Biomimetics For Passive Air Conditioned Design For Buildings In The Hot Arid Regions

ABSTRACT

The high energy consumed for air conditioning in buildings become a serious concern in the scientific research due to its negative consequences on the earth's ecological life. In nature, animals regulate their body temperature in extreme environments without using fuel or prejudice to their environmental system. Therefore, this study aims to emulate one of the biological cooling strategies to design passive cooling unit for buildings in the hot arid regions. It adopted a biomimetic exploratory method to determine three of the efficient biological cooling strategies in nature based on the morphological attributes. They are cooling through animals' respiratory passages, thermal radiators and air flow cooling in termite mound. A comparative study was conducted on four case studies under each of the three cooling strategies to come up with the working principles that can be used as a guide to design biomimetic cooling system. One of these strategies, the camel nasal respiratory cooling, was simulated to design a cooling unit installed in wind tower for buildings in the hot arid regions. To validate the applicability of the camel nasal-inspired cooling design, a set of experimental tests have been conducted in one of the desert cities that is Seiyun in Yemen by using both wind tower and wind tunnel. The study main parameter was the design cooling efficiency for (i) three materials which were clay, clay with jute fiber and clay with wood wool pads, (ii) the design height, and (iii) climatic environmental variables. The results showed that the best cooling efficiency among the three materials was the design of clay with jute fiber 85.2 %, followed by clay with wood wool pads 76.6 %, and the clay design 66.3 %. The former two designs have effectively dropped the temperature in hot arid climate up to 18.9 °C for jute design and 16.5°C for wood wool design. This indicates that the bio-inspired design can replace the mechanical air conditioning system. Additionally, the cooling efficiency of the design increases by the increment of its height and the ambient temperature. However, it decreases with the increment of the inlet air wet-bulb temperature, air humidity, and air velocity. It is concluded that emulating biological thermo-regulatory strategies is useful to design energy-efficient buildings. This study contributed to proposing a new passive cooling design for buildings in the hot arid regions.