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Research Article

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Comparison between Two Insulating Materials Used in House Wall System for Thermal Performance

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Abstract For global warming and climatic change, the residential houses are used by the greenhouse gas which will consume more amount of fossil fuel energy. This energy is used for heating/cooling the house inside and some energy is waste or lost through the house wall. The modern house requires more space because of this energy efficient can reduce the dependency on fossil fuel at the same time the smart house wall systems are required to get better energy conservation. Here the study was considered on different climatic zones with all major cities. The objective of this study is to investigate and compare their performances with a conventional house envelope. The performance of heat loss through the wall has been evaluated using modeling software.

Keywords Insulation Materials; Thermal Performance; House Wall; Greenhouse Gas; Thermal Mass

Introduction

The huge energy is required for newly designed houses/buildings. For building construction and dwelling, process needs 30 % of global warming. At the residential sector by 40 % of energy is consumed by heating and cooling. For household hot water system significantly 30 % of energy is utilized and ~10 % energy for refrigeration and other appliances. The lighting and cooking usage presented lower percentage which less than 7 % as illustrated in Figure 1.

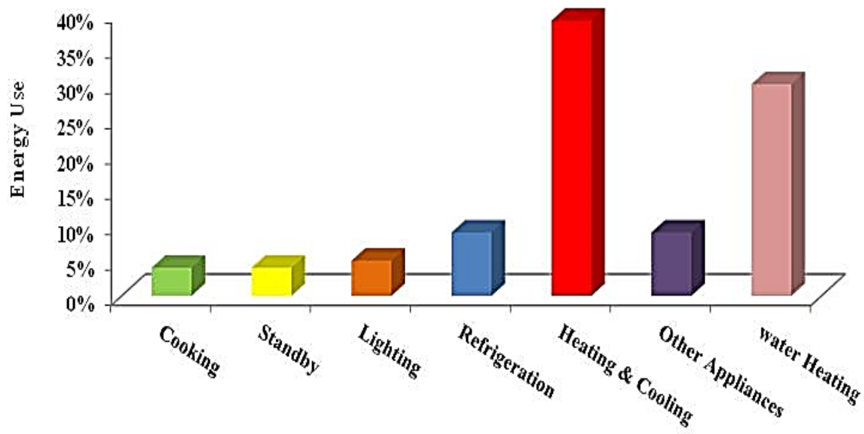

Figure 1: Residential household energy usage in Australia, 2007

The residential buildings demand has rapidly grown due to technology development, economic progress, and increase in population. Figure 2 displays a continuous upward energy consumption trend in Australian housing sector for the coming years. Nevertheless, the floor spaces are increases in modern housed the consumption of energy also will increase [3-4]. The energy consumption and CO_2 emission for heating and cooling from the residential house sector have significantly raised over the past decade and will continue in the foreseeable future [5]. Many researchers have used [6-8] different material and methods for a wide range of climatic zones for reducing the energy in house construction system. Hence the objective of this research is conducted in different Australian climatic zones for which consider important factor to reduce the energy consumption for newly designed house wall systems. The Australian government has initiated various policies, regulations, and guidelines to their modern construction which can be summarized as follows [9-15]:

- To minimize the energy consumption and improve the thermal energy performance, it must develop modern methods and standards can be used for construction.
- To reduce the energy consumption through introducing energy rating systems to find residential energy consumption it's very important to implement alternative ways.
- Apply various modern tools and reliable energy simulation software to calculate the heating and cooling need for the specific geographical location.
- Less energy consumption in an indoor environmentby using smart construction materials, which is having higher heat transfer resistance.
- Alternative energy uses especially solar & wind energy can provide inducements through a tax credit.

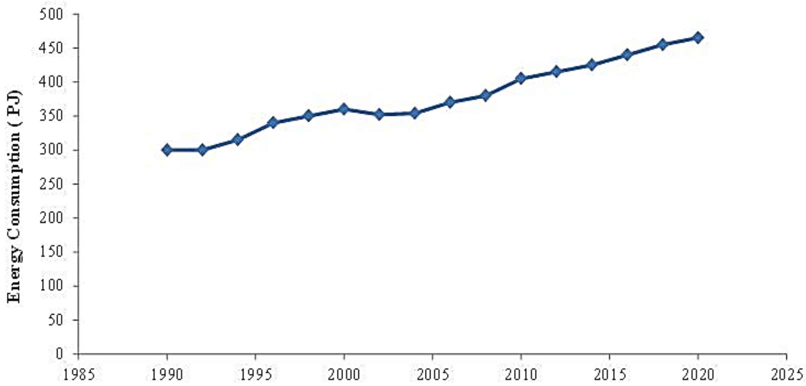

Figure 2: Australian housing sector energy consumption

Thermal mass

Once the heat source is removed from materials it may take a long time to lose the heat energy. In this way, concrete and bricks are having higher thermal mass as well as higher specific density. The high-density material can store more energy compared to a low density such as timber which is having low thermal mass and a lower time to release the heat content. Figure 3 illustrates the time was taken to release the temperature and heat flow through different house materials. These Materials are high thermal mass such as insulated reinforced concrete panel can absorb and keep the heat during day or night and release it gradually in 6-8 hours. However, materials with light weight and low thermal mass such timber or weatherboard take less time to store or release heat in 2-3 hours which will also lose heat faster. Therefore, proper use of high thermal masses for the house insulation can provide a comfortable house environment and reduce the energy required for heating and cooling. In this study, the new house wall has higher thermal mass than the conventional house as it uses concrete thermal masses [16-17].

Methodology

Simulated house description

In Australia, most of the houses are constructed ofBrick veneer and weatherboardin wall systems(conventional house wall system). In this study, we have selected the conventional house wall system and a new house wall system. The average floor area with three bedrooms is 100.2 m² and the total physical volume is approximately 460 m^3. The house consists of a living or dining area, kitchen, three bedrooms, two bathrooms, an alfresco and a laundry. The roof slope angle is kept at 20° as standard. The study is focused on bedrooms and living/dining areas as they need ongoing heating and cooling. The orientation of the house is north facing as the geographical location of Australia is in the Sothern hemisphere. Figure 4 illustrates a plan view of the house floor area used here.

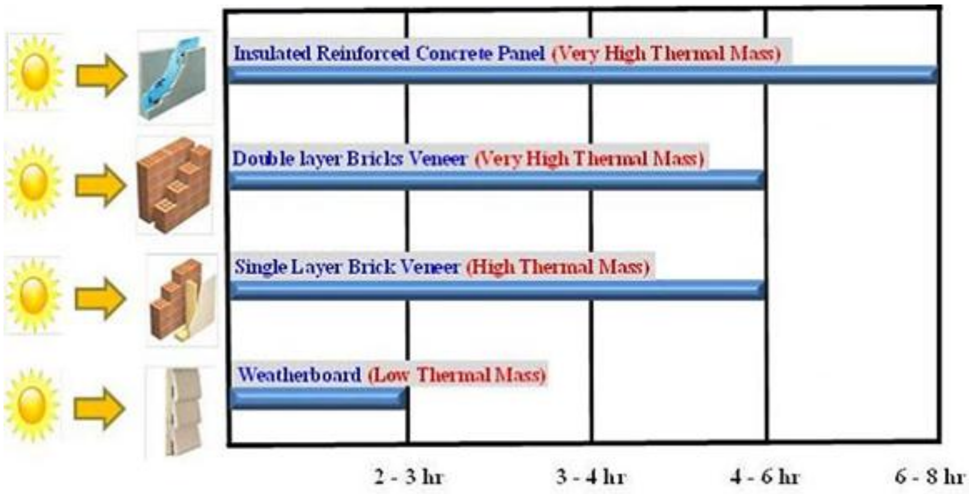

Figure 3: Heat flow through different house envelopes

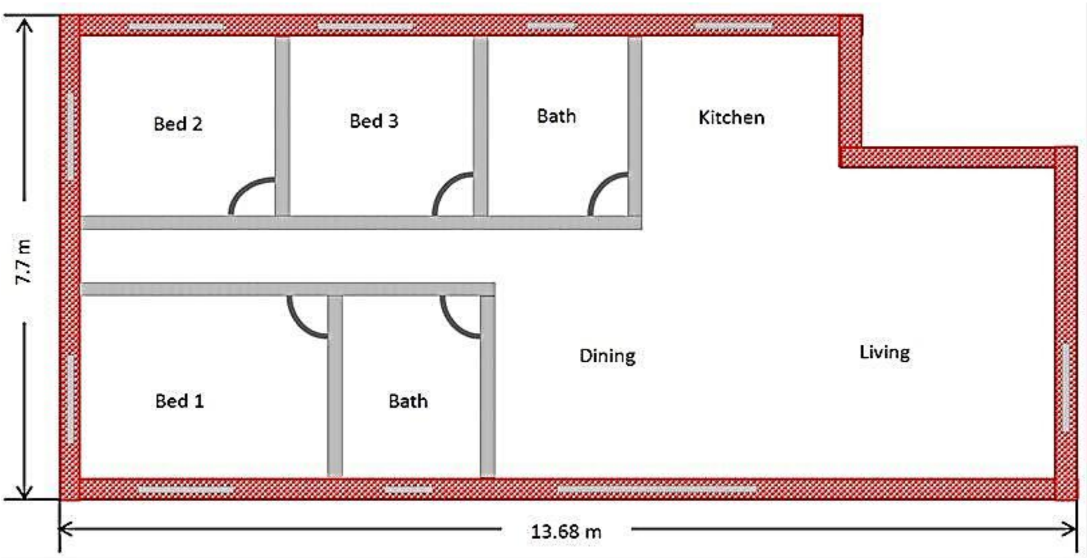

Figure 4: Simulated house layout

Simulation of computational analysis

The known software's are available such as Design Builder, Nathers, First Rate, BASIX, BERS Pro, NABERS and Accurate can be used to assist in estimating the energy need. Here the computational simulation call accurate software was used to estimate the thermal performance of the house wall systems which is significantly improved version of the first-generation software known as the National House Energy Rating Scheme (Nathers) developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) which is widely used and accepted for the simulation of house energy performance in Australian states and territories.A scale rating can result between 0 to 10 by the software. It has abuilt-in library of thermal properties of the common material and climatic data's. By showing the higher ratings the house requires less energy for heating and cooling to save the energy which is designated the effects of natural ventilation properties [19-20].

The climatic zones of Australia

Australia is divided into seven main climatic zones based on climatic conditions, metrological data, and solar radiation. Those zones are dry summer, humid oceanic, tropical dry, tropical, humid subtropical, desert, semi-arid, and subtropical. The states have been sub-divided into 69 microclimatic zones with a sure amount of energy required for heating and cooling. The weather configurations within the major seven climatic zones are also varied [21, 22].

Materials and house construction

House wall construction for the conventional design

As shown in figure 5 the schematic of the brick veneer house wall used in this research. The construction of the external wall of the conventional house consists of 110 mm thick brick, 40 mm air gap, and 90 mm timber frame structure. These materials are attached to the external structure of the timber with a 2 mm thickness. Fiberglass insulation with a thickness of 59 mm is inserted in between the external timber structure and 10 mm thick internal plasterboard.

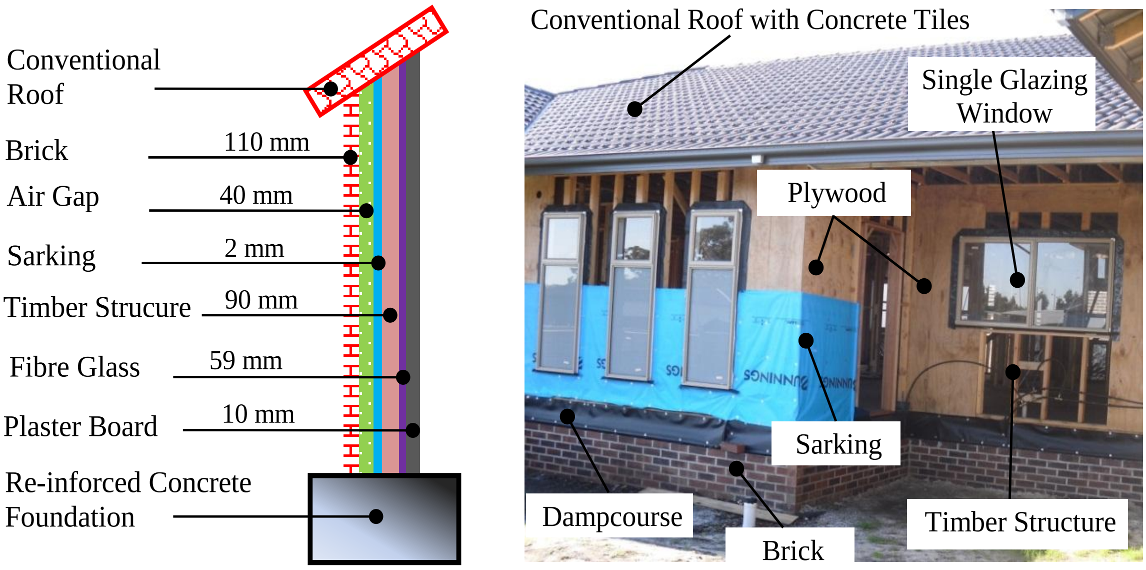

Figure 5: House wall construction for the conventional design

Two half concrete panels house wall and two panels of polyurethane insulation in-between

This design consists of double insulation with double-sided reinforced concrete panels. The insulation panel is polyurethane, placed in between reinforced concrete panels. The wall is made of 10mm render, 150mm (75mm and 75mm) reinforced concrete panel, 118mm polyurethane as insulation materials and 10mm plasterboard placed on the inside of the house wall. The schematic of design is shown Figure 6.

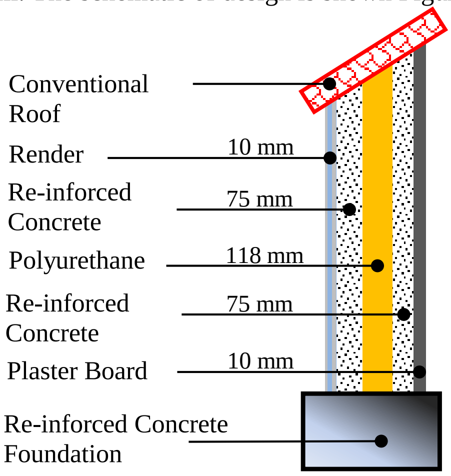

Figure 6: House wall configuration with polyurethane insulation

Two half concrete panels house wall with two panels of rock wool insulation in-between

This design has the same dimensions and materials of construction as the previous design but the types of insulation materials are different. These insulation material shave been used is rock wool with athickness of 118mm as shown in Figure 7.

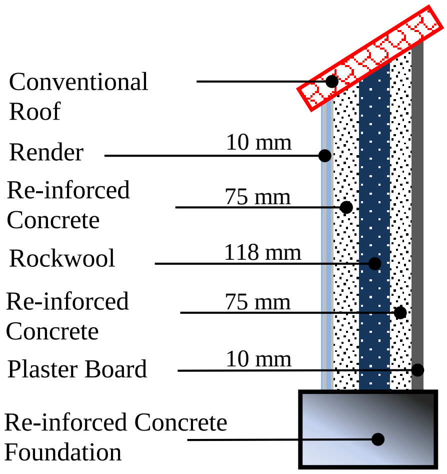

Figure 7: House wall configuration with rockwool insulation

Result and Discussion

In this study, the major change in the simulated house was in external walls, whereas other elements of the house were not changed. With the new setup, different construction methods and insulation materials are used to investigate the house wall thermal performance to achieve an optimum house wall design. The conventional system veer has the maximum energy needs for heating and cooling for all cities. The energy requirements for heating and cooling, star energy ratings and relative improvements for house wall used polyurethane insulation are requires less energy for all selected cities and towns. The highest reduction in energy requirement (56 %) is noted for Perth, followed by Adelaide (53.9 %) and Melbourne (42.2 %). The cities of, Sydney, Darwin, Sydney and Canberra have achieved energy savings of 30-40 %, while Brisbaneis 25.9 %. Similarly, the house wall performance which used rock wool insulation achieved notable reduction close to house wall that used polyurethane insulation but less percentage of improvements. For selected cities, the energy performance for conventional and house wall with polyurethane and rock wool insulation as shown in Table 1.

Table 1: Energy performance for conventional/house wall with polyurethane and rock wool insulation for selected cities

			Total energy required (MJ/m^2. Annum)			Improvement (%)	
No.	**City**	**State**	**Conventional**	**Polyurethane**	**Rockwool**	**Polyurethane**	**Rockwool**
1	Melbourne	VIC	150.6	87.0	103.0	42.2	31.6
2	Brisbane	QLD	71.3	52.8	60.4	25.9	15.3
3	Darwin	NT	630.4	412.5	475.8	34.6	24.5
4	Hobart	TAS	191.7	135.7	157.7	29.2	17.7
5	Adelaide	SA	121.9	56.2	73.0	53.9	40.1
6	Sydney	NSW	73.5	46.7	55.6	36.5	24.4
7	Canberra	ACT	216.4	149.4	174.7	31.0	19.3
8	Perth	WA	138.6	61.0	79.2	56.0	42.9

Conclusion

Comparing to conventional houses the doubling of thicknesses of polyurethane and rock wool insulation materials provides energy savings between 20 - 55%. However, the polyurethane insulation material gives better energy savings by 11% higher than the rockwool. Selection of these two materials as thermal insulation should be based on economic analysis and life cycle assessment that will be investigated in the future.

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