E3S Web of Conferences **3**, 01007 (2014)
DOI: 10.1051/e3sconf/20140301007

Biomimetic Architecture in Building Envelope Maintenance (A Literature)

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Abstract. The study of biomimetic architecture on building envelope is the main structure of this research. The concept is believed more sustainable and efficient for energy saving, operating cost consumption, waste recycle and design renewal in the future. The inspiration from the nature developed the intention on this study to explore on what and how this concept to overcome the problems through design. Biomimicry does catch the attention of human to study more on the system and function of its nature course. The designers are not exception influenced by this concept when the form, shape, texture and colour inspired them in their design. The domination of building form will affect the building envelope as the skin of the structure. A clear impact on building failure is begun with building envelope appearance without a proper maintenance. The faults in building design place a heavy burden on the building for the rest of its operational life and there is no compensation for it. In such situations, the responsibility falls on the shoulders of the designer.

1 Introduction

In this research, a study on the building envelope will carry out to explore the design and performance of maintenance on biomimetic concept. At the end of the study, the expectation on better maintenance design for building envelope by using biomimetic architecture is explored to achieve sustainability in design and maintenance. Furthermore, a better quality for building maintenance operational can be achieved via the journey of this research.

2 Literature Review

Biomimetic Architecture is mimic from the biomimicry concept into architecture [1]. This history of biomimicry started in the 15th century when Leonardo DaVinci took this type of mimicry from the birds and created drawing to depict flying machine [2]. The study of biomimicry by Salma (2011), shows that this is one of the tools for sustainable. Salma [3] founds that the nature's design process feedback systems are strongly related and affected by surrounding environment and much more advanced in terms of environmental and sustainable performance.

Gruber [4] defined that biomimetic architecture is known as Architekturbionik, an emerging field of nature into functional analogies, processes, mechanisms, strategies or information derived from living organisms. In addition, Grubber meet the application of observations made in nature to

architecture has always been a challenge for architects and designers. The strategic search for role models in nature is what discerns biomimetics from the ever-existing inspiration from nature.

Guild [5] defined that there are two categories of biomimicry in design process: Defining a human need or design problem, and looking to the ways other organism or ecosystems solve the problem. Design looking to biology, or identifying a particular characteristic, behaviour or function in an organism or ecosystem and translating that into human design, referred to as biology influencing design [5].

There are two categories of biomimicry technology approach is designed; which are biomimicry design to biology and biomimicry biology to design [5]. This approach of biomimicry design from biology brings the technology into safe the environment [1]. Maibritt [1] referring to Guild's approach and found that there are three levels applied to design problem are typically as *form, process and ecosystem*.

Maibritt [1] refined the biomimetic architecture from the above discussed approached. The first is by determined the human needs and requirements through design problems. There three levels of biomimicry that may be applied to a design problem which are given as form, process, and ecosystems [5]. Furthermore it is explained by Maibritt [1], biomimetic architecture may influenced design, structure, skin, texture, colour and more to physical appearance. The second is by the functional of organism and ecosystems react or worked with its characteristics, behaviour and function through design problems and solutions. Therefore, he divided the study in three levels of mimicry that is organism level, behaviour level and ecosystem level.

This study of the overlapping fields of biology and architecture shows innovative potential for architectural solutions shown by Grubber to transfer nature's principles to architecture have provided successful developments [4]. An example is the scientific analysis of the lotus flower emerging clean from swamy water, which led to many design innovations as detailed by Baumeister [6] including Sto's *Lotusan* paint which enables buildings to be self-cleaning. Fig. 1 shows how the lotus leaves texture acting as self-cleaning.

Fig. 1: The texture of lotus leaves

Grubber [4] stated that the design perfection is measured through issue and problem solving wisely on sustainability. Thus, this current finding through the study of biology is considered and applied widely in the elements of the design concept. In biomimicry adaptation in building form, it still lacks a showcase of innovative products or real breakthrough in the form of a 'really biomimetic building' [4]. This implies the interpretation of biomimetics as an architectural style, defining the entirety of a building, best reflected in the overall form.

The generative design process is limited by phylogenetic and physical constraints and according to Menges [7], support that the challenge of this approach lies in resolving the complexity arising

from the interrelation and reciprocal effects of material systems and dynamic environments. Manges found that the evolutionary design exploration is introduced as a method together with a detailed description of case studies exploring the design of form-performance relations of overall building morphologies and urban block morphologies.

The majority of green building assessment systems focus on the design of the constructed building, with little focus on the effect of the building system's life during operation. This tendency has resulted in a failure of many rating systems to properly consider durability, lifecycle cost and the effects on the premature building envelope failures [8].

It is proven by James and Hoff [9], the failure of building envelope design will encourage more internal problems and issues. This will result the impact to maintenance planning, operation and costs that might ruined the aesthetic and value of the building in the future.

Chen [10] says most of recent buildings are striving to achieve criteria of Green Building Index (GBI) to overcome the issues of global warming. In addition, Chen says the innovation and invention of building materials and systems are believed in leading to the GBI criteria could reduce problem. However, the sustainability building envelope design is addressed more in reducing energy consumption through building design that is more sustainable. The issues arise in expenditure in design stage (Fig. 2).

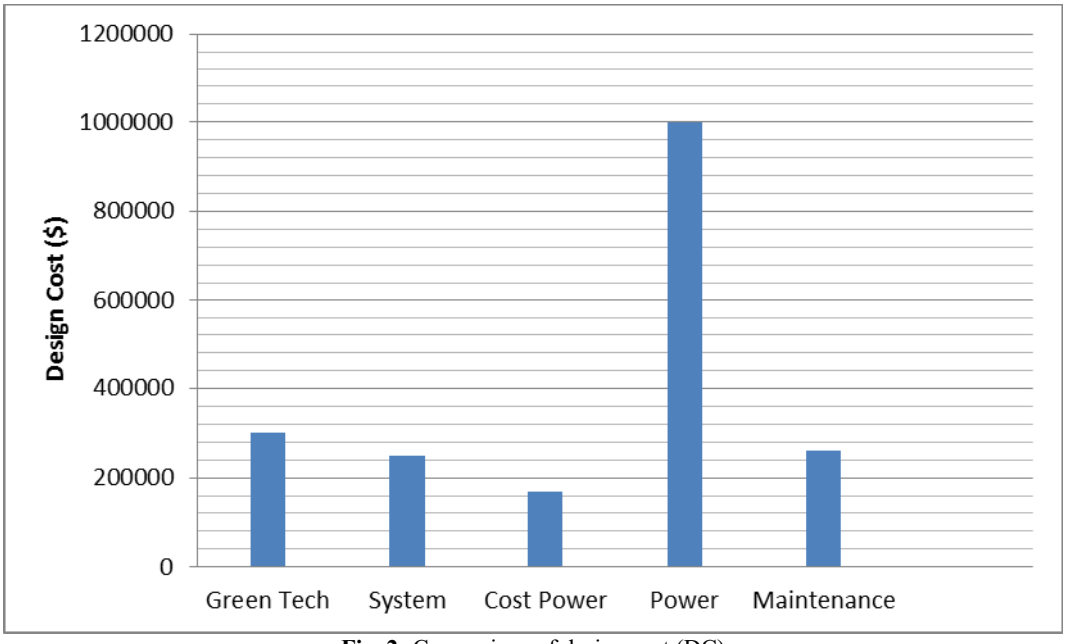

Fig. 2: Comparison of design cost (DC)

This is support by Optimal Maintenance Decision Inc, OMDEC [11] in its case study on "Failure Prevention through Designed-in RCM" defined that proactive maintenance should start at the design stage. However, this study found that failure prevention and maintenance cost control by Maintenance Managers is so often frustrated right in the equipment design phase. This is being supported by a survey had been carried out on 38 designer firms from architectural, civil & structural consultant firms and 30 maintenance firms located in Shah Alam and Kuala Lumpur districts. The awareness of most designers claimed to have knowledge and experience on building maintenance aspects but only few are aware of the importance to consider maintenance factors during design stage.

Furthermore, Michael [12] discovered on biomimetic architecture practicing is more sustainable and this building envelope design form and shape is particularly more solid, curvy and spiral; that is a challenge to maintenance when the building is in operation.

Through the interview on practitioner architect, Fahmi [13] claimed that he defined biomimetic is more than only the shape and form, imagine about human body or another organic life. There are structured (bone and flesh), system and protection distribution (electricity, blood, oxygen, etc), maintenance in how to survive in supporting our life. Some can solve the problems by itself and the rest is from outside source. It is a perfect analogy for the creation and we can only imitate (mimic) little part of it. Some only could implement the form and some only can a bit for the system. So if the consideration with the cost (initial cost and future cost). He himself defined that not all architects can take this matter and issues about how far the biomimetic form can overcome the problem in maintenance in the future.

Moreover, large amount of the country's maintenance resources is being expended on corrective or remedial measures to buildings and their services due to design or construction defects. Therefore, by reducing the number of design defects, the amount of maintenance expenditure can be reduced. Apart of this, the hard part is coming now, when we really have to improve the energy performance of our buildings in Week [14]. It is respond that they have to invest in the envelope and that's going to be a big challenge over the next three to four years.

The building envelope failures that have plagued Vancouver's condominium market since the early 1990's illustrate the importance of proper building envelope design and commissioning. The cost for repetitive maintenance, repairs, premature replacement, health effects and occupant disruption has escalated to multibillion-dollar levels. In addition, envelope has obvious impact on the sustainability of building.

3 Problem Statement

The biomimetic architecture concept on building envelope needs to meet the sustainability on maintenance in the future. Therefore, a maintenance sustainability is discovered in biomimetic architecture concept on building envelope (Fig. 1). The research on biomimetic architecture inspired the researcher to study on its perfection concept based on the literiture preview. The interest become more challenging when there is a lack research were done on the maintenance aspect on this concept. The prospect on maintenance in this perfection concept based on several issues is to find a guide for better building envelope performance in the future.

The impact on building design form and envelope is said that will effects to facility operation and maintenance [15]. This issues has been arise since 1986 when The Building Research Establishment in England conducted a survey of building failure patterns and their implications and found that 58 percent of the defects have originated from faulty design [16]. Today, sustainability is a part of perfection in every elements in design. Beside the challenge by the cost increasing in energy consumption and waste management, design is competed with sustainability in innovation and invention to search for better concept. Furthermore, each elements in design such as materials, technology and system are improved to produce better application, quality, durability and more sustainable with little concern on escalation of cost and maintenance in the future.

At present, the concept of biomimetic architecture is more sustainable for building. On the other hand, the appearance of the building consumed more cost in the future [15]. The design decisions are made without the benefit of realistic user needs, operational and functional requirements, and maintenance issues [15]. Nowadays, the stakeholder usually invest more on building design to present the image of the wealty and power of the core business [14]. The increasement on height and space of the building shall influence to building envelope design. Additionally, the passion on designer creativity and image do reflect to the building envelope [17]. Nevertherless, the selection on materials, technology and systems of the building thus allocated a certain impact on cost in present and future.

On the other part, design form is the most greatest authority in designing structure, materials and systems to meet the design satisfaction. The abilities of elements to be flexible, circular, spirally, curvy and other forms are determined in designing the building envelope. Moreover, the element shall meet the sustainable criteria. This characteristic of building envelope components opposite the maintenance perspective when the cost of cleaning, replacement and repairing is high.

4 Conclusion

To satisfy the aim of research, the following objectives are as follows and by refering Fig. 3:

1. To identify the biomimetic architecture concept on building envelope in design development.
2. To identify the adaptation of building maintenance through biomimicry concept for building envelope.

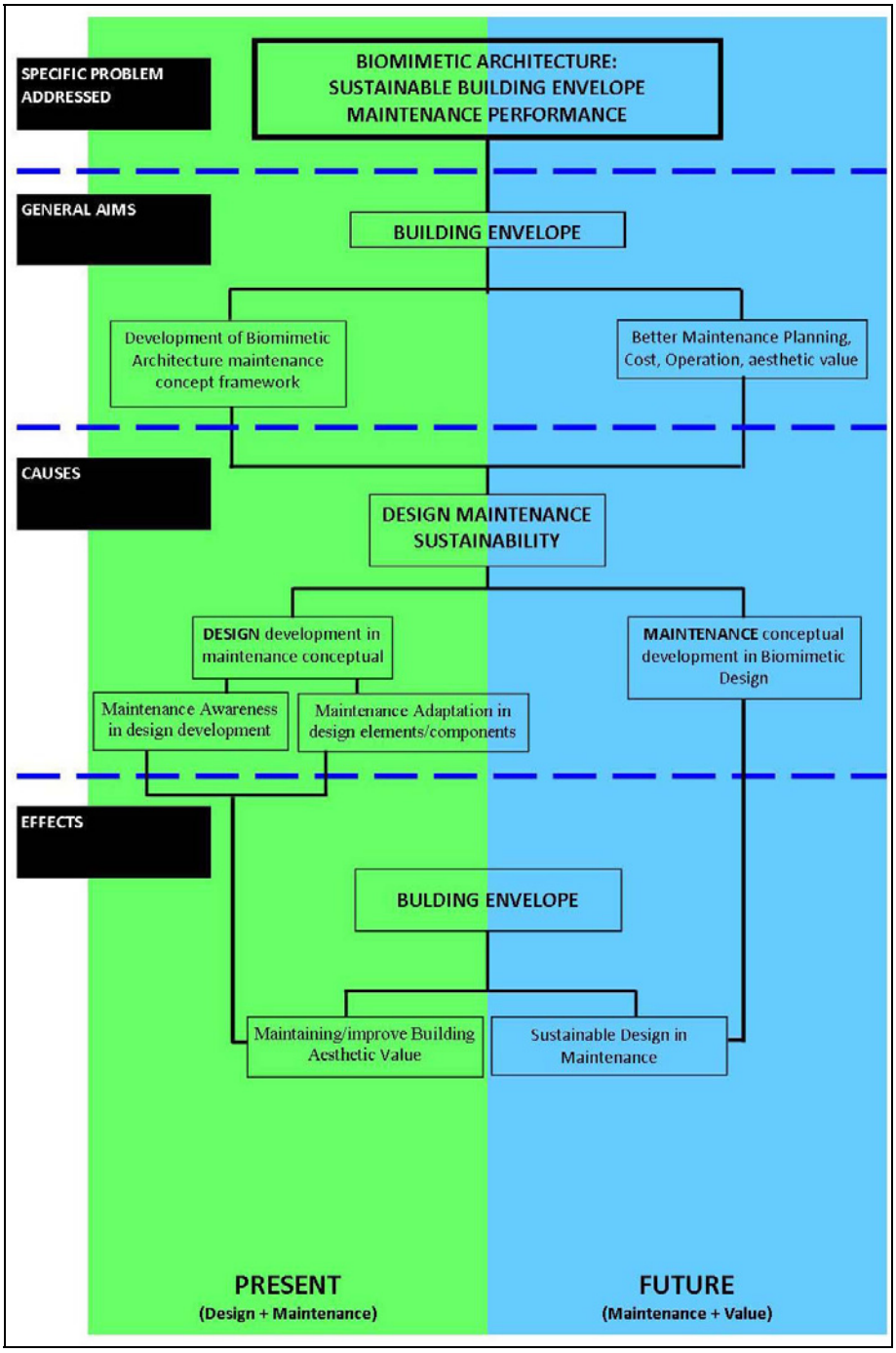

Fig. 3: Conceptual of problem statement understanding

4.1 Biomimetic Architectural Approach

This is the main purpose on how researchers review the concept of biomimicry applied in the building envelope design. This approach could solve the problem of biological design form of the building envelope elements.

4.2 Maintenance Planning Approach

The second most important focus of this research is maintenance. This is to investigate on how the biological and design systems consider to maintain the building envelope and how to solve the problem of maintenance in biomimicry concept. The criteria and characteristic of the building envelope design is an important criteria of this research. Among the aspects proposed are:

- Planning
- Operational
- cost
- Maintenance Performance

5 Simulation and Modeling Research

The strategy has been outline based on the understanding of the process on design development togetherness with a study on biological action on the selective pattern. The transformation of pattern and detailing to the building pattern are needed to produce a model and ready to be tested on the climate and effected sources from the environment. In the way of producing a better design for maintenance, once shall considered on materials selection to enhance the self-cleaning surface on building form (referred to Fig. 4).

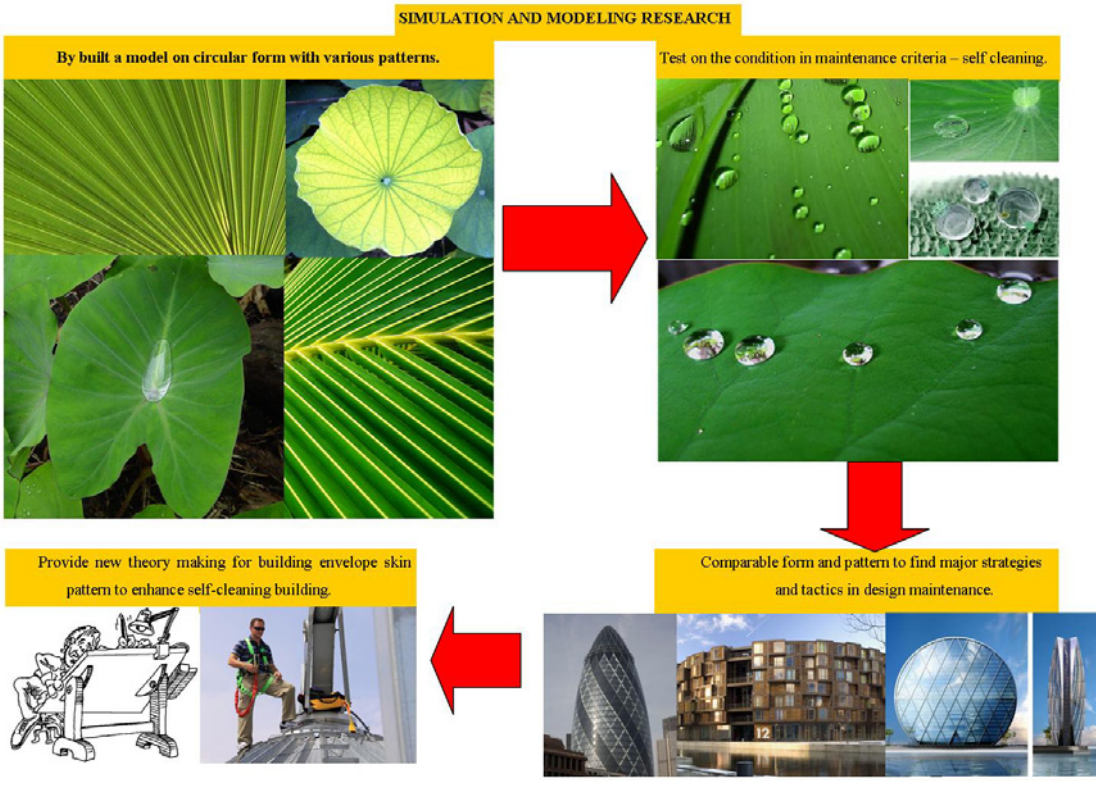

Fig. 4: Conceptual of research strategy approach

Biomimetic architecture approach shall be expand in maintenance design aspect to produce better maintenance planning in the way of sustainable building envelope design. Furthermore, it will reduce the risk and cost in maintenance planning in the future.

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