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Flamingo Strategies in Approaching Sustainable Design in Built Environment: Case Study in Dubai

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Abstract: *As Dubai is considered one of the fastest growing metropolises, it is important to mention that it was ranked first for highest ecological footprint due to the rapid development and environmental consequences (World Wildlife Fund of Nature 2010).*

Biomimicry is one innovative solution that helps reduce the environmental impact of our projects by taking inspiration from nature and in this piece of research the natural concept was the flamingo. The author highlighted different strategies that were inspired by the flamingo and implemented them on the case study (Uptown Primary School in Dubai). The main aim of the research is to investigate the effect of the strategies on the project by adopting a simulation study using Ecotect software analysis to approach the strategies that have the best impact on indoor space temperature and help in reducing the total energy consumption.

Keywords: *United Arab Emirates, Ecotect, biomimicry, sustainable design, innovative strategies*

1. Introduction

The world is full of amazing solutions that can solve many architectural problems and Biomimicry is the key to inviting nature into human life. Nature contains millions of sustainable designs that can be inspired to mitigate the impact that humans have on natural systems.

When Biomimicry is used as an architectural design method, Pedersen Zari (2007) highlights three levels of mimicry: the organism, behaviour and ecosystem. There are then five different features for each level (firm, material, construction, process and function).

One natural creature that is inspiring to architects is the flamingo; its ability to adapt to climate changes can be utilized in a large variety of methods and strategies in the architectural construction field to achieve climate comfort.

It is worth mentioning that the ‘Greater Flamingo’ exists in the United Arab Emirates in highly protected areas of coastal mudflat. The Environmental Atlas of Abu Dhabi Emirate (n.d) mentions three conservation sites in the Emirates:

- Island of Dayyinah in Abu Dhabi
- Wildlife sanctuary in Ra’s al-khor Dubai
- Khor al-BAdia in Umm al-Qaiwain

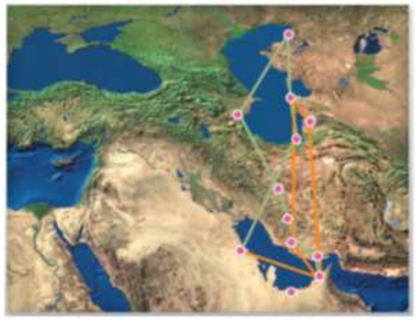


Fig. 1: Flamingo colony aided by locations from a satellite-tracked bird

2. Methodology

To approach to Biomimicry as a design process, there are two categories to follow. First defining the design problem and then looking into the ways other organisms solve it.

This research paper will start by presenting the anatomy of the greater flamingo to describe the physical form and behaviour that helps the flamingo in adapting to different climate changes.

Next will be a section highlighting design strategies inspired by the flamingo's anatomy and behaviour and after that comes a discussion of the case study (Uptown Primary School in Dubai) to consider the usage of the flamingo strategies.

The report will begin by presenting a description of Dubai's weather data and a site analysis. The report will conclude by presenting some applications inspired by the flamingo strategy using sketches and smart design.

3. Flamingo anatomy

3.1. Physical characteristics of the flamingo

It is important to analyse the physical characteristics and highlight the main figures that can be inspired through their designs (legs, wings and feathers).

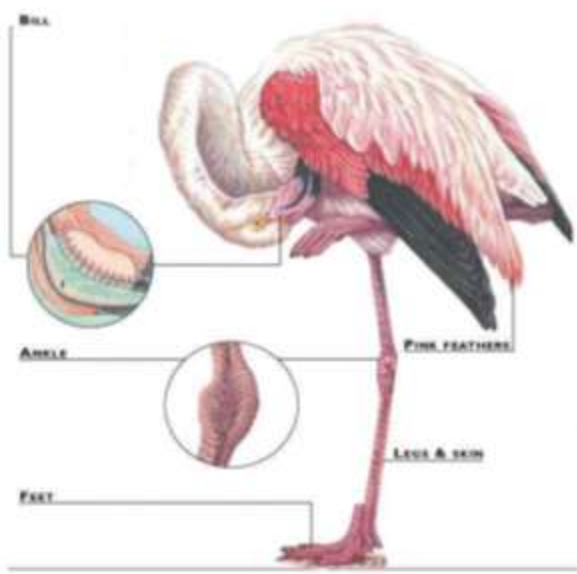


Fig. 2: Greater flamingo physical analysis

The flamingo's behaviour plays a massive role in adapting to their habitat, these behaviours are inspiring in learning lessons for architecture and thinking of new strategies that help reduce environmental impacts such as food filtering, thermoregulation, breeding and waterproofing.

3.2. Design methods

To approach Biomimicry as a design process, there are two categories to follow: these are defining the design problem and looking at the ways other organisms solve it. This project will focus on three main factors that affect the comfort level of students which are ventilation, insulation of the building and natural lighting.

In order to achieve sustainability, the report will focus on new concepts to be applied that help to improve building performance and mitigate energy consumption are inspired by the anatomy and behaviour of the flamingo.

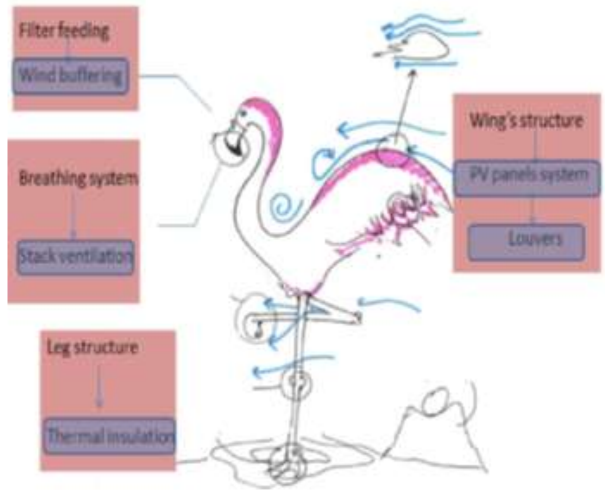


Fig. 3: Flamingo strategies and how they can be applied to the project

4. Case study (Uptown Primary School, Dubai)

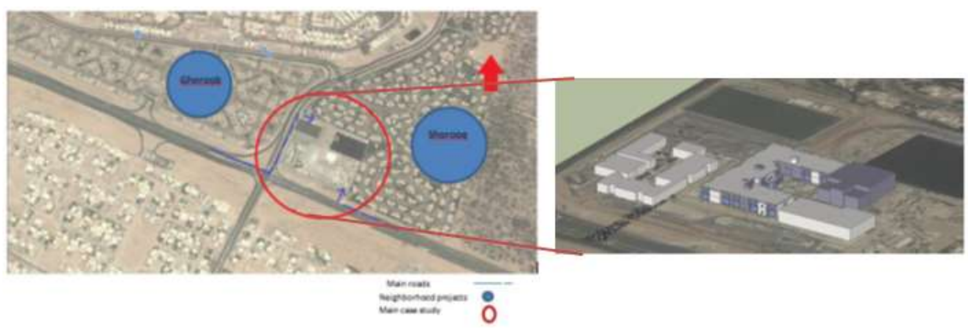


Fig. 4: The Case study's location in Mirdiff

This paper will present Uptown Primary School in Dubai as a case study, as shown in (Fig. 4). It will start by investigating and analysing the site beginning with the location, neighborhood context, size and zoning and natural physical features.

Analysis will help us to understand aspects that should be considered when applying methods inspired by flamingo strategies to achieve a sustainable design and compare it with a recent case. The author will start by highlighting Dubai's climate in order to understand the reasons behind the orientation of the structure and the materials used in construction.

5. Dubai climate data

Dubai has a hot desert climate, (Fig.5) shows that the heating period is from May to September with an average daily high temperature of above 37*C. The hottest month of the year is July with average high of 41*C, after that the weather starts to cool down.

The cold season lasts from December to March with average daily high temperatures below 27*C, the coldest day of the year is in February, when the temperature can reach 5*C.

According to (Fig.6) north-west wind is the common wind in Dubai, the highest record for that is 50 Km/h, and the north-east is the second most common wind.

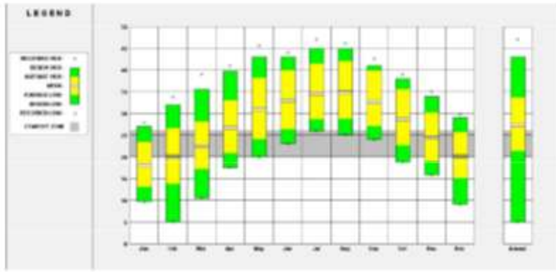


Fig. 5: Dubai temperature range

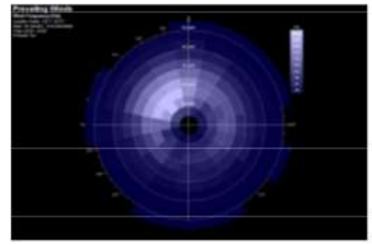


Fig. 6: Wind velocity in Dubai

6. Case study analysis and discussion

6.1. Month sun path diagram and Solar exposure

To reach the intended goal, the report will utilise a seasonal sun path diagram and energy simulation tool (Autodesk Ecotect Analysis) to explain how energy and environmental decisions were integrated into the design process.

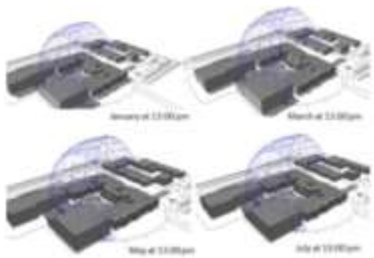


Fig. 7: The sun path diagram on January, March, May and July

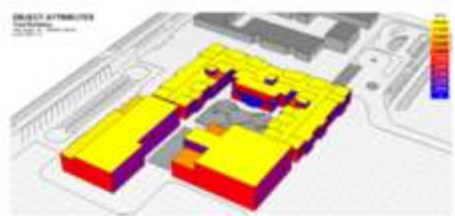


Fig. 8: Solar exposure analysis

(Fig.7) and (Fig.8) show the amount of sun hours the school is receiving during the day. This is useful to see the best position for the photovoltaic panels to produce maximum energy and suggest different designs to protect the façade from direct sunlight.

6.2. Daylight factor

The Daylight factor is very helpful in showing the ratio of internal light level to external light. The daylight factor for classrooms should not be less the 3% according to the optimal standards for lighting as Coldham (2003) suggested. This report will examine the daylight factor for four classes to compare the difference in results according to orientation and percentage of opening in each class (Fig. 9).

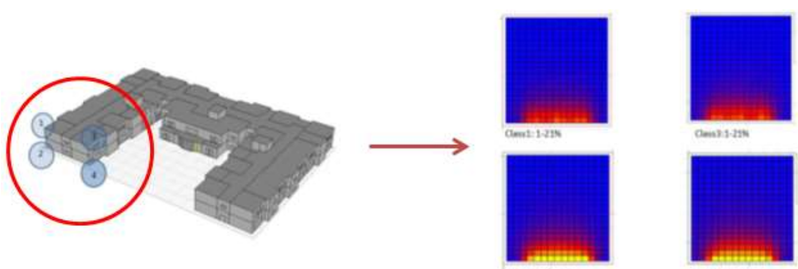


Fig. 9: Daylight factor for the four classes

6.3. Hourly heat gains/ loss

The graph in (Fig. 10) presents hourly heat gains and the HVAC load which is represented by the bright line.

The building envelope is the key element of an energy efficient design, by enhancing its performance through proper thermal insulation materials, the HVAC load will be reduced.

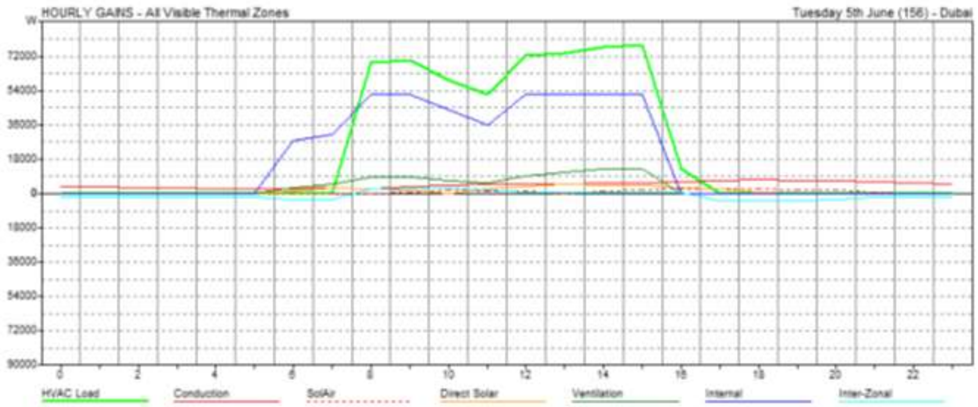


Fig. 10: Hourly gains/losses graph for all visible zones

TABLE I: The HVAC Loads For The Visible Zones

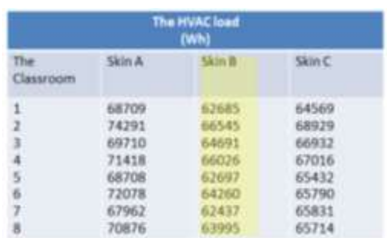
The classroom	Classroom1	Classroom2	Classroom3	Classroom4	Classroom5	Classroom6	Classroom7	Classroom8
HVAC Load (Wh)	68709	74291	69710	71418	68708	72078	67962	70876

7. Applying strategies

7.1. Enhancing the thermal insulation

The building envelope plays a big role in achieving the optimal condition for human bodies with the least energy consumption by enhancing the thermal insulation of the building, moreover, the building components have important characteristics that affect their performance.

The U-value of the walls, roofs and glazing has a significant effect on energy consumption and thermal comfort.



The HVAC load (Wh)			
The Classroom	Skin A	Skin B	Skin C
1	68709	62685	64569
2	74291	66545	68929
3	69710	64691	66932
4	71418	66026	67016
5	68708	62697	65432
6	72078	64260	65790
7	67962	62437	65831
8	70876	63995	65714

Fig. 11: HVAC loads in the visible zones

Three different types of building skin were suggested and the HVAC load for each type was calculated. Skin B had the lowest load according to (Fig 11).

7.2. Shading innovation via light shelves

With reference to daylight factors calculated for the classrooms, classroom number two had the highest rate of daylight factor (2.4 - 20.4%) and the distribution of the light was very week, so it was suggested that light shelves would protect the classroom from direct sunlight and help to distributing the light more. (fig. 12).

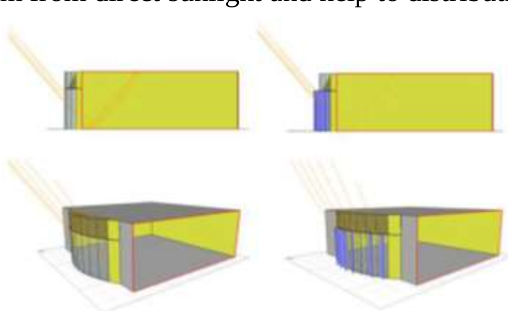


Fig. 12: Solar ray reflection before and after applying the louvres in July

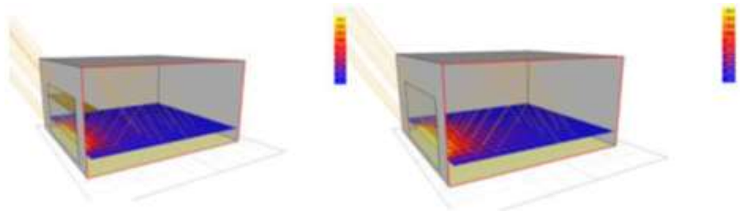


Fig. 13: The classroom (2) before and after applying the light shelves

7.3. Harnessing the solar thermal

Returning to the anatomy of the flamingo, they are able to warm up under insulating feathers, so have the ability to trap heat and keep the body warm. Essentially the flamingo's wings act like the PV panels, they absorb heat and act like heat storage.

With reference to the daylight factor, classroom seven had the lowest rate of daylight factor, so the application of artificial lighting was suggested, powered by using the PV panels.

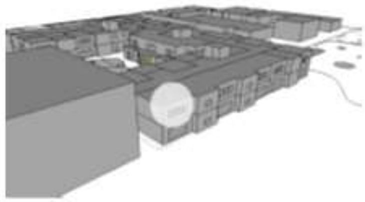


Fig. 14: Location of classroom seven

Fig. 15: Applying PV panels to the roof of the school

Reference is needed to total load demand for lighting in classroom seven of 306 W and to calculate the total electricity generated by a single PV panel, the dimension of the panel is also needed and details of solar irradiance in the city.

According to the (solar electricity handbook), solar irradiance in Dubai is 5.5 kW/m2/day.

Once the light source wattage has been determined, the following steps should be performed to calculate how many PV panels are needed:

Step 1 - Calculate daily energy consumed by the light source in watt-hours:

EDaily Consumed = Lamp Wattage × Daily Operating Hours

= 360 watt X 5 =1800 watts/day

Step 2 - Calculate the electric energy that the PV panels need to produce each day.

Assume the battery capacity of the system is large enough to allow the necessary charging and discharging for powering the lamp. **EPV Produced = EDaily Consumed / (Electronics Efficiency × Battery Charge/Discharge Efficiency)** = (1800 watt-hours/day) / (80% × 60%) = 864 watt-hours/day

Step 3 - Calculate the amount of solar radiation that the PV panels need to collect each day.

ESolar Radiation Needed = EPV Produced / (PV panel conversion efficiency)

7.4.3- Harness the solar thermal:

= (864 watt-hours/day) / 10%

=8640 watt-hours/day

Step 4 - Calculate the size of PV panels needed, Size of PV Panels = ESolar Radiation Needed / Daily Solar Radiation = (8640 watt-hours/day) / (5330 watt-hours/square meters/day) = 1.6 square meters.

8. Conclusion

The main purpose of this paper is to learn a lesson from nature to achieve environmental comfort and to shows how different strategies can be learnt from natural concepts to solve human problems.

The lessons learnt from the flamingo were implemented into the case study, resulting in an improvement in the envelope components (walls, glazing and roofing) which helped in reducing the U-value, managed to reduce energy consumption and the HVAC load was reduced.

With reference to the structure of flamingo wings, the feathers inspired the design of the louvres for shading; that was effective in reducing direct sunlight and helped in distributing more light within the class space.

PV panels were successfully installed to cover electricity demands for lighting.

Flamingos' breathing system inspired the author to create a flow of fresh air within the corridors and create a cross ventilation in the classrooms.

Food filtering was a significant influence, creating a buffer zone which helped in directing and filtering the wind.

Even if the school was improved, mixed-mode ventilation is still needed to achieve optimal thermal comfort.

9. Acknowledgements

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