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Determination of Thermal Performance of Wall Materials for the Construction of Green Building

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Abstract—
The thermal performance of a building depends on a large number of factors. The EnergyConservationBuilding code 2007 (ECBC - Given by Bureau of Energy conservation, Government of India) suggest that the wall of a Building should minimize Conduction losses by using modern/conventional wall material preferably with insulation like air gaps etc. They can be summarized as design variables (geometrical dimensions of building elements such as walls, roof and windows, orientation, shading devices, etc.); material properties (density, specific heat, thermal conductivity, transmissivity, etc.); weather data (solar radiation, ambient temperature, wind speed, humidity, etc.); and building's usage data (internal gains due to occupants, lighting and equipment, air exchanges, etc.). A total of 13-different types of wall material are experimentally tested under controlled condition to measure their thermal performance including new material like Gyprop(M/s Saint Gobain) for a given size of wall (21cm). Based on the thermal resistance value brick type-2 and Gyprop (M/s Saint-Gobain, Bangalore) with cement mortar with insulation offers the best thermal **resistance for the construction of a green wall.**

Keywords—
building, wall, thermal, insulation, green

I. Introduction

A green wall, where foliage covers the external wall of a building, is considered to be a stainable solution as it has many benefits for the direct environment. However, the advantages for the consumer (owner or building occupant) remain limited. One of these advantages is the potential energy savings that come from a reduction in the building's cooling load. Energy transfer in a Building constitutes mainly due to construction material and techniques of construction (Fig.1). The thermal performance of a wall material contributes30%- 40% of the total heat transfer from a building. The paper discuss about the thermal performance of various wall materials for a given thickness of wall, area and location of the building (Bangalore region). Calculations are made for expected heat transmission (U) through wall, based on total thermal resistance (R_T) of the building material for a given area (A=1m^2) and thickness (Lj=21 cm) of wall.

Factors Affecting Thermal Performance of Building:

According to the *Second Law of Thermodynamics*, heat transfer is only possible in the direction from a higher temperatures to a lower one. It becomes zero if temperatures are equal.
The heat loss through an envelope should therefore be proportional to the difference ($T_{inside} – T_{outside}$), or to a positive power of it for small differences. For a simple formula, a linear dependence on temperature difference is sufficient. Accepting further that heat loss grows linearly with surface area A, one finds.The following factors affect the thermal performance in a green building:

Material Data	*:* Density, Specific heat, conductivity
Design Data	: Orientation of Building and its components like windows, walls, Roof
Climatic Data	:Radiation, temperature of region, wind speed
Building Data	: Building usage, internal heat gains, Air exchanges etc.

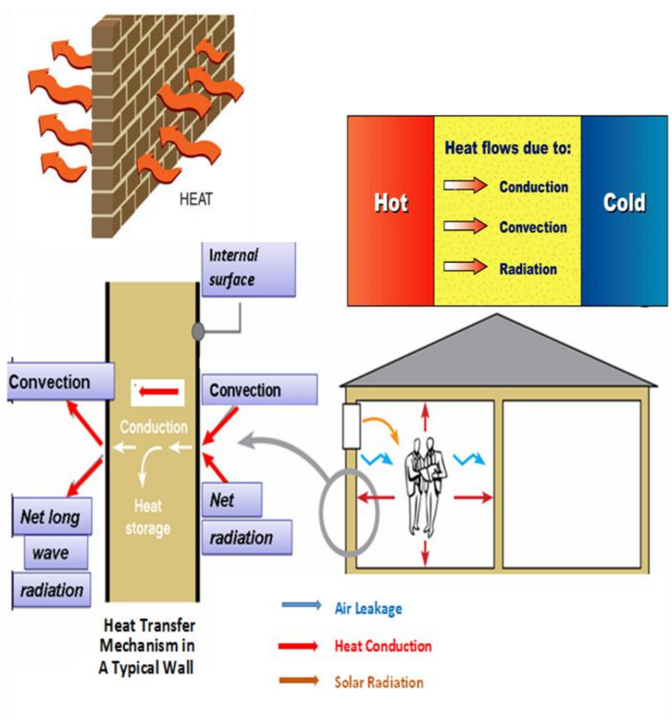

Fig.1 Heat Transfer Process through Building Wall

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II. Material and Methodology

The research paper discusses about the thermal performances of wall using seven types construction materials with/without air gap.Calculations are made for expected heat transmission (U) through wall (Fig.2) based on total thermal resistance (R_T) of the building material for a given area (1m2) and thickness (Lj=21 cm) of wall (Table-1).

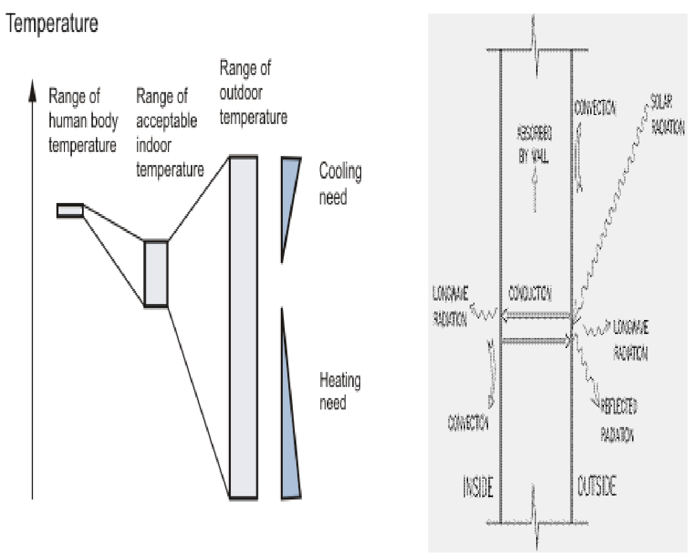

Fig.2 Heat Transfer Process in Wall

$$U = \frac{1}{R_T} \quad \text{Eq.1}$$

$$R_T = \frac{1}{h_i} + \left(\sum_{j=1}^{m} L_j / k_j \right) + \frac{1}{h_0} \quad \text{Eq.2}$$

Where, k_j is the thermal conductivity of the wall material in W/m-°k, and h_i and h_0 are surface heat transfer inside and outside the wall

The computations are carried out for Bangalore region which is considered under the ‘moderate climate’ zone amongst the five climate zones of India. The methodology adopted was based on assumptions that the building is not Conditioned (Non-AC). The heat transfer process through a typical wall material is considered for Conduction only. The Monthly Adaptive Comfort Temperature (ACT) at winter season of Bangalore region is calculated from:

$$\boldsymbol{ACT} = 16.2 + 0.41\boldsymbol{T_m} \qquad \boldsymbol{Eq}.3$$

$$\boldsymbol{ACT} = 23.1°\boldsymbol{C}$$

For T_m = 16.8 °C

The above analysis and result (Fig.3) clearly indicate the importance of wall material and insulation type for better thermal performance of a building. Higher Thermal Performance of building wall is desirable for modern residential and industrial buildings to achieve comfort, Long service life, and sustainable development. Energy efficient and resource efficient construction should provide comfortable indoor conditions.

The wall material temperature difference in control condition between inside and outside (Fig.2 (a) and Fig. 2(b)) is measured using a Thermocouple with digital indicator (k-type) having an accuracy of ± 1 °C. Very fine K-type thermocouples with a wire gauge of 0.025mm were used in order to reduce the measurement errors due to radiation.

Fig.2 (a) Measurement of Temperature across a Typical Brick wall with Air Cavity

The wall material temperature difference in control condition between inside and outside (Fig.2) is measured using a thermocouple with digital indicator (K-type) having an accuracy of ±1°C. Very fine K-type (WRNK-191), with a wire gauge of 0.025mm were used in order to reduce the measurement error due to radiation.

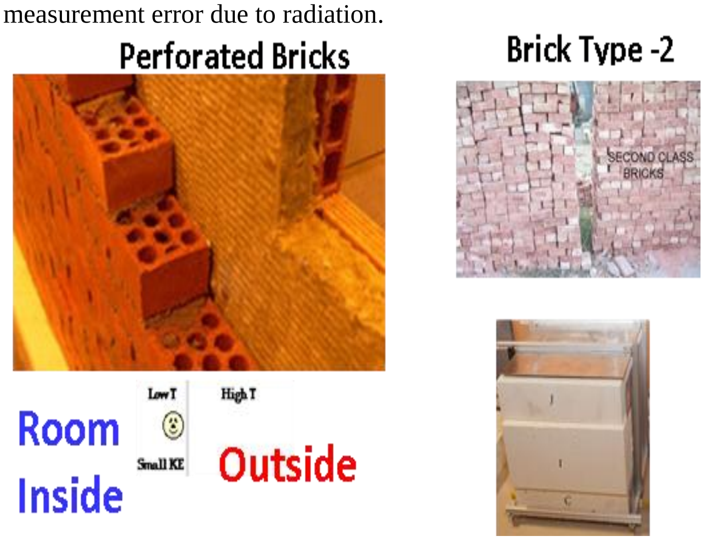

Fig.2 (b) Heat Transfer across Brick Wall with Air Cavity

III. Results and Tables:

The thermal performance of 13- different types of wall material is tested for assessing the thermal efficiency of each type and the values are concluded in Table-1. For each type of wall material the observation is done for 1-full day and the temperature variations for various types of walls are plotted along the time scale.

Expected Heat Transfer for Different Building Wall Material
Table-1

For a Given Area of wall 'A'= 1m², Thickness of Wall 21cm				
Wall Material	Wall Plaster	Insula -tion	Total Thermal resistance R_T (m^2-K/W)	Expected Heat Transmission U (W/m^2-°k)
Brick (Type-1)	Cement mortar	No	0.4322	2.3138
Brick (Type-1)	Cement plaster	No	0.4266	2.3441
Mud brick	Cement mortar	No	0.4512	2.2163
Mud brick	Cement plaster	No	0.4456	2.2442
Brick (Type-2)	Cement plaster	No	0.5577	1.7931
Brick (Type-2)	Cement mortar	No	0.5633	1.7753
Brick (Type-1)	Cement plaster	Yes	0.5749	1.7391
Brick (Type-2)	Cement mortar	Yes	0.7048	1.4188
Brick (Type-1)	Cement mortar	Yes	0.5806	1.7223
Brick (Type-2)	Cement plaster	Yes	0.6991	1.4302
Stone	-	-	0.2881	3.4710
Sand Stone	-	-	0.2112	4.7348
Gyprop(Saint Gobain)	Cement plaster	Yes	0.8625	1.1594

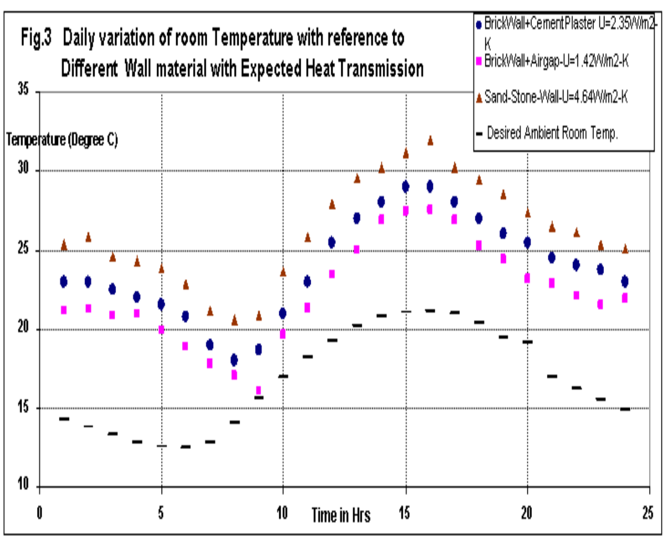

Fig 3. Daily Variation of Room Temperature and its Effect on Wall Heat Transfer

IV. Conclusions

- The above analysis and result (Fig.3) clearly indicate the importance of wall material and insulation for better thermal performance of a building. The brick type-2 and Gyprop (M/s Saint-Gobain, Bangalore) with cement mortar with insulation offers the best thermal resistance (Table-1) amongst the combination tested.
- Higher Thermal Performance of green building wall is desirable for modern residential and industrial buildings to achieve comfort, Long service life, and sustainable development.
- Paper gives a methodology to calculate the heat transfer through different wall material and select the best available local material to achieve the desired thermal comfort.
- These quantifications enables one to determine the effectiveness of the design and help in evolving improving designs for realizing energy efficient buildings with comfortable indoor conditions.

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