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The Use of Biomimicry Principles in Hotel Architecture Design: Case Studies of Biomimicry Applications in Luxury Hotels

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Abstract

As the hospitality industry rises in popularity, tourists constantly look for places that are unique, diversified, exotic, and ecologically responsible. Biomimicry is being used by architects, engineers, and builders who are devoted to enhancing energy efficiency while improving the qualitative human experience of ecotourism. Biomimicry, the practice of replicating the best of nature to generate visually appealing designs with high energy efficiency and minimal effect on the natural environment, enables the travel industry to develop one-of-a-kind, aesthetically beautiful, sustainable vacation destinations of exceptional quality. This study uses qualitative research methods to analyze the features of biomimicry in hotel architecture, how its design may significantly contribute to the development of appealing vacation locations that give eco-luxury, comfort, and a distinctive traveler's experience, and presents numerous case studies to show these notions. According to the findings of the study, applying principles of biomimicry in design and construction approaches may increase the performance of facilities while also being ecologically beneficial. Understanding and executing the features adds value to the facilities. The research challenge is described by highlighting numerous biomimetic methods of architectural designs by examining all prior ideas and researches, as well as analyzing biomimetic technologies that lead to varied results as an introduction to sustainability.

Keywords*: biomimicry, energy efficiency, ecotourism, comfort, architecture*

1. Introduction

Biomimicry (from the Greek words bios-life and mimesis-mimic, imitate) is a design discipline that employs natural patterns and tactics in architecture and engineering, and is one of the instruments used to promote the sustainability of products, materials, and the built environment. Biomimicry in architecture takes its cues from the methods, technologies, and concepts that living creatures employ to suit their demands and secure their existence on Earth. Self-regenerating and ecological architecture strives to handle the difficulties of creating and

optimizing processes that have a parallel in nature, while utilizing the least amount of energy and resources. Given the fact that completed buildings have a major environmental impact, sustainable design, such as biomimicry, is becoming a more accepted method of achieving sustainable development and reducing the negative impact of humans on the environment that meets the needs of current generations without jeopardizing future generations' ability to meet their own needs. Biomimicry in architecture is a design and construction movement that uses natural forms, structures, processes, and functional solutions for technological objectives, resulting in a sustainable and regenerative environment. According to Janine Benyus, if we embrace natural design techniques and ask ourselves, "How would nature handle this?" we would be able to tackle complicated issues through reverse engineering. As environmental concerns have grown, so has interest in mitigating the deteriorating natural environment in order to offset the negative and catastrophic effects that such degradation may produce. It is not unexpected that all businesses are looking to sustainability as inspiration in their efforts to decrease their influence on climate change, increasing temperatures, flooding, uncontrolled pollution, and other ills impacting humanity and global ecosystem. The hospitality industries are going through the same thing. While these businesses work together to produce tourism amenities, biomimicry design and construction approaches have the potential to improve both the performance and the aesthetics of those facilities. This study exposes the prospects for incorporating biomimicry into this industry, with an emphasis on hotel architecture.

2. Literature Review

2.1 Historical background of Biomimicry

Biomimicry has a history that dates back to 500 B.C., when Greek thinkers saw natural organisms as models for a harmonic balance and proportion between the pieces of a design that is synonymous with the classical ideal of beauty. Later, in 1482, Leonardo Da Vinci was inspired by birds flying to create a flying contraption, which was an early example of biomimicry. It aided in the development of Wright's brother's first prototype to an airplane in 1948. Bionics was coined by Jack E. Steele in 1958, and it was described as the science of natural systems or their counterparts. Biomimicry has a history dating back to 500 B.C., when Greek thinkers saw natural organisms as models for a harmonic balance and proportion between the pieces of a design that is synonymous with the classical ideal of beauty.

Later, in 1482, Leonardo DaVinci was inspired by birds flying to create a flying contraption, which is considered an early example of Biomimicry. It aided in the development of Wright's brother's first prototype into an airplane in 1948. Jack E. Steele coined the word "bionics" in 1958, defining it as "the study of natural systems or their equivalents." The word Biomimicry, on the other hand, first arose in 1982. Janine Benyus, a scientist and author, popularized the word in her book "Biomimicry: Innovation Inspired by Nature13" in 1997. Bryony Schwan and Janine Benyus co-founded the Biomimicry Institute in 2005. In 2007, Chris Allen joined Beynus and Schwan to help launch "AskNature," the world's first digital library that contains a list of natural

solutions. Designers can search through this collection of natural systems that are classified based on their design and engineering.

2.2 Levels of Biomimicry

Klein (Klein 2009) proposed in his study that in order to properly copy nature, especially in the design of the built environment, architects and designers need examine three levels/types of biomimicry. This comprises the natural world's shape, environment, and processes.

2.2.1 Design Inspired by Natural Forms

Biomimicry was initially imagined by environmental designers based on natural forms. Building designers look to the natural environment for inspiration and ideas, which they then interpret and apply in the field of design. The goal of natural-form-inspired design is to emulate or copy the look or characteristic of nature in the physical design. However, this idea is deficient and does not take into account natural processes and ecosystems. As a result, experts in this field recommended using the term "biomorphic" instead of "biomimicry." Natural-form-inspired design examples include Herb Greene's Prairie Chicken in Norman, Oklahoma, which was inspired by the natural look of grassland, and the Beijing National Stadium landscape, which was inspired by the shape of a gigantic inverted bird's nest. Other examples include Qatar's Cactus skyscraper and New York City's vertical farm, which is built after the huge wings of a dragonfly.

2.2.2 Natural-ecosystem design

Building designers are inspired by and copy the natural environment in the second level/type of biomimicry. In this scenario, the designers include the "ecological" notion into the design. When creating a structure, this technique not only mimics the look of natural dwelling places, but also attempts to reproduce and apply the activities that occur in the natural world. Janine Benyus, a biologist and author, coined the word "biomimicry" in her 1997 book Biomimicry: Innovation Inspired by Nature. Benyus highlighted biomimicry in her book as a design method that focuses on three factors:

1. Using biology as a model: A study of biological models that is then imitated or inspired by these models to address human issues;
2. Biology as a measure: The application of ecological principles to evaluate the ethics of design innovations
3. Biology as a guide: A new method of evaluating biological processes that can lead design approaches based on what we can learn from nature rather than what we can get from it (Benyus, 1997)

Both biomimetics and biomimicry have impacted the structural work of numerous designers, notably 20th and 21st-century architects, in recent decades. For example, architect Mick Pearce based the structure of macrotermes termite (Macrotermitinae sp.) hills on the architecture of his

Eastgate Centre (1996), a shopping complex and office building in Harare, Zimbabwe. These African termite species build their hills to allow passive internal ventilation, which allows them to maintain a steady interior temperature despite significantly changing exterior circumstances (AskNature, 2016). The Eastgate Centre's design incorporates a high thermal capacity structure, limited glazing, and deep overhangs in conjunction with an interior atrium, allowing it to passively ventilate airflow and balance interior temperatures while consuming only 10% of the energy of a comparable traditional building (McKeag, 2009).

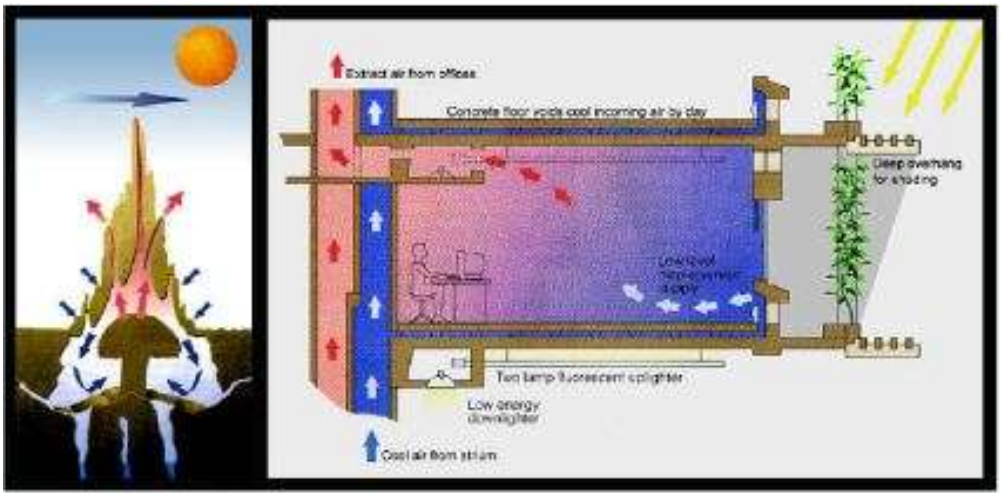

Figure 1: Macrotermes termite (Macrotermitinae sp.) hills affected the architecture of Harare, Zimbabwe's Eastgate Center. Diagrammatic representation of termite structure airflow [left] and structure airflow [right] that demonstrates the effect of biomimetic design. (From M. Pearce's website, https://www.mickpearce.com/Eastgate.html/.)

30 St. Mary Axe, a commercial skyscraper in London, UK, known as the Gherkin, is also said to represent a biomimetic design. Architect Norman Foster modeled this 2003 building on the Venus' flowerbasket, a kind of Pacific marine sponge (Euplectella aspergillum). The construction was built to resemble the form of a sponge in order to deflect wind and passively ventilate the structure via open shafts beneath each story. During the summer, these shafts also release warm air, absorb sun insolation to partially heat the building, and offer light for various interior places (Moussavi, 2020).

Figuer 2: The design of 30 St. Mary London, United Kingdom was inspired by Venus' flower basket (Euplectella aspergillum).Venus' flower basket (Euplectella aspergillum) on the left and 30 St. Mary on the right. (Source: Harvard design Magazine)

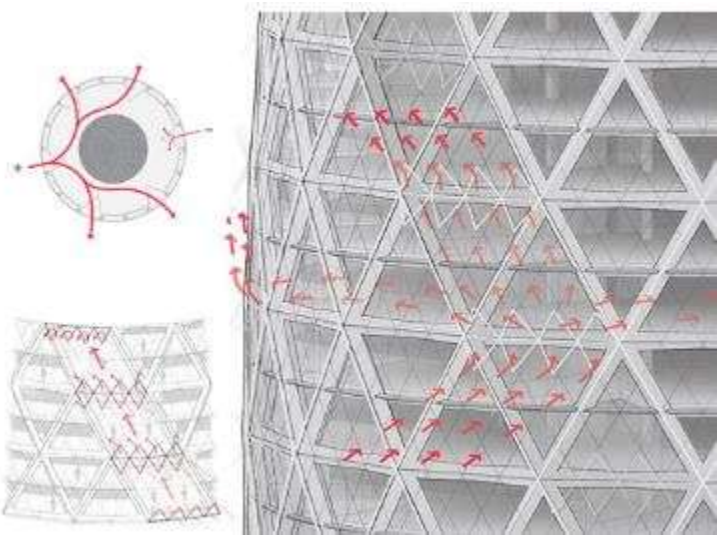

Figure 3 : Wind deflection diagrams at 30 St. Mary Axe in London, United Kingdom (Source: Archdaily)

While a growing interest in biomimetic techniques has impacted how designers turn to biological systems for inspiration and innovation, this method requires design standards and suggestions for architects to apply.

3. Methodology

The researcher used a qualitative research approach to answer the study question by conducting case studies . This technique was utilized to collect, analyse, and analyze data gathered during the case study process in order to better understand architects' perspectives on biomimetic design processes. Kepos Eco Hotel, Songjiang Hotel in China, and Proximity Hotel in Greensboro,

North Carolina are some of the greatest examples of hospitality facilities that were inspired by nature and biomimcry. These lodging and tourism facilities not only mimic the natural shape of eco-elements, but also incorporate natural processes and ecosystems in order to fulfill the triple bottom line: environmental sustainability, economic viability, and social equality.

3.1 Kepos Eco Hotel

Figures 1 and 2 show the eco hotel developed by John Naranjo in Florida. The goal of the design idea was to include natural features while meeting the demands of the hotel's guests. To construct an innovative ecological hotel, the designer was inspired by nature's time-tested patterns and tactics. The capacity of this hotel to absorb sun and wind energy through an open skin was its principal environmental feature. The eco-hotel was created to be a self-sustaining environment by drawing inspiration from many sorts of natural plant architecture components. This covers the deconstruction of tree components, as well as their biological kind, structure, and physical relationship to one another. The physical architectural design of the hotel was inspired by these elements, which also contributed to its sustainability and efficiency.

The hotel is made out of four structures, each having a root foundation, a trunk/stem column support, and a leaf branch canopy for the dwell areas. The major body of each structure was the root base. This gives the hotel guests with a horizontal topological landscape park.

Figure 4: Interior & Exterior View of Kepos Eco Hotel (Source: www.ecofriend.com)

This is an open grid design comprised of individual tiny leaf-like panels. It reflects and travels on the hotel's external canopy, allowing it to nourish natural plants on open terraces and create a passive cooling system. Furthermore, the natural vegetation offers fresh food for the hotel's restaurant. The hotel also offers interior open area where tiny crops may be grown using hydroponics or aerophonics. The eco-water hotel's system was similarly influenced by the natural water cycle. The water utilized is recycled and collected in open ponds before being used to irrigate the hotel's plants. The gray water is processed so that it may be reused. (Jolly, 2010).

The hotel's architecture was influenced by natural water and the quarry environment, which had a flowing green slope down a natural rock face. It has several sustainable advantages because it is located in a quarry. The usage of natural geothermal energy for its electricity supply and hot water supply from the quarry is the hotel's key eco-factor. The natural terrain of the region was examined and used in the hotel's architecture as another factor to attract tourists. The hotel's quarry site will not only be visually appealing to visitors, but it will also give shelter from the elements. Furthermore, the quarry will be used to lessen the hotel's energy requirements. Roof-mounted photovoltaic cells will also be utilized to generate electricity. Restaurants, cafés, conference rooms, and sports facilities would be housed in the hotel. Two underwater public spaces and ten-meter-deep underwater tanks are also available as additional attractions (Nithya 2008). Figure 4 depicts a bird's-eye perspective of the structure and its surroundings.

3.2 Songjiang Hotel

The Songjiang Hotel in China was designed by the British firm Atkins Group, as depicted in Figure. The 380-room resort hotel is built in a 100-meter-deep quarry. The hotel's architecture was influenced by natural water and the quarry environment, which had a flowing green slope down a natural rock face. It has several sustainable advantages because it is located in a quarry. The usage of natural geothermal energy for its electricity supply and hot water supply from the quarry is the hotel's key eco-factor. The natural terrain of the region was examined and used in the hotel's architecture as another factor to attract tourists.

Figure 5: Image of Songiang hotel completed and under construction (Source: Archdaily, Metro UK)

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Figure 6: Songiang hotel (Source: Archdaily)

3.3 Proximity Hotel

Fig 7: Proximity Hotel (Image source: Proximityhotel.com)

Figure 7 depicts the Proximity Hotel in Greensboro, North Carolina, which is regarded as one of the most ecologically friendly luxury hotels in the United States to date. Dennis Quaintance designed the hotel, which opened in 2007. On each level of the hotel, there is a 7,000-square-foot private event area, a large fitness studio, an outdoor swimming pool, and guest living quarters. Sustainable methods were included into the design of the constructed environment with the eventual goal of utilizing 40% less energy and 30% less water. Solar panels on the roof of the hotel capture heat from the sun and create heat for the hotel's whole water system. In order to increase efficiency and sustainability, the hotel also employs cutting-edge technology. This involves the installation of Otis' Gen2 elevator, which will help to cut energy use. Elevators only require energy when ascending. The rationale for this is because the system may catch the energy created as the elevator descends and transfer it back into the building's internal electrical grid. For refrigeration, the hotel also employs a geothermal cooling system. To minimize water use,

high-efficiency Kohler plumbing fittings were fitted. Watering the landscape and vegetation is also done with a drip irrigation system.

Fig 8: Proximity Hotel's Courtyard (Image source: Proximityhotel.com)

Aside from its architectural value, the structure was created with big windows and guestrooms with 10-foot ceilings. The practical goal is to enable and supply enough of natural light and fresh air in the rooms. Local and repurposed materials were employed for the interior décor of the guestrooms. Shelves and tabletops, for example, were built from walnut veneer and recycled wood pulp. Green vegetation on the rooftop was incorporated into the design to offer food for the hotel restaurant and to decrease the impact of urban heat islands. The use of native flora in the hotel's environment minimizes water use since the plants can quickly adapt to the local rainfall without the need for further irrigation. Sustainable methods in restaurants include the use of sensor-controlled ventilation for the kitchen, which can detect heat and smoke and alter its fan speed to meet the load. The hotel's furnishings are also built from recycled and local resources (for example, tabletops are made from reclaimed walnut). The hotel also has plenty of outside terrace eating places to give natural light and fresh air (Wright 2010).

4. Principles of Biomimcry

Janine M. Benyus's book Biomimicry: Innovation and Design is named Biomimicry: Innovation and Design. Inspired by nature, nine natural principles were identified, which are also the fundamental concepts underlying the notion of biomimicry. Nature operates on sunshine; it uses just the energy it requires; it fits form to function; it recycles everything; it encourages collaboration; it depends on diversity; it wants local competence; it controls excesses from within; and it exploits the force of limitations. The Biomimicry Institute, on the other hand, proposed biomimicry principles, which are an enlarged and complete version of nature's principles. These principles are abstracted biological techniques, some of which are clear and self-explanatory, that can be found in the majority of species and allow life to succeed in

recreating itself. They are innovative common techniques for assessing the sustainability of biomimetic designs, materials, and applications. They are key checklists to follow in order to ensure that biomimicry is used in a way that produces long-term results. The six (6) primary principles of biomimicry are as follows:

1. *Effective use of resources (materials and energy)*
   This is the skillful and careful use of resources and opportunities. It is composed of four (4) principles: using multifunctional design (meeting multiple needs with one elegant solution); using low energy processes (reducing required temperatures, pressures, and/or time for reactions); recycling all materials (keeping all materials in a closed loop); and fitting form to function (selecting shape or pattern based on need).

2. *Adapt to changing circumstances*
   This is an example of correctly adapting to changing situations. It is composed of five (5) principles: maintaining integrity through self-renewal (persist by constantly adding energy and matter to heal and improve the system); embodying resilience through variation, redundancy, and decentralization (maintain function following disturbance by incorporating a variety of duplicate forms, processes, or systems that are not exclusively located together); and incorporating diversity (include multiple forms, processes, or systems to meet a functional need).

3. *Locally attuned and responsiveness*
   This is blending in with and merging with the surroundings. It is composed of five (5) principles: use readily available materials (build with abundant, accessible materials); harness freely available energy (use solar/renewable energy); cultivate cooperative relationships (find value through win-win interactions); leverage cyclic processes (take advantage of phenomena that repeat themselves); and use feedback loops (engage in cyclic information flows to modify a reaction appropriately).

5. Conclusion

The use of biomimicry ideas in the design of touristic facilities has already resulted in the construction of numerous remarkable projects that are visually beautiful, sustainable, and deliver the distinctive and high-quality experiences that luxury visitors want. The study highlighted numerous examples of luxury travel initiatives that incorporated biomimicry ideas. According to the findings of the study, biomimicry design and construction approaches can increase the performance and appeal of luxury travel facilities. To provide greater value to the owners of luxury travel facilities, architects, engineers, and construction experts are advised to comprehend and use biomimicry methods as mentioned in this article.

Although the use of biomimicry can lead to the creation of creative building or material manufacturing technologies, techniques to boost sustainability have yet to be fully explored. So, in order to tackle the current difficulties, a new integrated architecture is necessary, in which buildings and nature will adapt to environmental circumstances and encourage biodiversity, rather than being a mere replica of natural forms. The solution rests in the discovery of appropriate biological systems, as well as collaboration and collaboration within the domains of engineering, design, and biology, in order to build a more sustainable world.

Recommendations

- There is a methodological framework that is followed through three levels of nature, organism, behavior, and ecological system, as formation has dimensions that are: form, material, and construction, to make nature the right course to go through for constructing an environmentally reactive and balanced building. The design process has a technique of operation while maintaining environmental balance; nevertheless, without function and sustainability, it is impossible to minimize revenue consumption and adapt to the external environment.
- The key advantage of biomimetic hotel architecture is that it would improve overall environmental performance. It would also be applicable on a variety of spatial and time scales, and this is seen to be a solid starting point for a building design that is really sustainable and regenerative of a specific location.
- According to studies, when designing a sustainable hotel building, nature should be viewed as a source of inspiration and mimicry, providing the designer with the course of work leading to the ideal situation, which means that buildings should multiply their systems, treating their wastes, generating their energy, and achieving comprehensive aesthetic formations over time.
- The architect can take natural or previous configurations or copy them, allowing nature to show itself in the design and come to the surface through the form of flowers and birds and the touch of materials, or even the characteristics that facilitate natural light and ventilation and represent into buildings.
- Designers must consider the natural context of the site rather than imagining it as isolated and so divorced from the ecosystem in which it is located in biomimetic design (see Songiang Hotel).

  Architect implications: Architects should strive to apply additional research and design imperatives that consider the natural and constructed environment in which their design concept will be implemented.

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