Biomimetic strategies for building facades

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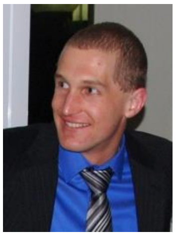

Abstract: Architecture has been inspired by biology throughout human civilisation. Today, through modern scientific investigative techniques, humanity has an unprecedented potential to learn from nature. In façade engineering, heat transfer performance may be optimised by biological systems – natural form, materials, surfaces, adaptive behaviour and physical characteristics. This study will draw upon specific biological models of heat transfer and translate these distinctive qualities to façade models. The methodology uses simulation techniques to test biological adaptions. By transposing these biological attributes for use in facades, the study aims to determine the extent to which biomimetic initiatives can improve the performance of facades with respect to heat transfer and building energy consumption.

Goal of the study – biomimicry for energy-efficient building facades

The relationship between building energy consumption and facades is well established. This PhD examines biomimicry as a strategy to design facades that boost thermal performance in order to decrease building operational energy consumption.

Biological thermoregulation and heat transfer

Thermoregulation allows organisms to maintain specific temperatures for critical biophysical and biochemical reactions. The physiology, behaviour and structure of animals and plants reveal consistent strategies to regulate temperature and prevent excessive heat losses and gains.

Strategies at the Surface

As endotherms, mammals generally maintain a relatively high body temperature (relative to surroundings) due to metabolic heat production. They must balance this against environmental heat gains and losses. Mammals use a number of physiological responses in order to achieve this. Heat transfer at the skin surface is particularly important, with hair/fur, blood flow (perfusion) and perspiration all having important roles.

Biomimetic Modelling

By studying these distinctive skin processes and translating key characteristics to building facades, we can assess the suitability of such measures for energy-efficient building envelopes. A transient mathematical model is developed to describe the application of fur, blood (fluid) perfusion and perspiration to a façade (see Figure 1).

The proposed biomimetic façade is compared to a conventional lightweight façade under sunny summer conditions. The biomimetic façade shows cooling greater than 35 W/m^2, similar to conventional hydronic systems. Contrastingly, the lightweight reference has a heat gain of ~16 W/m^2. The internal surface temperature decreases by ~5 K compared with the conventional approach (See Figure 2). Overall, the results of the modelling on the biomimetic façade begin to demonstrate the utility of biomimicry to develop energy-efficient building facades.

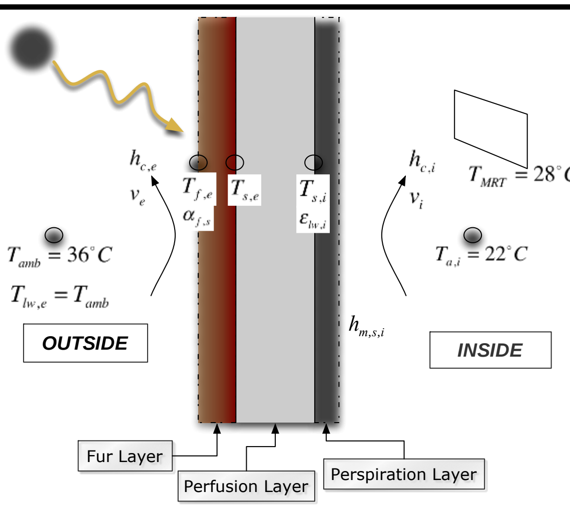

Figure 1: Proposed 3-layer biomimetic façade model

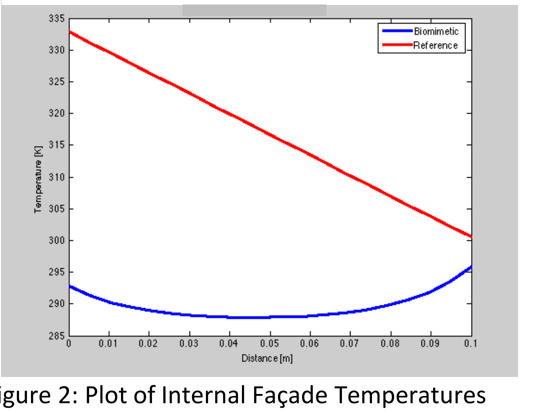

Figure 2: Plot of Internal Façade Temperatures comparing simulated biomimetic facade against conventional facade

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