Evaluation and Experimental Analysis of Composite Materials of Passive Earth Berming Techniques for Green Buildings

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Abstract

Earth Berming are used to reduce thermal load in building envelop and is passive technique to achieve comfort. The composite walls with insulation are costly It is necessary to try different local material using earth berming for building envelop.

This research work is associated with theoretical analysis of earth berming systems of different composites using lawn plus lateritic soil/black cotton soil/porous soil and, brick wall with plaster on either side.

The prototype earth berming building are developed at laboratory scale and tested, evaluated for its thermal transmittance U values.

Keywords — *Earth berming, thermal balance, passive wall, wall cooling effect, wall thermal analysis, wall and comfort analysis.Energy conservation, Insulation, Building Envelop, and Building Insulation*

I. ABBREVIATIONS

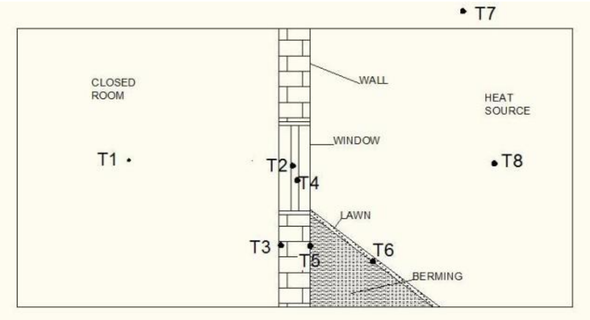
A= Surface Area (m2)
Ai = Area of the ith Transparent Element (m2)
B = Soil (m3)
C = External Plastering (m2)
C = Specific Heat of Air (J/ kg-K)
D = Brick Masonry (m3)
E = Internal Plastering (m2)
F = Lawn (m2)
K1 = Thermal Conductivity of lawn (w/m2-K)
K2 = Thermal Conductivity of soil (w/m2-K)
K3 = Thermal Conductivity of External Plastering (w/m2-K)
K4 = Thermal Conductivity of Brick wall (w/m2-K)
K5 = Thermal Conductivity of Internal Plastering (w/m2-K)
kj = Thermal Conductivity of its Material(W/m2-K)
L= Latent Heat of Evaporation (j/kg-k)
Lj= Thickness Layer (m)
M = Number of Transparent Elements
Nc = Number of Components
Q conduction = Rate of Heat Conduction (w)
Q evaporation = Rate of Evaporation (w)
Q ventilation = Heat flow Rate Ventilation (W)
Sgi = Daily Average Value of Solar Radiation (including the effect of shading) on the ith Transparent element (W/m2)
T1 = Temperature of Outside of Earth Berming (K)
T2 = Temperature of Lawn (K)
T3 = Temperature of Soil (K)
T4 = Temperature of External Plaster (K)
T5 = Temperature of Brick wall (K)
T6 = Temperature of Internal plaster (K)
Tf = Temperature of the fluid (K)
Ti = Indoor Temperature (K)
To = Daily Average Value of Hourly Ambient Temperature (K)
Ts = Temperature of the surface (K)
Tso = Solar-air Temperature
RT = Total Thermal Resistance
Ts = Daily Average Value of Hourly Solar Radiation Incident on the Surface (W/m2)
X1 = Thickness of Lawn (m)
X2 = Thickness of Soil (m)
X3 = Thickness of External Plastering (m)
X4 = Thickness of Brick wall (m)
X5 = Thickness of Internal Plastering (m)
U = Thermal Transmittance (W/ m2- K)
Vr = Ventilation Rate (m3/ s)
a = Base of Earth Berming. (m)
b = Height of Earth Berming (m)
c = Diagonal length of Earth Berming (m)
h = Heat Transfer Coefficient (W/m2-K)
hi = Inside Heat Transfer Coefficients(w/m2-K)
ho= Outside Heat Transfer Coefficients (W/m2-K)
i = Building Element.
m = Rate of Evaporation (kg/s)
ΔR = Difference between the long wavelength Radiation incident on the surface from the sky and the surroundings, and the radiation emitted by a blackbody at ambient temperature
ΔT = Temperature difference between inside and outside air (K).
ΔT = Temperature difference (To – Ti) (K)
αs = Mean Absorptive of the Space
ε= Emissivity of the Surface (m2).
ρ = Density of air (kg/ m3)
T*i* = transitivity of the ith transparent element

II. INTRODUCTION

The earth bearming techniques are passive in nature and are important. This can be effectively used for controlling inside temperature and humidity in composite and hot and dry zones. Earlier they are used at random considering the topography and the climate. However it can be used as passive technique. Many researchers have used and evaluated it; however no theoretical evaluation is done. It is an thermodynamic system and thermal equations can be established for evaluating the same before its uses and effectiveness can be experimentally checked. This research work establishes thermal equations and same are tested experimentally for its thermal resistance values U

III. RESEARCH

A. Thermal Load Design Calculations



1. Heat transfer and heat balance at Earth Berming Heat Transfer by Thermal transmittance Ui

$$Qc = \sum_{i=1}^{Nc} (Ai\ Ui\ \Delta Ti) \text{--------------}(1)$$

If the surface is also exposed to solar radiation then,

$\Delta T = Tso - Ti$ ----------------------------------- (2)

$$T_{SO} = T_0 + \frac{\alpha S_T}{h_0} - \frac{\varepsilon \Delta R}{h_0} \text{------------------}(3)$$

Ventilation The heat flow rate due to ventilation of air between the interior of a building and the outside depends on the rate of air exchange. It is given by:

$Qv = \rho\ Vr\ C\ \Delta T$ -------------------------- (4)

Solar Heat Gain The solar gain through transparent elements can be written as:

$$Q_S = \alpha_s \sum_{i=1}^{M} A_i\ S_{gi}\ \tau_i \text{------------}(5)$$

Internal Gain Thus the heat flow rate due to internal heat gain is given by the equation:

Qi = (No. of people × heat output rate) + Rated wattage of lamps + Appliance load ------------ (6)

Evaporation generally refers to the removal of water by vaporization from aqueous solutions of non-volatile substances. It takes place continuously at all temperatures and increases as the temperature is raised. Increase in the wind speed also causes increased rates of evaporation. The latent heat required for vaporization is taken up partly from the surroundings and partly from the liquid itself. Evaporation thus causes cooling.

Q evaporation = m x L ------------------- (7)

Equipment Gain If any mechanical heating or cooling equipment is used, the heat flow rate of the equipment is added to the heat gain of the building.

Heat balance equation

Q total = Q c + Q v +Q s + Q i + Q ev + Q equ ----- (8)

Q v, Q i , Q equ , this value are negligible in earth berming system.

Q total = Q c+ Q ev ----------------------- (9)

$$Q_{total} = \sum_{i=1}^{Nc} A_i\ U_i\ \Delta_i\ + mL---(10)$$

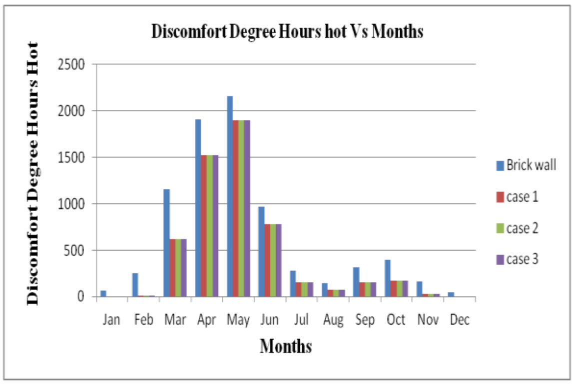
$$Q_{total} = \sum_{i=1}^{Nc} \frac{Ai(Tso - Ti)}{\frac{1}{hi} + (1/hi) + (\sum_{j=1}^{m} Lj/kj) + (1/ho)} + mL(14)$$

$$Q_{total} = \sum_{i=1}^{Nc} \frac{Ai\left(T_0 + \frac{\alpha S_T}{h_0} - \frac{\varepsilon \Delta R}{h_0} - Ti\right)}{\frac{1}{hi} + \frac{1}{hi} + \{\frac{x1}{k1} + \frac{\int_0^a da}{k2} + \frac{x3}{k3} + \frac{x4}{k4} + \frac{x5}{k5}\}}$$

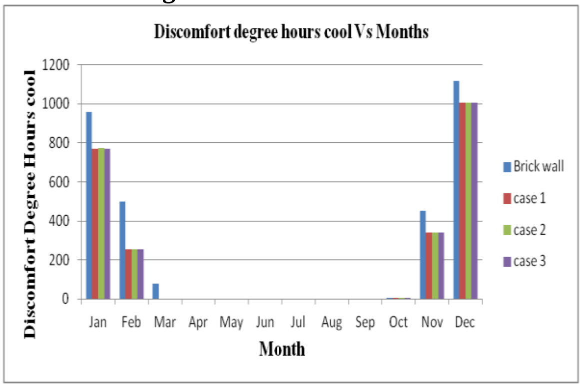
$$Q_{total} = \sum_{i=1}^{Nc} \frac{\sqrt{a^2 + b^2}\,x1 + \sqrt{\int_0^a (da)^2 + \int_0^b (db)^2}\ x\ 1\ + 3b}{\frac{1}{hi} + \frac{1}{hi} + \{\frac{x1}{k1} + \frac{\int_0^a da}{k2} + \frac{x3}{k3} + \frac{x4}{k4} + \frac{x5}{k5}\}}$$

B. Influence of Earth Bearming on Comfort by Discomfort degree hours

The equivalent composite wall is considered for triangular earth berming shape and discomfort degree hours for hot and cool conditions are worked out for a moderate zone in India with18° .32"North latitude and 73°. 51"East longitude using Ecotech 11, simulation tools and results are compared with standard burned brick wall.



Discomfort degree hours --hot Vs Months



Discomfort degree hours cool Vs Months

The laterite soil earth berming with lawn has been effective in reducing the discomfort hours as compared to that of burned brick solid wall. Lateritic soil with lawn results show that hot and cool discomfort degree reduced. The Ui values for different composites are represented below

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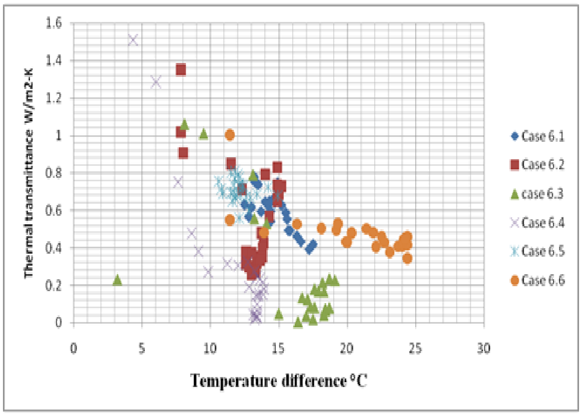

IV. CONCLUSIONS

The thermal performance in terms of thermal transmittance using these materials are evaluated and analysed as under

Finally it is concluded that the U value of earth berming using Laterite soil with lawn is lowest 0.245 and is supported by reduction in discomfort hours over the year in a moderate zone in India, hence it is recommended for achieving comfort in building envelope

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