Biomimicry inspired development of climate adaptive building shell with ground heat utilization in Northern Europe climate

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EU Directive 2010/31/EU has set a target for all member states - by December 31st 2020 all new buildings has to be nearly zero energy consumption buildings. Materials with static thermal properties do not ensure cost effective solutions for NZEB in Northern climate.

Authors have proposed a Climate Adaptive Climate Shell (CABS) able to adapt to ambient temperature drops. Design was developed using biomimicry ideas – temperature regulatory system of mammals (heat exchange processes in blood supply system) was studied and set as an example to follow. Proposed CABS is designed to gain ground heat and maximise heat loss in building wall construction via fluid circulation driven by temperature differences thus reducing energy consumption for space heating.

To see whether a fluid circulation and heat exchange with ambient environment in prototype corresponds to numerical model created an experimental setup was developed (see Figure 1). Acetone was used as heat transfer agent. The prototype tested and modelled is simplified version of the proposed CABS. It consists of two parts – 1) upper part of vertical pipe loop is embedded in façade insulation material and 2) lower part of loop is buried in shallow depth.

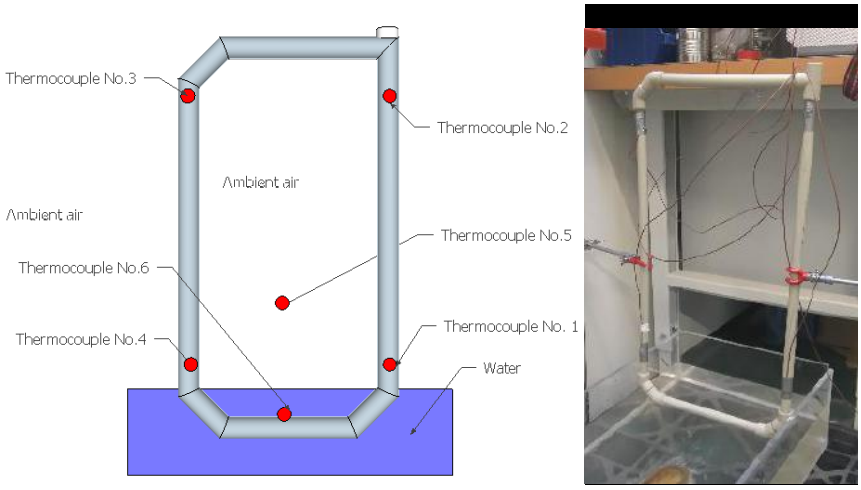

Fig. 1. Experimental setup.

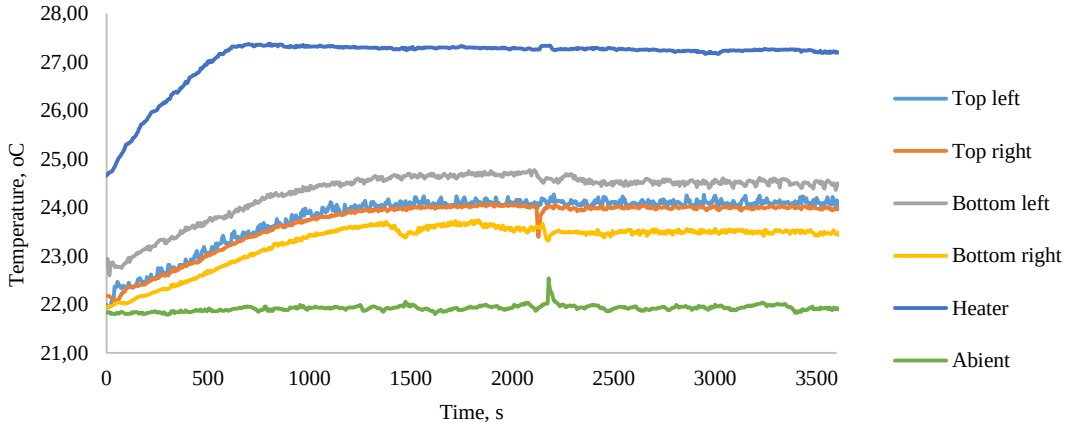

Fig. 2. Temperatures at various points of the prototype, ambient temperature (22 ^{o}C) and heater temperature (27 ^{o}C).

Obtained results with heater and ambient temperature difference of 5^{o}C are shown in Figure 2. As we can see the circulation is present and the fluid is working as heat transfer agent. It was found that both clockwise and counter clockwise circulations are possible. The experiment was repeated with different temperature differences and similar results were obtained.

The results obtained will be used for validation of numerical model which later will be used for feasibility studies for application of full size CABS.

Kopsavilkums

Darba mērķis ir izstrādāt klimata adaptīvu ārsienu, izmantojot biomimikrijas principus. Autori iedvesmojās no siltuma apmaiņas procesiem, kas norisinās ziloņu ausīs.

Darbā ir izstrādāts klimata adaptīvās ārsienas risinājums, kas utilizētu zemes siltumu no samērā sekla dziļuma (0–3,2 m). Siltumu paredzēts transportēt, izmantojot šķidrumu dabisko konvekciju, tādējādi netiktu patērēta papildus enerģija siltuma pārnesē.

Viens no darba uzdevumiem ir pārliecināties, vai paredzētais mehānisms darbojas, līdz ar to tiks izstrādāts maza izmēra prototips. Ar prototipu tika veikti eksperimenti pie dažādiem temperatūras režīmiem, kā rezultātā tika secināts, ka šķidrums cirkulē prototipā.

Izmantojot iegūtos rezultātus, tiks izstrādāts skaitlisks modelis, kas apstiprinās eksperimentāli iegūtos datus, ko varēs izmantot pilna izmēra prototipa aprēķinos. Tiks noteikts optimāls sistēmas dizains un apzināti iespējamie siltuma ieguvumi.