



Thermal and structural performances of insulated cavity rammed earth wall houses

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Table of Contents

Table of Contents	i
Abstract.....	v
Statement of Originality	vii
Acknowledgements.....	ix
List of Figures (excluding figures in papers).....	xi
List of Tables (excluding tables in papers)	ii
Chapter 1 Introduction.....	1
1.1 Research background.....	1
1.2 Research objectives	4
1.3 Organization of the thesis	5
1.4 Research contributions	9
Chapter 2 Literature review.....	11
2.1 Background knowledge about rammed earth	11
2.2 Thermal mass effect and thermal resistance of rammed earth wall	12
2.2.1 Thermal mass effect.....	12
2.2.2 Thermal resistance (R-value).....	13
2.3 Compliant with BCA requirements	14
2.3.1 Deemed-to-Satisfy Provision.....	14
2.3.2 Insulated cavity rammed earth walls	15
2.3.3 Energy Efficiency Provision (Star Rating Requirement)	16
2.3.4 Passive design strategies	18
2.3.5 Thermal performance of occupied rammed earth houses	18

2.4 Structural properties of unreinforced rammed earth walls.....	20
2.4.1 Vertical resistance of unreinforced rammed earth walls and design requirements	20
2.4.2 Vertical resistance of unreinforced insulated cavity rammed earth walls and requirements	22
2.4.3 Lateral resistance of unreinforced rammed earth walls and requirements	23
2.4.4 Lateral resistance of unreinforced insulated cavity rammed earth walls and requirements	27
2.5 Thermal performance simulation	31
2.5.1 Thermal simulation software	31
2.5.2 Adaptive comfort standard	33
2.5.3 Thermal performance in air-conditioned rammed earth buildings ..	35
2.5.4 Life-cycle cost	36
2.6 Research gaps	36
Chapter 3 Research Methodology	39
3.1 Experimental investigation on structural properties of rammed earth walls	39
3.2 Investigation on thermal performance of rammed earth wall houses with simulation.....	40
Chapter 4 Experimental Investigation on Flexural Performance of Insulated Cavity Rammed Earth Walls	43
Introduction	43
List of Manuscript	43
Feasibility of rammed earth constructions for seismic loads in Australia ..	45
Chapter 5 Prediction of Energy Loads of Uninsulated Rammed Earth Wall Houses	73

Introduction	73
List of Manuscript	73
Strategies for reducing heating and cooling loads of uninsulated rammed earth wall houses	75
Chapter 6 Prediction of Thermal Performance of Naturally Ventilated Rammed Earth Wall Houses.....	103
Introduction	103
List of Manuscript	103
Achieving thermal comfort in naturally ventilated rammed earth houses.	105
Chapter 7 Prediction of Thermal performance of Air-Conditioned Rammed Earth Wall Houses	143
Introduction	143
List of Manuscript	143
Design optimization of insulated cavity rammed earth walls for houses in Australia.....	145
Chapter 8 Discussions and Closing Remarks	183
8.1 Research outcomes	183
8.2 Recommendations for future work	184
References (excluding those in papers).....	187
Appendix A: Material test results	193
Appendix B: The Batch Files Code	215
Appendix C: Published Papers	223

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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List of Figures (excluding figures in papers)

Figure 2.1 Construction process of RE walls.....	12
Figure 2.2 Time lag and decrement factor (Baggs and Mortensen, 2006)....	13
Figure 2.3 Insulated cavity rammed earth wall.....	16
Figure 2.4 Acceptable indoor temperatures for naturally ventilated buildings (Adelaide).....	34
Figure 2.5 Basic model house.....	41

List of Tables (excluding tables in papers)

Table 1. 1 Minimum R-Value requirements for exterior walls in different climate zones.....	2
Table 2. 1 Maximum allowance for 6-star ratings in some climate regions.....	18