Similarity of Building Ventilation and Termite Mounds Architecture

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Abstract

In order to develop new technologies we just have to look around and to see that the nature already explained everything. All we have to do is watch, work and replicate. Biomimicry is a basic to solve human problem. A good ventilation system is a prerequisite for a healthy building to get comfortable in living. Architects have long been inspired by termite mound architecture and many examples chimney-style, and ventilation systems. The scientific search was conducted to answer the truth of buildings ventilation that have a similarity with the ventilation system in the termite mound. This study was conducted with the aim to know the similiraty of building ventilation and termite mounds Architecture. The result showed that biomimicry is literally the science and art of emulating nature's best biological aspects to solve human problems; building ventilation inspired by Termite Mound Architecture.

Keywords: architecture, biomimicry, termite mounds, ventilation

Introduction

Biomimicry or biomimetics is the examination of nature, its models, systems, processes, and elements to emulate or take inspiration from in order to solve human problems. The term *biomimicry* and *biomimetics* come from the Greek words bios, meaning life, and mimesis meaning to imitate. Other terms often used are bionics, bio-inspiration, and biognosis.

Architecture is both the process and product of planning, designing and constructing form, space and ambience that reflect functional, technical, social, and aesthetic considerations. It requires the creative manipulation and coordination of material, technology, light and shadow.

Ventilating is the process of "changing" or replacing air in any space to provide high indoor air quality (i.e. to control temperature, replenish oxygen, or remove moisture, odors, smoke, heat, dust, airborne bacteria, and carbon dioxide). Ventilation is used to remove unpleasant smells and excessive moisture, introduce outside air, to keep interior building air circulating, and to prevent stagnation of the interior air (http://en.wikipedia.org/wiki/Ventilation_(architecture), 2010).

The termite has long been known as highly social insects that live in large colonies with a very specific social order. However, the mound that they construct are quickly being identified as sophisticated structures. The termites build highly complex structures that ensure a constant internal environment (homeostasis) in which they can thrive, regardless of the fluctuating external conditions.

Based on implementation design, build, regulate the function and comfortable for living, it can be stated that the termite mound has a high architectural value. Termites mound building has been used as example of biomimetic designs for climate control in buildings, like Zimbabwe's Eastgate Centre, and various other "termite-inspired" buildings (Turner, 2008).

From the imitation fact of the nature to solve problems on people's lives, it was translated the theory to see the truth that ventilation system in building inspired by termite mound ventilation system.

Materials and methods

This study was conducted using the data compilation. The data of termite mound that result of the researchers in journals, blogs, and comments was collected from the internet network accessed. Most data was the results of its review of the biomimicry knowledge. The knowlegde regarding the building ventilation was obtained from literature review. The discussions was conducted with the timber structures experties.

Based on the data and knowledge has been obtained, it was analyzed and made a discussion to produce the ventilation systems similarity of building and termites mound.

Results and discussion

The health implication of the indoor environmental can be very important. This is not unreasonable considering the amount of time that most people spend within the room building. Within system for living, air flows required for sastisfactory ventilation mean that within the heat exchanger. Heat transfer is the most efficient when the air-flow is fully turbulent (Edwards, 2005).

There are three main reasons to ventilate a building:

1. Ventilation is needed to provide adequate air for respiration purposes. Unless a building is made particularly airtight, the provision of air for this purpose is not likely to pose any problem.
2. Ventilation is required in order to provide cooling effect.
3. It is for removal and dilution of airborne contaminants. Of these, the most important one is water vapour, although there are others that are others that are the worthy of consideration.

Water vapour is present in ambient air. Its presence is part of nature itself, being a by product of metabolism of most forms of life. Temperatures will be affected by ventilation strategy. The more ventilation that is supplied, the more energy will be consumed.

There are two main driving forces which induce the pressure differentials needed for nature ventilation to occur, Figure 1. The first of these is the pressure due to the incident wind as it strikes the building and flows around it. The transfer of kinetic energy from the airstream to the building cause pressure differentials, and these pressure differentials are ultimately responsible for a component of the overall flow of air through the building.

As the transfer is of kinetic energy, it can be said in general that a surface on which wind is impinging, the presure is a function of the square of the wind velocity.

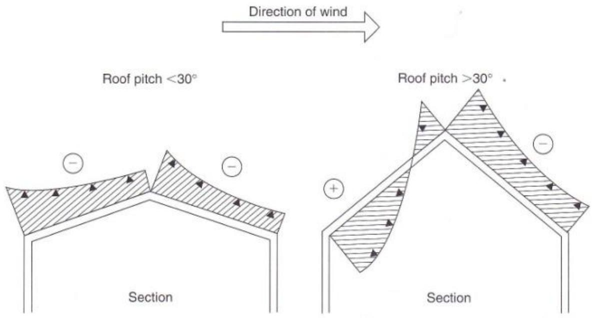


Figure 1 Air flow pattern around a roof of building

When the winds hits a building, it flows around it. Only a small part of the building envelope actually receives the wind directly. The distribution of positive pressure areas are influenced by roof pitch. For roof pitches greater than 30^0, apart of the leading edge of the roof will be under positive pressure. The velocity of the air changes as it flows over the rest of surface of the building. These areas are in a state of negative pressure to the inside of the building. For roof pitches lower than 30^0, all of the roof will be under negative pressure.

In areas that receive positive pressure means that the area is experiencing compresive pressure. Otherwise the area that receive negative pressure means that the area is experiencing suction or tension pressure.

Almost all of termite mounds have high slope inclination on its structure, besides being a stable structure also allows for the arrest of a wider wind on the termite mound surface. For example, Chrysler building in New York City USA of the Vogue for skyscrapers in Gothic style developed in early year of the 20th century has similar shape with African Tower Termite Mound, Figure 2.

(a) (b)

Figure 2 The similar building shape
(a) Chrysler Building, USA (b)African Tower Termite

In cases where heating system are of insufficient capacity, excessive ventilation, but may not only be a cause of high energy consumption, but may also result in low indoor temperatur. The ventilation effectiveness within space is also dependent on the sitting of air terminals, air-flow rate and the temperature of the supply air.

Martin Lüscher's thermosiphon model analogizes the mound to a heart-lung machine for the colony. Metabolism-induced buoyancy provides the motive force driving a *circulation* of air within the mound. The mound is more of a wind-driven lung, with complex wind-driven tidal and mixed-regime flows (http://www.esf.edu/EFB/turner/termite/mound%20as%20lung.html, 2010).

The ventilation system for building and termite mound can be seen in Figure 3. The internal air temperature within the space has an influence on relative humadity, since relative humadity is of course not merely a function of air moisture content but also of air temperature. The internal air moisture content, given the chosen value of air change rate, internal and external temperatures, and external air moisture content.

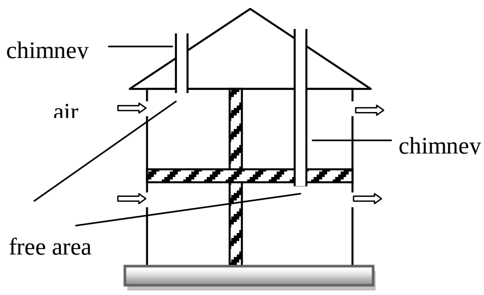
Termite mounds function as nests for their inhabitants, which are colonies of small potentially vulnerable insects that are also susceptible to environmental fluctuations.

Ventilation of the mound depends upon an interaction between metabolism-induced buoyant forces, which tend to move air upwards in the chimney and deep lateral connectives. These interact with wind-driven pressure movements in the surface conduits and shallow lateral connectives.

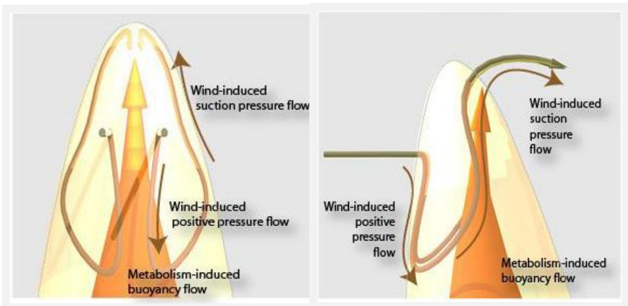
Wind-induced positive pressures at the mound's windward side tend to drive flows downward there. Winds are stronger at the mound's upper surface and induce a stronger positive pressure than lower to the ground, where the winds are slower.

At the leeward sides of the mound, the suction pressures are stronger higher than near the ground. Air will therefore follow a sinuous path, being ultimately drawn out the chimney. The actual ventilatory exchange will occur at the interface between these two patterns of air flow.

The compass termite of Australia orients it's mound along a north-south access to utilize the process of thermoregulation to maintain the interior temperature even as the outside air may vary from hot to cold, with it's largest elevations facing east and west, the mound collects the warm sun in the morning and evening. Once night falls, the heat captured by the exterior is transferred to the interior. Mounds also has ventilation in the structure. Warm air is drawn up through the network of tunnels that are similar to capillaries in the human skin and the warm gaseous air is exchanged at the structure's surface (http://architectureforguerillas.blogspot.com/2009/05/magnetic-termite-mounds.html, 2010).



(a)



(b)

Figure 3 The configuration of ventilation system

a. Building
b. Termite Mound

In colonies in comparably cool habitats, mound architecture is adapted to reduce the loss of metabolically produced heat to the environment. While this has no negative consequences in small colonies, it produces a trade-off with gas exchange in large colonies, resulting in sub optimally low nest temperatures and increased CO_2 concentrations (Korb, 2003).

Along with the alteration in mound architecture, the gas exchange/ventilation mechanism also changes. While mounds in the thermally appropriate have a very efficient circular ventilation during the day, the ventilation in the cooler forest is a less efficient upward movement of air, with gas exchange restricted by reduced surface exchange area.

The termites construct their mounds to maintain a constant temperature by continuously opening and closing vents, allowing cooler air to be drawn in from open lower sections while hot air escapes through chimneys (http://thecapstonegrp.wordpress.com/ 31 Maret 2010). A complex vein-like and thin capillary geometry enables a method of respiration through the mound's skin, similar to the way a lung works.

Internally, the mound is permeated by a complex network of tunnels that can be divided into three broad types: a capacious central chimney that extends upward through the center of the mound from the colony up to the apex of the spire; a vertically-biased network of surface conduits that lies roughly one to two cm below the surface, and an interweaving network of lateral tunnels that connect the chimney and surface conduits. A model of mound morphogenesis is proposed which accounts for most of these structural features, and which points toward a general model for the relationship between mound architecture and social homeostasis among the macrotermitine termites (Turner, 2000).

By having the opening end become narrower, warm air inside accelerates upward and out to the top of the mound while more dense cool air travels downward into the wider portions of the shafts, naturally cooling the interior as the day becomes warm. At night, as the temperature cools down the dense characteristic of the mound serves as a form of thermal mass; absorbing heat during the day and releasing it back into the interior during the night (http://langlor.com/blog/biomimicry-architecture, 2010).

The mound must be able to provide this constant temperature while compensating for the changes in temperature outside during the day. This difficult challenge is achieved by having vents located throughout the mound which has the capacity of opening and closing throughout the course of the day. The shafts themselves demonstrate a basic yet intelligent design geometry which also contributes to the mound's homeostasis environment.

An impressive example of this is the Mud Mosque in Mali, Africa, which is remodelled each year by the community and similar to a termite mound, Figure 4. It has thermal mass for constancy of temperature and regulates diurnal temperature swings through the act of a priest placing small clay caps on roof vents each evening and removing them in the morning (http://www.freeformengineering.co.uk/researchdetails.htm, 2010).

Some of the worlds biggest buildings will be made based on the special level technology of tubes used by termites mounds.

Figure 4 The Mud Mosque in Mali, Africa

One idea is that rather than look at moisture as a problem, humans could, like termites, also incorporate the threshold response to moisture in walls, using the 'buoyancy' of moisture that occurs with heat for ventilation and evaporative cooling.

Conclusion

From discussion above, it could be conluded that:

1. The future technology actually comes from nature.
2. Biomimicry is literally the science and art of emulating nature's best biological aspects to solve human problems.
3. Termites could help us better understand how we could design our buildings with the natural conditions of our environment, sustainable, and self-sufficient.
4. Building ventilation inspired by Termite Mound Architecture.

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