The Construction Ideas in Biomimicry Building process

أفكار البناء في عملية بناء التقليد الحيوي

Dr. Iman Mohamed Farag
Assistant Professor \ College of Arts and Media
Em.elsahli@uot.edu.ly

Mr. Hamed Shaban Algeblawi
Assistant Professor \ College of Arts and Media
algeblawihamed@yahoo.com

Abstract

To achieve nearly zero energy buildings While it is frequently not economically viable (AZE) level for buildings in northern climates, there is an urgent demand for innovative building thermal envelope designs or building insulation materials. the use of facade systems that can adjust to changing weather conditions outside or Numerous studies have focused on developing walls that use biomimetic principles to respond to changing indoor and outdoor temperature and lighting circumstances as well as dynamic optical and dynamic features. These solutions avoid the need for additional energy input. Such a system aims to capture solar energy in the summer for winter heating. Beijing, National Aquatics Center, Beijing, Beijing National Stadium, Council House 2, Melbourne, Milwaukee Art Museum, Wisconsin, The Gherkin, London are the five different buildings that were selected around the world and used as a sample in this research, the buildings selected were . The research concludes with…..

Keywords: building shell with a climate-adaptive design, energy-efficient structure; and biomimicry

الملخص:

لتحقيق مايقرب من صفر من المباني التي تحتاج الى طاقة يتطلب في حينها الكثيرمن التكلفة الباهضة كلمباني الواقعة في المناخ الشمالي. مما يزداد الطلب على المباني(AZE) ولاتكون ذي جدوه إقتصادية ذات التصميمات الحرارية المبتكرة وذات مواد عازلة ، كما يمكن أن تستخدم

أنظمة الواجهات التى تتكيف مع الظروف الجوية المتغيرة في الخارج التي تم التركيز عليها في الدراسة وتطويرالجدران في مباني المحاكاة الحيوية للإستجابة لظروف الإضاءة الداخلية والخارجية المنقلبة، بالإضافة الي السمات البصرية الديناميكية، وفي مثل هذه الحلول تتجنب الحاجة الى مدخلات طاقة إضافية. مما يهذف هذا النظام الى النقاط الطاقة الشمسية في الصيف، وللتدفئة الشتوية في فصل الشتاء، مثل المباني المركز الوطني للألعاب المائية ببكين في الصين، ومجلس البيت 2 في ملبورن، ومتحف ميلووكي للفنون في ويسكونسن، ومبنى ذا غيركين في لندن، وكل هذه المباني الخمس المختلفة تم إختيارها حول العالم و إستخدامها كعينة في هذا البحث. ويختم البحث بالمباني التي تم اختيارهم.

الكلمات المفتاحية :

تكييف تصميم هياكل المباني مع المناخ، تصميم هياكل مباني موفره للطاقة، تقليد الطبيعة.

1. Introduction

As the building sector makes up 40% of the EU's overall energy consumption, one of the initiatives to reach the EU objective of of 1990 is focused on this industry reducing CO2 emissions by 20% below the level . EU Directive

Keeping in mind the objective of improving a building's energy efficiency, 2010/31/EUBy the end of 2020, all new construction must be nearly zero energy buildings (AZE), which are structures with extremely high energy performance and almost zero energy requirements.. In accordance with the Directive, they should be powered to an extremely large part by using renewable energy, such as electricity generated nearby or on-site, Cost-optimality studies show that it is more difficult even with the best performing materials, to reach suitable AZE building levels in northern latitudes, from an economic, resource-use, and life cycle standpoint. To achieve AZE level in a Northern environment, new approaches to the thermal envelope must be developed 1.1 Shift of a paradigm in thermal envelope

The AZE structure itself must start producing energy, as the definition above says, the energy balance, must become "effective," which is one way, in order to be a part of the building's thermal envelope. Another is to employ the structure required to create an enclosure. In relation to climate adaptive building shells (CABS), Building energy efficiency has been considered. As defined by Loonen, Trka, Cóstola, & Hensen

(2013): functions or behavior over time in response to changing performance requirements and variable boundary conditions, CABS has the ability to reversibly and repeatedly change some of its features, this concept offers a shift from static systems in thermal envelopes to those that are dynamic, and does this with the aim of improving prevailing building performance.“

The emerging field that draws inspiration from nature might be able to suggest new ways to construct surfaces. From the Greek words bios, Biomimicry, which means "life," and mimesis, which means "to imitate," looks to nature for solutions to human issues (Benyus, 2002). The building's thermal envelope has been compared to the outer shells in nature in recent biomimetic studies because they deal with similar tasks and are exposed to similar weather conditions (Gosztonyi, Brychta, & Gruber, 2010). Storing and producing energy, preventing overheating, and responding to changing environmental conditions. These tasks include reducing heat loss through the thermal envelope (hibernation, insulation, metabolism,), In biomimicry, there are two design techniques identified: "biology to design," in which biological

principles serve as the inspiration for design concepts, and "challenge to biology," in which solutions to human problems are sought in biology.

1.2 Inventing systems with dynamic parameters using biomimetic approach

The goal of this research is to investigate and develop, using biomimetic principles, an appropriate solution for a building's facade or wall construction which has dynamic and optical properties that will adapt to able to respond to various indoor and outdoor temperatures and lighting conditions, external weather conditions and this will avoid the need for more energy input. (Zogla, Blumberga, & K., 2013) possess the latent energy of the transition from water to ice was used to produce an An illustration of how phase-changing material can be attached to a wall to reduce energy loss during the chilly winter. This article's main message is to store energy during the warmer months and use as much of it as you can before releasing it during the winter.

It is vital to prevent heat loss through the thermal envelope by absorbing as much solar radiation as feasible; In the winter season, yet, in the summer, to prevent the building from overheating, solar heat gains must be prevented or stored A material's spectral absorption coefficient can be used to characterize it. More wave lengths and energy are absorbed by objects with dark colors, while a narrower range of wavelengths are absorbed and energy is reflected by objects with light colors. The material's energy performance, or capacity to absorb energy, would change or even get better as a result of changing color in reaction to environmental conditions.

Brittle star surface properties examples has been chosen for further research because during the day it is dark, it has color changing properties on a daily timescale; and during the night it changes to white. As suggested by the "challenge to biology" approach (Aizenberg, 2010; Hendler, 1984) this defined problem is the need for color changing energy producing or gathering material in nature, Protuberances that act as the surface of the fragile sea star is covered in lenses and are arranged in a fine array. After receiving a neurological signal, lenses focus the energy into the focal point, but holes in valleys discharge pigment that covers the brittle star and turns it black. A visual representation of the brittle star's surface and its workings is shown by (Chen, McKittrick, & Meyers, 2012).

In this study, these characteristics will be developed in two ways:

a. creating a fluidic flow system for a facade that can absorb or reflect solar energy, alter color, and conceal or show lenses;

b. the capacity to design a facade system with lenses to catch and store energy using PCM and release more solar energy by utilizing a fluidic flow system in conjunction with a natural optical system to maximize energy transmission through lenses.

The facade system should simultaneously integrate five crucial phases, according to the second recommendation, in order to cut down on energy losses.

(Figure 1)

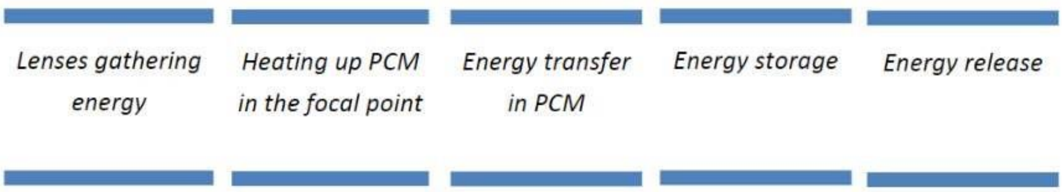

Fig. 1. The principle of thermal envelope solution – gathering and releasing energy

One reason Fresnel lenses were chosen for further study is that they offer higher optical strengths, allowing you to concentrate all of your efforts on raising focal point temperatures while keeping the projected lens surface area constant.

1.3 Biomimicry in architectural design

The natural world acts as a compass for all sciences. A certain area of study advances through observing and copying nature.This area of research, known as "biomimicry," can be characterized as the imitation of naturally occurring biological processes. In the world of architectural design, behavior often imitates nature, as it does in many other fields. The goals of this research are to discuss design and nature in relation to the study of architectural design and to explain the concept of biomimicry, which has recently gained attention in the field of architecture. For this reason, the Karadeniz Technical University's Department of Architecture provides courses in architectural design. The architectural design approach, which in-depth examines the connections between nature and architecture, is covered in biomimicry courses. Following the time when biomimicry was used to inform design concepts, a study of the relationship between biomimicry and design was carried out. (Tavsan, Tavsan, & Sonmez, 2015). In nature, defects are reduced by employing the greatest tools for the job, reusing them, and even adjusting each component as necessary. Biomimicry, one of the newest branches of study, looks at natural models and imitates or takes inspiration from them to develop designs that aim to address human problems. Over time, concepts and solutions in numerous sectors have been inspired by nature. Interior architecture is one of these disciplines. When designing furniture, the interior, interior structure, comfort, and materials are taken into account, as well as the effects of these designs. Throughout history, furniture has served as a symbol of human civilization and way of life. Form, structure, or natural materials are used in the design of furniture for both esthetic and practical reasons. Both large-scale and small-scale living creatures seen in the natural world served as inspiration for the designs employed in the study. The concept of "biomimicry" inspired the development of furniture designs that were meticulously based on the shapes and patterns found in nature. (Tavsan et al., 2015). The majority of energy used in the Panamanian building sector is used to cool and illuminate inside rooms. These two traits in the construction sector can be considerably influenced by a variety of natural strategies, such as the ones mentioned above. The literature on biomimicry-based techniques to improve building designs is examined in-depth in this article. This analysis is motivated by the growing need for energy legislation to achieve local goals for the future and to provide a framework for use in Panama. Additional study and evaluation of these biomimicry-based approaches suggests that three of the most common climatic types in Panama should be incorporated into organism-based design. Consequently, a SWOT analysis helped to realize the potential of adopting biomimicry-based techniques to raise the likelihood of fulfilling local and international regulatory requirements. The design of structures utilizing biomimicry requires diverse teams. This makes it more difficult to find highly skilled workers and broadens industry perspectives. Lastly, the research presented here may serve as the basis for further technical examination using computational and experimental methods. (Austin, Garzola, Delgado, Jiménez, & Mora, 2020). The increasing popularity of biomimicry in the built environment is a sign that architects and designers are becoming more conscious of the opportunities nature offers to enhance system and human function. Modern material technology frequently uses biomimicry. Its potential for usage in environmentally conscious architecture and construction, however, has not yet been fully explored. As a result, this book carefully examines the use of biomimicry in structural engineering and design. Additionally covered are the methods biomimicry employs to aid in building surroundings that are efficient and sustainable. In the first section of this review article, the concept of biomimicry is examined historically and practically along with how it is applied to architecture and design. It also gives a full analysis of its benefits and potentials and considers how it might be used to building envelops. The use of biomimicry in building and structural engineering is thoroughly examined in the second segment, which makes considerable use of various case studies. Finally, it is demonstrated how applying biomimicry in the design of physical surroundings can result in buildings that are both climate-sensitive and energy-efficient. (Jamei & Vrcelj, 2021). Nature provides examples of elastic materials and structures with high mechanical and structural qualities as well as ideal morphologies and topologies for the construction industry. This essay provides an overview of the various types of natural materials that can be used for construction projects, such as buildings. Recent research on building envelopes, facade systems, bacteriaenhanced materials, new cementation composites inspired by biology, inventive production techniques, and their applications are discussed. This report also makes recommendations for future research on developing and producing strong buildings and bio-inspired building materials. (Ahamed, Wang, & Hazell, 2022).full story "Termites and the structures they build have inspired biomimetic architectural cadvancethat have been used to build columns. Surprisingly, these designs are based on an incorrect perception of the actual operation of termite mounds. We explain how a better understanding of the structure and function of termite mounds might lead to innovative biomimetic architectural ideas. We further suggest that using the termite "extended organism" as a paradigm, architecture can be advanced "beyond biomimicry" and structures that seem to be alive can be built. (Zillante et al., 2013). Biomimicry is the term used to explain how nature employs its ingenuity. It only aims to satiate human desires while making the best use of the resources at hand. Kinetic architecture imitates nature's exceptional mobility in a similar way to biomimicry, and biomimicry studies occasionally consider kinetic architecture implementations. The way these two natural influences nested and eventually fused helped the development of sustainable building system design. To comprehend sustainable construction methods and related certification procedures, But it's crucial to include biomimicry and kinetic architecture. There is still a knowledge gap in the building business due to the dynamic nature of kinetic architecture and biomimicry technologies, which are perceived by experts in the field to be advanced. The traditional structure of the construction industry, which prioritizes short-term profits and a project-based strategy, makes these principles even more challenging for the projects. Consequently, it is essential to use We conducted a SWOT analysis on biomimicry and kinetic architecture to better understand how they may be used in sustainable building projects and how they can meet project requirements. This was done in order for project practitioners in the construction sector. This study uses SWOT as its research methodology to better understand these concepts for building professionals. This study identifies five major advantages for this viewpoint, as well as five major disadvantages. These disadvantages include the inefficient use of energy, increased reputation, adaptability to climatic change, increased value and rental costs, including higher initial or maintenance costs, a lack of systems expertise, comfort, and an increased need for coordinating different professions. Other disadvantages include the complexity of the design and the inability to meet specific production needs. There are five more opportunities and five risks identified, with the opportunities including government incentives, senior management support, a development strategy that emphasizes sustainability, new technology, and an increase in demand for green buildings. Threats might come from unfamiliar systems, broken systems, funding issues, materials that don't meet standards, and market conditions. It is intended that the study would strengthen the relationship between the design and construction processes in order to integrate the aforementioned concepts in sustainable buildings. (Bayhan & Karaca, 2019). The life cycle of a product includes the steps from supplying the needed raw materials for the product through use and disposal in the environment as waste.In this scenario, designers construct every stage of the product's life cycle in addition to the final product. The vast majority of consumables in the packaging we use are thrown after use because they are no longer useful. Our daily production and disposal of innumerable packages, as well as the fact that only a very tiny percentage of those that have the potential to be recycled, are actually recycled, are some of the problems we deal with. Two of humanity's largest problems are the lack of the natural resources required to support life and the irrevocable harm that human activity has caused to nature. The use of nature-inspired design to address a human issue for which nature has already discovered a solution is referred to as "biomimicry."In her book "Nature-Inspired Innovation," biologist Janine Benyus used the phrase for the first time. Cross-disciplinary collaboration is used to produce concepts and designs that provide long-lasting solutions and are inspired by those found in nature to address the problems that designers face. Research on the numerous ways that biomimicry is being employed in other design domains is still under progress, but few studies have examined the building and construction processes of nature in the design process, taking the life cycle of packaging as an example. Research on the numerous ways that biomimicry is being employed in other design domains is still under progress, but few studies have examined the building and construction processes of nature in the design process, taking the life cycle of packaging as an example. For this study, a literature review on packaging design, sustainability, and biomimicry was conducted. Efforts made to find a solution and the value of biomimicry in packaging design have been evaluated. Design solutions can be developed by drawing inspiration from the shape, technique, and system of nature in order to provide long-lasting solutions to human issues by using nature as a model in the field of graphic design. The environmental impact can be reduced by improvements in packaging design methods. It is thought that by looking into and applying ecologically friendly materials, designers from all disciplines can have an impact, draw attention to the negative environmental repercussions of consumption and production habits, and offer solutions. (Caferoğlu, 2021). The energy needs for the design, construction, and use of buildings have a considerable impact on the amount of energy resources used. For this reason, buildings should be built in a way that is both energy-efficient and least harmful to the environment. The façade, which is the building's first point of contact with the outside world, is the element that has the highest influence on energy use. The main objective of this study is to investigate whether energy efficiency may be included in the design of building facade systems by taking design cues from natural systems. The methods for providing these environmentally friendly solutions—including efficiency, protection, manufacture, etc.—are demonstrated through the aforementioned sample projects..—investigations of biomimetic façade systems. After the required literature review, five examples of projects with varying features were appraised. In each project that was influenced by a different kind of organism, it has first been investigated how organisms develop mechanisms for controlling air, water/moisture, heat, and light through structure, skin, surface, or layer. It was determined to what extent and how these techniques mirror biological processes when applied to facade systems. The type of façade system used in biomimetic façade systems was determined, as well as the degree to which these techniques were used to the system. Following a one-by-one analysis of the energy-efficient solutions provided by the system in line with the established principles, the projects were assessed using a comparative table in accordance with these principles. The study showed that novel, sustainable, and alternative solutions of the biomimetic approach may be used to design energy-efficient facade systems. Additionally, it has been noticed that developing approaches for controlling air and water, particularly with regard to controlling heat and light, in biomimetic facade systems yields energy efficiency. Biological solutions should be specifically outlined and implemented into the design of energyefficient facade systems in accordance with the difficulties experienced in the development of façade designs. In order to produce more reliable and understandable results, it is also proposed that biomimetic project analysis be conducted out using energy simulation software and energy performance calculation procedures. (Gündoğdu & Arslan, 2020).

1.4 The construction of 5 selected biomimicry building in Architecture around the world

a. Beijing National Stadium, Beijing

The Swiss architects Herzog & de Meuron constructed the Beijing National Stadium, also referred to as the bird's nest, in 2008 for the Olympics. As implied by its name, the structure rises out of the ground like an upside-down nest. The stadium's two primary components are the concrete seating bowl and the external steel frame, which serves as a stand-in for the nest's twigs. ETFE (Ethyl Tetrafluoroethylene) panels are utilized to line the façade to protect spectators, provide acoustic insulation, reduce dead weight on the roof, and allow sunlight entry, much to how a nest is insulated by stuffing material between the twigs.

Fig. 1: Beijing National Stadium, Beijing (www.architecturever.com)

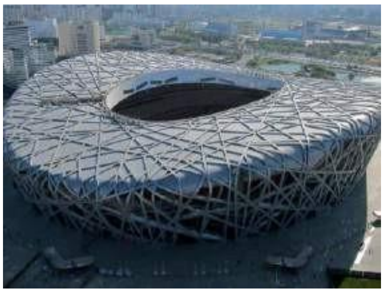

Fig. 2: Beijing National Stadium, Beijing (www.flickr.com)

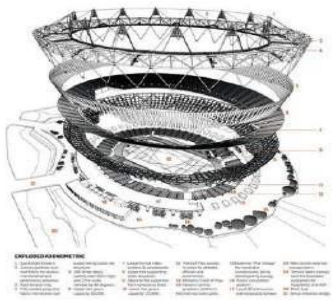

Fig. 3: The exploded view Beijing National Stadium, Beijing
(www.architecturever.com)

b. National Aquatics Center, Beijing

The National Aquatic Center, also referred to as a "water cube," was another stunning construction project completed in time for the 2008 Olympics."Its design was inspired by how cells and soap bubbles develop spontaneously. The unusual shape of the bubbles was constantly exploited to produce a structure that appeared random and organic. The continuous skin of the building was made of ETFE (Ethyl Tetrafluoroethylene), which is lightweight and provides great insulation. The covering allows for more light than glass and even catches 20% of the solar energy needed to heat the pools.

Fig. 4: National Aquatics Center, Beijing (www.modlar.com)

Fig. 5: National Aquatics Center, Beijing (www.thebeijinger.com)

c. Council House 2, Melbourne

The termite mound served as the inspiration for the office building's architecture. Natural convection, thermal mass, water cooling, and ventilation stacks were used in the building to mimic the termite process that was used to maintain the mound's temperature steady. The skin system's dermis and epidermis, which comprise the outer layer of the skin, served as a model for the façade of the structure (inner skin). The inner line defines the fire compartment, while the dermis serves as the outside zone and housing the stairs, lifts, and other structures. The wet systems' natural ventilation is aided by the bark façade of the building.

Fig. 6: Council House 2, Melbourne (www.archdaily.com)

d. Milwaukee Art Museum, Wisconsin

Designed by Santiago Calatrava, The Quadracci Pavilion is the museum's most exciting feature. The pavilion is home to Burke Brise Soleil, a mobile sunscreen with a bird-wing-like opening and closing mechanism.

Fig. 8: Milwaukee Art Museum, Wisconsin (www.fsb.de)

Fig. 9: Milwaukee Art Museum, Wisconsin (www.wuwm.com)

Fig. 10: The Interior of Milwaukee Art Museum, Wisconsin (www.flickr.com)

e. The Gherkin, London

The Venus Flower Basket Sponge, also known as Gherkin, is imitated in shape and lattice structure by this vegetable. Norman Foster’s iconic skyscraper, 30 St. Mary Avenue, Water and food are stored in the skeleton's hollow basket. The sponge's shape and lattice exoskeleton provide stability and strength. As a result of the building's design, the structural elements are connected at varied angles on each storey. wind resistance, ventilation on all floors, and vertical support without interior columns

This technology allows for an open floor plan

Fig. 11: The Exterior and the Interior of the Gherkin, London (www.arch2o.com)

Fig.12: The Entrance of The Gherkin, London (www.steemit.com)

2. Conclusion

Engineers and architects have recently been looking for construction concepts that draw inspiration from the spectacular termite mounds of southern Africa. The structure and function of termite mounds turns out to be much more complicated, unique, and interesting than had been anticipated, leading to a variety of new potential "termite-inspired" ideas for passive climate management in buildings. One of the most intriguing is a unique technique for capturing the "AC energy" transients that are present in turbulent wind. Despite being by far the most widespread and potent source of wind energy on Earth, modern wind power engineering largely ignores it because it has proven to be challenging to harness for useful purposes. This method has been perfected by termites. They accomplish this by using sophisticated structures to modify a variety of turbulent wind energy. Thanks to new fabrication methods, we can now envision integrating these complex turbulence-capturing systems in our own constructed buildings.

The "living building," which is the pinnacle of architecture, is revealed by the concept of the "living mound" as a whole. This dynamic dwelling is capable of emerging self-design and easily adjusts to the requirements of its occupants. The details of how termites build their "living mounds" are beginning to become clear. We can clearly see that homeostasis is the fundamental property of all biological structures. We believe that these fresh discoveries, along with others, point to a bright future for termite-inspired biomimetic building.

This article explained biomimicry and emphasized its significance while emphasizing the construction of the biomimicry building in an architectural context. In this study, pertinent literatures were revised, including articles from websites, books, journals, conference proceedings, and conference proceedings that dealt with biomimicry. In this project, 5 biomimicry buildings were afterwards chosen and examined. These biomimicry-inspired

structures, which were built all around the world, were Beijing National Stadium, Beijing National Aquatics Center, Council House 2, Melbourne, Milwaukee Art Museum, Wisconsin, and The Gherkin, London.

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