Thermal and structural performances of insulated cavity rammed earth wall houses

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Abstract

Rammed earth (RE) wall construction is perceived to carry extremely low embodied energy and have desirable thermal performance without much energy input for heating and cooling due to the thermal mass effect. In Australia, however, because of the low thermal resistance (R-value) of RE material, it is very difficult for houses constructed with only solid RE walls to comply with the *Deemed-to-Satisfy Provision* provided in the National Construction Code (NCC) by the Building Code of Australia, which specifies the minimum R-value for external walls. The NCC provides an alternative provision, named the *Energy Efficiency Provision*, which states a maximum allowance of energy use by a residential house. As houses have the potential to consume little energy load particularly when passive design strategies are implemented, houses built with RE walls may still be able to comply with the *Energy Efficiency Provision* of the NCC.

Adding thermal insulation to the wall construction is one way to ensure that RE wall houses comply with NCC. Normally, rigid board foam insulation can be inserted in the middle of RE walls to maintain the aesthetics of the wall surfaces and part of the thermal mass effect. The result of this solution is an insulated cavity rammed earth (ICRE) wall system. This solution, however, generates three questions. On one hand, inserting insulation in between two rammed earth wall “leaves” is likely to have an impact on the structural strength of the building and the integrity of the wall system. Using the ICRE wall system in seismically prone areas in Australia may not be wise since the seismic resistance of the walls is mainly achieved through flexural strength. On the other hand, although this solution can meet the R-value requirement of the NCC, the actual thermal performances (thermal comfort and energy demand for heating and cooling) of houses built with ICRE walls are unknown. In addition, the construction and operation costs during the life cycle of the house may be considerably increased.

In order to address these questions, in the presented research, firstly the energy loads of a hypothetical house constructed by uninsulated RE walls were investigated using thermal simulation, taking into account passive design strategies. The results indicate that uninsulated RE wall houses struggle to meet the *Energy Efficiency Provision*, particularly in cold climates. Secondly, the structural strengths (compressive and flexural) of ICRE walls were investigated by laboratory tests which proved that this wall system can be safely used for single story houses in any seismic zone in Australia, as long as the wall thickness and height are within a specified range. Thirdly, the thermal performances of houses constructed with ICRE walls (both naturally ventilated and air-conditioned) were investigated, from which the effects of key design parameters on the thermal comfort and energy loads were quantified, including the window size in each wall, window shading, window construction type, ventilation rate, the amount of thermal mass and insulation thickness. Also, the life-cycle cost of an ICRE wall house was minimised by optimising these key design parameters.

Statement of Originality

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