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Heat Transfer Phenomena Identification of a Non-Active Floor in a Stack-Ventilated Building in Summertime: Empirical Study

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Abstract : An experimental study in a Plus Energy House (PEH) prototype was conducted in August 2016. It aimed to highlight the energy charge and discharge of a concrete-slab floor submitted to the day-night-cycles heat exchanges in the southwestern part of France and to identify the heat transfer phenomena that take place in both processes: charge and discharge. The main features of this PEH, significant to this study, are the following: (i) a non-active slab covering the major part of the entire floor surface of the house, which include a concrete layer 68 mm thick as upper layer; (ii) solar window shades located on the north and south facades along with a large eave facing south, (iii) large double-glazed windows covering the majority of the south facade, (iv) a natural ventilation system (NVS) composed by ten automatized openings with different dimensions: four are located on the south facade, four on the north facade and two on the shed roof (north-oriented). To highlight the energy charge and discharge processes of the non-active slab, heat flux and temperature measurement techniques were implemented, along with airspeed measurements. Ten “measurement-poles” (MP) were distributed all over the concrete-floor surface. Each MP represented a zone of measurement, where air and surface temperatures, and convection and radiation heat fluxes, were intended to be measured. The airspeed was measured only at two points over the slab surface, near the south facade. To identify the heat transfer phenomena that take part in the charge and discharge process, some relevant dimensionless parameters were used, along with statistical analysis; heat transfer phenomena were identified based on this analysis. Experimental data, after processing, had shown that two periods could be identified at a glance: charge (heat gain, positive values) and discharge (heat losses, negative values). During the charge period, on the floor surface, radiation heat exchanges were significantly higher compared with convection. On the other hand, convection heat exchanges were significantly higher than radiation, in the discharge period. Spatially, both, convection and radiation heat exchanges are higher near the natural ventilation openings and smaller far from them, as expected. Experimental correlations have been determined using a linear regression model, showing the relation between the Nusselt number with relevant parameters: Peclet, Rayleigh, and Richardson numbers. This has led to the determination of the convective heat transfer coefficient and its comparison with the convective heat coefficient resulting from measurements. Results have shown that forced and natural convection coexists during the discharge period; more accurate correlations with the Peclet number than with the Rayleigh number, have been found. This may suggest that forced convection is stronger than natural convection. Yet, airspeed levels encountered suggest that it is natural convection that should take place rather than forced convection. Despite this, Richardson number values encountered indicate otherwise. During the charge period, air-velocity levels might indicate that none air motion occurs, which might lead to heat transfer by diffusion instead of convection.

Keywords : heat flux measurement, natural ventilation, non-active concrete slab, plus energy house
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