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COMPARISON OF COOLING AND HEATING REQUIREMENTS BETWEEN BRICK VENEER AND FIBRO CEMENT WALLING SYSTEM

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Space cooling and heating in residential sector is significant contributor to energy consumption in Australia. Therefore, it is important to reduce the cooling and heating requirements. The selection of a good walling system helps to save energy by homes. This research compared the thermal efficiency of a modern house (constructed using brick veneer walls with concrete floor slab) with an old house (constructed using fibro cement walls raised timber floor) using the AccuRate simulation tool. A standard house with two living rooms, one kitchen, one laundry and four bedrooms are simulated in a Sydney Suburb in Australia. It was found that modern house showed lower inside temperature variation than the old house all year around. The results also showed that the modern house has a lower energy consumption for space heating and cooling than the old house. The annual energy use for space heating and cooling in both the modern house and old house were 5,197 kWh and 15,712 kWh respectively. Moreover, the annual energy costs were found to be $1,403 and $4,242 respectively for modern and old houses. The modern brick veneer house saved about 33 % of energy compared to old old house. When the net present value of the energy cost for f both houses over 50 years is computed, the energy cost of modern house was found to be $25,629 while it of old house is was $77,488 for the old house.

Keywords: Energy, Walling system, AccuRate, Simulation, Brick veneer house, Fibro cement wall.

1 INTRODUCTION AND BACKGROUND

Walling system makes an important contribution on building envelope. The material used affects the energy consumption. High thermal mass materials like stone and brick are more and more popular as they take longer responded to temperature changes than low thermal mass materials such as timber and fibro cement. According to Australian Bureau of Statistics (2010), the top four building materials for external wall are brick veneer, double brick, timber and fibro cement. The use of double brick, timber and fibro cement decreased from 1999 to 2008 but it of brick veneer increased. Averagely, brick veneer accounted for about 45% of the external walling system during this period while double brick; timber and fibro cement took up about 28%, 14% and 8% respectively (Australian Bureau of Statistics 2010).

Extensive research has been investigated and examined for the energy requirement in both residential and commercial sectors to improve the energy efficiency. Ren *et al.* (2013) conducted research and reported that five factors affect total energy use in residential buildings. They are thermal performance of building envelope, occupants' behaviors and patterns, and household equipment and appliances. Ren *et al.* (2013) simulated total energy consumption of a demonstration house in Melbourne for one year using AccuRate. Rosa *et al.* (2015) used software called Building Energy Perfomance Simulator (BEPS) to explore the annual heating and cooling consumption by using different external wall discretization in different climate zones for a basic building. BEPS is using nodal approach for building component such as floor, walls and roof to exanimate the thermal performance.

Building thermal insulation has become one of the most important energy saving strategies for heating and cooling. As a result, choosing the optimum thickness of insulation is vital important on saving energy and money. Bolatturk (2007) carried a study to determine the optimum insulation thickness of outside walls depending on cooling and heating demand of a building in various cities in Turkey. The thermal efficiency for external wall materials is very important to energy conservation. Therefore, Australian Energy Efficient Building Consultants (2009) aimed to determine the heating and cooling loads by comparing outdoor wall materials between ICF, brick veneer, double brick and framed construction. More concerns are on energy efficiency in building in recent years in Australia. Gregory *et al.* (2007) aimed to determine a better thermal performance from four typical walling systems, which are brick veneer (BV), reverse brick veneer (RBV), cavity brick (CB) and lightweight (LW) by using software called AccuRate. There are many energy-rating tools available such as EnergyPlus, EN 13790 and INVERT/EE- Thermal Module and AccuRate to analyze energy use of a building. AccuRate enables to calculate many thermal parameters such as cooling and heating demand, lighting, CO_2 emission and temperature in any one of 69 different climate zones in Australia.

In this study, AccuRate software is selected to find out the space cooling and heating requirement in a house used of brick veneer walling system and fibro cement walling system. It can be applied to assess the thermal performance of designed and existing buildings as well as assess the compliance of energy efficiency requirements of building Code of Australia. In this paper, AccuRate is used to model a standard house for its capability of building envelope. Finally, energy consumption for space cooling and heating consumption including a typical HVAC system used in Australian market is calculated to compare the thermal performance between brick veneer and fibro cement external wall.

2 RESEARCH METHODOLOGY

For comparative study of the heating and cooling consumption between brick veneer and fibro cement walling system, a standard double-stories house module is simulated in this study. It has a total area of 200 m^2 with dimension of 20 m by 10 m. Each level is 2.5 m heights. The house consists with two living room, one kitchen, one laundry and four bedrooms. The two living rooms are faced toward to north with window of 20 square meters respectively on the northern external wall. Other zones are faced toward south, and each zone has a window of 1.8 square meters. Figure 1 shows the house plan and Table 1 shows the relative parameters of the house. The location of the standard house is selected at Harris Park, News South Wale in Australia.

The dimensions of each zone and their conditioned time are showed in Table 1. Two model houses are simulated in this paper. The modern house is brick veneer walling system with concrete slab. The floor is made of concrete slab on the ground and constructed with brick veneer wall system. The old house is fibro cement walling system with timber raised floor. The floor is made of timber 0.75 meters above the floor and constructed with fibro cement wall system. The main parameters of house constructions are reported in Tables 2 and 3.

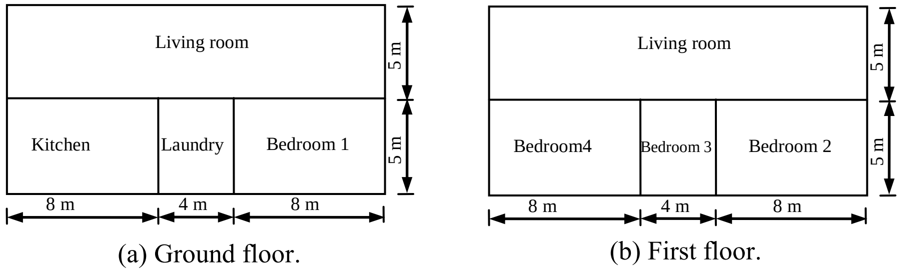

Figure 1. Plan view of ground floor and first floor.

Table 1. Parameters of the house.

Floor	Zone	Dimension (m)	Conditioned time
Ground floor	Living room	20 × 5 × 2.5	7:00-24:00
	Bedroom 1	8 × 5 × 2.5	16:00-9:00
	Laundry	4 × 5 × 2.5	No heating and cooling
	Kitchen	8 × 5 × 2.5	7:00-24:00
First Floor	Living room	4 × 5 × 2.5	7:00-24:00
	Bedroom 2	8 × 5 × 2.5	16:00-9:00
	Bedroom 3	4 × 5 × 2.5	16:00-9:00
	Bedroom 4	8 × 5 × 2.5	16:00-9:00

Table 2. Parameters of modern house – brick veneer walling system with concrete slab.

Building constructions	Descriptions of parameters
External wall	Brick (110 mm) + Air gap (40 mm) + R 4.0 cellulose fibre insulation (40 mm) + Plasterboard (10 mm)
Internal wall	Plasterboard (6 mm) + Air gap (40 mm) + R 0.14 cellulose fibre insulation (7 mm) + Air gap (40 mm) + Plasterboard (6 mm)
Floor	Concrete slab (110 mm)
Ceiling	Plasterboard (13 mm) + R2.5 bulk insulation
Roof	Roof tiles - clay (20 mm)

Table 3. Parameters of the old house – fibro cement walling system with timber raised floor.

Building constructions	Descriptions of parameters
External wall	Fibro cement (6 mm) + Air gap (40mm) + Plasterboard (10 mm)
Internal wall	Plasterboard (6mm) + Air gap (40 mm) + R 0.14 cellulose fibre insulation (7 mm) +Air gap (40mm) + Plasterboard (6mm)
Floor	Timber- mountain ash (110mm)
Ceiling	Plasterboard (13mm) + R2.5 bulk insulation
Roof	Roof tiles - clay (20 mm)

3 FINDINGS

The temperature variations for extreme winter and summer of ground floor living room of both houses are reported in this paper due to the page limitation. The extreme winter week from 6 June to 12 June and the extreme summer week 28 November to 4 December are selected because of their representativeness. In the figures, the results of modern house with brick veneer walling system with concrete slab are represented by ‘P1” and the results of old house with fibro cement walling system with timber raised floor are represented by ‘P2”.

3.1 Temperature Comparison of the Modern and Old Houses

3.1.1 *Space heating and cooling during extreme winter*

In extreme winter (from 6 June to 12 June) in Harris Park, the temperature changes of ground floor bedroom of the modern and old houses are showed in Figure 2. In the living room at the ground floor (showed as Figure 2), both houses have a higher temperature than outdoor during the week. The variation of temperature in modern house is less than it in old house, 19-24^{o}C and 12-25^{o}C respectively. The temperature of the old house at night is significantly lower than the modern house. For bedroom 1, the modern house is 2^{o}C warmer than the old house all week around. Moreover, two houses have a higher temperature than outdoor, but the old house presents a lower temperature than outdoor at some times during the week. For the laundry, the modern house is 5^{o}C warmer than the old house all week around. Two houses have a higher temperature than outdoor, but the old house presents a lower temperature than outdoor at the midday during the period. For the kitchen (the variation of temperature in modern house is much less than it in old house. The temperature of the old house at night is significantly lower than the modern house. In the living room at the first floor, the temperature changes are similar to the changes in living room two at the ground floor. The variation of temperature in modern house is less than it in old house, 17-25℃ and 11-29℃, respectively. The temperature of the old house at night is significantly lower (5℃) than the modern house. Modern house (brick veneer walls with concrete ground slab) shows a better thermal performance than the old house (fibro cement walls with raised timber floor). The former has relatively higher temperature maintained and lower fluctuations in temperature. The average indoor temperature of the modern house is 18℃. Comparatively, the average indoor temperature in the old house is 16.5℃. In addition, the average temperature variation of the modern houses is 4.5℃ and that in the old house is 9℃.

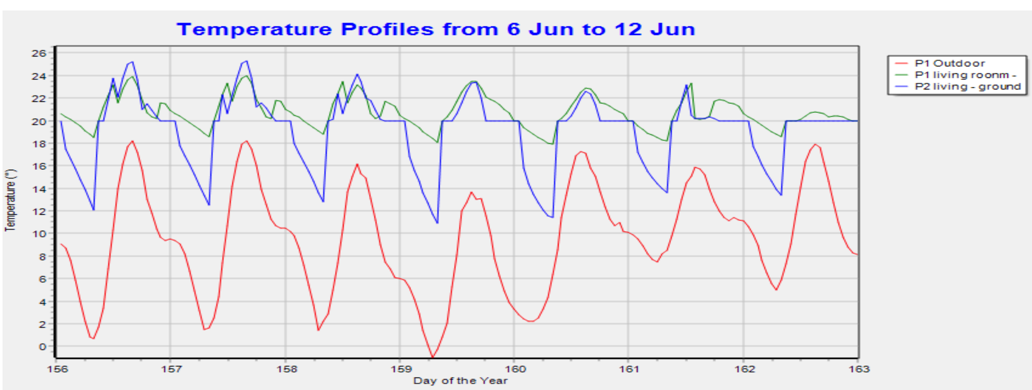

Figure 2. Temperature comparison of ground floor living room between two houses in winter.

3.1.2 *Space heating and cooling during extreme summer*

Figure 3 shows the temperatures changes of first floor living room of the modern and old houses for extreme summer (from 28 November to 4 December) in Harris Park. Both living rooms at the ground floor in both houses maintain temperature between 18 to 25℃ in extreme summer week (showed as Figure 3). Both houses are cooler than outside at daytime and warmer at night. However, the temperature variation of modern house is slightly lower than the old house. The bedrooms 1 in each house present a more comfortable temperature than outside during the week. The temperature variation of old house is much higher than the modern house. The former temperature ranges between 17℃ and 30℃ during the week while the latter between 22℃ and 26℃. The bedrooms 2 in both houses have similar temperature variation. They are cooler than outdoors at daytime and warmer at nighttime. The temperature of modern house is about 2℃ warmer than the old house during the nighttime. For bedroom 3, both houses have similar temperature variation. They are cooler than outdoors at daytime and warmer at nighttime. However, the temperature variation of the old house is more significant, ranging from about 18 to 32 ℃. It is hotter at daytime and colder at night.

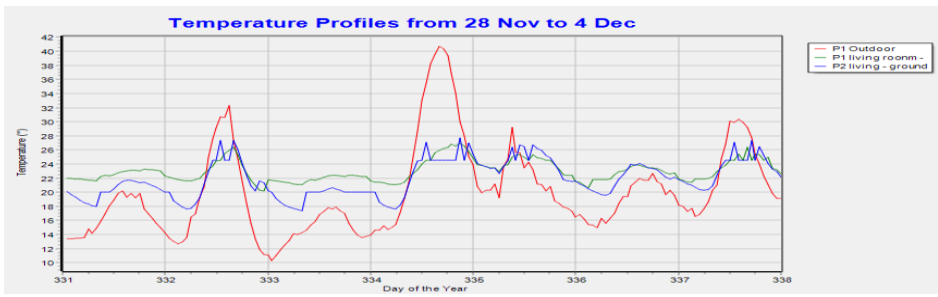

Figure 3. Temperature comparison of the ground floor living room between two houses in summer.

According to the temperature profile comparison between the modern brick house and old fibro house, the modern house is more comfort than the old house because it has lower temperature variation, warmer in winter and cooler in summer. The brick veneer walls with concrete ground slab show a better ability to absorb and maintain heat energy than the fibro cement walls with raised timber floor. It is also predicted that the modern house will have a lower cooling and heating requirement.

Table 4. Annual energy use and cost for space cooling and heating in both houses.

System	Modern house		Old house	
	Annual energy use (kWh)	Annual cost ($)	Annual energy use (kWh)	Annual cost ($)
Space cooling	4,739.2	1,280	12,293	3,319
Space heating	457.9	123	3,418.9	923
Total	5,197.1	1,403	15,711.9	4,242

Table 5. Net present value for space cooling and heating in both houses for 50 years.

Net present value	**Modern house**	**Old house**
Space cooling ($)	23,382	60,628
Space heating ($)	2,247	16,860
Total	25,629	77,488

3.2 Heating and Cooling Requirement of the Modern and Old Houses

The energy consumptions of modern house and old house for space cooling and heating are measured. The annual cooling and heating energy use and their cost are reported in Table 4 for both types of house. The net present value of cooling and heat for both houses are showed in Table 5. The AccuRate shows that the energy consumptions of modern house and old house for space cooling are 17,061 MJ and 44,255 MJ respectively. Moreover, the energy consumptions of both houses for space heating are 1,645 MJ and 12,306 MJ respectively. According to the Origin Energy (2016), the electricity price for NSW residential buildings is 27 cents/ kWh.

4 CONCLUSION

In this study two-story standard house with two walling systems were considered for comparison for the thermal performance. Both houses simulated using AccuRate are modern house and old house. The results indicate that brick veneer walling system with concrete slab shows a better thermal performance than Fibro cement walling system with timber raised floor all year around. Firstly, the modern house is warmer in winter and cooler in summer. In winter, the modern house is 3.4℃ warmer in an average than the old house and 2℃ cooler in summer. Secondly, the modern house has lower temperature fluctuations. In winter, the average indoor temperature fluctuations are 4.5℃ and 9℃ respectively for modern house and old house while 6℃ and 10℃ respectively in summer. In summer, the average temperature variation of the modern house and the old house are 6℃ and 10℃ respectively. In addition, the modern house is 2℃ cooler than the old house during day in summer and about 2℃ warmer at night.

The results also show that brick veneer walling system with concrete slab has lower energy consumption on space cooling and heating then the fibro cement walling system. The annual energy use for space cooling and heating in the modern house and old house are 5,197.1 kWh and the annual energy cost is $1,403. Comparatively, the annual energy use for space cooling and heating in the old house is 15,711.9 kWh and the annual costs are $4,242. Therefore, the modern house can save 33% energy and energy bill more than old house every year. When considering the net present value of both houses for 50 years, the energy cost of modern house is $25,629 while it of old house is $77,488. This means that the life cycle energy cost for the modern brick house is about one third of that of old fibro house. This can be one of the motivating factors for replacing existing old house with a modern brick home.

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