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Modeling & Thermal Analysis of Cavity Wall Using Simulation Technique.

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Abstract: Urban regions are facing emerging problems of Urban Heat Island creation. It has been observed by researchers that the urban regions or areas are having 4 to 5^0C more as compared to nearby regions. This increased in temperature difference is leading to more consumption of energy for making this zones thermal comfort areas. Change in mode of construction from mud, clay , bamboo , timber to concrete and cement based product is responsible for this urban problems. The thermal conductivity of concrete products like PCC, RCC , Brick Blocks are more and thus the inner temperature of room increase with minimum temperature gradient , making discomfort to the habitants. In earlier decades the technique of cavity wall was invented so as to mitigate the walls thermal conductivity. The study in this paper is done to check out the feasibility of cavity wall with insertion of various materials in cavity area and its thermal property is studied. The aim of the study is to find out feasibility of cavity wall as an alternative technique for wall which proves to be thermo resistive, economical and durable. The study is done by making the model of cavity wall and normal conventional brick wall and observation for inner –outer temperature difference is made for various cases. Further study is done to find out equivalent conventional brick wall thickness for providing same thermo resistive effect as of Cavity wall.

Keywords – Cavity wall , thermo resistive , Urban heat islands, feasibility study , waste material
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1. INTRODUCTION

In the operational phase of builing or structure it requires varoius types of energy for different purpose. It require electrical energy for cooling, lighting, etc. to conserve such such energy is also very essentional. In tropical region like, Akola where temperature is too high mainly operational energy is use for cooling pupose. Various precaution at time of construction are made too keep the structure cool. The temperature inside the building can be kept low by providing some thermal resitive medium. It will prevent the heat transfer form the sorrounding. The structure has roof of RCC and wall as brick wall, these two compontent can be replaced with thermal resitive medium. It should also serve the other required characteristic as slab and wall. For this we can use the technique of cavity in the wall known as cavity wall. Similarly instead of RCC slab, we can use green roofs.
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1.1 Cavity Wall

Cavity wall construction is similar to normal wall. In 9" wall we create a cavity and such wall construction is called cavity wall. The gap between the 'leaves' or walls of the building which was originally created to allow any rainwater that penetrates through the outside wall, to drain down the inside of the wall to below the damp proof course (DPC). The cavity (ranging from 2inches to 4.5 inches in width) may or may not contain insulation. Combining these elements with a sound structural design, appropriate details, quality materials and good workmanship will result in high performance cavity walls.

2. LITERATURE REVIEW

A healthy building can be defined which having sound designing and planning for heat, ventilation and air is conditioning. The improper design of illumination or ventilation leads to poor indoor air quality and may lead to serious health problem of habitants. John D. Spengler (1) studied the various rules and regulations that are to be followed for having good HVAC system. The IAQ factor needed and the present ventilation system is also specified. Further the study was done for changing construction material used and its effect in indoor air quality, emissions from surfaces and its potential harmfulness.

It is essential to quantify the Embodied Energy of House, depending upon the geographical location, material used and purpose of building the value of EEV changes. The value of EEV is very high as they are required in large quantities in the building construction. Embodied Energy value matrix is the total energy required in manufacturing of the material (sourcing, processing, transportation, handling, wastage. Thus when the type of material changes total EEV also changes. This evaluation of EEV is done for green building material by D.Bansal (2).

Building envelop insulation is another approach for sustainability in housing is suggested by H. Agrawal (3). Building across the globe consumes 60 to 70 % of energy and building envelops contributes 75% of energy consumption out of it for heating and cooling effect .This huge amount of energy can be saved by insulating this envelops with provision of roof insulation, Brick bat coba , Tar felt membrane , mud Phuska technique , wall insulation techniques like double brick wall with cavity etc.

Y.P.Kajale (4) suggested prefabrication of concrete elements as sustainable approach for future green construction. 3-s prefab for housing sector includes precaste RCC dense concrete slabs , autoclave light weight RCC slabs, floor and roof , light weight cellular building blocks , precast dense cement concrete columns , beams ,stairs , galvanized powder coated iron frames , door and windows etc. All this methodology leads to speedy, safe and strength construction practice. J.S.Chauhan (5) studied and presented various sustainable materials that can be used in buildings like solid concrete blocks fly ash mixed, hollow blocks, calcium silicate bricks and their adoptability in construction. K.D Sadhale , K.A.Sahakari & N.Dias (6) studied the use of precast technology for low cost housing. It is unavoidable to shift and rehabilitate project affected people due to infrastructure projects and at such time the rapid and sustainable method for construction should be adopted. This construction can be achieved by application of pre caste technology. For the case study under taken complete construction was based on precast members including lintels, chajja , brackets, slabs, panels , doors and windows , stairs and it has been estimated the saving of 30% economy in this technology followed.

B.W.Olesen,(7) conducted study of various International codes and found that the development of codes should be done on the basis of classes. Critical issues such as adaptation, effect of increased air velocity, humidity, type of indoor pollutant sources etc. are still being discussed, but in general the standards does not include this. It is nevertheless important to take into account people's clothing related to regional traditions and season. And thus , there exist to revise codes and specifications considering all this aspects for proper IOQ

O.Boccia,et.al (8) compared the experimental and numerical results for the natural ventilation and energy efficient design of window with the name ventilated illuminating wall , the prototype with 1:1 scale model , consisting of precast removable window and room was tested for its feasibility. The internal, external temperature, external and indoor wind speed were checked with simulated model made in fluent/Airpak. The numerical analysis considers steady state condition however, the simulation model benefited with dynamic mode consideration too.

Alexander Kayne(9) carried out research work on computations fluid dynamics modeling of flows in buildings , as it has become matter of concern from last few decades. In 2009, buildings wee the second largest energy consuming sector in U.S, using upto 33.9% and 77.8% of electrical energy consumption. Thus, the research work was carried out to calculate indoor velocity using computation fluid dynamics method considering normal, forced mixed convection in 2D cases and 3D enclosures using simulation in FLUENT software.

Similar work is done by A. Peri. Et,al.(10) with considering the importance of air temperature, air flow, velocity in hospital ward so as to avoid infection and contamination due to improper ventilation designing. The simulation of various models with air flow and boundary parameter were designed and with concept of moving wall the thermal , air velocity pattern and graphs are obtained using CFD FLUENT simulation techniques so as to find most efficient ventilation design.

3. MODELING AND DESIGNING

A model of cavity wall in total area of six square feet with height of one foot six inches is made up. The model is built on the wooden plank. This has PCC layer at the bottom. The model is has the wooden frame in which wall is made of cement sheet. Model consist of a room in which one side is cavity wall and remaining three wall are made of cement sheet. The model is fitted with two thermometers one on the cavity wall face and another on opposite wall for measuring the temperature difference. The cavity wall is made with one layer of brick wall with a cavity of 2 inches and then another brick wall. The cavity is filled with various waste materials and temperature variation is observed. The various waste material are: agricultural waste, paper, ash, jute etc. . AC sheet are used as barrier for other sides. The top of cavity wall and room is covered with the AC sheet. The model is prepared as shown in figure. The model is kept in open surrounding and reading is taken on various timing for different atmospheric condition.

Dimensions:

Width of wall: 0.30 m
Length of wall: 0.60 m
Height of wall: 0.45 m
Surrounding Condition: all other 3 sides covered by asbestos sheet and bottom is provided with PCC so as

to gain natural room conditions. Top is again coved with asbestos sheet.

Thermometer locations:

1. Outside to measure outer temperature
2. Just near face of cavity wall
3. Away from cavity wall and close to asbestos sheet.**Frequency of readings**: 4 times in a day.

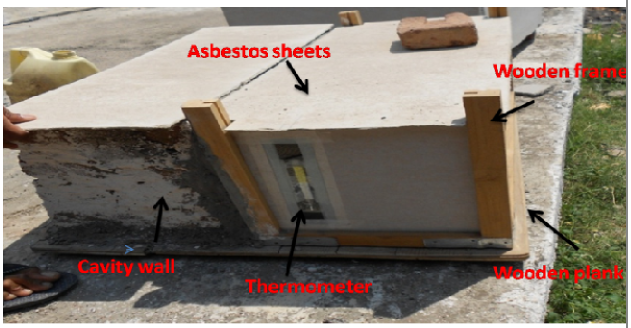

Fig-2: Cavity Wall Model

3.1 General Behaviour of AC sheet with Increase in inner outer temperature difference.

The calculation is made to study the behaviour of AC sheet wall surface with change in inner outer temperature difference and is represented in form of chart as show below:-

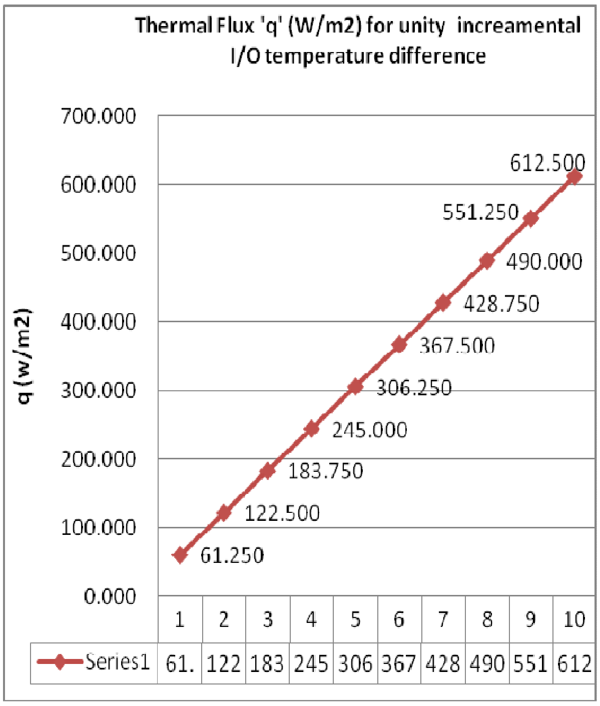

Fig-3: Thermal Flux values for AC sheet wall

3.2 Thermal Behavior of Burnt Brick wall

Similarly the study and calculation is done for making out the thermal behavior of conventional brunt brick wall of predefined thickness and its thermal flux values for inner outer temperature difference are represented in form of chart as shown below:-

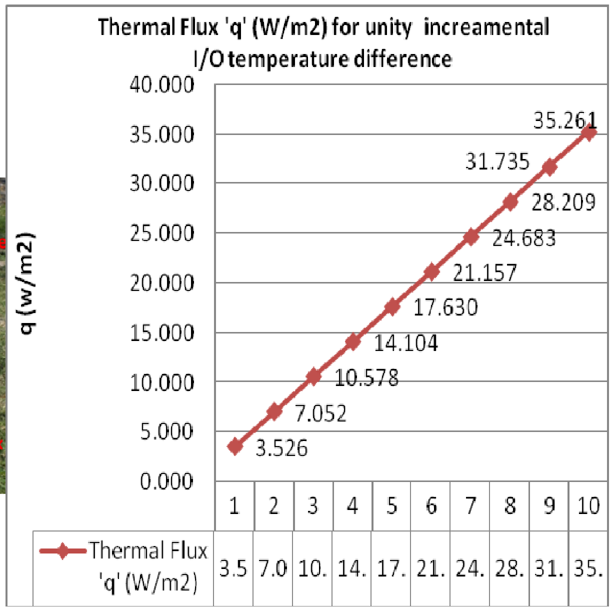

Fig-4: Th. flux value for burnt brick 0.23 m wall

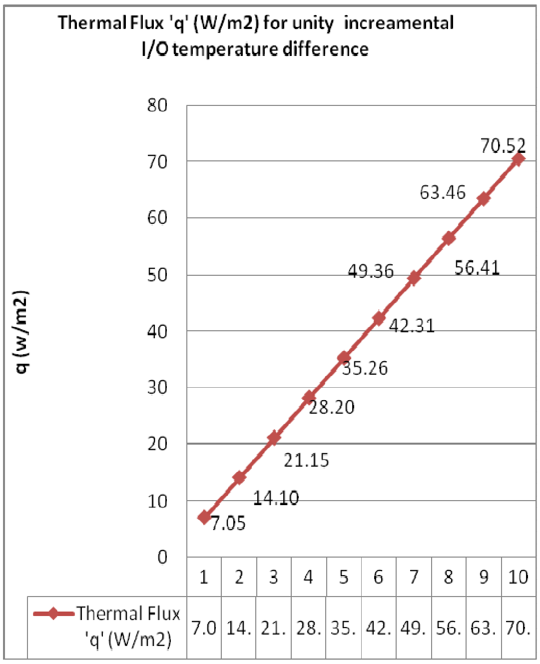

Fig-5: Thermal flux value for brick 0.115 m wall

Thermal flux for unit increment of element thickness keeping K, dt & A constant for Brick wall

Using Formula :-

Q= dt/(L/KA) = dt/Rth

q=Q/A

Constant Values:-

Thermal Conductivity K= 0.811 (Source: CSIR,IIT Roorke)

C/S area A= 1 sqm

I/O Temperature Difference = 1 (°C)

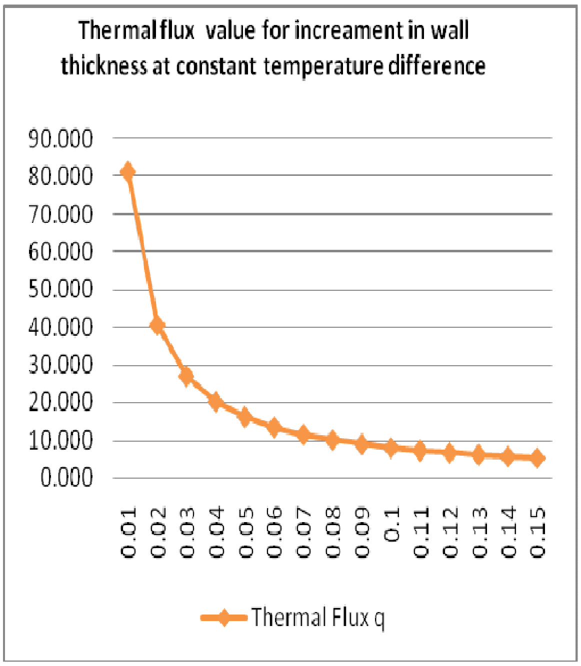

Fig-6: change in flux with change in thickness

4 Modelling and anlysis by Ansys :-

Thus, Further work is done by porcess of simulation for Clay Brick wall and Cavity wall subjected to same temperature values , known thermal conductivity and flux , so as to determine equivalence thickness of nomal wall for maintaing same inner temperature as provided by cavity wall .

1) Cavity wall Simulation :-

Constant parameters:-

Thickness overall : 0.25 m (0.1 + 0.05 + 0.1)

Area C/S : 3.6* 3.1 m^2

Inner outer Temperature Difference : 4 °C

Thermal Coefficient of Clay Brick 'Kb': 0.811 (W/m°C)

Thermal Coefficient of cavity section 'Kc': 0.024 (W/m°C)

Unknown factor :-

Heat flow Q (w)

Heat flux q (w/m2)

PRINT HEAT REACTION SOLUTIONS PER NODE

***** POST1 TOTAL REACTION SOLUTION LISTING *****

LOAD STEP= 1 SUBSTEP= 1

TIME= 1.0000 LOAD CASE= 0

NODE	HEAT
1	19.159
4	-19.159

TOTAL VALUES

VALUE 0.63594E-12

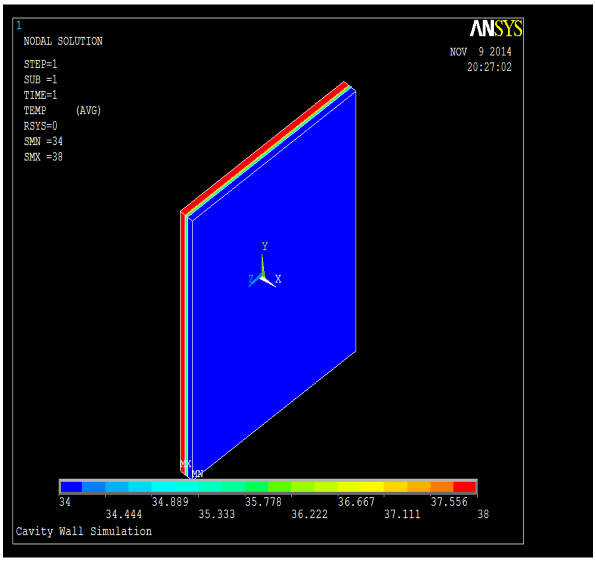

Fig 7. Temp. Gradient in cavity wall.

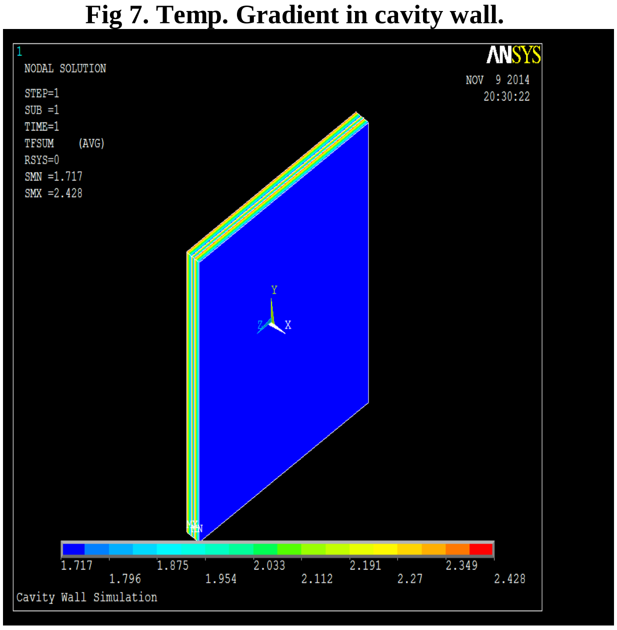

Fig 8. Thermal flux in cavity wall.

2) Normal wall Simluation :-

Constant parameters:-

Area C/S : 3.6* 3.1 m^2

Inner outer Temperature Difference : 4 °C

Thermal Coefficient of Clay Brick 'Kb': 0.811 **(W/m°C)**

Heat flow Q (w) : 19.159
Heat flux q (w/m2): 1.717

Unknown factor :-

Thickness :

PRINT HEAT REACTION SOLUTIONS PER NODE

***** POST1 TOTAL REACTION SOLUTION
LOAD STEP= 1 SUBSTEP= 1
TIME= 1.0000 LOAD CASE= 0

NODE HEAT
1 19.165
2 -19.165
TOTAL VALUES
VALUE 0.0000

***** POST1 NODAL GEOMETRY LISTING
TIME= 1.0000

NODE LOCATION
1 0-0-0
2 1.889-0-0

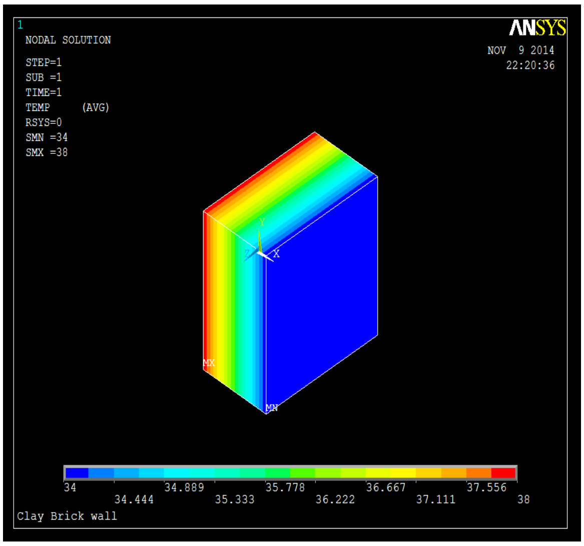

Fig 9. Temp. Gradient in normal wall.

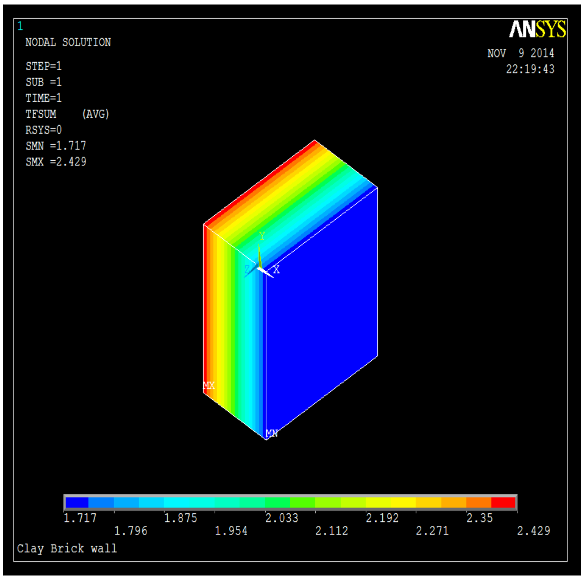

Fig 10. Thermal flux in normal wall.

Equivalence thermocooling calcualtions:-

The calculations below highlights the effectiveness of cavity wall for cooling purpose . Various sets are considered , keeping respective material conductivity , Area , Thermal flux constant to get the values of thickness required for normal brick wall to get equivalent I/O temperature difference for increamental values by unit ^{o} c .

The chart below highlights that if 0.25 m thick cavity wall bring 1 degree temperature differce , same differece will be achived by normal wall with thickness of 1.889 m , set of constants considered. Similary calculation is done for 3 incremental values of temperature differece.

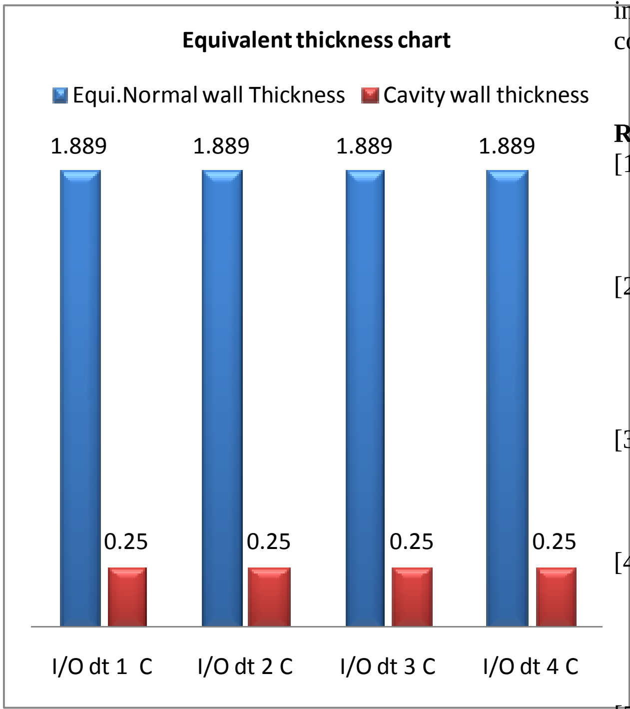

Fig 11. Equivalent thickness Chart for normal wall to create same cooling as that of cavity wall.

CONCLUSION

As the value of heat transfer governs by both i.e temperature difference 'dt' and Thermal Resistance 'Rth' of material , the calculations highlight that more the value of dt more will be rate of heat transfer , so for thermo resistive material if inner outer temperature is high , the rate of heat transfer will increase and will decrese with incresase with increase with value of Rth i.e thermal resistance.

Along with that the inner space of model was surrounded with AC sheets so as to avoid direct air flow in inner area , so the tempeature recording of inner faces are influenced by thermal flux of AC sheets too.

To avoid errors in calculations , for various sets of systems the relative diffrences are calculated .

However, in actual construction practise the effect of walls and replacment will be observed significantly when compared to Brick wall.The experimental work done for various waste materials mixed in cavity shows possiblies of using this waste as effective and usefull insulating material for housing systems. Thermal resistive poperty of wall changes with change in filling material and thus application shows positive approch towards acceptance of such cavity walls for reduction in energy conumption and innovative method for waste utilization in construction industry.

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