Proceedings of 8th IOE Graduate Conference
Peer Reviewed
ISSN: 2350-8914 (Online), 2350-8906 (Print)
Year: 2020 Month: June Volume: 8

Biomimicry, An Approach to Energy Efficient Building Skin Design: A Case of green commercial building in Kathmandu

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Abstract
The major problem worldwide is shortage of energy with the high consumption of energy in buildings. Architects are attempting to find solutions for managing buildings energy consumption. One innovative approach is Bio-mimicry ,Which is defined as the applied science that derives inspiration for solutions to human problems through the study of natural designs, systems, and process. This study examines how eco practitioners perceive bio-mimicry as a design approach in architectural eco design practice. Bio mimicry though not a new field of study, has been designated as a separate scientific field just in recent decades. It emphasized the importance of seeing bio-mimicry as a potential approach to architectural eco design practice. In context of Nepal nature inspiring green building are taken to incorporate the concept of bio-mimicry. Energy modeling of a green commercial building called Hama Iron and Steel Building is done to explore the energy efficient measures and other qualitative approached are highlighted. Through applying the bio-mimicry approaches on the building 42.7% total load reduction is seen in the rental floor of the building.

Keywords
Bio-mimicry, Energy Efficiency, Building Skin, Bio-inspired design, Commercial Buildings

1. Introduction

Currently, in the 21st century all over the globe, enormous amount of primary energy is wasted due to the inefficient design of buildings. In addition to the running of the equipment used to convert energy into required services. As a result, an encouraging growth in awareness of energy conservation and efficiency has been rapidly growing, forcing, a number of design approaches and solutions have been researched and applied in order to overcome energy problems. One of those approaches is Biomimicry which is defined by as" the applied science that derives inspiration for solutions to human problems through the study of natural designs, systems, and process". The following paper discusses the principals of Biomimicry as an approach for sustainable and efficient design [1].

In the past, there used to be a common language amongst the built environment. Architects, engineers, designers, and society, understood that buildings were used to function as a form of shelter, creating a physical separation between people and the environment. As time went on the world was introduced to many different styles of architecture; and as this happened, the word architecture and the word building slowly began to split into two different meanings. When one thinks of a building we think of permanence. As architects began to become more sensitive to the idea of how important the impact that permanence (a building) had on the society as a whole, architecture began to break away from the typical cube and embarked on thinking outside the box [2].

The building sector has a key role to implement energy efficiency objectives: around 42.7 % of the energy consumption and a third of CO2 emissions are attributable to buildings. Architects are attempting to find solutions for managing buildings energy consumption. Bio-mimicry is considered to be a new approach for achieving energy-efficient building design [3].

2. Research objectives

The main objectives of this research is to carry out depth reserch on biomimicry and investigate the ability of reducing energy consumption by applying the bio-mimicry approach on Hama Iron and Steel building of

Kathmandu.

3. Methodology

In the first phase different international journals, national pilot studies, policies and class lectures have been reviewed to know about the nature inspired buildings, approaches step and levels of bio-mimicry. In the second phase, the study focuses on the quantitative analysis of the climatic condition, energy consumption pattern of nature inspired building. A sample survey is be conducted in the selected green building of Nepal to know about the building concepts, building material use and energy consumption pattern of existing building.

The foremost step will be energy modelling using simulation tool. This, experimental strategy is perceived through positivism paradigm to evaluate energy performance of a selected building, as a philosophy, positivism adheres to the view that only "factual" knowledge gained through observation (the senses), including measurement, is trustworthy.

Further the indicators of bio-mimicry will be incorporated in the same building and the comparison will be done. Simulation research will be carried out using Ecotect model, the validity of the software will be calibrated. The calibration is directed by comparing recorded weather data and evaluated weather data by Ecotect, of certain year interval. In this way, energy performance of a building will be observed in a virtual lab with strictly objectified quantitative data.

4. Literature review

Historical background of bio-mimicry While humans have only studied bio-mimicry for the past half century, the earth has been developing efficient methods of life for 3.8 billion years. Our planet is the oldest and wisest teacher we could ask for.

However, throughout our extremely short history we have not exactly seen eye to eye with the earth. It is because of this that we are experiencing changes in the climate that will prove detrimental to our future. This project is designed to open the minds of the reader to a new form of innovation.

Bio-mimicry and building skin In order to be able to draw the analogues of building skin and bio-mimicry it is important to analyze the commonalities of each. This includes evaluating the main similarities and the driving forces that affect nature and the architectural design process. The building skin is a thin membrane that covers the skeleton (structure), regulates the organs (mechanical, plumbing and electrical) and defines its interior spaces. The building skin is similar to natural skin as it consists of different layers and filters that react to light, air, moisture, sound and heat. The frequent quality among natural skin is for its capability to maintain internal conditions while be responsive to its function. The building skin similar to natural skin is the boundary the controlled and uncontrolled environment. It is the configuration of the results of both internal and external forces. They both act as a filtration in the process of allowing what is allowed to enter and exit [1].

Approaches to Bio-mimicry Approaches to bio mimicry as a design process typically fall into two categories: Defining a human design problem and looking to the ways other organisms or ecosystems solve this (design looking to biology), or identifying a particular characteristic in an organism or ecosystem and translating that into a human need (biology influencing design) [4].Within these two approaches, there are three levels of mimicry: The organism level, the behavior level and the ecosystem level [4].

The organism level refers to a specific organism and may involve mimicking part or the whole of the organism. The second level refers to mimicking behavior, and may include how an organism does things. The third level is the mimicking of whole ecosystems and the common principles that allow them to successfully function. Within each of these levels, are a further five possible dimensions to the mimicry: what it looks like (form), what it is made out of (material), how it is made (construction), how it works (process) and what it does (function) provides examples of the differences. [4]

Name of building	Inspiration	Application in design	Problem solved	Level of biomimicry
Eiffel tower 	Thighbone 	-The outward flare resembles that of a femur bone. -The lattice is built from metal studs and braces.	-Withstands bending and shearing effects due to wind -Ventilation problem solved	Organism Level
National Aquatics Center, Bejing 	Water bubbles 	-The surface is covered with membrane of lit blue bubbles of pneumatic cushion created from ETFE allowing for the bubble effect.	-The bubbles collect solar energy that heats swimming pools. -Allows for temperature regulation.	Organism level
Bejing National Stadium 	Birds Nest 	-Contains ETFE panels that insulate by stuffing small pieces of materials in the twigs. -Panels protect and provide sunlight filtration.	-Facade openings allow for natural ventilation -panels reduce the dead load supported by the roof. -cost reduction, durable, and recyclable.	Behavior Level

Figure 1: Application of Bio-mimicry in Architecture,
Source: [1]

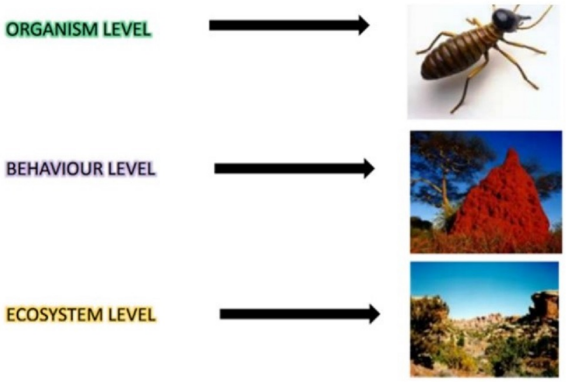

Figure 2: Levels of bio-mimicry,
Source: [4]

5. Research setting

Building was selected by studying the international case areas and green architecture of Nepal where the bio-mimetic concept could be incorporated. Energy modeling of a green commercial building called Hama Iron and Steel Building was done to explore the energy efficient measures and other qualitative approached are highlighted.

It is a LEED certified commercial building located at Kamaladi, Kathmandu with the site area 633 sq.m and built up area 6405 sq.m. and footprint 353 sq.m. the building consist of basements upto 2 floors, 6 rental floors, 2 floor apartments and upper two floors cafe.

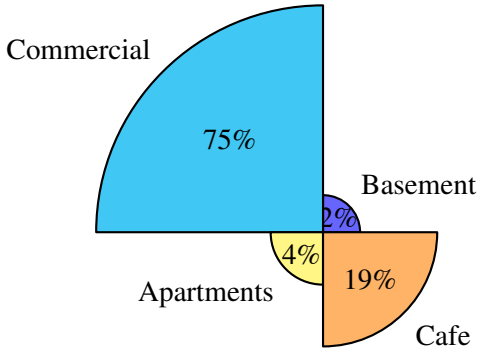

Figure 4: Use of the building

Figure 3: Hama Iron and Steel Building

During this survey, it is found modern materials mainly glass and steel are used in the buildings. Building is double basement plus 12 storied. Up to 6th floor – rental area for commercial purpose 7th floor- for Hama office, 8th -10th- for apartment and 11th and 12th –for pent house.

Maximum area of the building façade uses double glazing windows as shown in the chart below.

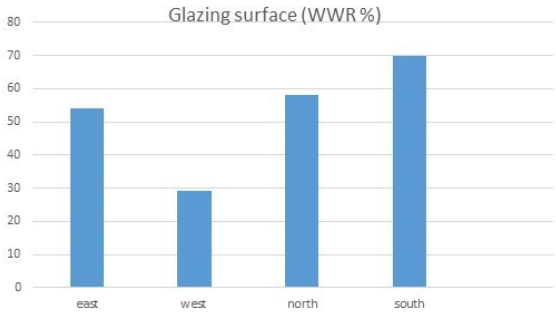

Figure 5: Window to wall ratio (WWR) in facade

6. Analysis,discussion and findings

The base scenario was modeled as existing scenario using a software Ecotect 2011. All specifications were as per actual site measurements and conditions. This scenario was modeled with best possible way to represent the actual findings in site.

Table 1: Base case for modeling

Building Elements		
Plinth	Stone plinth with PCC as flooring	4500mm thick
Wall	Interior wall, Cement board	10mm thick
Wall	Exterior wall	12mm thick
Floor	Tile floor	12mm thick
False Ceiling	Fiber board	6mm thick
Openings	Aluminum paneled door and Aluminum paneled double glazed window	6mm thick glazing window

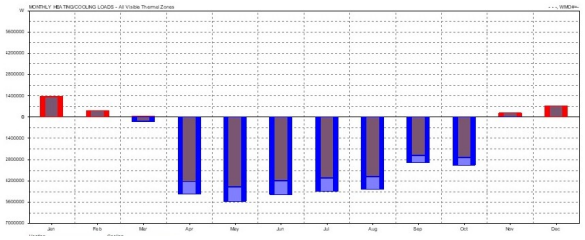

Figure 6: Monthly heating/ cooling load analysis of base case

Simulation Result of base case:

a.Monthly loads/discomfort: This graph shows the monthly heating and cooling load per floor to maintain thermal comfort of the building. According to calculation made by Ecotect Analysis the total annual heating load in commercial floor is 2831980 Wh. Per floor.

The graph shows maximum heating load is 26970 w at 9am on 1st January. The total annual cooling load is 31991956 Wh. per floor the building has maximum cooling load of 53923W at 2pm on 14th April. According to result the heating and cooling load is maximum and minimum at January and April respectively. Therefore, the total annual heating-cooling load of the building is 34823936 Wh.

Per floor.

Proposed Scenario 1:

Appropriate design of building insulation can facilitate heat retention during winters and prevent ingress of heat during summers. One of the finest examples of insulators is the feathers of the Gentoo Penguins (pygoscelis papua) from Antarctica. [5]

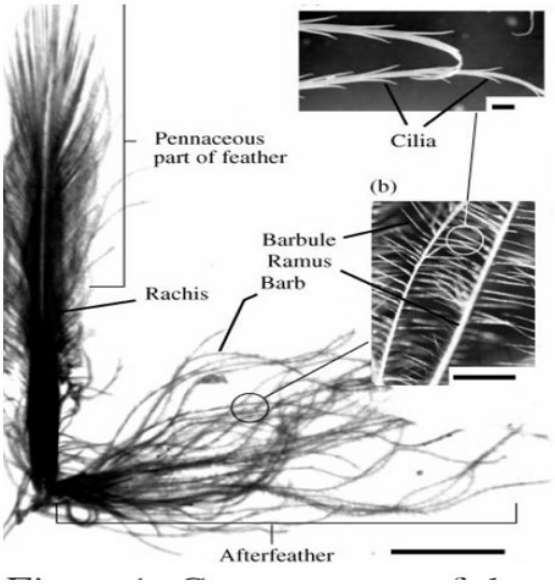

Figure 7: Components of Penguin feather, Source: [5]

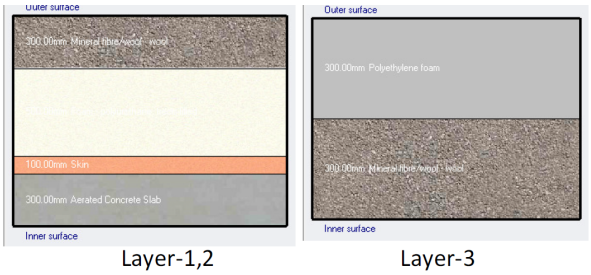

Figure 8: Building Layers

Table 2: Scenario 1 for modeling

Building Elements		
Plinth	Stone plinth with PCC as flooring	4500mm thick
Wall	Interior wall, Cement board	300mm mineral fiber wool,100mm skin,300mm aerated concrete slab
Wall	Exterior wall	12mm thick
Floor	Tile floor	12mm thick
False Ceiling	Fiber board	6mm thick
Openings	Double glazed low aluminum frame	6mm thick glazing window

Simulation Result of scenario 1:

a. Monthly loads/discomfort: This graph shows the monthly heating and cooling load per floor to maintain thermal comfort of the building. According to calculation made by Ecotect Analysis the total annual heating load in commercial floor is 2797151 Wh. Per floor.

The graph shows maximum heating load is 21816 w at 9am on 1st January. The total annual cooling load is 17143712 Wh. per floor the building has maximum cooling load of 43337W at 2pm on 14th April. According to result the heating and cooling load is maximum and minimum at January and April respectively. Therefore, the total annual heating-cooling load of the building is 19940864 Wh. Per floor as shown in figure 9.
Bio-mimetic facade of penguin feather is proposed and the difference in load is seen in the typical floor of the building.

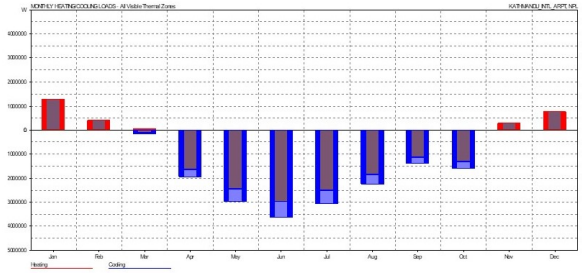

Figure 9: Monthly heating/ cooling load analysis of proposed scenario. 1

Load Comparison

Heating and cooling load in base case is 34823.936 kWh and that of proposed scenario 1 is 19940.864 kWh per floor.

By which 42.7% total load reduction is seen in the rental floors of the building.

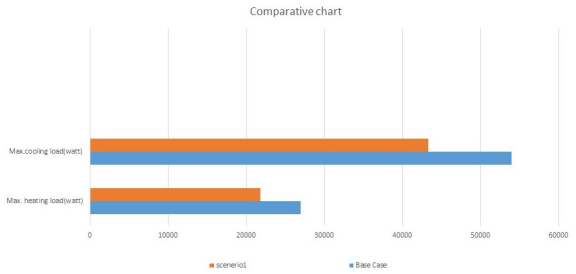

Figure 10: Load Comparative Chart

7. Conclusion

Nature has been sustainable and energy efficient for billions of years. In this article bio mimicry approaches are used for the energy efficient buildings. Through applying these characteristics into architecture, human problems can be solved.Mimicking nature has significant potential in order to accomplish a new approach for energy efficient building envelopes.Bio mimetic facade of penguin feather is proposed and the difference in load is seen in the typical floor of the building. Heating and cooling load in base case is 34823.936 kWh and that of proposed scenario 1 is 19940.864 kWh per floor. By which 42.7% total load reduction is seen in the rental floors of the building.

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