

The Concepts of Animal Architecture

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Abstract: *Animals survive in the nature with their instincts and sustain for better living. Their life goes with the challenge in search of food and shelter. Every animal species have its own different kind of habitat. The main purpose of animal built structures is to build a protective home against weather conditions, to keep young ones safe, trap prey and communication. Either they construct one with their capabilities or find one in the nature. The animals that construct their own habitat are Animal constructive structures. There are unique concepts that can be inspired in architecture. The question is that what is the uniqueness of animal built forms? Architect and Designers get inspiration from various places in nature, animal architecture is also one of those to inspire. These concepts of animal architecture serve and influence in design, beauty, form, function and structural and design solutions as well. Animals build many beautiful structures which are not made of any modern technology, but by using material available in the nature. If wonders can be made by simple use of natural materials (mud, sticks, twigs), we have a wide range of technology and flexibility and could create more enormous structures. This research study is for understanding the concepts of animal architecture in which animal constructive structures are focused. These concepts can be further used in buildings, thus case studies done.*

Keywords: Animal built structures, architectural design, Natural and animal architecture

1. Introduction

Animals create or use existing habitats in the nature using materials which are found naturally, these natural forms are created scientifically which is inspirable. The sustainable technology animals use, remind us that natural forms have innovative solutions. Man has been always learning from nature, Animal Architecture is the study of these forms related to science and technology. Birds are one of the largest species that construct their habitat on trees using simple traditional material. They create various forms according to the climate and safety of the region [1]. In the ancient times architecture was inspired by many things found in the nature; sculptures, carvings, forms of animals and trees would inspire the decoration and paintings. We have been studying and understanding many concepts in the nature, thus animal study is not only beneficial for biological study but also useful for designers. Many architects get inspiration from the form of the leaf, mushrooms, skeleton structures, trees, plants, flowers, mountains and more. Animal structures are classified into four groups, according to Bahaman and Pérez; [5]

- a. Animal anatomical structures
- b. Animal constructive structures
- c. Social animal constructive structures
- d. Temporary animal structures

Animal anatomical structures are those types in which animals secrete and create a habitat. For example a larva secretes and forms a pupa which is a home to it. The spider creates a silky web itself; the web is basically a tensile structure, which is an anatomical structure. Animal Constructive Structures are those which are built by individuals or group of animals. Birds are one of the most common examples that build constructive forms (nests) using various materials like mud, clay, grass, sticks and leaves. Social animals such as bees, termites, ants, Meer cats and many others build habitats in a group.[4] There natural patterns can be inspired and seen in architectural patterns. Further we try to look at some example of animal species and their habitats.

Aim: To study the concepts of Animal Architecture and its Inspiration in Architectural Buildings.

Objective:

- To study the different types of habitats with respect to construction and science achieved by animal builders in environmental and structural terms focusing on animal constructive structures – individual and social.
- To analyze achievements of building case studies constructed and inspired by animal architecture.

2. Methodology

The methodology used is studying various literature and secondary data. The architectural designs relating to animal and organic architecture are identified and studied for selection of case studies. Collection of data is done by observation and extraction from books. Refer to the author who analyses animal habitats in terms of architecture and design. Refer to articles and research projects based on animal architecture. Animal study has been an influence to research on this topic as the awareness of nature is declining day by day. Many animals are getting endangered and extinct while many of them do not know the importance and uniqueness of their life. Relating animal architecture to the modern world will provide better solutions and awareness of how beautiful the nature is. Firstly studying animal architecture books and analysing the materials used by animals. Understand the natural materials used and its review and then case studies taken to analyse the concepts. Case study analysis helps to understand the outcomes of the concepts. This will help understand the concepts of animal architecture supported with case studies to give awareness to this topic.

3. Literature Review:

A paper by Mozghan Heidari and Mahmud Rezaei with paper titled ‘Architectural Design Review Based on Animal Architecture and Biogas’ has demonstrated the bionic science and organic architecture in detail. A new method of design is highlighted by studying and reviewing the design procedures. Animal architecture methodology has unique features and can be used beyond architectural applications. Biogas being a renewable energy is obtained from animals. Analogy of the animals includes animal architecture which is a design methodology. The paper focuses on architectural design methodology of animal architecture. Thus the authors have listed various buildings and their locations with influence of animal architecture on them. Further a study of biogas production is done. Animal life and structure always match with the origins of architecture not only for decoration but also for function and form with better performance.

A paper by Jin Kim and Kanggeun Park written a paper titled ‘The Design Characteristics of Nature-inspired Buildings’ state that designers get solutions from the systems, processes and organisms of nature. The beauty and forms initially inspire by nature’s elements. The inspiration levels are classified as visual, conception and computational. That includes shapes and patterns in nature that comes under visual, principles of nature lie under conception and computation is biomimetic structure of environmental ecosystem. The culture of human is also been inspired by nature. Civilizations and their development was evolved and inspired by nature systems. The ancient landscape nature, trees, flowers and bamboo paintings explain that how nature was visualized in culture, poetry, art and architecture. Traditional landscape theories, settlements houses and many more are studied and what concepts of nature were used. The paper also briefs green building certification explaining that nowadays buildings have extraordinary designs but the performance is very low. The life and safety of building is very less. Solutions to better

performance and durability are not focused much. Environmental pollution, urban and economic loss are not considered which are very important. The case studies done are nature inspired architecture – Hexagonal shapes inspired by beehives, skin patterns or other forms in nature, cable structures inspired by spider web, inspirations by flowers and seashells, tensegrity systems inspiration from nature, snowflake structure, algae, and many more inspirations illustrations are given.

4. Materials

There are two natural materials available in the nature; mineral and organic. Materials like soil, sand, clay, mud, stones, etc. are classified under mineral materials. Vegetation, grass, sticks, leaves, etc. are classified under organic materials. These materials get decomposed and do not last forever like mineral materials. But if they are dry and do not have any moisture, they give a longer life. Although both are natural and sustainable materials they have different properties which sustain in different conditions.

Mud is a mineral material having plasticity properties thus can be moulded into any shape with details. During mud is wet it gains good plasticity, after deformation it hardens and becomes durable. Mixing mud with fibrous material adds compressive and tensile strength and toughness. The mud quality may vary in its mineral composition, water content and organic composition. When mud consistency is appropriate to use for building construction, it provides a good structure. Mud is a popular material used in traditional architecture used as a mortar and mud plaster which is reinforced by mixing straw. Stones are heavy and hard to deform, animals usually don't use stones for building habitat, but they collect and store or use caves for hiding. While humans widely use stone by carving then into desired shape, our capabilities are much greater that we can deform and use in any applications. However, stone resources are decreasing due excessive demand in construction.

Organic materials can be used for limited time as they cannot sustain forever. But still animals use them for a temporary living. Dried sticks and grass have properties to resist tension, grass and intertwined or weaved to form a fabric like structure which can hold weight and keep warm. In building construction, organic materials such as wood, straw, bamboo, cellulose insulation, clay and other products made out of organic compounds can be used to build low energy and carbon neutral buildings. As organic materials absorb carbon dioxide during growth, they store the greenhouse gas and do not release into the atmosphere. Thus organic materials have properties to breathe and regulate healthy environment. Research and experimenting new eco-friendly products made with organic materials will help for a sustainable future. Organic materials are renewable or can be reproduced, thus if strategies are made to increase production of raw material, there will never be decrease of these resources. Organic building materials like unfired clay and other fibres regulate indoor humidity by effectively capture and release humidity whenever necessary.

5. Animal Architecture Concepts

5.1. Birds

The purpose of focusing on birds as an individual constructive animal is because almost all the birds are intelligent creatures that construct nests on trees, ground and available spaces in nature and urban. By using simple twigs and mud they build comfortable nests. Some of the examples of nests shown in the Figure are of Bowerbird, Weaver bird, Red Oven Bird, Swallows, Megapodidae bird,

blackcap/humming bird. Each of them has different concepts [6]. The bowerbird builds a nest on ground which is supported by a soil mound at the centre. Then by using dried sticks and grass it creates a hut like structure with an opening at one end. The framing of bent sticks and grass creates a warm insulation as they are weaved and also protects from sun and rain. The weaver birds intertwine twigs and create a strong net structure that holds weight and hanged on the branches of the trees. Hanging structures with opening at the bottommost point provides safety from predators as the only entrance is possible through air. It sustains wind, harsh climate and rain also at the same time keeping safe. The ultimate goal of building habitat is clear – safety and protection. This makes them create wonders with the available material in nature [6].

The Red oven bird has a unique nest. It builds dome like structures made of mud and clay on elevated surfaces or trees. Domes one over the other are also built each having separate nest. Generally up to three nests are build one over the other. The dome nest has an oval shape opening at the front. The bird collects mud and clay in its beak and builds mud plaster with its saliva as a binding material. Sometimes they use small twigs as a reinforcing material to make it strong and compressive. The dome is not completely seen in the opening. A mud partition is made to hide the eggs, as the bird enters through the opening it turns around to the secret room. This is the one of the amazing concept of the bird used in the wild to keep young ones safe as well as control temperature. The flexibility of plant materials is greater when it is fresh, thus most of birds like weaver birds and humming birds use fresh grass. While other birds like Megapodidae and owls prefer underground nests as they need warm and cosy place.

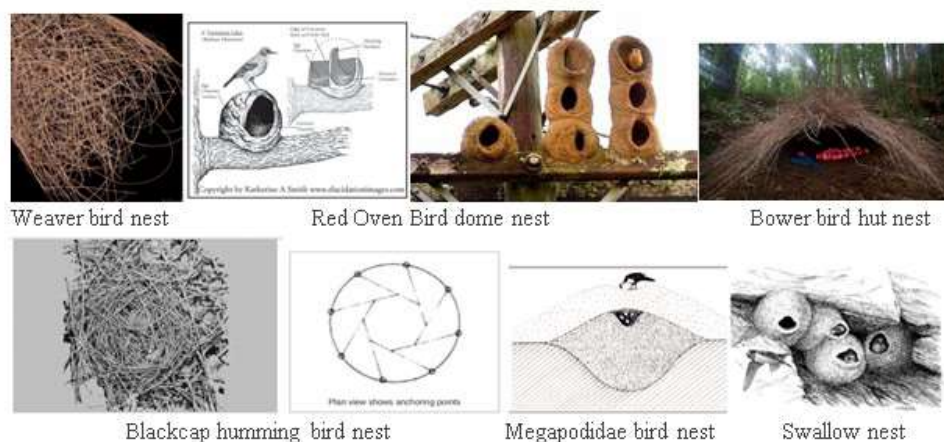


Figure 1. Various Types of Bird's Nest

5.2. Social Animals

In this paper we shall focus on common social animals. Social animals work in a team, although their size may be small but when working together in greater numbers they build massive structures. Some of the common examples are bees and ants. Beehives have hexagonal structures which are very commonly seen in building façade and design. Social animals are intelligent, efficient and always work for the whole family and young ones. 'A hexagonal honeycomb is the way to fit the most area with the least perimeter.' This statement is given by Thomas Hales-the mathematician.

The hexagonal chambers in the beehives are not only for aesthetics or honey storage but also for potential cradle and food supply for the larva developing in it. Thus the main concept of the structure in architecture should also be the same- aesthetics and function.

This we get inspired by the nature that aesthetics has certain value. Efficient space is what can be studied through honeycomb structure and with six sides around each hole it creates a better compressive structure. Controlled heat loss is also well maintained in honeycomb structures as the walls are made of wax, they have potential to melt in high temperature, hexagonal structure prevents this. Thus efficiency, strength of the structure and controlled heat are concepts which are also important in human buildings.

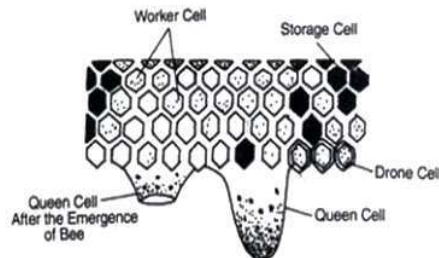


Figure 2. Beehive Structure

Ants being very small in size can carry more than its body weight. They create giant mud ant hills which are skyscrapers to them. Ventilation and safety is well designed in the ant hill. Ant's species are of many types, termites are bigger in size and stronger. Termite mounds are very large and can be up to three meters in height. The figure shows that their habitats are well designed for ventilation. The airflow is of two types: thermo-siphon flow and induced flow. The mound having thermo-siphon flow is a capped chimney mound of termites which has a porous surface at the outermost layer which traps wind flow and regulates inside the mound. The open chimney mounds have air inlets at the ground level at a small distance from the mound, cool air flows inside and induced flow of air when it heats up it rises above and passes through the outlet. This is also similar to stack effect. The same concepts are also used in ant hills, air movement is an important part of design of habitat and these are well maintained by ants.

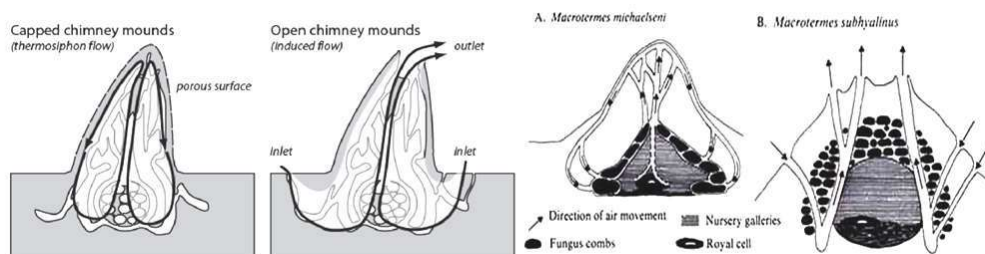


Figure 3. Termite Mound (left) and Ant Hill (right)

6. Case Studies

6.1. Beijing Olympic Stadium, China

This Olympic stadium was designed by Herzog & De Meuron Architekten, Arup Sport and the China Architecture Design and Research Group. The roof is designed in a twisting steel sections structure which has similar concepts of the birds nest. Most of the birds like sparrows and blackcap humming bird (as discussed earlier) use sticks and twigs as a reciprocal frame intertwined to each other. The same concept is used an amalgamation of steel beams and structural elements to create and inspire natural structure. The spaces between the structural beams and supports are filled with translucent membrane. This makes the roof resistive to weather. This concept is also similar as birds cover soft fillers above open spaces on the nest (Similar to weaver bird).

The cantilever trusses support the roof of the seating. Geometry, airflow, Seismic studies and external envelope have been designed by parametric design software and thus achieving maximum sustainability. The nest structure may look random but it follows specific geometry as well and consists 36km unwrapped steel. In this study we can understand that inspiration from nature may give us many solutions and concepts that perform better.



Figure 4. Beijing Olympic stadium designed using bird's nest concept

6.2. Eastgate Building, Harare, Zimbabwe

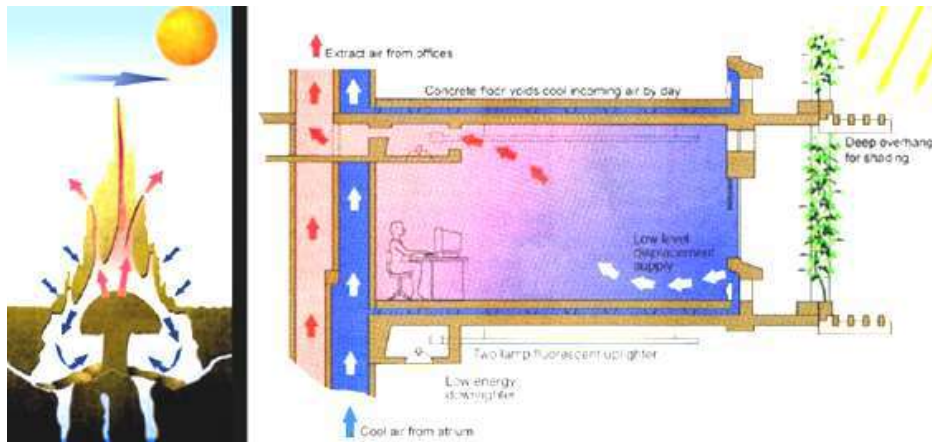


Figure 5. Animal Architecture inspiration of termite mound ventilation concept in Eastgate Building

This shopping centre building located in Zimbabwe is designed by Architect Mick Pearce. The design of ventilation in this building is inspired by termite mound's ventilation concept. The whole project comprises of two buildings linked together by a glass roof. As studied before, termite mounds are constructed like a chimney in which warm air rises up when outdoor temperature falls and at night when the temperature is cold, the mound maintains warmth. This concept keeps stable temperature and the same is inspired in this building, the Eastgate building has brick chimneys to regulate air flow. This building is the first to inspire termite mound animal architectural concepts in architectural practise. Cool air is drawn by underground gaps which are released during daytime through pipes in the building. Thus at harsh temperatures it keeps the interiors cool just like HVAC. Now, the building saves upon energy and installation/maintenance cost of HVAC, providing a sustainable and green building. Eastgate has achieved less consumption of 35% total energy than average conventional buildings in the city.

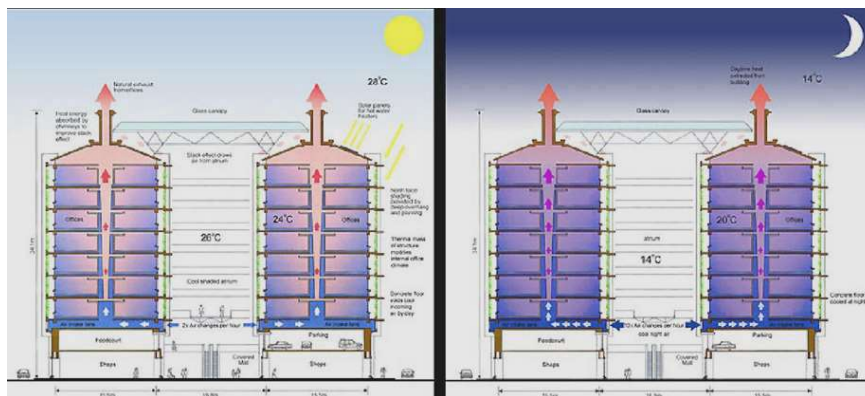


Figure 6. Daytime and Night time cooling strategy in Eastgate Centre

7. Analysis

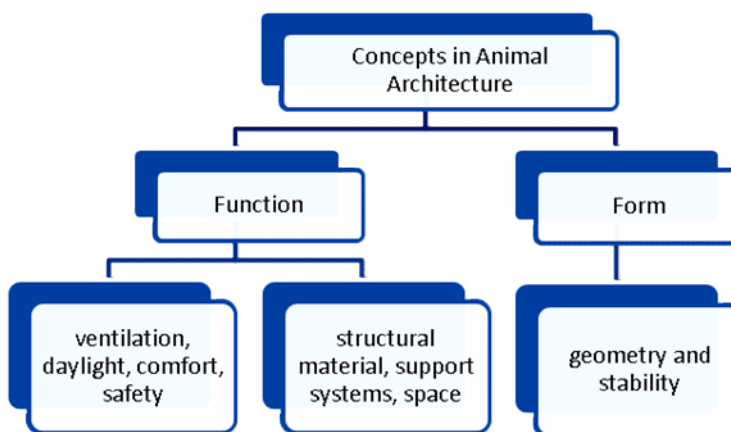


Figure 7: Concepts we get inspired from animal architecture

Not only are these two case studies but there numerous buildings that are inspired by animal architectural concepts. We have elaborated a few types of birds with various concepts in their habitat. Also social animals like bees and ants, one case study each was selected for study. It doesn't matter whatever type of habitat we see, all of them including plants, spider webs, cocoons, etc. have architectural concepts for inspiration and providing sustainable solution. Along with this architects designing with animal architecture concepts develop awareness among people of importance and beauty of natural beings.

Table 1. Summary of two Case Studies

Terms	Beijing Stadium	Eastgate Building
Animal architecture	Birds nest	Termite mound
Concept	Framework & structure	Natural ventilation
materials	Steel framework, translucent membrane, glass, concrete	Brick, Concrete
Achievements	Cantilever roof and controlled airflow	Natural ventilation system without air conditioning
Sustainable strategies	Seismic design, weather resistance, durability	Energy savings, comfortable indoor environment.

By the above table we understand that animal architectural concepts also provide us remarkable sustainable solutions which are a need of the situation today. They all achieve a sustainable solution and provide better facilities. Some other building examples are: Eden project, England; Glass glow science museum, UK (Snail concept); SECC Conference Centre, UK (turtles); Keenan Tower, USA (Nest); River Restaurant Switzerland (beaver); Davies Alpine Greenhouse, UK (termite nest); Izola Apartments, Slovenia (beehive); and many more examples exist that are inspired by animal architecture. [2]

8. Conclusion

There are many types of animal constructive structures in the nature and which all of them cannot be studied at once. The unique and important concepts are taken into consideration and thus some of the animals and their habitats with mineral and organic material are studied. The paper explains the concepts of animal architecture thus individual and social animals both are considered for study and analysis. Case studies help us analyse how we can inspire the concepts of animal architecture and their importance. The beautiful and sustainable animal concepts give strong inspiration in architectural design while also reminding us the awareness and importance of nature. Simple solutions do matter.

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