COMPARATIVE STUDY OF THE INTERLOCKING BLOCK AND CLAY BRICK MASONRY BUILDING

N. CHAIMOON[1*†], C. LERTSATITTHANAKORN[2], and K. CHAIMOON[3]

[1]*Division of Environmental Engineering, Faculty of Engineering, Mahasarakham University, Thailand*

[2]*Division of Mechanical Engineering, Faculty of Engineering, Mahasarakham University, Thailand*

[3]*Division of Civil Engineering, Faculty of Engineering, Mahasarakham University, Thailand*

ABSTRACT

This paper presents the results of an inquiry into the comparative thermal performance and economic viability of interlocking block and clay brick. To this end, two test rooms of 2.4 m width, 2.4 m length and 2 m height were built. The first room was constructed using interlocking block wall whereas the second room used a commercial clay brick wall. Data recorded included room temperature, inside and outside surfaces temperatures of all walls, and solar intensity. The experimental results showed that heat conducted better through the interlocking block than through the clay brick. This was not surprising because the thermal conductivity of the interlocking block is 234% higher than the clay brick. However, the cost of interlocking block wall was lower than the clay brick wall by 34.5%.

Keywords: conduction heat transfer, thermal conductivity, interlocking block.

1. INTRODUCTION

In these times of the diminishing energy sources and concern over global warming, the performance of any new construction material with respect to heat gain in buildings must be taken into consideration. This becomes particularly true in countries located in hot tropical zones where air conditioners, which consume a major amount of electrical power, are commonly utilized to reduce indoor temperature and humidity. Typically, the energy consumed by air conditioners is almost 60% of the total energy consumption in any building (Vangtook and Chirarattananon 2007).

In Thailand, a commercial interlocking block made from soil and cement has been developed by the Thailand Institute of Scientific and Technological Research (TISTR) as a new construction material for low-rise residential buildings. As a result, a niche market of some 200-500 residential houses per year of 200 m^3 volume has been created. Unfortunately, the interlocking block has two main

[*] Corresponding author: Email: n.seelsaen@gmail.com

[†] Presenter: Email: n.seelsaen@gmail.com

disadvantages: heavy weight and high thermal conductivity (Khedari et al. 2005). There are however, several advantages to using the interlocking block in building construction. They include a reduction in construction time and cost. Due to its keying system, a wall can be constructed easily and quickly. In addition, as it must be for traditional load bearing wall systems, no reinforced concrete (RC) columns and beams are needed. This technology also provides an alternative to framed structures which are generally used for residential buildings. Framed buildings consist of columns, beams and in-filled walls. However, to date, the heat gain performance of the interlocking block has yet to be measured.

In this study, a full scale test was conducted. Performance of the interlocking block wall was assessed by comparing it with a wall constructed with the type of commercial clay brick generally found in the construction of framed buildings.

2. INTERLOCKING BLOCK

The interlocking block was first developed by the Thailand Institute of Scientific and Technological Research (TISTR) in an attempt to provide a cheaper and faster construction product for the housing sector. This technology has been disseminated to and promoted by the commercial sector, and presently, the interlocking block continues to be manufactured and used due to its aesthetics and simplicity in construction. The use of interlocking block in building construction reduces construction time due to the self-aligning features through key connections of the block and no mortar layers. Mortar is simply used for filling in the holes of the block to make the system solid.

This technology also represents a new method for construction of masonry buildings and an alternative to framed buildings. The typical raw materials used in manufacturing the interlocking block are type I Portland cement and fine ground lateritic soil.

Figure 1 shows the interlocking block and the clay brick used in this study. The interlocking block had a composition of Portland cement to lateritic soil of 1:7 by weight.

Top and Side Views   Bottom View

(a) Interlocking Block   (b) Clay Brick

Figure 1: (a) The interlocking block and (b) the clay brick used in this study.

The fundamental properties of the interlocking block and the clay brick were determined according to ASTM C 140 (ASTM 2002a) and ASTM C 67 (ASTM 2002b), respectively. The thermal conductivity was determined according to JIS R 2618 (JIS 1995). Table 1 presents an average of the properties of three specimens of the interlocking block and clay brick that were considered in this report.

Table 1: Properties of the interlocking block and the clay brick used in this study

Properties	Interlocking Block	Clay Brick
Nominal Size (W×L×H, mm)	125×250×100	60×145×60
Compressive Strength (MPa)	15.61	5.97
Bulk Density (kg/m^3)	2380	1740
Water Absorption (%)	11	17
Thermal Conductivity (W/mK)	1.82	0.53
Absorptivity [6]	0.80	0.25

It is obvious that the compressive strength and bulk density of the interlocking block are 161% and 37% higher than the clay brick, respectively. The water absorption of the interlocking block is 6% lower than the clay brick. However the thermal conductivity of the interlocking block is 243% higher than the clay brick.

3. TEST PROGRAM

In order to investigate and compare the performance of the interlocking block wall and the clay brick wall, two separate rooms without windows were built. One was constructed using the interlocking blocks. The other was constructed using the clay bricks. Each room was built using typical construction practices. Mortar plastering and white painting were put on all exterior and interior surfaces of the clay brick walls, while the interlocking block walls were not plastered or painted and had the same color as the main constituent, i.e., lateritic soil, as shown in Figure 2. The thickness of the interlocking block walls was equal to the block thickness of 125 mm whereas the thickness of the clay brick walls was 100 mm. Each room was 2.0 m high with base dimensions of 2.4 m × 2.4 m as shown in Figure 3.

(a) the interlocking block room

(b) the clay brick room

Figure 2: Pictorial view of the test rooms: (a) interlocking block room (b) clay brick room.

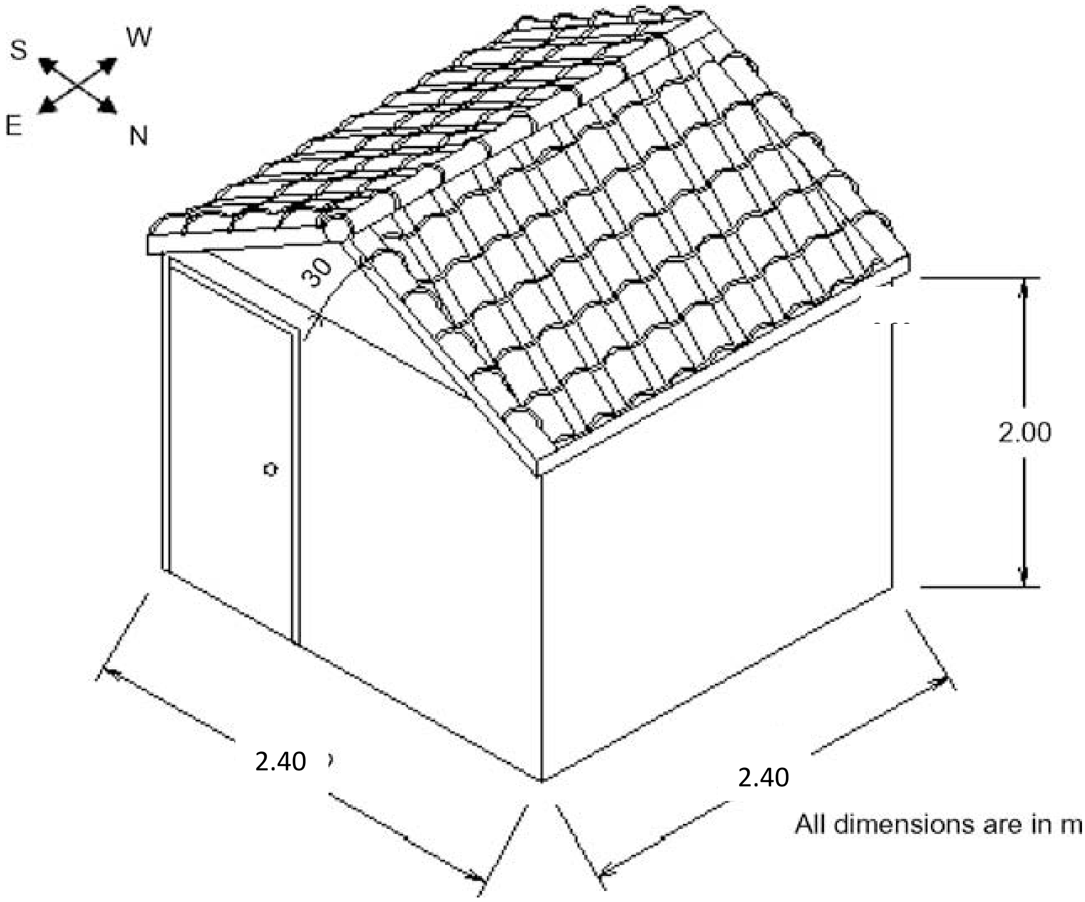


Figure 3: Dimensions of the interlocking block and the clay brick room.

The roof was covered using concrete roof tile, CPAC Monier, laid at a tilt angle of 30º. The gypsum board ceiling was insulated using glass wool for preventing heat gain from the roof. A plywood door was located at the eastern wall. In each room, eleven Type T thermocouples were installed to measure the room temperature, eight for measuring at the center of the outer and inner surfaces of each wall and three for measuring at the three centered vertical positions (R1, R2 and R3) as shown in Figure 4.

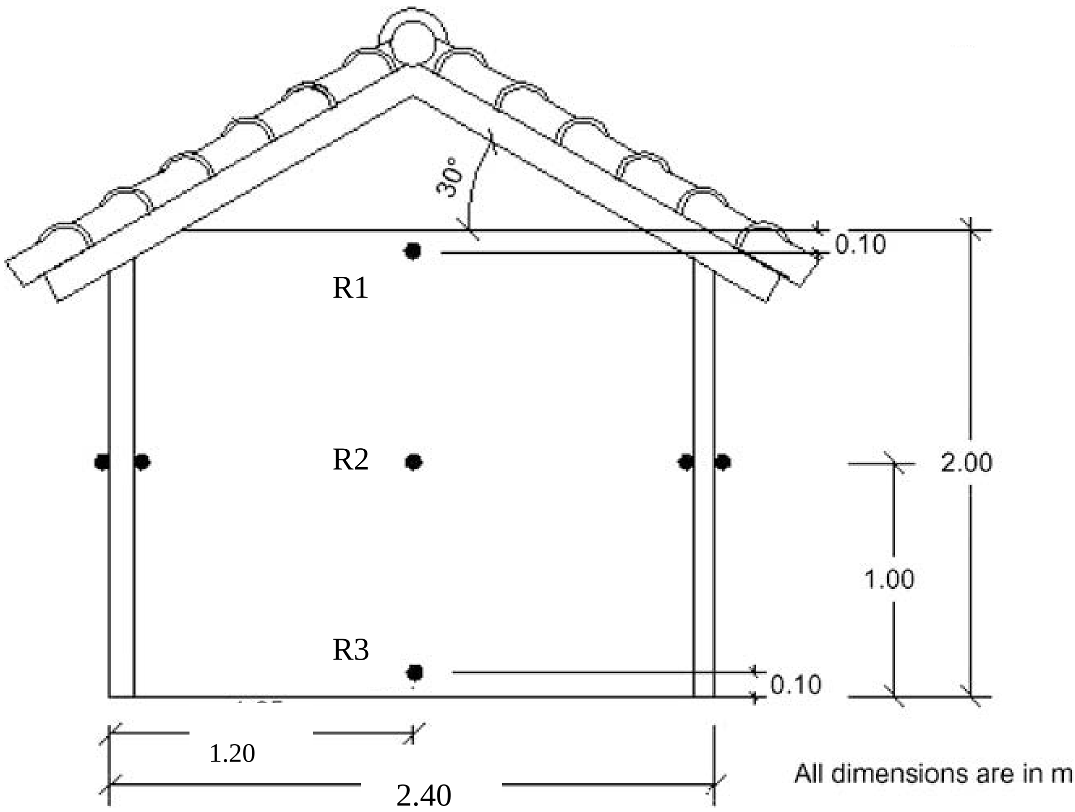


Figure 4: Positions of the thermocouples.

Ambient temperature was recorded with a shielded thermocouple. Global solar radiation was measured by a Kipp and Zonen B.V. model CM 11.

Data were recorded using a data logger and sampled every 5 min during 24 h. The tests were performed for 30 days in the summer period. In this paper, only the results of a representative day are presented and discussed.

4. RESULT

Figure 5 shows the hourly variation of ambient conditions including the ambient temperature (Tamb) and global radiation (It) of a representative day in summer.

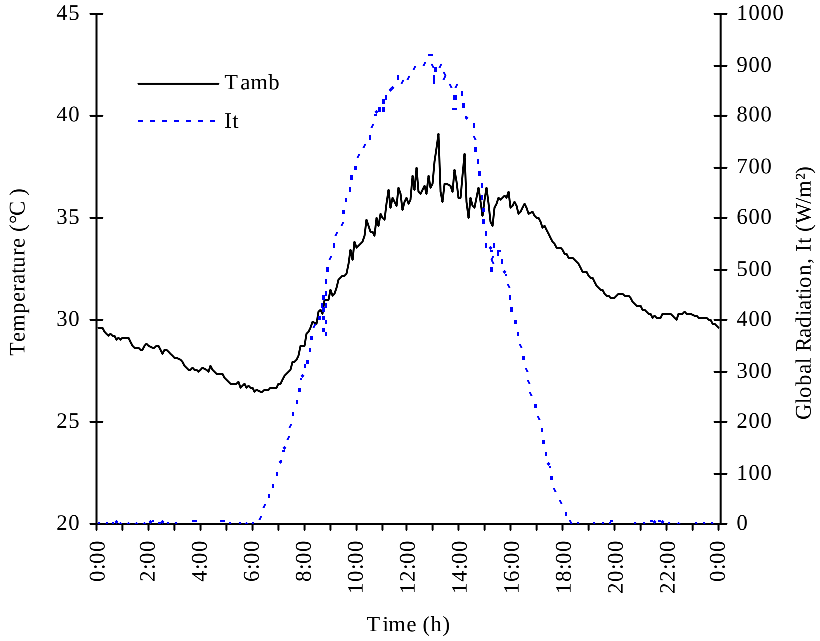
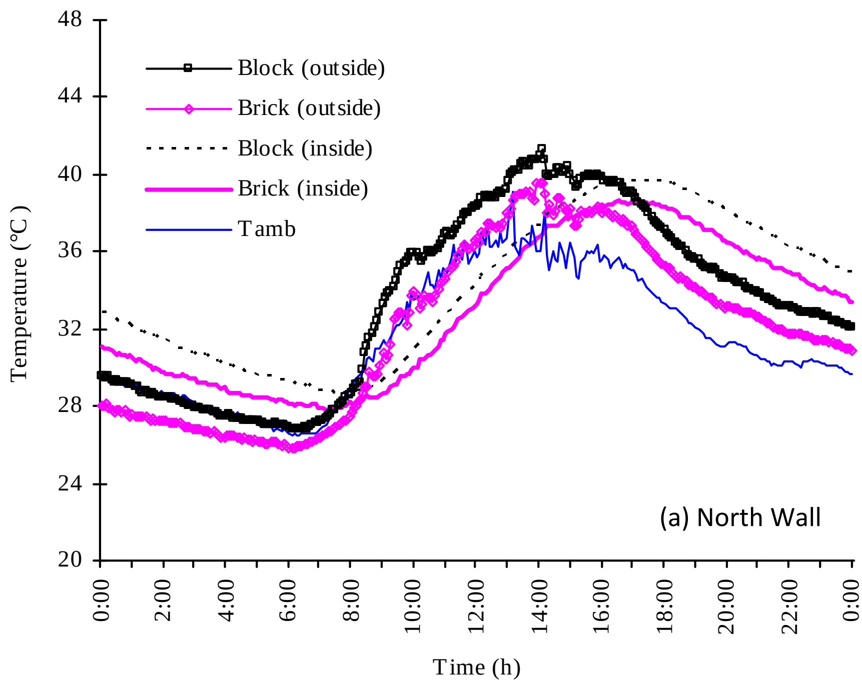
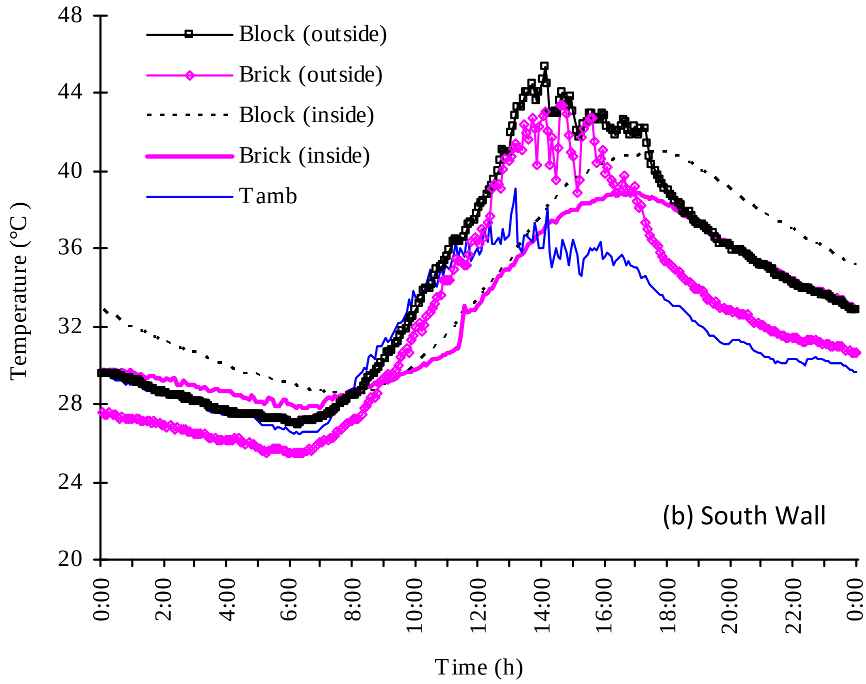
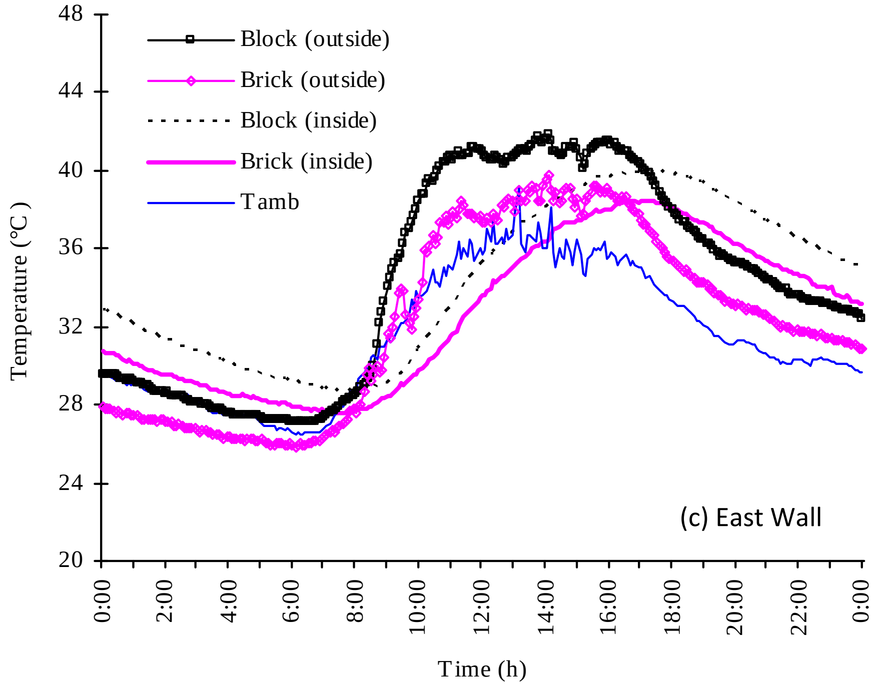


Figure 5: Ambient temperature and global radiation during 24 h in the representative day of the test (1 April 2010).

The walls of the interlocking block room and the clay brick room were exposed to solar radiation. Figure 6 shows a comparison of the outside and inside surface temperatures of the four walls of both rooms.




48
44
40
36
32
28
24
20
Temperature (°C)
Block (outside)
Brick (outside)
Block (inside)
Brick (inside)
Tamb
(b) South Wall
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time (h)


48
44
40
36
32
28
24
20
Temperature (°C)
Block (outside)
Brick (outside)
Block (inside)
Brick (inside)
Tamb
(c) East Wall
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time (h)

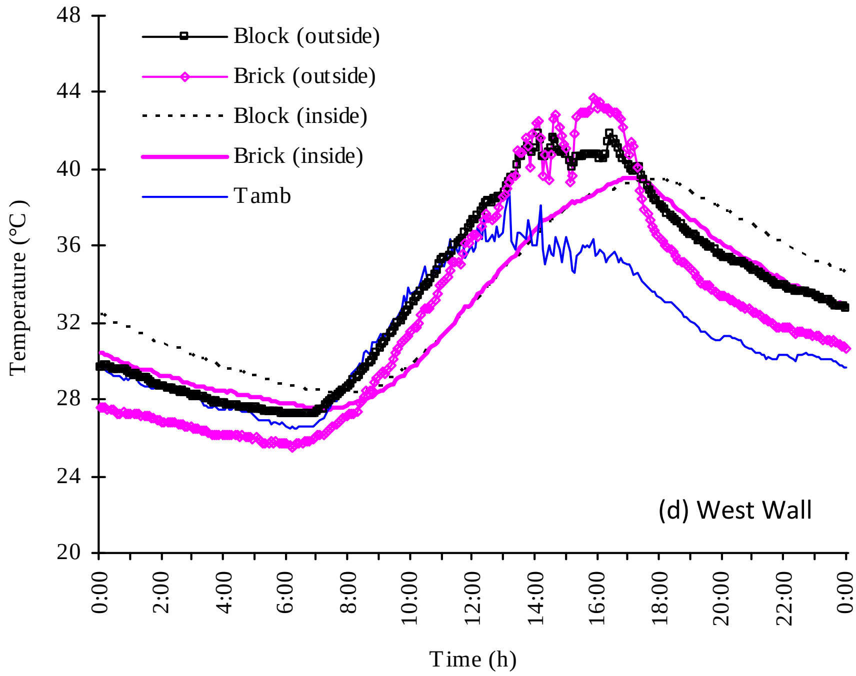


Figure 6: Variations of the outside and inside surface temperatures of the interlocking block walls and the clay brick walls: (a) north wall, (b) south wall, (c) east wall and (d) west wall.

It can be seen from the figure that the outside surface temperatures of the interlocking block walls were higher than the clay brick walls. The results also reveals that the influence color was dependent of solar radiation, the darker the color, the more sensitive to solar radiation. Dark surface has high absorptivity, and absorbs most of impinging solar radiation. The absorbed heat was transferred to the internal surfaces by conduction and finally heated up the indoor air through convection. The instantaneous conduction heat transfer from the outside to inside surfaces of the interlocking block walls and the clay brick walls is given by Cengel 2003.

$$Q_{\text{cond}} = kA\frac{T_o - T_i}{L} \qquad (1)$$

where Q_{cond} is the conduction heat transfer rate, A is the wall area, L is the thickness of the wall, k is the thermal conductivity, T_o and T_i are the temperature of outside and inside walls, respectively. Applying equation (1) to the temperature data recorded during the day, we calculated the corresponding conduction heat transfer rate (Figure 7). We can observe that the interlocking block has better isolation properties than the clay brick.

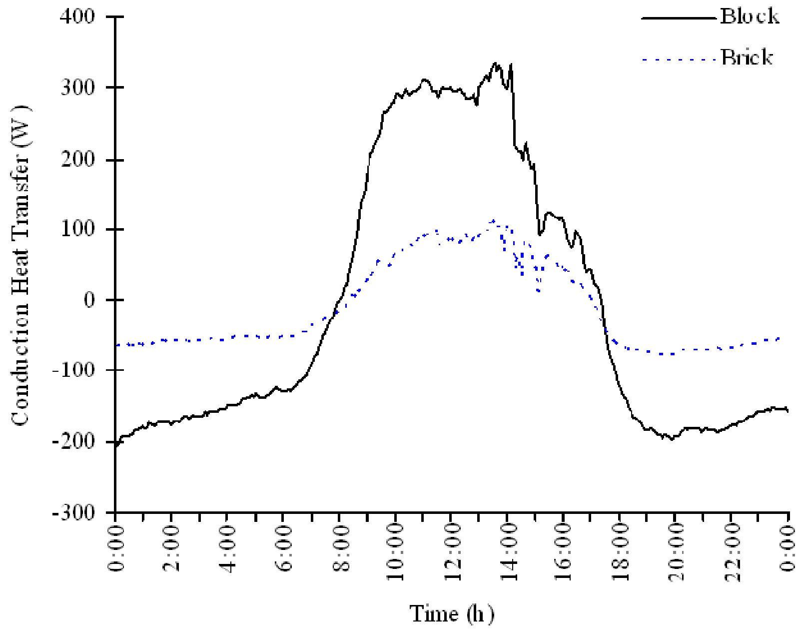


Figure 7: Comparison of conduction heat transfer between the interlocking block and the clay brick walls.

The interlocking block walls have both higher absorptivity and thermal conductivity than the clay brick walls. Thus, the interlocking block walls gave a higher heat transfer from outside to inside as shown in Figure 7. However, the thermal mass of the interlocking block is also higher than that the clay brick which means that the thermal capacity (thermal capacity of most materials depends on their density and thickness) of the interlocking block must be higher than the clay brick. As a result the average indoor temperature of the interlocking block room was slightly higher than the clay brick room (in the range of 0.4 to 1.7ºC) as shown in Figure 8.

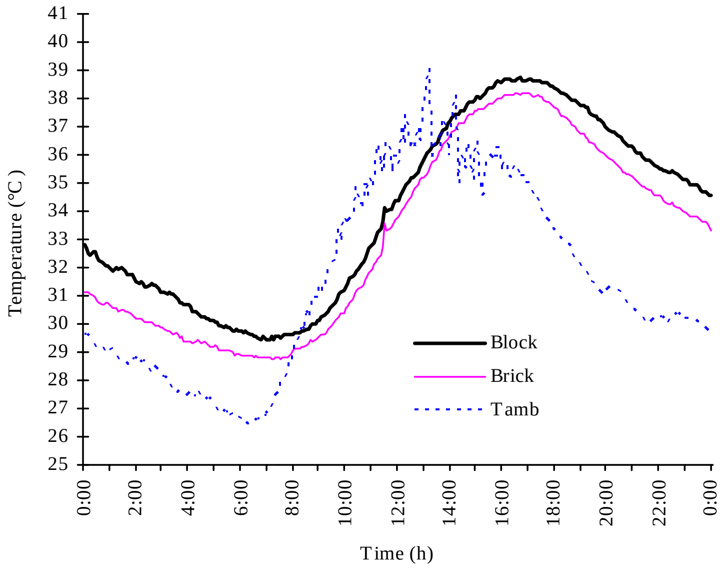


Figure 8: Comparison of average room temperature between the interlocking block and the clay brick walls.

5. CONCLUSION

A comparative study of thermal performance of interlocking block and clay brick has been carried out. The interlocking block has a higher conduction heat transfer rate than the clay brick, because both thermal conductivity and absorptivity are significantly high when compared with the clay brick. Therefore, the clay brick wall can reduce the electrical energy consumption of the air conditioner.

6. ACKNOWLEDGMENTS

The authors are grateful to Mahasarakham Univeristy for providing funding for this research work. The experimental helped by Mr. Taweewood Unarmart and Mr. Sarayoot Pholsud is highly appreciated.

REFERENCES

American Society for Testing and Materials. (2002a). ASTM C 140-02a: Standard Test Method for Sampling and Testing Concrete Masonry Units and Related Units, ASTM International, Philadelphia, United State.

American Society for Testing and Materials. (2002b). ASTM C 67-02c: Standard Test Method for Sampling and Testing Brick and Structural Clay Tile, ASTM International, Philadelphia, United State.

Cengel, YA (2003). Heat transfer: a practical approach. McGraw-Hill Inc., Singapore. 2nd edition.

Japanese Industrial Standards. (1995). JIS R 2618: Testing Method for Thermal Conductivity of Insulating Fire Bricks by Hot Wire.

Khedari, J, Watsanasathaporn, P, and Hirunlabh, J (2005). Development of fibre-based soil-cement block with low thermal conductivity. Cement and Concrete Composites 27, pp.111-116.

Vangtook, P, and Chirarattananon, S (2007). Application of radiant cooling as a passive cooling option in hot humid climate, Building and Environment. 42.pp. 543-556.