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Sustainability and Bionic Biological Strategies as Parametric Patterns in Architectural Design

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Abstract

Today, climate change and consequently reducing fuel use is a very important issue. Since the structural part of the building consumes the most energy, it is apparently necessary to analyze the various aspects of the construction. The development of tall buildings relies more on technological achievements than on other factors. And architects try to adapt to their growth speed. Thus, one of the undeniable technologies is the use of software to analyze complex structures such as "Bionics". After almost 50 years, biological knowledge has had consequential developments in the field of building structure. Findings and research in the field of bionics are somewhat ineffective in the energy consumption sector. This study reviews the concepts and knowledge of the parametric system of cognitive skin design. The proposed method is based on hourly energy simulation analysis. Moreover, with the help of the LAVA skyscraper as a study, the final expectations from this research, which shows the rational parametric design of the bionic exterior to reduce energy consumption, can be analyzed. The results show that the parametric models implemented for bionic skyscrapers lead to saving a significant amount of energy.

Key words: *sustainability, biology, architectural problem solving.*

Introduction and statement of the problem

Construction analysis shows that the demand for sustainable buildings is increasing. This is due to the fact that building operations are responsible for approximately 40% of carbon dioxide emissions, which directly relates to the amount of energy consumed in the building to maintain user comfort. In other words, it is believed that the building sector consumes approximately 24% of the earth's energy and this amount has increased to 40% in developed countries. The result of the current situation is to lead to more accuracy and more energy consumption for effective manufacturing methods for design.

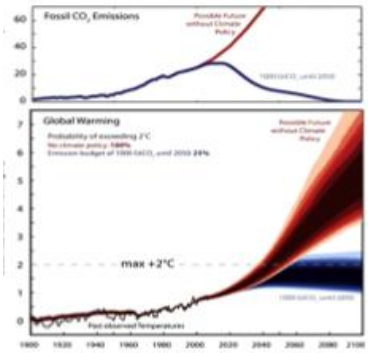

Fig 1. Global warming and carbon dioxide emissions; Source: Research findings

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In order to achieve the goal of sustainable consumption, it is clear that some principles should be considered in the design stage. The advantage of sustainable consumption on human health and the natural environment is unavoidable. It has been shown that a 2% increase in initial investment cost – to support sustainable design – results in approximately 20% overall building cost savings. While our planet is affected by global warnings and uncertainty in long-term energy consumption, it is important to find ways and principles for energy consumption. To find practical ways to reduce energy consumption, all aspects of the building, especially tall buildings with wide exteriors, must be analyzed. Therefore, the concepts and techniques accepted as sustainable ideas and the concept of environmental protection have progressed and have been considered as building design. On this basis, nature has been the source of human discovery and the creation of knowledge and technology. This was the first spark of bionic ideas inspired by the biological prototype. This highly creative activity is based on a deep understanding of nature's objects and aesthetic principles and modeling. In other words, the bionic design method refers to the design process, which is done by implementing various features such as geometry, text, color, pattern and structure of nature. Technology is the basis of the role structure. The understanding and implementation of all structures must be based on sustainable materials, and energy support. Now, progress always comes from unexpected advances in science and technology. It often expresses new technology on demand. According to bionic concepts guidelines, technological advances can learn rules from nature. As has been shown in many cases, compared to today's science and technology, the natural structure of certain features has advanced over millions of years. Therefore, the teaching approach from the biological structure; Roles and systems are a new direction in technical and revolutionary innovation. In addition, the relationship between naturalness or between humans and nature is an excellent source of structural innovation, especially in mechanistic biology. In other words, adding natural knowledge and laws to the design process helps humans feel happy in life. In addition, these days, there are regulations that force designers and architects to consider energy use projects and their impact on the environment. Therefore, regarding the analysis of construction energy performance, they use energy simulation schemes in the design phase, which can be one of the best possible solutions. Over the past 50 years, a wide range of energy simulation schemes have been developed through the building energy community. However, these programs are still not widely used. These studies try to show designers the efficiency of implementing parametric patterns and bionic strategies in tall buildings. This energy analysis software helps designers and architects to perform overall building analysis, optimize energy consumption and work with carbon-neutral building designs in the process. The software adds assumptions and defaults according to the type of building and location that completes the energy analysis model. It helps designers to perform useful and valid analysis for decision making. Also, for existing construction projects, designers can

enhance the history of building facilities. This software automatically collects weather information from the same time period. These types of strategies can provide benchmarks that lead to inspired design approaches as well as more sustainable and effective engineering solutions. Therefore, it is related to the shape of tall buildings as a study, created by digital tools, based on structural and architectural criteria.

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Research methodology and background

These days, the simulation of energy consumption in the structure sector is the favorite of architects and engineers. These simulation programs are designed to evaluate the efficiency of energy conservation before a building is constructed or modified. Two basic levels of energy analysis tools are currently available. The first of them is the simplified energy calculation, which is used for the degree-day method and is suitable for the use of building energy in small scales. This method can be developed and adapted to be more accurate. The second energy calculation method is calculated in detail, which is based on two hours with hourly and annual energy analysis of average weather data. They provide detailed analyzes of building energy consumption based on various factors such as occupancy, plan and building volume of the structure. Therefore, in this approach, the method of data collection is basically through the theoretical approach obtained by reviewing the texts and analyzing the study. In other words, it includes the field of work and systematic review that leads to the use of descriptive research methods in the article. In this case, "Autodesk Green Building Studio" simulator was used for data evaluation and calculation.

Research literature

The main purpose of using simulation software is to create more design alternatives that lead to finding energy efficient options. Therefore, with almost minimal input options, you can achieve simulation results that check the proposed structure and climate. This simulator is based on the independent structure of each other as a whole system. The results are necessary to maintain the rating to reduce the energy consumption of the building. The "Autodesk Green Building Studio" simulator design automatically obtains all the geometrical information of the building from gbxml or 3D CAD programs. It has been determined that the building type and zip code can be considered as the minimum required input for the guide. In addition, in order to calculate the energy consumption per hour that is used for many years, all other simulator variables are prepared using the software. Incidentally, the research has presented a systematic and documented attempt to analyze and simulate the energy performance of the bionic tower. This attempt is used to measure the models which are based on only reference sources of structural data.

Sustainable tall buildings

Tall buildings are a type of buildings with low impact and a small roof compared to its large exterior surface. In the design of these buildings, the general concepts of the surface have different importance, which affect the behavior of the building and at the same time its aesthetics. However, the development of the building form is a very complicated task in the case of the above criterion. According to the role demand of the structure, a simple change in one element can affect other factors as well. In other words, tall buildings need special engineering and design systems that lead to an increase in their exterior appearance. Although achieving sustainability was an important topic in the 1970s, there is still ambiguity in the construction industry based on this term. Generally, this is due to the common belief among builders that sustainable activities are not financially viable. There are different definitions of sustainability, but in general,

a kind of balance is found between the growing economy, social responsibilities and environmental protections. Thus, there are many alternatives to achieve this sustainability goal. For example, using different types of materials, implementing the most efficient energy source, etc. These considerations lead to the achievement of advantages; Including: reducing the amount of greenhouse gases, 30% reduction in the need for light, increasing productivity by at least 30%, saving 70% of electrical energy and 50-60% of water, reducing cooling to about 5-10% and in Finally, it can save about 36% of energy consumption compared to standard buildings. Regarding sustainable design, tall and large-scale buildings need more attention. This fact is due to the greater demand for energy and resources. Therefore, in short, the construction of tall and large-scale buildings is an unavoidable phenomenon in the whole world. It can be concluded that the design of high-scale structures, especially high-rise buildings and skyscrapers, all kinds of urban buildings with a lot of materials and energy, is a matter that needs urgent investigations.

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Bionic design

Since long ago, mankind has learned a lot about nature and will learn more in the future. In the field of current rapid change, humans have made themselves closer to the man-made environment. Various competitions in the building market motivate companies to design new buildings, which creates many opportunities for designers to search for a new harmonious relationship between humans and nature. Since 1972, when the United Nations Conference on the Human Environment was held in Sudan, environmental awareness has been raised as a global issue. Therefore, with a deeper understanding of innovation and sustainable development, designers and architects were led to rethink the sources of inspiration that were nature and humanized materials and followed flexible methods as serious alternatives for problem solving. . In other words, due to the philosophy of design and social development, it is clear and obvious that common inclusion should be considered for the construction of buildings with bionic design. It is said that drawing in nature was first introduced by Leonardo da Vinci. However, the term bionics and related theories have been proposed almost in the 20th century.

Parametric design

Although the meaning of parametric design is apparently clear, it is somewhat complicated to explain. This term has the advantages of parameters to create a shape. In other words, it is designed in this field. Where design differences are effortless. Therefore, it only replaces several samples and thus uses a parametric model. A parametric model is a computer design model that is based on geometry. This geometry itself includes two fixed features, which are called limited and variable parameters. The model responds to changes by adapting itself or reconfiguring for new parameter values without erasing or redrawing. As mentioned, parametric design is a set of relationships and variables - parameters - that are used to form a shape. Therefore, by changing the parameters, different shapes can be defined. In addition, the entire shape of the building can be manipulated and controlled by correcting and changing certain parameters. It involves careful thinking in finding an efficient geometric structure based on a complex model that is flexible enough to accommodate changes. Therefore, the designer or architect must calculate and identify the type of change he wants to investigate in order to determine the type of change he should have. Therefore, since the nature of the design process is unpredictable, this process is very difficult and complex. Throughout history, computer writing has created various design models, and these simple models have created parametric design. Every time this script is executed with different parameters, advanced structures based on parent-child relationships are proposed. Today, when a parameter is changed, CAD software provides a complex three-dimensional interactive relationship model that allows the designer to have more control over the project and faster feedback. In general, apart from the complexity of the design,

parametric models fall into two categories: ♣ The first category is created by the implementation of changes and ♣ the second category according to parametric geometric interventions. Although this requires computer operations and very complex modeling, parametric model creation has been developed as a combination of both mentioned types. It should be noted that the boundary between what we now know as parametric design and computer aided modeling is created by the basic composition. For example, the line can be recognized as the basic element in the model by determining its direction and length. In this case, the polyline is considered as a set of connected lines with a specific location. Finally, the volume added to the model is done through four parameters, width, length, height and position. Although the implementation of parametric design in the construction industry has many advantages, what is focused on in this research is the design and combination of requirements and relationships of different design elements in one form. This process helps the architect in analyzing all kinds of solutions quickly. In order to design with these relationships, a set of parametric approaches must be created. The development of tall buildings can be characterized by different design factors and these factors have different parameters such as role needs, structural demand and user needs.

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Expression of research findings

Intelligence of Lava Bionic Tower

Architectural system Bionics is the study of natural behavioral structures that are technologically implemented. It has an integration of natural and mechanical systems with the Bionic Lava Tower in Dubai. The architect of this building was Lava Group, which was created by Chris Bass, Tobias Walliser, and Alexander Rick. The height of this tower is 240 meters and it was designed in 2007. This skyscraper tries to show the combination of future technologies with organizational patterns to reach a friendly, smarter and more social state with the environment. Bionic Lava Tower has been damaged by natural factors as well as the technological advancements of our time. In addition, this tower is combined with biology to achieve a design similar to other models seen before. The architecture of the future has not only focused on the form but also on the intelligence system as an important factor. The traditional external curtain is passive and does not have enough power to change and adjust the external environment. Therefore, architecture should act as an ecosystem in organic cities. In this case, lava has been integrated with the structural principles of nature, digital workflow and the latest digital technologies with the aim of achieving a more suitable architecture and using less materials, energy, time and cost, etc. Therefore, the structure, materials and covering of the building (external facade system) are three important factors to investigate the natural pattern.

Structure and materials

This bionic skyscraper aims to unify structure, space and architecture and show natural systems in an organizational form at the same time. The combination of natural forms with advanced computational technology enables the skyscraper to achieve magnificent, efficient and clear structures. Therefore, instead of individual elements, the building behaves like a living organism or an ecosystem. On the contrary, new technologies and materials enable adaptation, response and environmental awareness, which are not the subject of this research. 4-3 Geometry and transmission Geometry plays a key role in creating construction, structure and form. In schematic design, its role is to search and determine design ideas. The geometric shape has its own structural and architectural features. Skyscraper shapes can be designed by focusing on symmetry. The center of

one shape can be the corner of another shape or vice versa. These combinations have created many symmetrical patterns. In this case, the lateral distances as well as the corner columns determine these symmetrical geometric features. In general, building forms along with height can be considered. However, this research only considers non-contractual vertical transitions such as twisting. In this case, it displays the start and end points that are combined to create new patterns and define geometry. Through this process, many new concepts of tall buildings can be defined. Digital methods were developed to transfer the shape of the starting room screen to the final shape. Such operations as scaling, rotation, and chaining are displayed for different shapes.

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Fig 2. Lava tower, Source: lavatermal.com

Parametric combinations

Parametric combinations are the second class of parametric models based on the amount of use. This model consists of a set of geometric shapes and configurations. This model is also called communication model or geometric communication model. According to the order of criteria, parametric combinations show another level of complexity beyond geometric components, which is obtained by combinations of constructions. In these models, the key aspect of design is the combination of rules that represent different design combinations. Therefore, it is possible to achieve different design solutions using design components and elements in different ways. Lava Bionic Tower aims to find a way in which both the laws of architecture and the laws of nature can be combined to create the ultimate structure for the inhabitants. This type of design works in its own way from the smallest unit to the intelligence of the entire system. Therefore, by benefiting from the modeling of parametric combinations of behavioral logic in project design, the system is continuously optimized. In other words, by taking inspiration from nature and using advanced design techniques, this tower intends to create an efficient and light structure. In addition, the use of construction technologies and new materials creates more compatible and friendly buildings with the environment.

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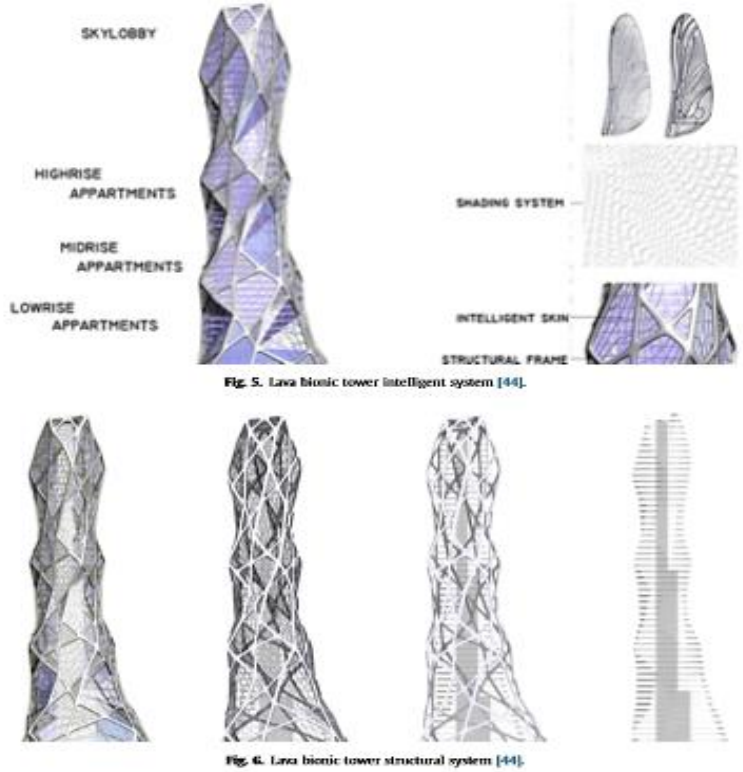

Fig 3. Lava tower in parametric model; Source lavatermal.

Exterior view system

Lava bionic tower is combined with the architecture of tomorrow. The architecture of the building has replaced modern concepts. Which is inspired by nature and its surroundings. Because it is a building with maximum energy efficiency and user comfort. Its shape is natural. Moreover, the overall exterior is an integrated element of the elements that make up the tower. It means imitating nature in the sense of part and parcel. Like any other system, the whole structure is as efficient as its parts. Each apartment in the tower has an unspoiled ocean view, as the minimal organizational principle allows for optimization of the aspect ratio. Skyscrapers can efficiently react to external and environmental influences such as atmospheric pressure, solar rays and temperature, air pollution, humidity, etc. New building technology and materials have created strong and light structures that can adapt to the surrounding environment. In addition, architects apparently consider important criteria such as obtaining sunlight, natural ventilation, rain collection, etc. These are equipped with the exterior surface system in the form of intelligent surface automation.

Simulation analysis

Unfortunately, unlike the use of digital tools and software, the schematic phase of tall buildings is still quite limited. This technology is used in order to create a more accurate construction evaluation and on the other hand, it is done in order to facilitate the comparison of the design with its alternatives. Since 50 years ago, building energy simulation programs have been developed and are commonly used. The main tools in the field of building energy are general building energy simulation programs prepared for users. These days, many energy simulation programs are available all over the world. Some of them are based on quick analysis of annual energy use. On the other hand, the rest of them are used for partial models. Therefore, which software is used is not very

important. However, it is an important issue to measure and grade simulator models, which is essential for using energy simulation. The simulation results are checked with the measured data. Efficient results have been achieved by recent advances in computer architecture implementations, for example in the fields of advanced geometry and computer application methods. Computers are used to develop old toolboxes. It is clear that the scope of the mentioned methods can lead to the implementation of the executive aspects of the building. Otherwise, there is no tool that integrates performance evaluation into the design process. Overall performance evaluation has not been investigated in any of the computer-aided architectural designs. Therefore, as mentioned, simulation of insertion is not a very accurate method. However, it is necessary to measure and analyze the energy demand of the building and its storage amount under certain conditions. Such as: the time saved cannot be easily measured, or when the measurements interact with other buildings, it is difficult to separate them, or when all the electrical data of the building is not accessible. Etc. On the other hand, the simulation method cannot be used under some conditions. For example, when buildings or mechanical HVAC systems are ready for simulation. or when measurements can be analyzed without a modeler. The Autodesk Green Studio energy simulator program can generate some design alternatives that measure the energy performance of a wide range of options. The best thing about this software is that the simulation results can be used for proposed building climates and building types, exterior features and active systems with relatively minimal options. System, the result can be used as a solution to reduce the energy consumption of the whole building. Then, at this level, it is time to create a model with the "Auto Desk view" program, analyze the study and create input for the program. The created model is used to represent the overall building geometry, which includes information such as the number of rooms, communications and external space relationships. Considering these data, Autodesk software can analyze the hypothetical operation of the building. Then, after setting a number of parameters, such as the type of building, location, number of rooms and basic building and system details will be available.

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Conclusion and summary

The human population strives to fight global warming, develop sustainable energy systems, and protect the environment and ecosystems of the earth. We have all the samples we need to display in the natural environment. The companies that have started to observe the possibilities have been inspired by nature in their designs. It can be said that nature is the ultimate solution and the best example in sustainable engineering and is truly an inspiration for innovative and intelligent engineering. Mimicking the level of biology has a potential impact on executive technology. Nature shows us various specialized fields whose structure depends on the characteristics of the surface. Imitation of the technique that has been used, to this imitation and repetition of complex biological surface structures with cavities, allows collapse and large aspect ratios. Biological surface structures, which are responsible for visual properties, can be used as the basis for the development of prototypes and innovative designs.

Declaration of no conflict of interest

The authors declare that there was no conflict of interest for them in conducting this research. (Conflict of interest refers to a situation where the material or non-material personal interests of the author or authors are in conflict with the research results and this affects the research process or the honest announcement of the results).

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