International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072

Analytical Investigation of Heat Transfer in Fly Ash Brick and Clay Brick Masonry

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Abstract - *In the view of global warming and increasing environmental temperatures, it is necessary to study the heat transfer in wall which plays an important role in maintaining the building internal temperatures. Thus, to modify the internal temperature of a building, thermal insulation properties of wall element must be improvised. From the previous studies, it is observed that the fly ash brick has 33% higher compressive strength and the heat transfer rate is 7% lower than that of clay brick. This paper represents thermal properties of fly ash brick wall using analytical method of analysis i.e., IS-3792:1978.*

Key Words: Fly ash brick, Clay Brick, Thermal conductivity, Thermal resistance, Analytical Investigation.

1. INTRODUCTION

In understanding the thermal performance of building envelope, study of various thermal parameters of masonry units are fundamental, which helps in moderating the building internal temperatures. Several separate studies have been carried out on thermal and structural performance of various masonry materials. An attempt has been made in the current study towards analyzing the thermal behavior of masonry materials corresponding to clay brick and fly ash brick. This analysis comprises of evaluation of various thermal parameters of clay brick and fly ash brick masonry materials using analytical method.

In 2016, P.P. Gadling, Dr. M.B. Varma describes that fly ash bricks are more advantageous when compared to that of normal clay bricks. Experimental tests were conducted on two types of manufactured bricks for the comparative study.

In 2016, Saride Lakshmi Ganesh, Sambangi Arunchaitanya, focused on experimental study of hardened and thermal properties of fly ash bricks by use of polystyrene beads in varying proportions. The results of an experimental investigation on hardened and thermal properties of fly ash bricks containing expanded polystyrene beads (EPS) as a partial replacement of natural fine aggregates, it was proved that brick with 25% EPS content is having low thermal conductivity and low water absorption with good compressive strength of 8.12 N/mm2 is advantageous.

In 2017, K. Gourav, N. C. Balaji, B. V. Venkatarama Reddy, Monto Mani studies made an attempt for understanding the structural and thermal characteristic properties of masonry materials. Comparative studies have been carried out for Fly ash-Lime-Gypsum (FaL-G) Brick with locally available table moulded brick (TMB). This study concluded that the structural performance of masonry units, for both TMB and FaL-G brick are inversely proportional to the thermal performance.

In 2018, K. Suryaprakash, Dr.M.Raja, studies focused on experimental analysis of heat transfer in clay brick and fly ash brick walls. The walls are built using various bricks like clay brick, fly ash brick and hollow bricks and experiments were conducted to analyse their thermal characteristics and compressive strength. On the basis of results authors concluded that, fly ash brick is preferable for building without cement plastering using m-sand as a constructing material compared to clay brick. And also the compressive strength for fly ash brick is 33% more compared to clay brick. Fly ash is a waste product from coal based thermal power plants. India produces about 170 million tons of fly ash with only 67.63 percent of fly ash being utilized [5]. Fly ash is being used in the construction industry for making bricks and other applications. Venkatarama Reddy & Gourav [6] extensively studied the structural and durability characteristics of fly ash bricks.

2. METHODOLOGY

2.1. Selection of materials

The main objective of the study is an analytical evaluation of thermal parameters for masonry materials (clay brick and fly ash brick). Various inputs required for the calculation of thermal parameters are thickness of the component, thermal conductivity, density and specific heat capacity of the material as shown in Table [1].

Table -1: Thermal properties of building masonry materials

Specimen Type	Clay brick masonry	Fly ash brick masonry
Total thickness of wall (mm)	230	230
Thermal conductivity, k (W/m.K)	0.62	0.36
Density, ρ (kg/m^3)	1800	650
Specific heat, Cp (J/kg.K)	840	857

Fig -1: (a) Clay Brick (b) Fly Ash Brick

In this study two types of masonry materials i.e., clay brick and fly ash brick are considered for the analytical analysis and various thermal parameters are taken as shown in Table [1].

2.2. Analytical evaluation of thermal parameters

In analytical computation for the masonry materials considered thermal parameters like thermal resistance (R), thermal transmittance (U) are determined using equations taken from IS 3792-1978.

Thermal Transmittance or U-Value and Thermal Resistance

The U-Value is an important concept in building design. It represents the air-to-air transmittance of an element. This refers to how well an element conducts heat from one side to The other, which makes it the reciprocal of its thermal resistance.
Thus, if we calculate the thermal resistance of an element, we can simply invert it to obtain the U-Value see equation 1.

Thermal resistance can be written in a simplified form as

$$R = \{(1/f_o) + \sum (l/k)_n + (1/f_i)\}$$

$$= 1/U \qquad (1)$$

Where: U = Thermal Transmittance (W/m^2 K),
n = Number of inside layers of the element,
f_o= Outside surface coefficient (W/m^2 K) and
f_i= Inside surface coefficient (W/m^2 K).

3. RESULTS

Thermal performance parameters i.e., thermal transmittance and thermal resistance values are determined using the equation [1] (taken from IS 3792-1978) for two types of building masonry materials are shown in the following table [2].

Table -2: Thermal transmittance and thermal resistance values

Specimen Type	Clay brick masonry	Fly ash brick masonry
Outside heat transfer coefficient, f_o (W/m^2.K)	19.86	19.86
Inside heat transfer coefficient f_i, (W/m^2.K)	9.36	9.36
Thermal resistance, R (m^2 K/W)	0.53	0.80
Thermal transmittance, U (W/m^2.K)	1.89	1.26

Thermal resistance of fly ash brick is more than that of clay brick masonry as the thermal conductivity of fly ash brick is lower due to its low density as shown in the following figures [1 & 2].

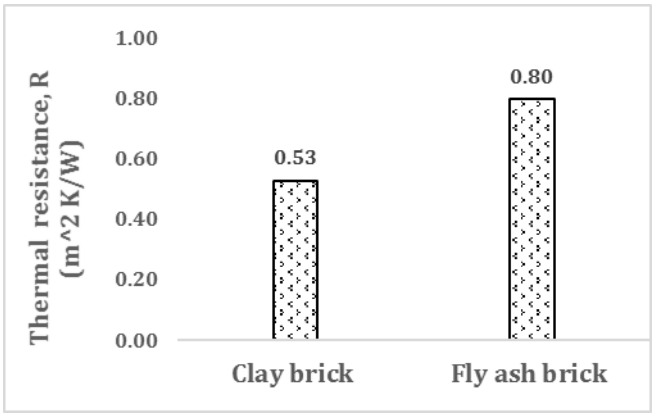

Figure 2. Thermal resistance values

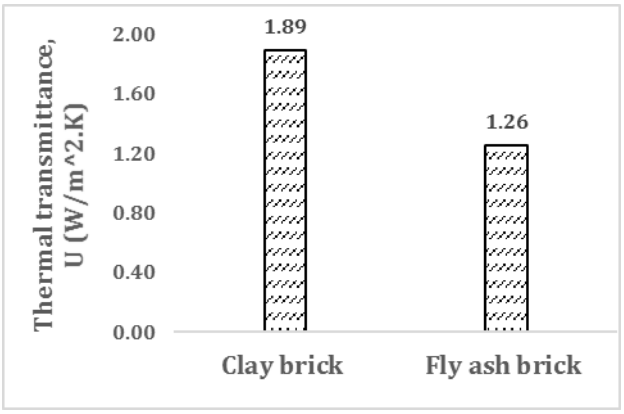

Figure 3. Thermal transmittance (U-Value) values

CONCLUSION

Two types of masonry i.e., clay brick and fly ash brick were selected for evaluating the thermal properties. An overview of evaluation of thermal properties of building materials using IS 3792-1978 was presented. From this study it can be concluded that fly ash brick masonry shown better thermal performance than normal clay brick masonry.

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