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Bioclimatic building envelope based on an active control system

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Abstract – A study has been carried out to enhance ceramic building envelope thermal efficiency. A ventilated façade was modified by incorporating thermal sensors and an active control system that adapted the available energy to either heating or cooling demands. The control system modifies the airflow in the envelope inner chamber and the heat transfer by radiation from the outer to the inner sheet of the envelope. It was verified that the system enables significant energy savings (up to 20%–30%) to be achieved.

The growing social awareness of sustainable construction is leading specifications writers and end-users to take into account features that enhance energy efficiency in buildings.

This paper analyses the thermal behaviour of ceramic building envelopes, the study starting point being the ventilated façade (1,2). In order to examine heat transfer in building envelopes and to analyse efficiency enhancement options, an envelope prototype was designed and built to which certain features were fitted to improve energy efficiency depending on heating or cooling demands (Figure 1). The prototype consists of an external sector that collects solar energy, an intermediate air duct and, finally, an internal sector in which heat is accumulated (certain phase change materials could be incorporated into this sector, though this option was not examined). The internal and external sheets, in addition to the air duct, are fitted with thermocouples connected to a control system that, depending on the temperature set point and following certain heuristic rules, automatically modifies four vents that regulate the airflow inside the duct. There is, furthermore, a reflecting curtain that can be opened or closed to also enable radiative heat transfer between the collector sector and the internal wall to be controlled. The system allows solar heat to be used in winter and the cooling demand to be reduced in summer. Figure 2 shows system efficiency under heating demand.

Finally, a mathematical model was developed for this envelope. The model takes into account dynamic effects (heating/cooling of the inner wall during 24 hours). Using this model and the experimental data collected from the prototype over several months under very different operating conditions, the thermal efficiency of this solution was evaluated under different environmental conditions (external air temperature, wall orientation, solar radiation, etc.). The results demonstrate that, under certain conditions, the system provides energy savings up to 20%–30%.

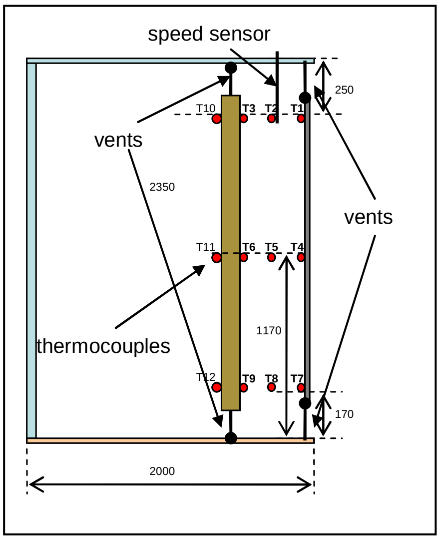

Figure 1: Prototype cross-section.

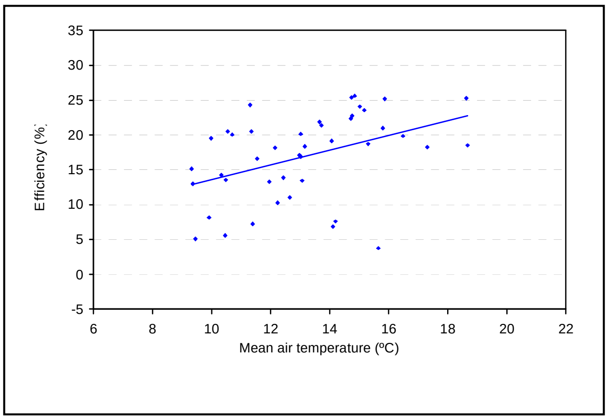

Figure 2: Thermal efficiency of the envelope.

References
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