Investigating of Thermal Optimization of Mud Concrete

B.V.D.N Bandara[1], F.R.Arooz[2]and R.U Halwatura[3]
Department of Civil Engineering, University of Moratuwa, Sri Lanka

ABSTRACT: In this study, a sensitivity analysis has been carried out on comparing thermal behavior of mud concrete panels with mud concrete blocks and other walling materials. For this, actual models with different walling materials were experimented to obtain the variation of surface temperature, time lag and decrement factor. Furthermore, computer simulation was done using Design Builder in order to find out conductivity, R value and U value for mud concrete panels. From results it was found that mud concrete panels can create thermally comfortable environment inside buildings than mud concrete blocks and other walling materials. The outcome of present study is useful for designing thermally comfortable buildings with more passive features and low energy consumption.

1 INTRODUCTION

Enormous consumption of energy in present time has alarmed a critical notice about the situation of future world and indicates why world should turn into more sustainable approaches (Madhumathi, Vishnupriya, & Vignesh, 2014).This situation pressures building sector utterly because there is a massive energy consumption for both construction and maintenance sectors (Halwatura, Chamila, & Somarathna).

At present, a huge mass of energy is utilized to maintain the thermal comfort inside buildings. As a tropical country, Sri Lanka tends to use more energy feeding techniques such as fans, air conditioners to reduce indoor temperature (Santamouris, Cartalis, Synnefa, & Kolokotsa, 2015). But as a developing country these methods are not suitable because they lead to energy crisis and can affect the economy of the country. In order to overcome this problem, it is very important to introduce more passive concepts into building sector.

Building material is the most contributing part when applying passive features to maintain indoor thermal comfort. Among them, walling material plays the most significant role as wall covers a large part of the building (Elias-Ozkan, Summers, Surmeli, & Yannas, 2006).

In Sri Lanka burnt clay bricks, cement sand blocks, cement stabilized earth blocks and rammed earth are the most commonly used materials for wall construction. Although these materials provide high thermal comfort, they are required high embodied energy(Reddy &Jagadish, 2003).

To avoid this issue it is essential to investigate materials which have low energy consumption both in manufacturing and operational stage. For this, earth is the most suitable resource which can be utilized to produce building material with low embodied energy and high thermal comfort (Binici, Aksogan, Nuri Bodur, Akca, & Kapur, 2007). Mud concrete is a patent product which is newly introduced as an earth related material in Sri Lanka. Several experiments are ongoing to investigate various parameters of mud concrete to achieve thermal comfort goals as a building material. This research is mainly focused to investigate thermal behavior of mud concrete material using mud concrete panels.

2 OBJECTIVE AND APPROCH

The main objective of the study is to compare thermal behavior of mud concrete panels with other walling materials such as mud blocks, bricks with English bond and rat trap bond. Actual models for different walling materials were experimented to make a comparison of inside and outside surface temperature, decrement factor and time lag for different materials. The results were obtained and analyzed to interpret the thermal behavior and suitability of mud concrete panels as a thermally comfort walling material. Furthermore, computer simulation was carried out in order to find out several thermal properties of mud concrete.

1 Former Student 2 Postgraduate Student 3 Senior Lecturer e-mail : rangika@uom.lk

3 METHODOLOGY

3.1 *Sieve analysis test*

Sieve analysis test was carried out to check the particle size distribution of existing soil then the selected soil has been improved to achieve the mixture of Mud-Concrete.

Composition of soil

- 5% fines (particles < 0.425 mm)
- 35% gravel (particles > 4.75 mm)
- 60% sand (0.425 mm < particles < 4.75 mm)

3.2 *Constructing a model and measuring temperatures*

An actual small scale model of a house (as shown in figure 1) which was constructed using mud concrete panels was compared with other models casted using mud blocks and bricks with English bond and rat trap bond.

Figure 1: Model with mud concrete panels

Indoor and outdoor surface temperatures of walls and roof, inside and outside ambient temperature of each model were measured using data logger and several thermo couples. An accurate data set for 24 hours period from recorded temperature values was obtained for analyzing.

3.3 *Computer simulation*

"Design Builder" is the software which was used for the simulation. A model was simulated to represent the actual model of mud concrete panels. Then values for inside and outside surface temperature of walls obtained from simulation were compared with measured values and parameters of the software were calibrated until both above values become same.

According to the calibrated data, thermal conductivity, specific heat, R value and U value for mud concrete panels were obtained from Design Builder software.

4 REULTS AND ANALYSIS

4.1 *Comparison of inside surface temperature of each model*

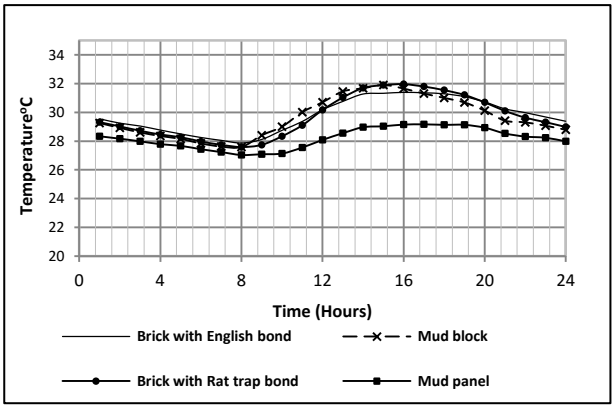

Figure 2: Temperature variation of inside surface

Considering comparison between mud concrete panels and other walling materials, mud concrete panel has the lowest surface temperature variation.

4.2 *Comparison of outside surface temperature of each model*

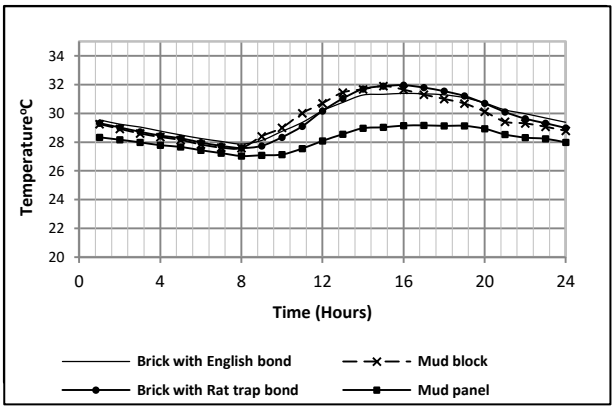

Figure 3 : Temperature variation of outside surface

According to outside surface temperature variation among mud concrete panels and other walling materials, mud concrete panels showed the lowest surface temperature.

4.3 *Comparison of time lag and decrement factor*

The time it takes for the heat wave to propagate from the outer surface to the inner surface is named as ''time lag'' and the decreasing ratio of

1 Former Student 2 Postgraduate Student 3 Senior Lecturer e-mail : rangika@uom.lk

its amplitude during this process is named as ‘‘decrement factor’’ (H. Asan, 2006).

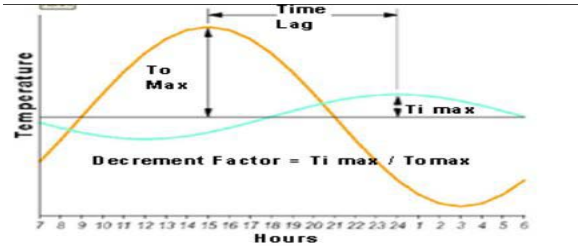

Figure 4 ; Time Lag and Decrement factor

$$Time\ Lag\ = t\,Tomax\ -\ tTi\,max \quad (1)$$

$$Decrement\ factor = \frac{Timax}{Tomax} \quad (2)$$

Tomax- maximum outside surface temperature
Tomin- minimum inside surface temperature

Time lag and decrement factor for all materials were calculated according to equation (1) and (2) using measured temperature data and comparison was done with each other.

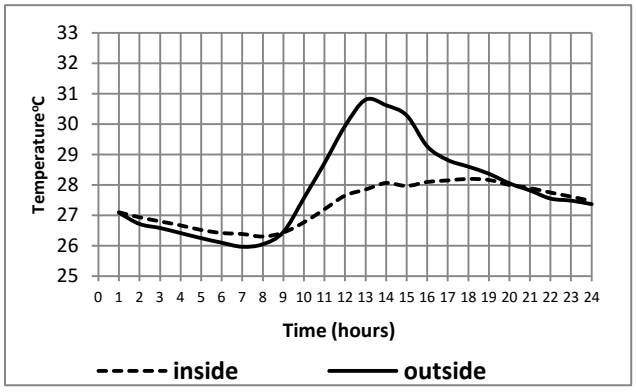

Figure 5: Inside and outside temperature variation of mud concrete panels

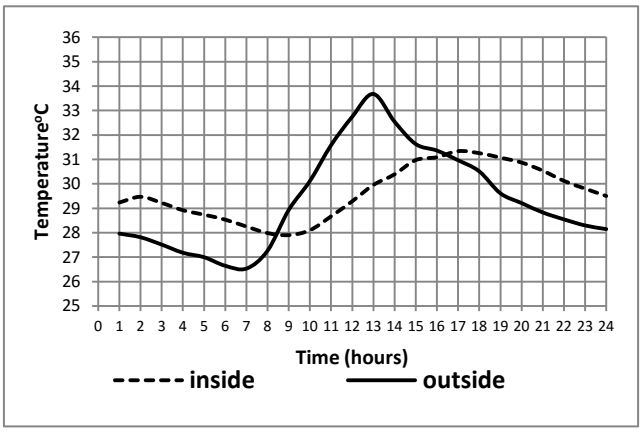

Figure 6 : Inside and outside temperature variation of mud concrete blocks wall

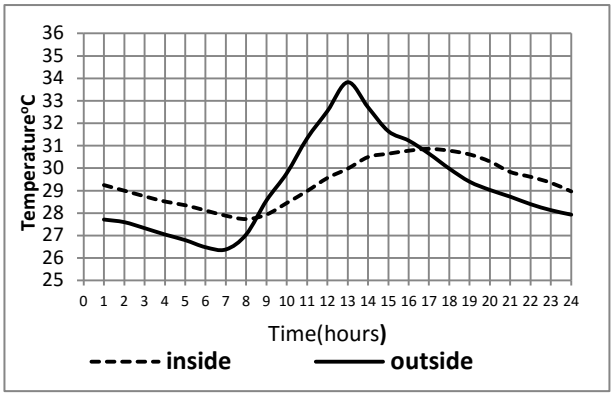

Figure 7 : Inside and outside temperature variation of brick wall with English bond

Table 1: Time lag for different walling materials

Type	Time Lag
Mud Panel	5.45h
Mud Block	5.32h
Brick with rat trap bond	5.25h
Brick with English bond	5.25h

Table 2 : Decrement factor for different walling materials

Type	Decrement Factor
Mud Panel	0.914
Mud Block	0.929
Brick with rat trap bond	0.941
Brick with English bond	0.964

According to time lag which is shown in table 1, Mud panel has the highest time. It means that mud concrete panels take more time to transfer heat from outside to inside. It indicates that mud concrete panels can form more thermally comfortable atmosphere inside buildings compared to the other materials.

The decrement factor is the ratio between the temperature fluctuation on the outer and the inner surface (H. Asan, 2006). According to calculated values shown in table 2, decrement factor for mud concrete panels is the lowest. It signifies that the variation of inner surface temperature of the wall is lower compared to the outer surface. Low decrement factor of mud concrete panels will ensure greater stability of the internal surface temperature, and is another means of helping reduce the risk of overheating.

1 Former Student 2 Postgraduate Student 3 Senior Lecturer e-mail : rangika@uom.lk

4.4 *Results from computer simulation*

Simulation was done for the model with mud concrete panels to find out the thermal properties.

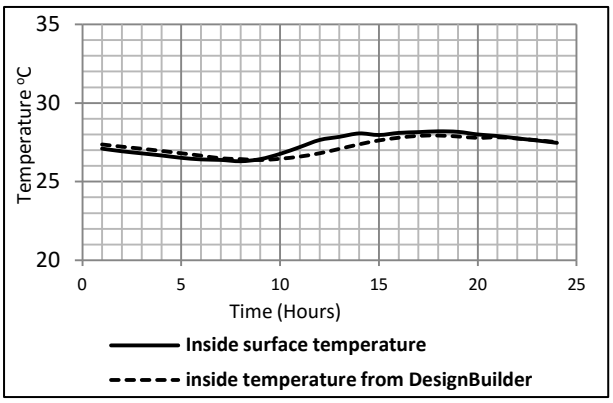

Figure 8: Inside surface temperature from Design Builder and actual inside surface temperature of mud concrete panel house

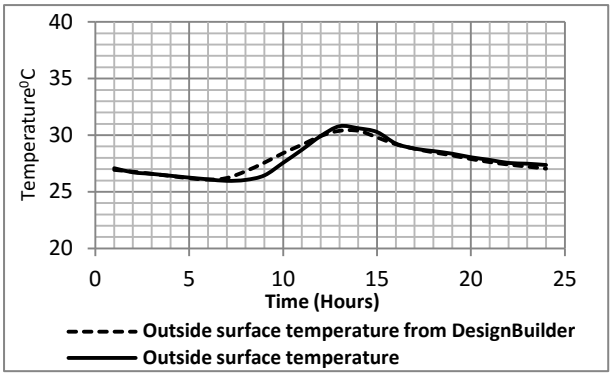

Figure 9 : Inside surface temperature from Design Builder and actual outside surface temperature of mud concrete panel house

According to figure 8 and 9, curves obtained from measured data and curves simulated from DesignBuilder were matched with each other by calibrating properties of Design Builder model. Then calibrated data were used to find out following actual thermal properties for mud concrete panels.

Table 3: Thermal properties for mud concrete panel obtained from Design Builder

Thermal property	Value
Conductivity (W/m.K)	1.2
Specific Heat (J/kg.K)	1440
Density(kg/m^3)	1540
R value(m^2-K/W)	0.366
U value(W/M^2-K)	2.17

According to results obtained from Design Builder (Table 3), it can be seen that mud concrete panels have high thermal conductivity but on the other hand it shows that specific heat and density of mud concrete panels are higher too. It means that mud concrete panels have high thermal mass which can store lot of heat energy in day time and can release in nighttime. Therefore mud concrete panels are capable with providing thermally comfortable atmosphere throughout the entire day.

5 CONCLUSION

The present study reveals that mud concrete panels can be used as a walling technique because it is capable with creating more thermally comfortable environment. The results on comparing temperature values of actual models show that mud concrete panels have the lowest temperature values for both inside and outside surfaces. And according to analyze of decrement factor and time lag, mud concrete panels have the lowest decrement factor and the highest time lag. In addition results obtained from computer simulation provided conductivity for mud concrete panels as 1.2 W/m.K, specific heat as 1440 J/kg.K, R value as 0.336 m^2-K/W and U value as 2.17 W/M^2-K. According to above values and outcomes, it can be concluded that mud concrete panels are capable with achieving more thermally comfortable atmosphere inside buildings. Hence mud concrete panels can be used as a thermally comfortable walling material for building construction.

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1 Former Student 2 Postgraduate Student 3 Senior Lecturer e-mail : rangika@uom.lk