



Sustainability; as a combination of parametric patterns and bionic strategies



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ABSTRACT

Nowadays, climate change and consequently reducing the use of fossil fuel has become a significant issue. As building construction sector is the largest energy consumer, it seems necessary to analyze various aspects of constructions. High-rise building development mostly relies on technological achievements more than other factors and architects try to adapt themselves with this rapid development. Through this way, one of the recent irrefutable technologies is using software to analyze a significant complex structural type such as 'Bionic'.

After about 50 years, bionic knowledge had some consequential developments in building's structure part. Findings and researches in bionic were rather deficient in energy consumption section. In bionic design, one common pattern is parametric method. This study has reviewed the concepts and knowledge system of parametric bioskin design. The method outline is based on hour-by-hour energy simulation analysis. Furthermore, with the aid of LAVA skyscraper as a case study, the ultimate expectation of this research, which is illustrating the logic of parametric design in bionic facades to reduce energy consumption, can be analyzed. The results display that applying parametric patterns to bionic skyscrapers, lead to a considerable amount of energy saving.

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1. Introduction

Construction analysis has illustrated that the demand of sustainable constructions is increasing [1,2]. This is due to the fact that building operations are responsible for about 40% of the CO₂ emissions (Fig. 1), which is directly related to the amount of

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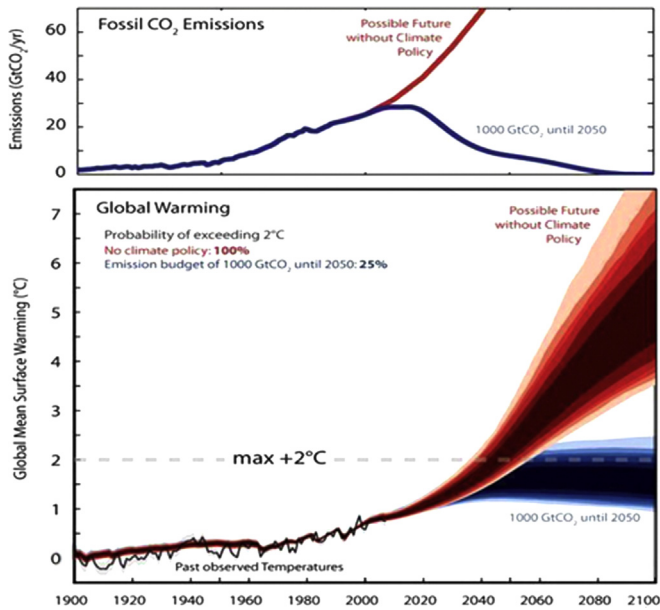


Fig. 1. Global warming and CO₂ emission [11,12].

energy consumption in construction in order to maintain the level of users comfort [3–5]. In other words, it is believed that building section consumes nearly 24% of the earth's total energy and this amount is increased up to 40% for developed countries [6,7]. The result of current situation causes solicitude [8,9] and more energy efficient constructions methods are needed to be designed accordingly [10].

To reach the aim of sustainable construction, it is clear that some principles should be considered in the design stage [2,13]. The advantages of sustainable constructions will be inevitable on the human health and natural environment. It has been shown that increasing about 2% in the initial investment cost-in order to support sustainable design-leads to nearly 20% saving in overall building cost [2,14].

While our planet is affected by global warming and uncertainty over long-term energy supplies, it is truly consequential to find some ways and principals to diminish energy consumption [15]. For finding practical ways of energy usage reduction, all aspects of the building, especially high-rise buildings with their vast facades, should be analyzed. Hence, the green concepts and techniques have been progressed as sustainable ideas and the notion of environmental preservation has also been considered in the construction plan.

Accordingly, since much earlier, nature has been the origin of human discovery and invention of significant principles of knowledge and technology. This was the first spark of the bionic ideas. 'Bionic design is a kind of the creative activity, which is inspired by biological prototype. It is a highly creative thinking activity based on the deep understanding of the natural objects and in the principles of esthetic and modeling' [16,17]. In other words, the bionic design procedure refers to the design process, which fulfills the design by applying different characteristics, such as geometry, texture, shape, color, function and structure of nature.

Technology is the base of construction of structural functions. The realization and performance of all constructions must rely on suitable materials, energy support craft and structural organizations. New progress always follows a breakthrough in science and technology. It usually expresses the new-tech on human demands. Under the instruction of bionic concepts, technological developments can learn the rules from nature [18]. As it is shown in many

cases, comparing to today's science and technology, natural creatures have developed specific features during millions of years, which are far more critical to understand and hard to cope with. So, the trend of learning from the biological structure, functions and systems has become a new direction in technical innovation and revolution.

Moreover, the relationship between natural beings or between human and nature creates a perfect source in the construction innovation and especially in its ergonomics [19]. In other words, adding the organic knowledge and rules to the design process helps human beings feel happy in life when put into practice [20]. Thereby, this kind of inspiration from the nature can lead to efficient energy consumption in the construction section, which will be focused more in this study.

Furthermore, these days, there are some regulations, forcing designers and architects to consider their projects energy usage and their effects on the environment. So, in the case of analyzing the building energy performance, benefiting from energy simulation programs in the design stage, might be one of the best possible solutions [10,21,22]. Although there will be discrepancy between the result of the simulation and the actual amount in the real building, it can lead designers and architects to develop more energy efficient alternatives [23,24].

Since 50 years ago, a wide range of energy simulation programs have been developed throughout the building energy community [22,25]. However, still these programs are not widely used [10]. By using 'Autodesk Green Building Studio' simulation program, which is a commercial software package, this study tries to show designers the effectiveness of applying parametric patterns and bionic strategies in high-rise buildings. This energy-analysis software enables designers and architects to perform whole-building analysis, optimize energy consumption, and work toward carbon-neutral building designs earlier in the process. The software adds defaults and assumptions according to the building type and location to complete the energy analytical model. This helps designers perform a valid and useful analysis for decision making. Green Building Studio gives access to over a million virtual weather stations, which are compiled from a variety of trusted sources. Also, for existing building projects, designers can upload building utility history. This software automatically collects historical weather information from the same period of time, so, architects can create a calibrated energy model for their designs [26].

These types of strategies can provide benchmarks that lead to design inspirational approaches and also more efficient and sustainable engineering solutions. Therefore, it is concerned with the high-rise construction form, as a case study, which is generated by digital tools, based on the architectural and structural criteria. In other words, it expresses and analyzes an innovative parametric bionic façade system design using digital methods in order to fill the current gaps and lack of knowledge and it also proposes a key message to change the designers' viewpoint in dealing with the subjects.

1.1. Research methodology

These days, energy consumption simulation in construction sector has become the matter of interest and benefit for architects and engineers. These simulation programs are benefited in order to evaluate the effectiveness of energy conservation measures before the building is constructed or modified [9]. Two basic levels of energy analysis tools are available at present. The first one is the simplified energy calculation, which uses the degree-day method and is suitable for small scale buildings' energy usage. This method can be developed and be more accurate to adapt with larger buildings. In this case it is called the modified-bin-method. The

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