APPLICATION OF BIOMIMCRY TOWARDS SUSTAINABILITY OF BUILDINGS

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Abstract— **In order to explore and fulfill his desires, man has always exploited Nature and destroyed natural environment. This has resulted in some negative repercussions on the environment in which man lives – Global Warming. To curb the horrifying impacts of global warming people are aiming towards sustainable living. Everyone wants a development that meets the need of the present without compromising the needs of future generations and having a minimal negative impact on nature. Currently, buildings account for 40% of world's energy, and it is projected that in next decade 60% of world's population will be living in buildings in cities with a population of over one million. And world's energy is expected to grow more than 30%. In order to meet the required energy needs without further harming the nature, architects and other professionals are trying many different passive and active techniques in which they can switch from non- renewable energy to renewable energy. Biomimicry is a science that studies nature's models, takes inspiration from them and shapes designs and processes that help reduce source depletion. Learning from nature, one can create efficient, living buildings, learn to use sunlight and recycle energy, reduce pollution and be in tune with our environment. The present work aims to explore the application of Biomimicry in buildings, how nature inspired buildings can save resources and energy use and draw inferences of how biomimicry can bring about a change in the built environment with respect to environmental concerns globally.**

Keywords: Biomimicry, nature, sustainability;

I. INTRODUCTION

The Biomimicry Institute defines biomimicry as the science and art of emulating Nature's best biological ideas to solve human problems. For billions of years nature—animals, plants, and even microbes—has been solving many of the problems we are still dealing with today. Each has found what works, what is appropriate, and what lasts.

Biomimicry and biomimetics come from the Greek words bios, meaning life, and mimesis, also meaning to imitate. Scientist and author Janine Benyus popularized the term biomimicry in her 1997 book *Biomimicry: Innovation Inspired by Nature*. Benyus believes that most of the problems that have ever existed have already been solved by nature. Benyus suggests shifting one's perspective from learning *about* nature to learning *from* nature as a way to solve human problems. Sustainability issues are among those that can be addressed by applying the biomimicry process to a project. Utilizing an integrated design process can help open up opportunities to identify biological solutions to building problems and include the perspective of nature in the design process—as it is likely that nature already offers a solution.

Humans have always looked to nature for inspiration to solve problems. Leonardo da Vinci applied biomimicry to the study of birds in the hope of enabling human flight. He very closely observed the anatomy and flight of birds, and made numerous notes and sketches of his observations and countless sketches of proposed "flying machines". Although he was not successful with his own flying machine, his ideas lived on and were the source of inspiration for the Wright Brothers, who were also inspired by their observations of pigeons in flight. They finally did succeed in creating and flying the first airplane in 1903.

II. APPLICATION OF BIOMIMICRY

Recent success stories exist in terms of how biomimicry can be applied to building design. While buildings serve to protect us from nature's extremes, this does not mean that they do not have anything to learn from the biological world. In fact, nature regularly builds structures with functionality that human-built structures could usefully emulate. Biomimetic research, science, and applications continue to grow and are already influencing the next generation of building products and systems as well as whole building designs.

For example, photovoltaic systems, which harvest solar energy, are a first step at mimicking the way a leaf harvests energy. Research is underway to create solar cells that more closely resemble nature. These cells are water-gel-based—essentially artificial leaves—that couple plant chlorophyll with carbon materials, ultimately resulting in a more flexible and cost-effective solar cell

The bumpy surface of a lotus leaf acts as a self-cleaning mechanism allowing dirt to be cleansed off the surface naturally by water, for instance, during a rain shower. Even the smallest of breezes on the plant causes a subtle shift in the angle of the plant allowing gravity to remove the dirt without the plant having to expend any energy. This same idea has been applied to the design of new building materials such as paints, tiles, textiles, and glass that reduce the need for detergents and labor and also reduces maintenance and material replacement costs.

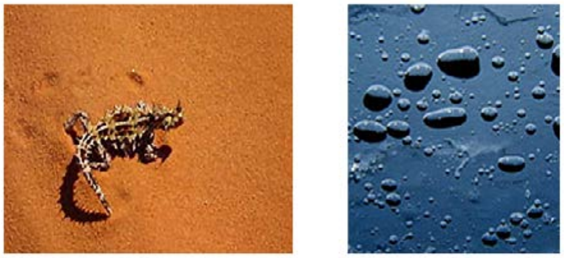

Fig :1 Thorny Devil, application of biomimicry

Construction-materials technology requires continual improvement focus in the built environment. Of particular concern is improvement of indoor air quality and volatile organic compound (VOC) reduction and removal. Although VOC's are best never having made it into the indoor environment, they have been a major contributor to poor indoor air quality and sick building syndrome. Colombia Forest Products has looked to biomimicry in solving the issue of carcinogenic, formaldehyde-based glue in its plywood products. The blue mussel mollusk creates a unique amino acid, which formulates a strong thread, connecting it to rocks in the ocean. By remaining attached to the rocks, mussels withstand the pounding waves of the surf. The mussel "glue" is created at ambient temperatures, under ambient pressures, and in a wet environment. Looking to nature, researchers were able to mimic the mussel recipe, creating a soy-based and formaldehyde-free adhesive now used in its products.

Fig :2 Blue Mussels, application of biomimicry

As the second most consumed substance in the world behind water, concrete is the most used building material. At a cost of $37 billion per year, about 10 billion tons are produced annually. The creation of portland cement emits 0.8 tons of CO_2 for every ton of cement produced. Obviously, cement production comes at an environmental cost. Brent Constantz is a bio mineralization expert from Stanford University; Constantz used biomimicry to observe the construction of the coral reefs and as an application technology for concrete production. CO_2 gas and ocean water have a natural reaction, which creates calcification. This rapid mineralization uses CO_2 as a raw material that creates the coral structures.

By using waste gas from a local power plant and dissolving it in water, Constantz and his company Calera are using CO_2 as a feedstock for concrete production. In addition to sequestering carbon within the concrete they are producing, they are helping to reduce the carbon footprint from portland cement production.

Biomimicry has since become a design discipline that investigates how the natural environment operates, and more specifically, how living organisms create and solve design challenges. Design solutions adapted through the use of biomimicry are intended to foster a more sustainable human experience and existence. Major architectural design firms, in building and city design, are actively using this new discipline.

Through a process of reconnecting with nature and researching living organisms, the design teams, together with biologists, are looking at how natural systems operate and are "asking nature" as a means to inform their building design. How do living organisms capture, store and process water, sunlight and waste? How does nature cool, shade and recycle nutrients? In addition to some of the more basic building functions, other designers are looking at 3D printing and nanotechnology as a means to advance building material design and construction. The observations of lessons in nature are having a profound impact and are challenging the way things have been done since the industrial revolution.

Applied biomimicry can be utilized in three ways or in a combination of these three ways:

Organism Level

The first level is Organism- this refers to mimicking a specified organism.

Behavioral Level

The second level is Behavior- this refers to mimicking a specific type of behavior or act that the organism does to survive or replicates on a daily basis in relation to a larger context.

Ecosystem Level

The third level is Ecosystem- this refers to mimicking a specific ecosystem and how it functions successfully as well as what elements and principles are required for it to function successfully.

III. APPLICATION OF BIOMIMICRY IN BUILDINGS AIMING SUSTAINABILITY

CASE STUDY 1 Cactus and Temperature Regulation- MMAA building- QATAR (Organism Level)

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

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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. Aesthetics Architects in Thailand designed a building in Qatar that uses these technologies to create a unique sustainable solution to a complex problem.

The 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.

Fig:3 MMAA Building at 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. But Biomimicry also provides the opportunity to go even further and look at the micro level, such as looking at the design of the specific technologies that connect to the whole.

CASE STUDY 2 Zira Island Master Plan- Azerbaijan- (Ecosystem Level)

The Zira Island is located within the crescent bay of Azerbaijan's capital Baku, on the Caspian Sea. This project was designed to be a Zero Energy resort and entertainment city on the island. Creating a zero energy resort that consumes a 1,000,000m² island may seem impossible, but BIG architects has found a way to do it successfully and beautifully. The project was brought to BIG architects by a minister from Azerbaijan who was inspired from a previous project that BIG architects had proposed. The minister was inspired in the way that you can recreate "mountains" out of architecture because Azerbaijan is known as the Alps of Central Asia. With this in mind, the minister asked BIG architects if they could create a resort and entertainment city that would recreate the silhouette of the seven most significant mountains in Azerbaijan. This is how the building forms were derived. Each structure not only represents one of the seven most famous mountains in Azerbaijan, but they are all also inhabitable. What is unique about this site is that the Zira Island has absolutely no vegetation, no water or resources. Bjarke Ingels describes it as being a desert. Because of this, BIG architects overall master plan was designed to be its own independent ecosystem. They were able to do this by using a variety of new sustainable technologies to produce enough energy to power the entire island.

Fig: 4 Overall Concept of Master Plan

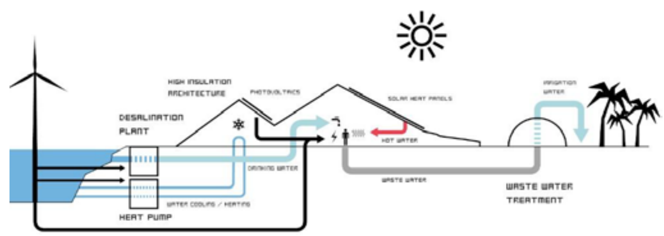

Fig: 5 Section Displaying Sustainable Technologies

Wind energy from wind turbines which are seated in the Caspian Sea, are used to power desalination plants. The desalination plants are used to extract the salt from the sea water and convert it into fresh water which is suitable for humans. The water is then used for heating and cooling the buildings. All of the excess waste water is then dispersed into the landscape to provide nutrients to the new vegetation on the entire island. In addition to the waste water, storm water is also collected and recycled for irrigating the plant life around the island. During the extraction process to make the water suitable for humans,

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there is a large amount of solid waste that is filtered and collected. The solid minerals that are gathered are also recycled by turning these solids into top soil and thus used to fertilize the vegetation. Evacuated tubes and photovoltaic panels were also placed on the exterior facades and at the top of the buildings to generate power as well. With all of these elements working together, the island becomes a self sustaining, independent ecological system; one that combines private resort villas with a gorgeous green valley that is easily accessible to all who inhabit the island.

CASE STUDY 3 Eastgate center building in Zimbabwe (Behavioral Level)

Extreme termite mounds are formed when the aboveground nests grow past the capacity that was initially made. The nests are made to protect the nesting and royal areas as well as fungus combs (their primary food source). The fungus can only grow and be sufficient if it is kept at exactly 87^o F. The temperatures outside of the mound fluctuate greatly due to the location, Africa. At night, the temperature can drop to a chilling 35 ^{o}F and during the day can reach a scorching 104 ^{o}F!, they open and close specific “vents” which are precisely placed in the mound to regulate the air within the mound itself.

Eastgate convention Centre tower-buildings in Zimbabwe was designed to mimic the heating and cooling systems termites use in their mounds. The way they construct their mounds to maintain a constant temperature. The insects do this by constantly opening and closing vents throughout the mound to manage convection currents of air - cooler air is drawn in from open lower sections while hot air escapes through chimneys. The innovative building uses similar behavior in the design, and air circulation planning consuming less than 10% of the energy used in similar sized conventional buildings, hence moving towards a more sustainable building

Fig: 5 Termite inspired office in Harare, Zimbabwe, with no air conditioning

CONCLUSION

The built environment is increasingly held accountable for global environmental and social problems with vast proportions of waste, material and energy consumptions' impact on nature. Biomimicry which is a multi-disciplinary innovative tool involving a wide diversity of domains like electronics, biology, chemistry, physics design and engineering, studies nature and emulates its creative functions , processes and eco systems using advanced technology to solve human problems in integration with nature. it is possible to shift the future of designs into mimicking nature's design principles and developing it into a built environment, that is able to gather and use natural resources efficiently, diversify and cooperate to fully use the habitat, and is capable of functioning in a sustainable and regenerative way

Nature has been sustainable and energy efficient for billions of years. Natural organisms have evolved and developed strategies in order to be energy efficient. Through applying these characteristics into architecture, human problems can be solved. Mimicking nature has significant potential in order to accomplish a new approach for energy efficient buildings.Through discovering and emulating nature’s strategies the energy consumption level can be decreased by applying the biomimicry approach.

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