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IP-001

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1. INTRODUCTION

The needs of mankind differed day by day with the developing conditions, and the artificial productions to provide them. They are used as a guide to the functional and visual design of these new materials and their mechanical operation. Learning from nature is a continuing convention since the existence of mankind. Nature is a set of design patterns that can be used to create elegant, sustainable, and innovative designs for human technologies as a result of 3.8 billion years of evolution (Benyus, 1997). For past two decades, many new approaches have been taken to reduce the energy consumption and cost of the conventional construction process. Considering nature as a model, Measure and Mentor can help to design a better and sustainable future. (Santhosh and Nair, 2016). A sustainable future can be achieved through wholly evaluating biological models (Minsolmaz Yeler, 2015).

Biomimicry is sustainable innovation inspired by Earth's diverse lifeforms which embody high-performance and resource-efficient design solutions (Kennedy, 2016). Biomimicry comes from the Greek (bios - life and mimesis - imitation) and has the capability to not only imitate the products of nature but also nature's materials and processes (Pedersen Zari, 2007). Although biomimicry is considered to be a new approach for achieving sustainable design (Chayaamor-Heil and Hannachi-Belkadi, 2017), it is still in the developing phase and is not largely applied as a design method. As there is a growing need for buildings that work with nature to create a regenerative built environment, architects can no longer ignore the relevance of bio-inspired theories and approaches to achieve a more sustainable future (Nkandu and Alibaba, 2018).

In the light of the mentioned-above points, the reflections of human interaction with nature to spatial designs was investigated based on the literature in the current study.

2. BIOMIMICRY APPROACH TO DESIGN

Biomimicry offers a transformational approach to meet the needs of the construction industry through emulating natural form, function, process and systems (Santhosh and Nair, 2016). Instead of simply copying and imitating organisms, the architects can integrate certain concepts of nature into their structures such as economy, optimization, resilience, functionality and aesthetics (Minsolmaz Yeler, 2015).

The connection between spatial design and biology and the starting points for biomimicry are in the design of projects, where innovation is needed, especially in cases like these (Gruber, 2011):

- Spatial design for new environments
- Solutions for new challenges have to be found, based on role models provided by nature
- Investigation of optimized and adapted building traditions informs modern design
- Better relationship between spatial design and living organisms
- Better relationship between spatial design and environment
- Better quality of life
- Better design of the cultural environment.

Biomimicry can be applied not only to the design but also to the development of the construction and operation processes, as well as the selection of the materials used. Imitating shape and geometry from nature

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is probably the most well-known type of biomimicry in engineering. As imitation of natural processes is also a key factor in biomimicry, renewable sources could be incorporated into the method of construction, used for power supply, ventilation climate control and lighting. In addition, the manufacturing process of different natural materials which can restore themselves or change their environment is so crucial for biomimicry (Yiatros et al., 2007).

Biomimicry inspires spatial design in different levels as biology does in the nature and these levels can be summarized under three categories: the organism, behavior and ecosystem. Within each of these levels, a further five possible dimensions to the mimicry exist. The design may be biomimetic for example in terms of what it looks like (form), what it is made out of (material), how it is made (construction), how it works (process) or what it is able to do (function). The differences between each kind of biomimicry are showed by looking at how different aspects of a termite, or ecosystem a termite is part of could be mimicked in Table 1 (Pedersen Zari, 2007).

Table 1. A Framework for the Application of Biomimicry

Level of Biomimicry		**Example - A building that mimics termites:**
Organism level (Mimicry of a specific organism)	Form	The building looks like a termite.
	Material	The building is made from the same material as a termite; a material that mimics termite exoskeleton / skin for example.
	Construction	The building is made in the same way as a termite; it goes through various growth cycles for example.
	Process	The building works in the same way as an individual termite; it produces hydrogen efficiently through meta-genomics for example.
	Function	The building functions like a termite in a larger context; it recycles cellulose waste and creates soil for example.
Behaviour level (Mimicry of how an organism behaves or relates to its larger context)	Form	The building looks like it was made by a termite; a replica of a termite mound for example.
	Material	The building is made from the same materials that a termite builds with; using digested fine soil as the primary material for example.
	Construction	The building is made in the same way that a termite would build in; piling earth in certain places at certain times for example.
	Process	The building works in the same way as a termite mound would; by careful orientation, shape, materials selection and natural ventilation for example, or it mimics how termites work together.
	function	The building functions in the same way that it would if made by termites; internal conditions are regulated to be optimal and thermally stable for example. It may also function in the same way that a termite mound does in a larger context.
Ecosystem level (Mimicry of an ecosystem)	Form	The building looks like an ecosystem (a termite would live in).
	Material	The building is made from the same kind of materials that (a termite) ecosystem is made of; it uses naturally occurring common compounds, and water as the primary chemical medium for example.
	Construction	The building is assembled in the same way as a (termite) ecosystem; principles of succession and increasing complexity over time are used for example.
	Process	The building works in the same way as a (termite) ecosystem; it captures and converts energy from the sun, and stores water for example.
	function	The building is able to function in the same way that a (termite) ecosystem would and forms part of a complex system by utilizing the relationships between processes; it is able to participate in the hydrological, carbon, nitrogen cycles etc. in a similar way to an ecosystem for example.

3. REFLECTIONS OF BIOMIMICRY TO SPATIAL DESIGN

In this section, some examples for reflections of biomimicry to spatial design were presented.

East Gate Building Harare, Zimbabwe

The building was completed in 1995 (Figure 1) and an example of process and function Biomimicry at the behavioral level. The building was based in part on techniques of passive ventilation and temperature regulation observed in termite mounds in order to create thermally stable interior environment (Adebisi et al., 2015).

Figure 1. East Gate Building Harare, Zimbabwe

London's 30 St. Mary Axe building, England

This building, known as the Gherkin, was finished in 2003 (Figure 2) and covered uniformly around the outside with glass panels to provide energy efficiency and is rounded off at the corners and there were open shafts built in between each floor that act as ventilation for the building and they require no energy for use. It was inspired by structural reinforcement in sea sponges (Kennedy, 2016).

Figure 2. London's 30 St. Mary Axe building, London

Munich Olympic Stadium, Germany

The stadium is opened in 1972 (Figure 3) band an example of using nature as a model for design. Dragonfly wings are one three-thousandth of a millimeter thick, despite being so thin; however, they are very strong since they consist of up to 1 000 sections. This is as a result of the compartmental structure of the wings which do not tear, and are able to withstand the pressure that forms during flight. The roof of the Munich Olympic Stadium was designed along the same principle of compartmentalization (Adebisi et al., 2015).

Figure 3. The Munich Olympic Stadium, Germany

Ultima Tower, United State of America

The tower is completed in 1991 (Figure 4). Its shape takes the shape of a termite mound. The architect chose the termite mound form because no other shape can dispel loads from top to bottom, its effective aerodynamic form help to retain stability in a tall building (Adebisi et al., 2015).

Figure 4. Ultima Tower, United State of America

Hydrological Centre for University of Namibia, Namibia

This particular building was mimicked the Namibia desert beetle demonstrating biomimicry at organism level (Figure 5). The beetle resides in the desert with negligible rainfall. It is able to capture moisture however from the swift moving fog that moves over the desert by tilting its body into the wind (Adebisi et al., 2015).

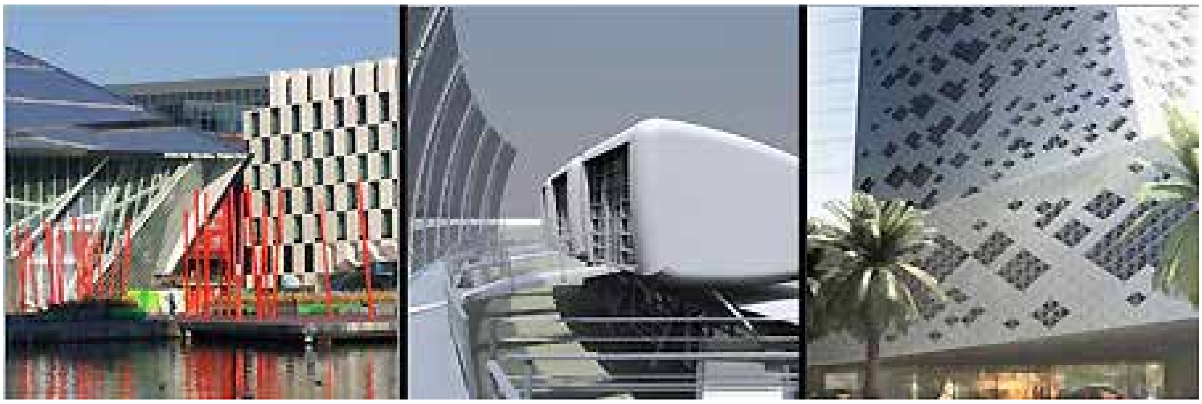

Figure 5. Hydrological Centre for University of Namibia

Bejing National Stadium, China

The Beijing National Stadium, known as the 'bird's nest' because of its beguiling latticed surface, was finished in 2008 at the behavior level (Figure 6). It contains ETFE (Ethylene Tetrafluoroethylene) panels that insulate by stuffing small pieces of materials in the twigs. These panels protect and provide sunlight filtration. Facade openings allow for natural ventilation. Panels reduce the dead load supported by the roof. They have cost reduction, durable, and recyclable (Adebisi et al., 2015).

Figure 6. The Bird Nest Stadium, China

The Humid Tropics Biome, England

The Humid Tropics Biome was officially opened in 2001 (Figure 7). It has two huge artificial enclosures; each enclosure emulates a natural biome. Soap bubbles inspired the forms of the biomes and cellular structures inspired the hexagonal frames. The artificial biomes in the Eden project feature a humid tropic rainforest and Mediterranean biome. The Humid Tropics Biome is home to hundreds of trees and other plants from rainforests in South America, Africa, Asia and Australia such as fruiting banana plants, coffee, rubber and giant bamboo; it is kept at a tropical temperature and moisture level (Pawlyn, 2011).

Figure 7. The Humid Tropics Biome, England

Eiffel Tower, France

The tower was opened in 1889 (Figure 8). The outward flare resembles that of a femur bone at the organism level. It withstands bending and shearing effects due to wind – solves ventilation problem (Yuran and Taşgetiren, 2010).

Figure 8. Eiffel Tower, France

National Aquatics Center, China

The center, better known as "Water Cube, was completed in 2008 (Figure 9) with a form inspired by the natural formation of soap bubbles at the organism level. The bubbles collect solar energy that heats swimming pools and allows for temperature regulation (Radwan and Osama, 2016).

Figure 9. National Aquatics Center, China

Council House 2, Australia

It was completed in 2006 and emulated a trees bark at the organism and behavior level (Figure 10). Air is 100% filtered and natural lighting and ventilation are saved by 65% (Radwan and Osama, 2016).

Figure 10. The Council House 2, Melbourne

Esplanade Theatre, Singapore

The Esplanade theatre, located at the Marina bay near the historic Singapore River, was completed in 2007 at the organism and behavior level (Figure 11). The building skin, based on biology of the tropical durian fruit, is unique as provides for shading and repetition against its hot climate drawings. It reduces energy by 30%, captures solar energy and also reduces artificial lighting by 55% (Radwan and Osama, 2016).

Figure 11. The Esplanade Theatre, Singapore

Turning Torso, Sweden

Turning Torso was officially opened in 2005 (Figure 12). It was inspired by a sculpture called Twisting Torso, which was made entirely from white marble by Santiago Calatrava. One hundred percent of the energy consumed in the building is renewable, coming from hydro, solar, wind, and geothermal sources (URL-1, 2018).

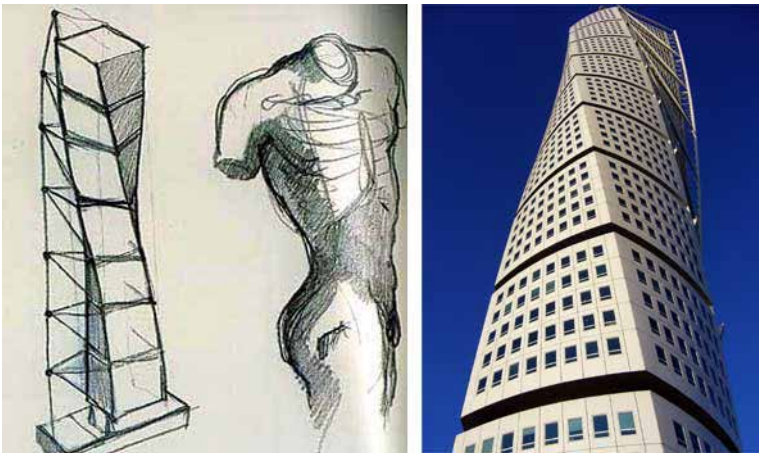

Figure 12. Turning Torso, Sweden

Tenerife Auditorium, Spain

The auditorium, situated between the Marine Park and the edge of the port, was opened in 2003 (Figure 13). The distinctive concrete shell roof takes its inspiration directly form the landscape of Tenerife set against the Atlantic Ocean. The massive arc swooping up and over the building like a wave takes on symbolic power, serving not only the building that houses a modern 1558 seat auditorium for music and culture but also as a focal point for the islands (URL-2, 2018).

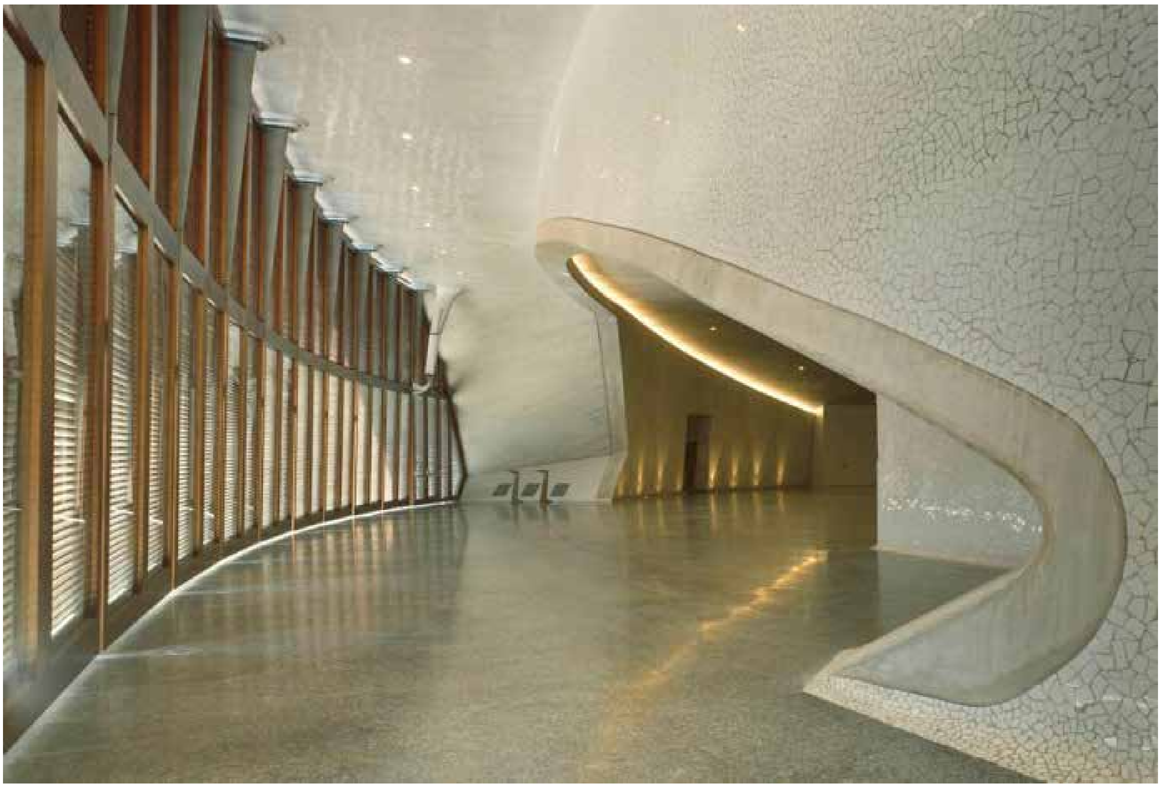

Figure 13. Tenerife Auditorium, Spain

Lavasa Hill Station Master Plan, India

The target completion date of this master plan is 2021 at the ecosystem level (Figure 14). Foundation stores water and uses a drip tip system water to clean its surface. It responds to the seasonal flooding and moves excess water (Radwan and Osama, 2016).

Figure 14. Lavasa Hill Station Master Plan, India

CONCLUSIONS

The usage of minimal materials and sustainability as in nature play an important role in the cities of the coming centuries with the struggle to achieve lighter constructions. This case also will affect the physical conditions of city and lifestyle of people. Finally, biomimicry, inspired by biological systems, is a candidate to produce new solutions in order to live in harmony with the world and create a sustainable environment in terms of spatial design.

REFERENCES

A. Santhosh, S.R. Nair, "Nature's Gift: Study on Biologically Inspired Scenario for Construction Industry," *IOSR Journal of Mechanical and Civil Engineering*, 13(3): 82-86, 2016.

A.F. Yuran, S. Taşgetiren, "Doğadan esinlenerek tasarım," Biyoteknoloji Elektronik Dergisi, 1(2): 23-30, 2010.

A.N. Radwan, N. Osama, "Biomimicry, an approach, for energy efficient building skin design," *Procedia Environmental Sciences*, 34: 178-189, 2016.

E.B. Kennedy, "Biomimetic Buildings: The Emerging Future of Architecture," *Global Built Environment Review*, 10(1): 1-12, 2016.

G. Minsolmaz Yeler, "Influences of the living world on architectural structures: An analytical insight," *Uludağ University Journal of the Faculty of Engineering*, 20(1): 23-38, 2015.

G.O. Adebisi, J.O. Onuwe, A.M. Sani, "Assessment of Biomimicry Design Concept Adoption in Architecture: Towards a Sustainable Built Environment in Nigeria," *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 9(4): 41-46, 2015.

J.M. Benyus, "Biomimicry: Innovation Inspired by Nature," New York: William Morrow & Co., 1997.

M.I. Nkandu, H.Z. Alibaba, "Biomimicry as an Alternative Approach to Sustainability," *Architecture Research*, 8(1): 1-11, 2018.

M. Pawlyn, "Biomimicry in Architecture," RIBA Publishing, UK, 2011.

M. Pedersen Zari, “Biomimetic Approaches to Architecture (poster),” *Toronto Sustainable Building Conference 07,* Toronto, Canada, 2007.

N. Chayaamor-Heil, N. Hannachi-Belkadi, “Towards a Platform of Investigative Tools for Biomimicry as a New Approach for Energy-Efficient Building Design,” *Buildings*, 7(19): 1-18, 2017.

P. Gruber, “Biomimetics in Architecture—Architecture of Life and Buildings,” Springer: Wien, Austria, 2011.

S. Yiatros, M.A. Wadee, G.R. Hunt, “The load-bearing duct: biomimicry in structural design,” *Proceedings of the Institution of Civil Engineers - Engineering Sustainability*, 160(4): 179-188, 2007.

URL-1 2018, https://theculturetrip.com/europe/sweden/articles/the-story-behind-malmos-turning-torso-the-worlds-first-twisting-tower/ (Accessed Date: 15.02.2018).

URL-2 2018, https://arcspace.com/feature/tenerife-concert-hall/ (Accessed Date: 22.02.2018).