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Review Paper

Bionic Architecture, Forms and Constructions

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Abstract

Natural figures are originally efficient and considering the aesthetics are also satisfying and eligible. Although in the world of engineering an efficient schema doesn't mean a successful design in aesthetics. There are lots of structures which are efficient but don't have any aesthetic value. Connecting a schema with natural figures and rules can avoid this imperfection and can help the engineers to unite the streak quality with the real and practical structure demands. This article briefly explains the bionic science and introduces the bionic construction systems, in continuation discusses the context of beauty, efficiency and movement in the structural engineering and illumes the topic by indicating some examples. Designers exerted two styles for using and imitating the natural forms. In the first style the goal of designer is only imitating the external appearance of natural forms so the building will just reflect the appeared beauty of the surrounding environment. In the second style designer is inspired to create new designing by the proses which formed the natural figures. Finally this article emphasizes the necessity of paying the structural engineers' attention to the natural morphology to inspire them from optimum patterns so that it helps the inventive engineers become structural artists.

Keywords: Bionic, architecture, structure, forms, construction.

Introduction

Description of bionic: Bionic also called biometric or creative biological engineering, is the collection of biological methods and systems existing in nature used in engineering and new technology. Beside bionic, the word of biomimix is also proposed. This word first was invented and used in 1950 by Otto Schmitt and jack steal when working on an astronomer project in Right Peterson aerial station in USA. They recognize the bionic as the science of systems based on living creatures.

One of the most classic symbols of this science is the usage of impervious colors facing water which was achieved by observing the impervious surface of Lily flower. This effect is called "The Lily effect"[1].

Generally we can consider 3 biologic levels that modern technologies can be modeled based on them: i. Imitation from the natural producing methods, ii. Imitation from the mechanisms existed in nature, iii. Study of organized principles based on social behavior and organisms.

There are lots of modeling by human from nature during the history of life. But the first scientific projects in this context were done by Leonardo Davinchi. He was trying to build a flying machine by studying the birds while flying. Although he couldn't success but his trying were known as the first biometric studies around the world.

Modeling and pattern detector thought

Patterns conclude a completed schema and responding which has general pervasive aspects and is free of any temporal or spatial limitations if used in propitiated conditions for the correct issue; they supply the considered target. The main feature of pattern is refusing to try and performing the activity and using less time and energy.

In a pattern detector's or pattern maker's point of view, any phenomenon contains lessons and ideas to solve half of the problem.

Pattern detector thought' knowing the structure and parts and the way they are connected and their type of connection with the external world and discipline which cohesion all technologies in structure; are all important.

In fact, a pattern detector mind is full of same subjects as universal structures, changing models, the life style of ants and honey bees, stability and flexibility of tree structures facing different strengths such as wind and earthquake, the style of nest building on trees by birds.

Actually it is not ungraceful to observe the global pattern with a realistic appearance so we ill gain some achievement in world. But if we observe world with inward oriented and context detector, we will step to the world of basic semantics.

Since the first day of human life, he always faced problems and matters which without them his life was impossible to develop.

One of many methods discovered by human to solve problems is solving them by patterns or model detector thought. In this method scientists believe that about many life matters we should follow patterns to gain the best result.

Modeling forms and structure of nature to design buildings any invention was rooted from human thought approached by unconscious source of natural talent. Architectural from and operation of nature is the process that we understand it as inceptions and growth by instinct. Most stable form of it is the obligation to life, that the person reveals in the frame of material and in fact it is a process which gives the schema a structure and gives the structure a schema. Architecture is a process that combines different connected powers in the general unit shapes.

One of the first usages of natural inceptions to innovation in architecture is seen in the second half of the nineteenth century. English experts for the first time in 1846 successfully planted a type of Lotus that the diameter of its leaves would reach to 2 meters. Paxton, the English descent architect, after observing the strengths of this Lotus leaves started to study circular shelving and radial structure. The result of this research was the invention of a new structure for light glass ceilings. The crystal palace in London Global Exhibition in 1851 captured the critics.

In two last decades with using the increasing power of computers, architects likeLin got the chance to give new dimension to architecture. These architects' tool are new computer software which don't only design possible 3D schemas but also make complex mathematic models, non-geometric forms and living creature's stimulations calculations feasible[1-3].

Bionic structural systems

Construction system of columns: In nature, lots of tall plants are found with a small straddled surface which is also stable against the different environmental powers. For instance, in cluster of buckwheat; the ratio of chaff diameter to its height is 1.500. Cluster weight is a little more than 1.5 times to the stalk. Height of Sugarcane is approximately 3 meters and its stalk diameter is 15 millimeters (figure 1).

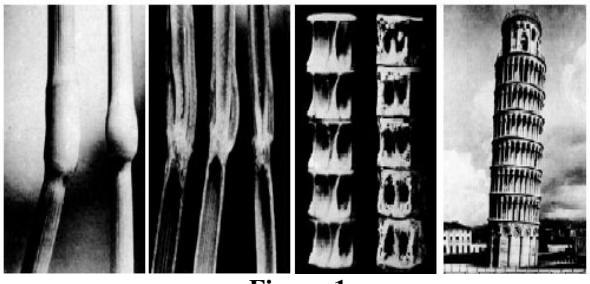

Figure-1
Construction system of columns

Persistence and abidance of these natural buildings can be explained by a collection of features; mutual arrangement of hard and soft texture in the stalk, the great valiancy in reacting to pressure and extension. Grain stalk is like a porter ankle and its nodes display elasticity.

A strong wind can only bend the weak grain stalks, although a tree resists the wind by its root or breaks down. Based on this studies skyscrapers are built[4,5] (figure 2).

Figure-2
Bionic structuresin the form of architectural structures

Structure of cortex style: Searching the environment, dome shaped buildings are easy to find (egg, nut, shale animals, leaves and pet louses). These structures with very narrow walls bend in space and because of their smooth shapes and streaked features can expand the powers equally. A unique, ideal structure considering stability is the egg case. Features of this structure are not only its geometric shape. Even if the diameter of the egg case is 0.3 millimeters, it will have seven layers which each of them have its own operation and the elastic cover that surrounds internal side of egg changes to a structure with the opposite stretching power.

These kinds of structures maybe the most widespread patterns for building the huge spaces with the long distance between the mainstays (pavilion, cinema, theater, sport fields,…) and they need a low amount of material, almost all of them are light and the depth of the sidewalls would only be some millimeters[6-8] (figure 3).

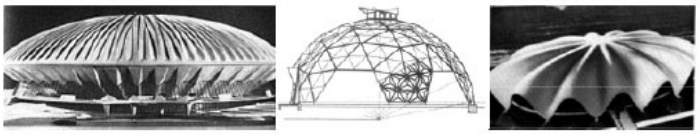

Figure-3
Cortex structures in the form of architectural structures

Elastic cable structures: Spider webs are one of the miracles of natural buildings. They are stronger than steel wires with the same diameter and have elastic affection which lets them stretch 1.25 times more than steel wires. This light, delicate and strong structure caught the attention of engineers. Engineers utilize those structures to create the elastic cables. Spider webs are

used as the first symbols of the suspended bridge structures which are considered as an artistic phenomenon by their variety.

Beside spider we can find the same building style in other natural models such as: bat wings, fish swim fins and finny waterfowl legs in which their structures are distributed and fixed on a tegmental surface.

In contrast with elastic cables, carrier elements and steel mesh there are some cables or systems made of steel cables which can carry different materials on their surface. These structures are useful for covering the space with straddles. (The ceiling diameter of Moscow Olympic stadium is only 5millimeters and its area is about 30000 m^2)[9,10](figure 4).

Figure-4
Structures based on elastic cable

Geodesic structures (structures formed from geometric figures): Nature is the origin of hexahedrons and trihedral which can be observed in aspheric cells or bubbles. Whether they are complex natural organisms or any other figures, these shapes can form a new figure under pressure which their axes make degrees about 120.

These shape surfaces are elastic and there are some tensional events on them. The same figures can be seen on giraffe skin or turtle back. We can see the same shapes in the internal parts of beehive. A bee builds the honeycomb by chewing the beeswax alluvia and salivary splutters in the shape of hexagon and sticks these shapes to each other. This phenomenon has been always the source of inspiration for philosophers, naturalists and mathematicians.

Radiolarians are fixed monocles or microscopic planktons which lived in brine and some of them live in aqueous. A radiolarian is generally like a sphere that is a combination of bony silicon, strontium or bony objects which are flowed in cell content. This bone mesh is like separated bubbles. Existed energy and elastic surface in the environment ends in a hexagon and sometimes leaky shapes so the cytoplasm can capture the nutrition[4,7,8].

Fouler believed the best structural mesh with a spherical shape, hexagon or trigon which is called geodesic (figure 5). A geodesic structure is formed from some quadripartite like sphere and never change. This structure is a fixed, hard, symmetric and simple combination that contains remarkable elements in another word this structure is a combination that is made simply, shortly and cheaply.

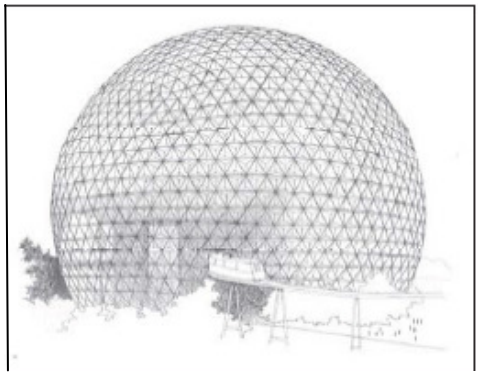

Figure-5
Geodesic dome, united states pavilion, fooler, 1967

Nature and structure function

Shapes in nature are formed in nature for the best function and transfer large amount of power with using the least material. Timpson in his book “about growth and figures” says that living creature shapes are the result of matching with physical powers. Finings in his book “the anatomy of nature” says the structure evaluation in form is a wise reaction for living. In fact form and structure are the result of compromising with the environmental powers. Usually all natural structures have textural layers which cause these form changes under pressures and makes elastic or pressures reactions in them[9].

This issue is seen in wheat stalk or strong trees and used in creating airplane structures and skyscrapers which is named monochromic system or mesh case.

On the other hand all the natural structures must be fixed when facing elastic physical powers and pressures. As an example, we can consider spider web which is a mesh of strings and spider and victim are the pressure axes. Another example is the elastic structure in Munich, Germany in which steel string meshes are elastically and huge steel rolling pin tolerates the pressure (figure 6).

Figure-6
Munich Olympic stadium

The famous motto "less is more" is achieved in the world of structure in order to gain the most operation using the least material. Some important examples of these successful organic shapes are: Munich stadium, diplomat club in Riyadh and Manheim exhibition fair (figure 7 and figure 8).

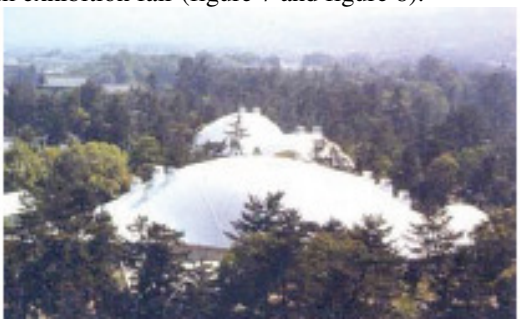

Figure-7
Manheim exhibition fair

Figure-8
Diplomat club in Riyadh

Nature and structural aestheticism

Natural shapes originally useful and utilizes schemas. In nature there are desirable and eligible considering aesthetics. Although, in the world of engineering, utilized schemas are not always successful designs based on aesthesis. Connecting a schema to the natural shapes can avoid this weakness. Video perception from the natural figures are very important in development of our basic structure which made by human.

The reason which an ordinary person may not like a completely correct design is not seeing anything similar to it in nature. Although arch is valuable in aestheticism, a frame is neither beautiful nor ugly and placed out of the art world. In environment concave objects and elements are almost usual. Scallop is not only symbol of protection also is considered as a well-shaped element of aesthetics[9,11].

Pantomimic structures in despite of being light pretend heaviness and are comparable with the traditional stone domes which don't let us understand their structural behavior and confuse the audiences. These kinds of confusion never happen when talking about tents because there are some symbols like them in nature although in smaller scale.

Examples of connection between nature, aesthetic and structural function

Ludwig Erhard Haus building in Berlin, Germany was built by Nicolas Grim Shaw is a great symbol of this aim. Repeated oval arches inspired by grave-digger skeleton to suspend floors on atrium (figure 9).

A bowed bridge makes buoyance it power out in basements although a suspended bridge pulls the power inside considering these item a bridge can be designed to reduce these powers, like the structure of royal Albert bridge near plymouth in England (1859) by Isambard Brunel (shape No 9). Designer built a light structure comparing a bowed or suspended bridge. This combination was used for millions of years in the skeleton of animals[12,13].

Figure-9
Royal Albert bridge (No. 9)Ludwig Erhard Haus building in Berlin

Best examples for that can be "Brontosaurus", a kind of dinosaur, in its body legs equal towers, stomach is like chains and spinal column acts as arch. Its legs are shorter so we can save expensive materials[12] (figure 10).

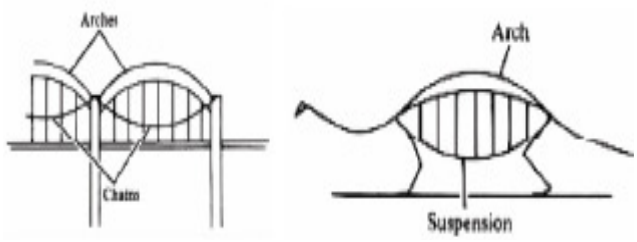

Figure-10
The similarity between royal Albert bridge and Brontosaurus

Inspiration by nature doesn't only take place in bridges also is used in modern buildings such as central Swiss Re in London which is designed like a sea sponge (figure 11). This little creature sticks to the bottom of sea-bed and has a perfect silicon skeleton with a completely geometric shape. This office helps the wind flow exactly like a sea sponge. Comparing a rectangle shape, this cone reduces the wind speed. Beauty of this structure is the result of a natural figure modeling.

Figure-11
Sponge structure of the shell structure Swiss Re building

Another admirable building which inspired by fingers is Waterloo train station, designed by Nicolas Grimshaw (figure 12).

Figure-12
Knuckles of the hand as a concept of waterloo station design

Nature and Movement: One of the features of natural organs is their ability to move and change. Basically one of the points of atomic discipline in universe is movement which is also so easy to find examples for in nature like typhoon, flood, plant growth, hunting and so on. Movement is followed by contexts like changing place or shape. So if we follow the context of movement in building we will learn the best lessons from nature. Considerable note in structure movements like human body is the balance while moving. Most examples of these structures are seen in the stadiums, public spaces, coverings or historical sites, mobile bridges, mobile doors, small structure confirmed with environmental conditions and …

Between architects and genius engineers in the world of aesthetic structures and mobile structures Santiago Calatrava is a unique member. He starts his sketches by the studying the shapes, manners and natural structures like human or animal body and trees then he follows rules controlling the proportion and balance in their structure. In most of his projects it's so hard to distinguish architecture, structure and sculpture. But the note is they all belong to the world of art. Even in buildings which are not mobile we can recognize the powers in the structure form and its parts. As he says: "powers even when formed in forms still show movement and movement and beauty are one!" another feature of his projects is making movement or pretending the sense of soft, curve movements using the changes of straight lines[14,15] (figure 13, 14).

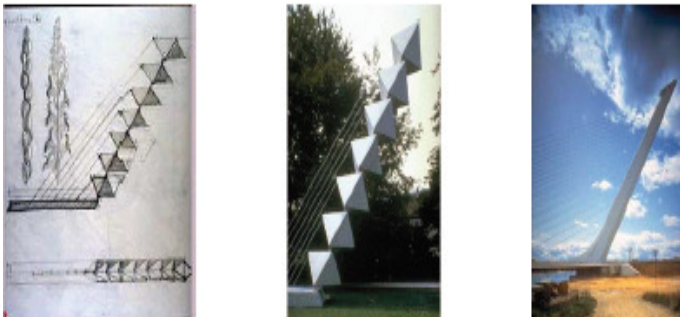

Figure-13
Alamillo bridge, sketch to reality

Figure-14
Residential building in *Switzerland*, concept :Spine

Conclusion

Man attempts to impose order or accept the irnature or the irnature in order to create a structure has always been the question. Although any point in the past here was no contact between engineering and biology. Human unconscious imitation of nature and the payment of interestsought surrounding it. Today, wear creatures of a specific type of machine and mechanisms that are used in specific and complex. The relationship between these two phenomena is expressed by bionics. The architecture of this science, like other sciences, is highly efficient and provides a wonderful solution architects of the victim.

With new bionic approach to facade architects have tried to construct the built environment and nature are better matched. Ideas from nature to architecture helps to relate the various forces organized in the form of units and mix. Components of an overall balance and composition may not appear, but will never seem unrelated.

The relationship between nature and architecture, is nearing its apexbionic and partly compensates for the shortcomings. Compensate for the shortcomings of human life in harmony with nature, and puts him to compromise and not damage it makes. This is what all of today's technology in the field of engineering sciences, architecture and more are expected.

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