elements and the order among creatures either animals or minerals ranging from simple and basic geometrical relations among nature and its parts to complexities concerning chaos among them are discussed.

Keywords: Nature, Landscape architecture, Organic architecture, Fractal geometry, Chaos theory

1. INTRODUCTION

Humans have always used architecture as a tool to facilitate their life in nature. In fact, experience has proved that, when the human uses his tools against nature, the tool stands against him and goes on to destroy him. One of the best examples is the use of industry to protect humans against natural disasters, to increase welfare, and to mechanize life, which has been irreversibly destroying human life by widespread noise, light, and environmental pollutions. Nonetheless, in this state of frustration, returning to nature and coordinating with it has become the center of focus of modern architects and they have demonstrated a positive outlook on that.

On the other hand, in some cases, people and architects throughout history have revered nature and scrutinized it. The present paper attempts to investigate nature with an emphasis on romantic, tangible, and intangible concepts and with a refer to attending nature as discussed by prominent architects like Frank Lloyd Wright, Louis Sullivan, Le Corbusier, Eero Saarinen, Gunnar Asplund, Alvar Aalto, and Jørn Utzon to elaborate on the concept. The main emphasis of this paper is on tangible aspects, imitation doctrine of nature and finally the need for getting accustomed to experiencing diverse natural environments and nature based drawing drills.

Nowadays, the natural environment is observed in various forms and structures. At first glance, they may seem not to have many commonalities. These structures have raised discussions on nature and wildlife to be followed. This discussion is not about fixed and unchangeable facts though. In fact, like people in different eras, nature has indeed changed greatly over time.

2. RELATION BETWEEN NATURE AND GEOMETRICAL SYSTEM

Regarding the use of geometry in architecture, various approaches have been proposed. Gruber (2011) "Architectural space forms based on a simple or complex geometry, is in any way much simpler that the natural environment and the human has implemented his dominance on nature through geometrizing it".

Ardekani (2001), refers to the use of geometry in Islamic Arts and states that they mainly are the balance between pure geometric forms and so-called bioformic forms. Eminzade (2005), "fully geometric architecture of a mosque with its fascinating dimensions is placed in the mazy and yet organic context of cities just like geometric motifs are woven into a complete set of organic fireclay patterns".

Facing the geometry of nature in modern and postmodern eras is not unexpected. However, those who value conflict, try to contrast traditional architecture with nature. Architectural products, especially in the past when human behavior was closer to his nature, demonstrated contrast to nature. Ziggurats of Mesopotamia were like artificial mountains on a completely flat surface. Minarets in Central Iran were vertical lines rising up in the desert and bright colors of tiles, carpets and ethnic costumes in those regions compensate for the lack of color in their nature. Aesthetically speaking, the value of an observed element reveals in contrast. In other words, the contrast increases the value. In his trip to Greece, Le Corbusier emphasized and praised the contrast between white marbles and their geometry with green and disorganized patterns of jungles and trees and acknowledged them to be inspirations for his architectural designs (Golabchi, 2012).

2.1. Structural Order and Euclidean Geometry

Speaking of square and cube roots, an old definition associating a mathematical transaction with plant roots is utilized. Like the mathematical root, plant root is a causal one for the latter is located in the soil and the former is located in the square (Figure 1). A plant grows exponentially out of the fracture. However, there is no logical explanation for the reason behind growing out of a single thin root or bringing a square out of another square. This is a power transformed that used to exist in a causal root (Lawlor, 1988). The logarithmic spiral of golden mean affects the distribution of seeds on a sunflower. In fact, sunflower seeds have a watch-like turning with 55 spirals located on 34 or 89 anticlockwise spirals (Figure 2).

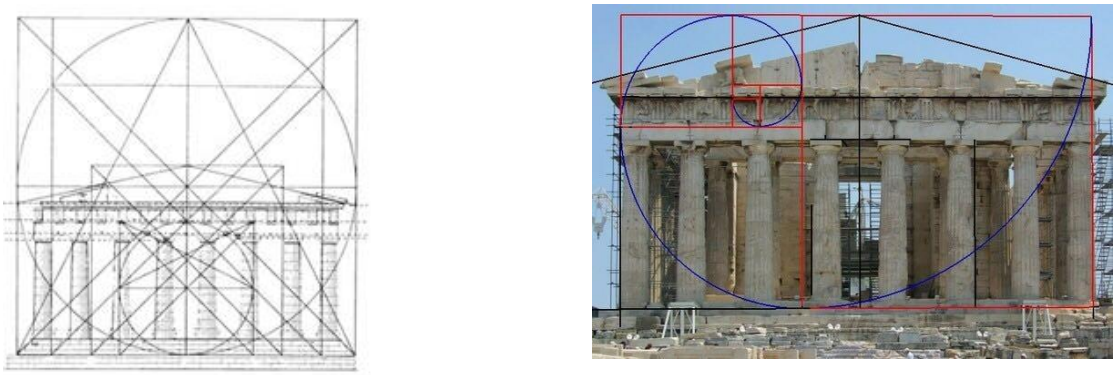

Figure 1. Geometrical analysis of Parthenon: Architecture through the relationship between side and diameter in a set of squares each of which has a ratio of 1 to 25.1 with its bigger side square (Lawlor, 1988)

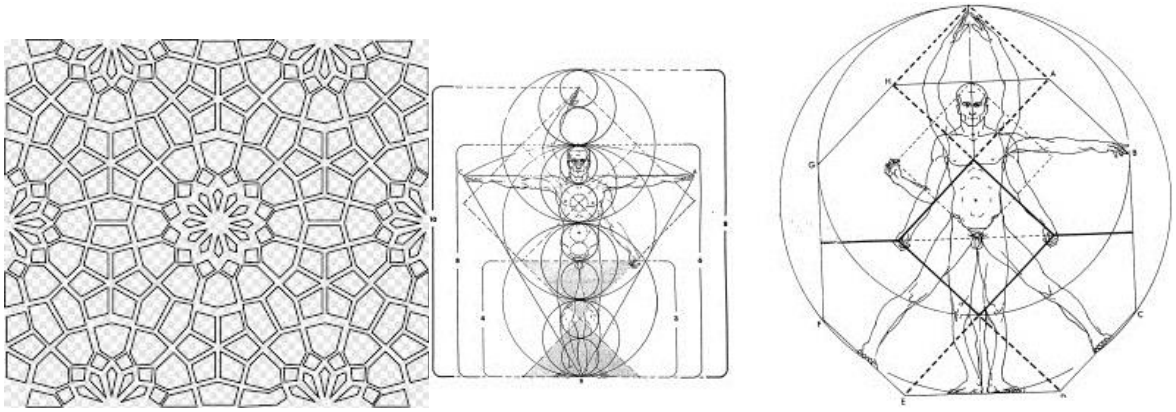

Figure 2. √2 ratios in Islamic mosaic floor covering along with form and proportion in the beehive (Lawlor, 1988)

Offshoots are other interactive models for natural growth controlled by Fibonacci or φ (golden ratios) (Figure 3). Since this ratio is present in pentagons, the golden ratio could be found in flowers with 5 or the multiplication of 5 petals. In Chrysanthemum, for example, petals have a Fibonacci pattern in their number. The rose or any edible fruit-bearing flower has 5 petals. Five is true of great significance in the infrastructure of critical forms while 6 and 8 are specific to soulless minerals. Six-petal flowers like poppy, Lilium, and tulips are generally poisonous or have medicinal applications. Nevertheless, plants with 7 petals are considered to be toxic in traditional medicine. On the other hand, flowers like Orchid and Azalea adapt generally pentagonal symmetry. Pentagon is the symbol of life particularly human life (Figure 4) and Pentagons are the basis for rose windows in the Gothic period (Lawlor, 1988).

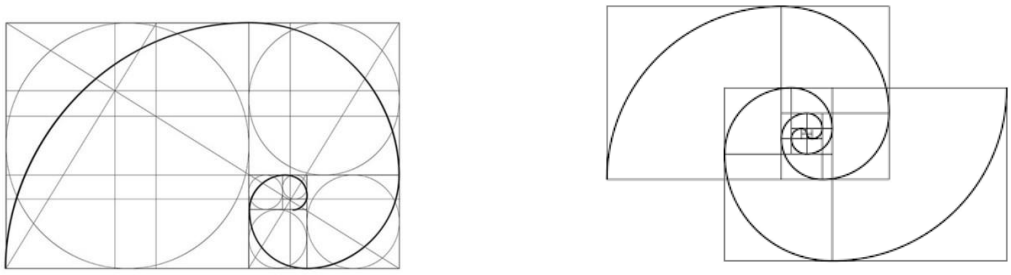

Figure 3. Fibonacci patterns in nature (Mandelbrot, 1982)

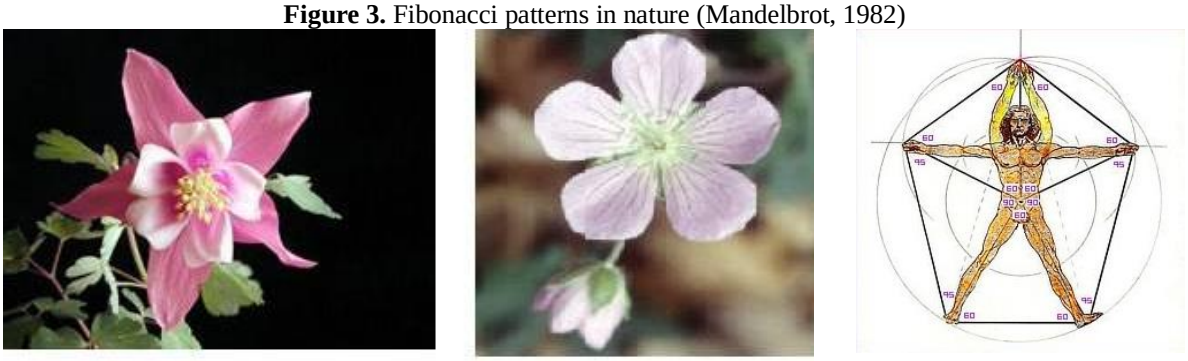

Figure 4. The number "5" is the symbol of blossoming or the essence of life and Human in a pentagonal form (Mandelbrot, 1982)

2.2. Structural Order in Fractal Geometry

Fractal geometry provides the human with an opportunity to describe nature with all its mysteries. Just like linear systems as a particular form of non-linear systems, Euclidean geometry is a simplified and small section of real and natural geometry, and just like linear systems as controlled and laboratory models of real nonlinear systems, Euclidean geometry is an abstract and hypothetical geometry that could identify single-dimension lines, two dimensional surfaces, and three dimensional shapes. In fact, Euclidean geometry is the dominant geometry in nature and adventurous scientists have always been observing and contemplating natural phenomenon and have been trying to uncover its mysteries (Broadkent, 1977).

Mandelbrot (2004) “Unlike a mountain, the cloud is not conical and thunderbolt does not move in a linear pattern.” He believes that a novel geometry that could reflect the coarse, rough, non-spherical, and non-linear world of pores, folds, mazes and entanglements is required to describe nature. Needless to say that classic geometry covers the only line, surface, circle, sphere, triangle, and pyramids. These forms and shapes were the abstract concepts based on which, 200 years ago, Euclid established his geometry and have ever since been the center of focus of artists and craftsmen looking for beauty and Ptolemaist astronomers founded their hypothesis on the world. Mandelbrot coined the term Fractus for crushed and broken rock and this was the basis for the modern Fractal Geometry and the title Father Fractal Geometry for him. Unlike Euclidean geometrical shapes and forms, fractals are shapes without any particular order or regularity. Firstly, they are full of irregularity; Secondly, their irregularity is equal in all scales for there is no sign of regularity in them. A fractal shape is irregular from far and near. In other words, they are stationary. When we are approaching a shape, it's smaller pieces that looked irregular from distance, become shapes with some similarities to the original shape from distance. One interesting model for understanding the formation of fractals is the Sierpiński triangle (Figure 5). A small shape similar to its whole is called a “linear stationary”. However, it should be noted that natural fractals in nature are not linear stationaries. They are indeed fractals describing nonlinear and chaotic systems. It should be noted that there are differences between self-stationary (in casual fractals) and self-uniformity (in self-linear stationary fractals). Thus, self-similarity is the similarity and symmetry in scale. Nevertheless, this does not mean an exact repetition of a design in all scales. This is however the reason behind astonishing diversity in the natural world (Mandelbrot, 2004).

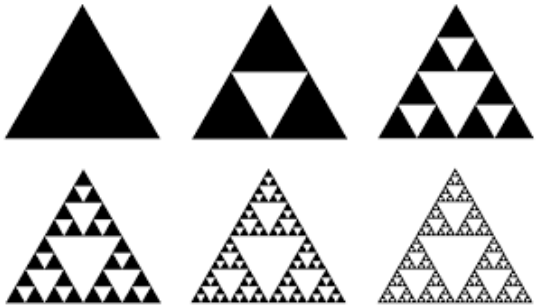

Figure 5. Sierpinski triangle, a simple fractal made by dividing bigger triangles into smaller ones (Mandelbrot, 2004)

In fact, Mandelbrot goes beyond Zero, one, two, and three dimensions and reached an external impossible i.e. fractional or the fractal dimension. Fractal dimension is the method of measuring qualities like coarseness, fracture, or irregularity that could not be clearly defined or measured outside this method. There is order in a multilayer and involute world; thus, many of the natural shapes and forms seemingly without order, have an irregular quality while following a certain scaling rule. This uniform rule of no fractal dimension is discernable in all surfaces (Moore, 2008). In this fractal shape, the degree of irregularity conforms with the level of space occupancy of the shape (Figure 6).

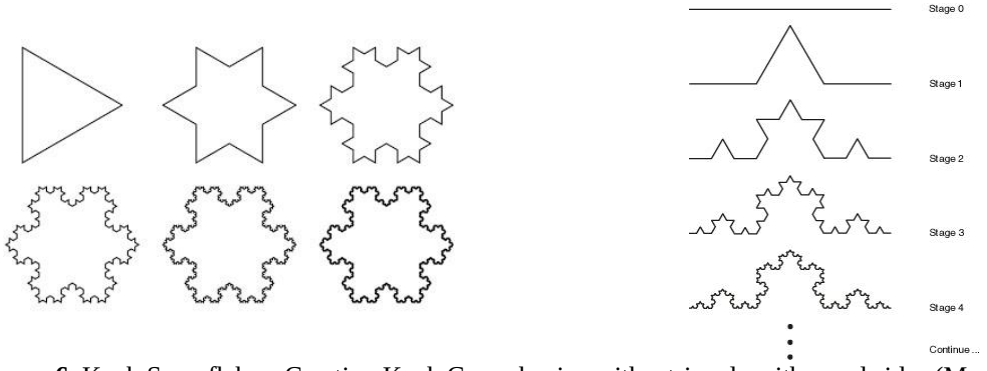

Figure 6. Koch Snowflakes, Creating Koch Curve begins with a triangle with equal sides (Moore, 2008)

In the middle of each side of the triangle, a new triangle is added the same size of the previous one and this trend goes on. However, the circumference of the triangle is always smaller than that of the circle around three angles of the triangle; thus, a long and infinite line encircles the surrounding. Natural fractal forms in two ways: Similar forces in numerous surfaces act simultaneously as they do in a cloud

or a river or act in a timely manner one after another in a scale as they do in a snowflake (Kitchley, 2016 Afractal shape is formed through a simple feedback process (Table 1). When a geometrician repeats an equation instead of solving, the equation turns into a process instead of a description and becomes dynamic instead of being stationary. Any number inserted into the equation produces a new number and the produced number is again put into the equation and the process continues (Yannick, 2007).

Table 1. Scientific classification of geometry in nature (Yannick, 2007)

Types of Geometry		**Definition**
Euclidean		A geometry defined based on the following five principles: 1- For each P and Q point, there is a unique L line passing through P and Q. 2- For each AB and CD line segment, there is a unique point like E if B is in the middle of A and E and the CD line segment conforms to BE line segment. 3- For each D and A point, there is a circle with an OA center and radius. 4- All right angles conform with each other. 5- For each L line and P point not located on it, there is an M line if it passes P and is parallel with L.
Non-Euclidean	Hyperbolic (Lobachevsky)	A geometry acquired through accepting all ideas of absolute geometry (part of non-Euclidean geometry independent from symmetry principle) and instead of Hilbert's symmetry principle its negation, the hyperbolic theorem is placed. In this geometry, there is an L line and a non-conforming P point where at least two parallel lines with L line go through P pint.
	Oval (Riemann)	Curved two dimensional space is shown through a sphere and the concept of the straight line is interpreted as a sphere. In this space, there is no parallel line for, if we take both large circles into account, they will cut each other. Two points are connected via numberless straight lines to each other.
	Fractal (Mandelbrot)	A geometry to describe nature reflecting a coarse and non-linear world. The geometry of pores, fold, involutes, and entanglements

3. ORDER IN DISORDER AND THE RELATION BETWEEN CHAOS THEORY AND NATURE

The synonym o chaos in mechanics is turbulence; however, in theory, it refers to understanding non-linear phenomena and discovering mysteries in nature and the real world. There is no consensus on the definition of chaos; yet, one of the acceptable definitions states that “Chaos is investigating non-continuous behavior in definite dynamic systems” (Rehimi and Huseini, 2008).

Aperiodicity is a behavior occurring in a way that no variable predicting system status could not demonstrate periodically. Aperiodic behavior never repeats and effects of even small changes are seen in the system. In order to understand the concept of aperiodic behavior, human history could be analyzed as an accessible example. In fact, history is an aperiodic phenomenon. Numerous patterns could be drawn for the ups and downs of civilizations even though no single incidence repeats exactly as it occurred (Turner and Rupert, 2008).

The system is composed of a set of interacting elements which preserve some form of stability in their relationships over time. A dynamic system is the one demonstrating dynamic and nonlinear behavior. In other words, a dynamic system may change at any moment. In fact, the law that determines the future of variables in the system considering their size at the present is a dynamic law. Moreover, Elements of this system have a mutual effect on each other and show an unproportioned relationship between cause and effect. In such systems, a tiny cause has the unpredictable potential to end in a gigantic cause or vice versa (Lorenz, 2003).

A chaotic system on the other hand is a system with non-repetitive behavior. However, although the rules governing such a system are clear and definite, the nonlinearity of the relationship among its components may end in unpredictable and complex behavior. As a result, chaos contradicts with nature if a Newtonian approach is taken toward rules for, according to this theory, simple definite systems could show such non-repetitive and complex behaviors that would seem arbitrary. Nevertheless, they are not arbitrary but nonlinear, and nonlinear is in fact unpredictable and uncontrollable (Ahnert, 2008).

Classical mechanics rules like those of Newton and Kepler introduce the world of order; yet, chaos is defined as something from another arena of nature in which physical rules do not work. In other words, not only is chaos a higher level of complexity but is a state in which nature does not follow linear laws as well. Chaos is beyond order. Chaos is indeed observable in the behavior of air, the behavior of a

flying airplane, and the behavior of cars passing beside each other on a highway along with natural forms like those of mountains, clouds, plants, rivers etc. in nature. Chaos does not help identify phenomena through analysis and abstraction; however, due to its stability, this approach could be better understood through ideas based on system theories (Crawford, 1996).

Historically speaking, architecture has been nothing but utilizing various geometries to express the concepts and their essence. Geometry has always been revered as sacred and Euclidean Geometry in particular has been used to create significant buildings especially those of religions. However, surprisingly enough, the emergence of novel theories in mathematics, geometry, and other sciences has prompted new approaches and techniques in architecture; yet they have failed to fade their significance.

4. RELATION BETWEEN NATURE AND ORGANIC ARCHITECTURE

An architecture jargon borrowed from biological sciences that have induced discussions on form and shape, relationships and, study or comparison of architectural concepts with living creatures is the term "organic". In fact, organic in its common use refers to studying structures and skeletons of animals and plants.

Comparison of nature and architecture was previously expressed by American Sculptor, Horace Greene, in the mid 18th century. Seeking a way to overcome aesthetic concepts of his time which were despised by him due to their eclectic nature, Greene, turned toward nature as a source for the most diverse forms with no predefined patterns. He believed he possessed a deep understanding of conformity of form and function and took it more of a divine principle rather than being the product of logical thinking (Sprin, 2016).

Frank Lloyd Wright used the term 'organic architecture to transmit this idea'. For him, the relationship between part and whole was a vital characteristic for parts have to have their identities while being an inseparable part of the whole. Like Wright, Haring believed that the issue is the mere pursuit of objects and making their form ready for expansion and development. He began his job with the hypothesis that explicit order of objects space is in close connection with lively evolution and conducting of tasks. Thus, when a human intends to discover form, it has to be in concordance with nature (Belma and Ayyıldız, 2016).

In Frank Loyd Wright's point of view, as creatures distance, useless forms and parts from themselves, organic architecture has to lack redundant and useless forms as well. In spite of the fact that his idea of organic architecture and the analogy he makes between his architecture and living organisms is ambiguous and does not offer criteria to identify them, the concept has to be searched not in his words but in his works like his buildings and houses in Oak Park, Guggenheim Museum in New York and V.C. Morris Building in San Francisco (Figure 7). The outcome of this architecture is a paradox based on both human interferences in nature and his return to nature.

Figure 7. From left to wright; Oak Park Home & Studio, Guggenheim museum, V.C. Morris Building (Belma and Ayyıldız, 2016)

On the other hand, attitudes toward architecture as a living creature is one of the significant concepts historically discussed. However, such a concept became the center of attention in the 1910s when Lamarck introduced biology as the science of life. Gideon believed that architecture could be influenced by various conditions; yet, after it comes to existence, it becomes a living creature with particular characteristics and a long life. The value of such a creature, could not be expressed through socioeconomic expressions and its effects linger even after change or destruction of its context. Architecture could reach beyond its birth time. Goethe brought terms like morphology into discussion and builds a close link between architecture and morphology. Despite a profound understanding of

Goethe from this term in two main grounds of 'living structures' and 'lifeless forms' like forms on the earth, there were numerous ambiguities about its definition for it was not easy to decide if morphology refers to form of living structures in its common form or refers to growing structures. Ideas on form and particularly its link to function, point out the significance these concepts have for any phenomenon or an object. However, the relationship between form and function could indeed be a basis for several analogies between phenomenon and objects. Such analogies about expanded phenomenon and objects with limited parts and elements are more useful than complex phenomenon and objects with numerous parts and elements (Hossein Eskandani, 2020).

The fact that form follows function, or function follows form is an intriguing puzzle raised in biology. It in fact prompted a heated discussion for over 50 years which was mostly based on the growth of forms rather than their function. Nevertheless, this discussion was brought into architecture with some delay. This however promoted biological analogies for referring to the relationship between form and function, that facilitated the comparison of city, body, and architecture with a living creature or better put biologically compared a fake and contractual form in the physical level. In a biological analogy between humans and architecture, the comprehensiveness of humans (mater and soul) is forgotten and the materiality of architecture is generally emphasized. For instance, Le Corbusier refers to Larousse Encyclopédique which defines a human as a composition of a skeleton, nerve system and blood system and takes human as a machine. As a result, his idea of human scale, human function, and human need is the material scale, function, and need as they are linked to machine-like parameters (Jencks, 2002).

5. LANDSCAPE ARCHITECTURE AND ITS ATTITUDE TOWARD NATURE

Landscape designs are not at all as well-known as paintings, sculptures, and buildings. Lorenz (2003), there are very few artworks in the society that are so little-understood by people from the point of view of purposes and ideas than landscape design. Several examples throughout history could prove this claim and act as a compass in the field: 19th century parks helping many American cities to advance, State and National Park Systems enhancing urban development plans of the 1920s and ending in the development of landscape architecture, Green City Development in the works of modern architects and finally protecting ecology in recent years.

Landscape architecture is based on individual and group experiences of nature and covers all material, historical, and even romantic, mystic, and communicative concepts. Sustainable growth of population especially in the developing world has intensified the need for standards to predict urban landscape while increased leisure time in modern countries has induced extra costs to protect parks and natural resort centers on governments. Time is a complex concept in landscape architecture as well. Any plan is part of the interferences done or to be done in the region. In fact, inspired by architecture and fine arts, landscape architecture creates huge changes in the social environment. However, it is still evolving and becoming even more complex. It provides the supplementary and artistic tools through which social and environmental needs are fulfilled, the link between architecture and nature is observed and perceived and different cultures are promoted. In other words, landscape architecture directly faces and facilitates challenges of urban life, protection of open spaces, proper use of resources, and preserving and rebuilding the environment to improve quality of life (Yannick, 2007).

5.1. Nature in the works of Calatrava

Santiago Calatrava begins designing with several sketches. These sketches consider and evaluate not only the design but also the technical and executive specifications of the project. In his designs, natural motifs and forms are of an indispensable position. Profile of a bull ready to charge, human body curves, or tree designs are all mingled with Calatrava's architectural work and comprise his structural sketches. In other words, his love for nature, plants, and even animal skeletons bring them into his designs in the form of a bridge, a train station, an exhibition etc. For instance, the buildings of the Natural Science Museum, Planetarium Museum, Science and Telecommunication Tower of Valencia are all designed and constructed based on the concept of natural forms. Although the shade and ceiling of Stadelhofen railway station represent the rib cage of a Stegosaurus, Calatrava is in love with movement and movement is the inspiration behind his designs. His closest link between Calatrava's architecture and nature is his definition of the tree as he uses in his works (Figure 8). He did not choose the form of a tree due to its basic form and its resistance against movement of arches, domes, and heavy loads but for their frankness in clearly stating the structure and balanced form (Gruber, 2011).

The natural form expresses a behavior independent of scale. As the scale increases, details increase as well, thus, the external appearance stays the same. In the case of parts, details are always more than what can be seen. Calatrava, there are two prominent features in nature worth utilizing in a building: one is optimum use of building materials and second is the ability living organisms have to evolve, grow, and move particularly a form that inspired him greatly (Eminzade, 2005).

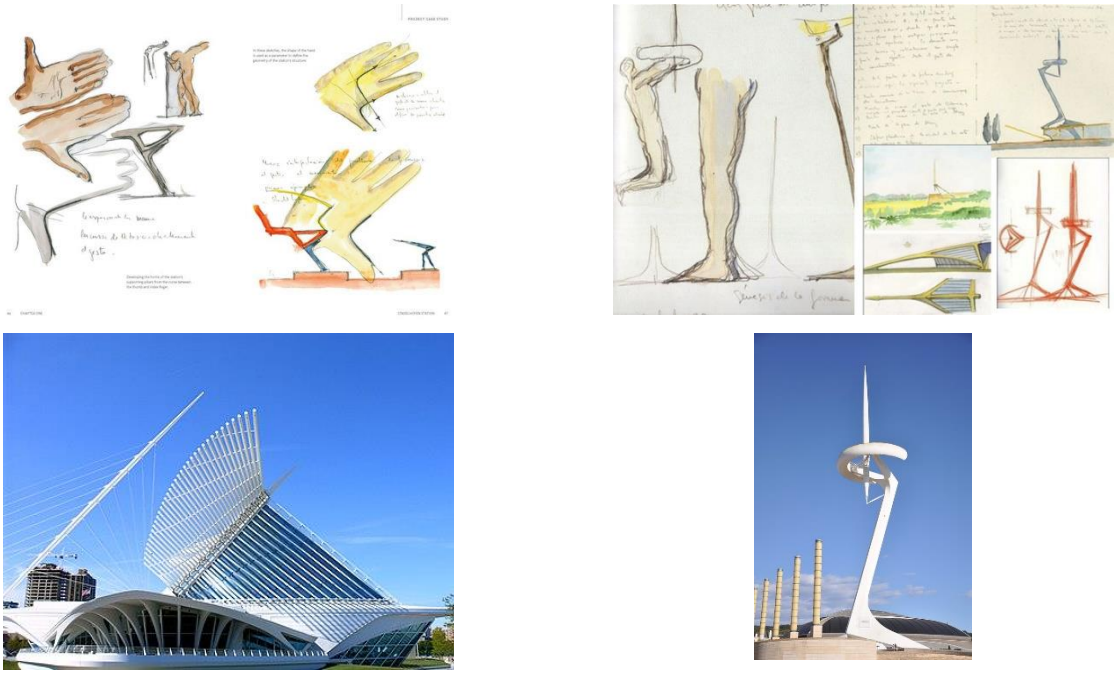

Figure 8. Calatrava' sketches inspired by nature (Gruber, 2011)

6. CONCLUSION

In the past two decades and after the modernism movement began, global attempts began to be made to create emotional, exciting, warm, and sentimental spaces and highlight the role nature plays in human life and work. In fact, the geometry of the artificial space has to be a complement of the geometry of nature. Diverse and complex natural structures have always been an inspiration for designers and architects. Identification, appreciation, and exploitation of forms and structures in nature and its dynamic mechanisms have helped architects create appealing, meaningful, and humane designs. Current advancements in computer sciences, on the one hand, have provided a better and deeper understanding of nature and on the other hand, has affected the structure of human buildings and cities. Natural forms are formed out of diverse compositions and are extremely complex from the point of view of structural geometry. Therefore, taking them as models for creating architectural spaces is a double challenge and an outstanding experience.

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