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# Manipulating Architectural Design Forms Based on Nature

## 1. Introduction:

Since the creation of earth, all of its creatures started establishing shelters for themselves. Humans as well started to build dwellings to protect themselves from the climatic conditions and predatory animals. All what they looked around was nature to assemble all available materials helping them to build those accommodations. Not only materials, but also built structures were inspired from those configurations found in nature like bird nests or other animal huts. No aesthetic aspect was taken into consideration as much as the structure and its stability. (merriam-webster, 2009)

Throughout time, architects have believed that nature is a very good source of inspiration for their works. Louis Khan said on nature as a powerful and trustful foundation:

> "It is my feeling that living things and non-living things are dichotomous… but I feel that if all living plants and creatures were to disappear, the sun would still shine and the rain still falls. We need nature, but nature does not need us."

William McDonough and Michael Braungart also said:

> "Nature doesn't have a design problem. People do... Instead of using nature as a mere tool for human purposes, we can strive to become tools of nature who serve its agenda too...What would it mean to become, once again, native to this place, the Earth - the home of all our relations?"

Primarily, all structures are affected by the surrounding that are built in context. For example, when the structure is being built, many variables should be taken under consideration, such as the configuration and morphology of the ground, the altitude or the distance between the site and the sea. Nowadays in many cases materials from the local pub at are preferably used both in terms of influence as well as sustainability.

Another important factor is the weather. Climate conditions are a crucial factor in the design process of the building as it is advisable to be utilized, in order to get the maximum benefits and accumulate a better way off usage. In many cases people usually tend to study the way nature functions and try to apply them on buildings. Generally, this happens in order for the building to be more functional and save as much energy as possible. Based on all different ways that nature affects architecture, different types of architecture have been created with major examples organic and biomedical architecture. (Benyus, 2006) An example is the way ants create spaces in their underground nests in order to take advantage of the higher temperature in contrast with the air temperature using the ground as insulation and saving energy.

Another form of inspiration is the forms created. To be more specific, the main question is about the reasons that architects in many cases study nature to take inspiration for the design and the form of the building they design. These shapes could be the shape of a flower he way

that waves are moving or the way that a jaguar is running. In order to answer the main question more sub-questions emerge. What is the definition of nature, architectural form and design? Why is nature and it inspiration source for design? (Feuerstein, 2002)

In the first section of this paper an analysis of the main definition of nature, form and design, concept ideas and the connection between them will be discussed. The second section will focus on nature as an inspiration do you link the history of architecture, do ways that nature can inspire architects and more modern case studies to be analyzed. This third and the last section will discuss the findings of this paper.

# 2. Literature review

## 2.1. Definition of architecture

There have been given a variety of different definitions in order to explain what exactly is architecture. *Architecture is the art and science of designing and erecting building*. Differently, it is known as *the art or practice of designing and constructing buildings*. *The complex or carefully designed structure of something.* Despite the small differences between these definitions they essentially explain the same fact which is that architecture is an art and it is the philosophy behind the design of the building that makes it functional, efficient, combined with its natural and environmental context by the use of well-thought design forms materiality and structure in order to be built.

## 2.2. Definition of nature

It will be attempted to discover what exactly it is meant when someone refers to nature, what is the meaning of the word nature and which elements belong in the physical planet. "Nature is the phenomenon of to the physical world collectively, including plants, animals, the landscape and other features and products of the earth as opposed to humans or human creation". Based on this definition, nature is the natural world without any change that people made, thanks to the development of the civilization. The nature includes all the elements of the natural world, for instance, mountains, trees, animals or lakes.

## 2.3. Definition of form and design

Form and design, our fundamental terms of architecture. The definition of form and design mentioned that: "Form is the external appearance of a clearly defined area, as distinguished from color or material". "Design is the preparation of the preliminary sketch for the plans for a work to be executed, especially the plan, form and the structure of a certain scheme".

## 2.3. Definition of concept

"Concept is an idea of something formed by mentally combining all its characteristics or particulars in a construct". The process of designing a building or general scheme incorporates all these terms that were mentioned. The concept is the initial idea of the project and as it is developed through the design it gets a clearer and realistic form.

## 2.4. Relation of Nature with Architecture

Some facts have been mentioned about the direct connection of nature and architecture. That is explained by the fact that there are so many different kinds of architecture that are connected to nature. Organic, biomimicry, vernacular and landscape architecture are some examples. All these categories uses nature as inspiration for the building form, the function applied or the way that building could be combined with natural environment. *"What is made by man is not natural. However, there must be a certain distance between the natural and the manmade. But,*

*there must be still a direct dialogue between both. Architecture comes from nature forms but it also transforms nature…"*

# 3. Nature as a source of inspiration

## 3.1. The sources

*"Inspiration is the process of being mentally stimulated to do or feel something, especially to do something creative"*. (Avery, 2018) When a project starts, architects try to inspiration in order to design their idea. This idea after many changes and a lot of development will take the final shape. Inspiration could be almost anything for an architect. Four instance come on inspiration for an architect could be a painting that they saw, the shape of the site for which they have to design the building or the functionality of the building. If an architect who is designing for example a shopping center, which needs to have a very well-thought circulation that could be the main inspiration for the building. (Eckert & Stacey, 2000) In many cases, architects find new sources of inspiration to explain their concept. There are many common sources of inspiration, which are used very often and other sources of source of inspiration tend to be extraordinary. One of the most used sources of inspiration is nature because it offers many ideas that an architect could use in a design. The variety of forms in nature seems endless. Out of a limited quantity of mathematical rules a seemingly endless quantity of forms and patterns arise. Patterns derived from mathematic rules. The beauty of patterns and forms in nature based on mathematics rules, the regularity and uniformity, and symmetry are what man feels harmonious. (Feuerstein, 2002)

## 3.2. Nature as inspiration in the history of architecture

The design and therefore architecture have a tight connection with nature. This connection started when people started to build their first buildings. Throughout will be mentioned some characteristics examples of inspiration that people had during history that evidence that nature was always an inspiration for architecture from the first buildings till nowadays. (Kuz & Gans, 2003)

The example of architecture inspired by nature during the period that the first buildings were erected are countless. This was absolutely normal as the first shelter-like residences that were ever built had nature as the only source of inspiration. One very characteristic exam is that the form of birds nest inspired the shelters that were built. Apart from the natural inspired from of buildings that the people design, they were using the functions of nature in their buildings in order to make them more functional. As Albert Durer has said about importance of nature to use it *"Because truly the art is in nature, who can tear it out, got it"*. (Finsterwalder, 2011)

Architecture started from the time that human being feels that they need to go out of the caves in summer times for hunting and gathering; they start to create the primary shelters to protect themselves from the climatic conditions and other possible dangerous. To start architecture the only available source that they could use it or getting idea from it was nature. They create their shelter by getting idea from the bird's nests and other animal hut as it shown in figure 1; and create their first natural tent by using the trees branches and leaves. The first human dwelling trace found from as early as thirty thousand years ago.

*Figure 1 Inspirations from nature in pre-history*

After the bones and trees branches implement the early improvement of human tools was the stone material and later on it went to be the building material. Stone Age made a challenge in narrative of architecture by the invitation of stone tools and instrument and via these tools they start to grave the stone pieces to construct the buildings and mostly the temples. One of the fist and historical stone monument is Stonehenge in England as it shown in Figure 2; which was the genius of architecture on that time.

*Figure 2 Stonehenge in England*

Although humans invent new tools and material but still the material that he used was directly from nature and just the design ideas are altered in compare with pre-history periods. As it mentioned in that time humans for creating their shelters they were getting idea from nature like bird nest. After civilization and invention of new tools their architectural forms is change but still they had some idea from nature. Development in technology is getting faster and faster and it effect all the industries especially architecture which by looking through the history and the building forms it is easy to feel it.

For a period these development of technology and architecture also was in the slow timeline. Suddenly by industrial revolution the great change happened in all industries and also it effects on architecture. In this period the invention of machine and also mass production helps to create more and fast. The forms, shapes and design idea are also change totally for example the Eiffel monument (Figure 3) which is in different style of its previous ages.

*Figure 3 Eiffel tower, one of the first steel structures*

## 3.3. Historic examples of buildings inspired by nature

### 3.3.1. The Parthenon of Athens

The Parthenon in Athens, built by the ancient Greeks from 447 to 438 BC, is regarded by many to illustrate the application of the Golden Ratio in design. The photo below shows a Golden Rectangles with a Golden Spiral overlay to the entire face of the Parthenon. This illustrates that the height and width of the Parthenon conform closely to Golden Ratio proportions. This construction requires an assumption though, that the bottom of the golden rectangle should align with the bottom of the second step into the structure and that the top should align with a peak of the roof that is projected by the remaining sections. Given that assumption, the top of the columns and base of the roof line are in a close golden ratio proportion to the height of the Parthenon. This demonstrates that the Parthenon has golden ratio proportions, but because of the assumptions is probably not strong enough evidence to demonstrate that the ancient Greeks used it intentionally in its overall design, particularly given the exacting precision found in many aspects of its overall design. (Meisner, 2013)

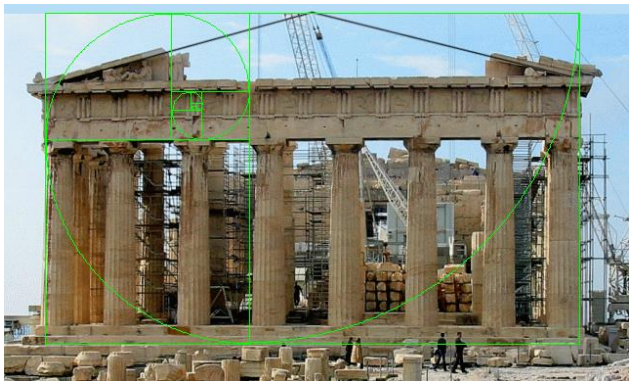

*Figure 4 Parthenon (goldennumber, 2013)*

### 3.3.2. The Sagrada Familia of Barcelona

Nature has inspired humans in many ways over many centuries. But maybe none match the completeness of Antonio Gaudi's relationship with nature – Nature as structural, functional, spiritual and decorative inspiration. (Zammit-Lucia, 2011)

Gaudi was a spiritual man with a great regard for nature as God's creation. The newly consecrated Sagrada Familia "strives to compress all of earth and heaven into its structure – endless saints, biblical scenes, symbols, inscriptions, seashells, reptiles, birds, flowers and fruit." (Moore, 2011) Gaudi even included in his highly decorative sculptural details, images of the animals that were going to be displaced by the building of the huge church on the then outskirts of Barcelona. Neither are sculptural details reproducing nature limited to the Sagrada Familia – they are widespread across Gaudi's full range of art-in-building.

*Figure 5 Interior of Sagrada Familia*

But Gaudi also realized that nature provided more than mere decoration. His structural forms mimicked those found in nature thereby providing him with both aesthetic and functional benefits. Columns mirroring trees or human bones, roof structures mirroring leaves, arches

mirroring rib cages; all these allowed him to reduce the materials needed to build strong structures because of the supreme functionality gained from reproducing nature's designs.

*Figure 6Left: a tree in nature, Right: Sagrada familia column structure*

So what creative personality traits did he display? Traditional and conservative, yet at the same time rebellious and freethinking is the juxtaposition that stands out. As a dedication to his faith, he designed the tallest cathedral in the world. The design is traditional and conservative, yet vigorous. It is rich with a stupendous amount of details, influenced by his faith. Gaudi channels his faith into his art making the Sagrada Familia the perfect case study. Still constrained by physics Gaudi had to make it possible to be built. To realize his vision, he used tree-like pillars to hold up the roof. He had to be objective to understand his limitations.

## 4. Natural form becomes the Architectural form

During the history of architecture there have been many buildings inspired by nature. It is obvious that in some of them it seems easy to understand, that their shape and form was inspired by the natural environment but in some others is not that easy. Examples of buildings that are difficult to recognize that their design is inspired by nature are the monuments that will be mentioned accordingly. The examples that will follow emphasize that the architect didn't just choose to use nature as inspiration, but also to represent nature through the form of the buildings they designed.

Taipei 101 (Figure 7) officially became the world's tallest in October, 2003, when the final section of the spire was put into place. Of the many ways to define the world's tallest, the building claims three categories: the tallest height to roof, tallest to structural top, and tallest occupied floor.

Among the commercial and corporate uses of the building, a five-story shopping mall is housed at its base; the Taiwan stock exchange occupies seven floors; and several restaurants offer spectacular views on the upper levels of the building. An indoor observation deck is located on the 89th floor and an outdoor deck sits two floors above. (Taipei 101, 2003)

Taipei 101's architecture is inspired by traditional Chinese buildings, labeled by some as "Oriental Revivalism." The number "8," a symbol for prosperity and luck in China, appears prominently in the stacked segments of the building, made to resemble the shoots of a bamboo tree. Ancient coins are affixed to the exterior of the 26th floor and a Feng Shui master was consulted as part of the design process.

*Figure 7 Left: Taipei 101 Right: Bamboo Plant*

Aldar HQ designed by MZ Architects (figure 8) has a distinctive and innovative design of this kind; its circular convex shaped façade gives it an outstanding and unique frontal altitude. This iconic fully glazed structure is completely circular in elevation and curved in all other directions.

When challenged to create an iconic structure on Al Raha beach, Marwan Zgheib decided to create a simple building that would possess the calm, ideal beauty of classical architecture while also having considerable expressive power, a building that would compete with the iconic architecture of the UAE and create a sense of place and identity for the area.

To attain this end, Zgheib first had to select from natural forms, under the guidance of a concept of regularity. Accordingly, he was inspired by the clam shell which has deep meaning for Abu Dhabi with its seafaring heritage, as well as the symbolism of the geometric round shape, and imagined two giant circular curved walls of glass mirroring an open clam shell. (ArchDaily, 2012)

An extremely pure geometrical but daring design was born: a round skyscraper with a curved glass skin covering the area of four football fields.

*Figure 8 Left: Aldar HQ Right: Seashell*

Animal fascination is culturally desirable. As environmental awareness moves increasingly center-stage, it is vital that architects demonstrate their respect for the earth's forms. It may be starting with symbols and visual gimmicks, but zoomorphism has a serious aim: synthesis rather than conflict for those age-old enemies, the rural and the urban.

One of the stars of the show, pictured here (figure 9), is the Milwaukee Art Museum. Spanish architect Santiago Calatrava has based his extension to the museum's original low-lying building on a bird in flight. Seventy-two thin steel cantilevers, between eight and 32 meters in length, are hinged either side of a huge sloping spine. (Davies, 2002)

*Figure 9 Milwaukee Art Museum*

Another organism that has adapted to arid, dry climates is the cactus, which has also been mimicked in design. What makes the cactus so unique is the technology it uses in order to survive. The signature characteristic of a cactus is the spines that encompass the entire plant. But these spines serve more than just one purpose. The obvious purpose for the spines is for protection. It makes it very dangerous and difficult for herbivorous animals to eat the plant. They also serve to channel the rain water down to the base of the plant where it gets collected and stored. Being that most cacti live in areas that receive very little rainfall, it is crucial that it takes advantage of capturing water when the opportunity presents itself. But the most important function that the spines serve is to help shade the plant from the intense sun.

By having so many spines throughout the exterior skin, it shades the plant enough to keep the internal temperature low enough to where the water that the plant stores does not evaporate. This is key for surviving in such an extreme climate So how can these technologies influence the design of a building? Aesthetics Architects in Thailand designed a building in Qatar that uses these technologies to create a unique sustainable solution to a complex problem.

The new Minister of Municipal Affairs and Agriculture office (MMAA) in Qatar is going to be a first of its kind. Aesthetics Architects was looking for inspiration to design a building that would be situated in the hot, dry climate of Qatar, an area that only receives approximately 3.2 inches of rainfall annually. They decided to investigate the cactus for ideas on a building solution.

The new MMAA building was designed based on the shading properties of the cactus' spines. It achieves this by incorporating sunshades on the exterior of the building. Much like in Kieran's analysis on a buildings envelope and a filter, these shades act like filters with the sunlight that is penetrating the spaces. With the intensity of the sunlight that beats down onto the building and its occupants, a normal building would have to have a large cooling system in order to make that space comfortable for the user.


*Figure 10 Cactus plant/ MMAA Doha, Qatar*

The sunshades on the MMAA building however have the ability to automatically fluctuate up and down, depending on the desired interior temperature, to regulate the amount of sunlight and heat that is transferred into the space. This innovative solution allows this building to lower the size and amount of artificial cooling necessary for the building to operate properly as well as providing a sustainable solution that is aesthetically pleasing. At the base of the building is a botanical garden which will hopefully be used as an edible garden and living machine.

Overall the building is an example of a solution at the macro level, encompassing the building as a whole and how it functions within a specific environment.

## 5. Conclusion

This report tried to discover the reasons that architects use nature in their buildings. Throughout this paper it was determined that architecture and nature are connected since architecture started to have some certain rules and philosophy behind every design that utilize natural elements forms and theories. Furthermore, there were found many different answers about how nature should be used by architects. There are beliefs suggesting that nature should be studied in order for the architects to develop the building design, from concept to its final stage, establishing an implementation of natural elements and mechanism to it. There are also other beliefs which support that a building could have natural form that it can be derived from a natural environment. From the case studies it has been understood that every architect according to his architecture philosophy, the place, this scheme and the period they designed it choose a natural form for certain reasons. In addition, architects use the advantages offered by nature such as, functionality, efficiency, form, structure, and materiality, in order to apply these advantages on their buildings. The question is, if the architects will continue to be based on nature for design concepts and building forms? In addition, another question how is this going to influence the architecture in the future? According to Jaun Torras, *"the architect of the future will boot inspired by nature he goes it is the most passionate, the most you would've been and the most economical of all methods."* (Senosiain , 2003)

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