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The role of thermal mass in energy efficiency for office buildings under different climatic regions of South Africa: optimising the dual role of concrete for structure and thermal mass

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Abstract

As a passive design intervention, material selection of thermal mass and its effects on thermal performance of buildings should be assessed as part of the energy performance strategy for buildings. This study highlights the influence of heavyweight versus lightweight concrete as thermal mass on indoor thermal comfort of office buildings in two different climatic regions of South Africa.

The study focuses on two case study office buildings, one in Johannesburg and the other one in Durban. Energy performance of the buildings was based on a quantitative research approach, whereby the heating and cooling energy loads were simulated for both baseline heavyweight concrete versus lightweight concrete as thermal mass interventions. Simulation was based on the Integrated Environmental Solutions Virtual Environment (IES_VE) software and involved building modelling parameters such as building envelope composition and properties, solar radiation, climatic factors, internal gains and natural air flow.

The study finds that lightweight concrete construction was only favourable for annual heating energy loads required for thermal comfort, with an energy savings of 12.71MWh per annum and 4.58MWh per annum for the Johannesburg and Durban case study buildings respectively. In contrast, baseline heavyweight concrete construction was deemed favourable for cooling energy loads required to achieve thermal comfort. The difference in annual cooling energy loads performance between heavyweight and lightweight concrete amounted to 21.32MWh and 22.85MWh for Johannesburg and Durban respectively. Since cooling energy loads accounted for 85% of overall simulated energy loads in Johannesburg and 96% of overall energy loads in Durban, heavyweight concrete was deemed favourable for both buildings and hence for their respective climatic regions. In contrast, lightweight concrete as thermal mass was found to be neither technically viable nor economically feasible as thermal mass for building energy efficiency for both climatic regions. Its additional energy costs were derived to be R11 340.00 for the building in Johannesburg and R23 020.20 for the building in Durban when compared to heavyweight concrete construction. Furthermore upfront cost of construction with lightweight concrete would be greater than the cost for heavyweight concrete in South Africa, thus resulting in greater losses, which further weakens the viability case for lightweight concrete.

Key words: Thermal mass, passive design, energy performance simulation, heating and cooling energy loads.