Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 5, May -2015

Investigation on effect of coconut husk as an insulation on primary energy and CO_2 emissions of residential buildings

Mr .Arpan Upadhyay[a], Asst Prof. Harshal Oza[b] , Asst Prof. Jyotin Kateshia[c]

a *Post graduate student-Gandhinagar Inst. Of Tech., Gandhinagar*
b *Asst Prof. - Gandhinagar Inst. Of Tech., Gandhinagar*
c *Asst Prof - Gandhinagar Inst. Of Tech.,Gandhinagar*

Abstract *—This paper discusses the effect of coconut husk as insulation on fixed space closed volume for energy conservation in multi storey residential buildings. Currently air conditioning system is used for maintaining the temperature of room in residential buildings which consumes more electricity. This method, by using coconut husk as insulation within buildings will help to reduced heat transfer within closed space and maintain the room temperature thereby electricity consumes less. Heat loss analysis has been carried on fixed volume spaced without insulation and predicts energy consumption. Than developed insulation from coconut husk using suitable binders and implement it on fixed volume wall and carried out heat loss analysis again. This study discusses the results obtained by testing effect of coconut husk as insulation on fixed space volume in both case with and without insulation. On the basis of it how much primary energy sources consumption in kg can be predicted by comparing heat loss analysis in both cases and co_2 emissions can be prefdicted*

Keywords- *Coconut husk, Insulation, Energy consumption, Heat loss, Primary energy sources*

I. INTRODUCTION

Maintain a comfortable indoor building environment is necessary for reduce energy consumption from the nation. In country due to burning of fossil fuels and increasing environmental pollution leads to increase in CO_2 emissions in atmosphere so, energy demands can be reduced with the use of thermal insulation. Thermal insulation is the reduction of heat transfer between objects in thermal contact or in range of radiative influence. Thermal insulation can be achieved with specially engineered methods or processes, as well as with suitable objects shapes and materials. In thermal insulation heat flow through the contact between objects of differing temperature. Thermal insulation provides a region of insulation in which thermal conduction is reduced or thermal radiation is reflected rather than absorbed by the lower-temperature body. Low thermal conductivity (k) materials reduce heat fluxes. The smaller the k value, the larger the corresponding thermal resistance (R) value.

(A) Building insulation

Building insulation is the insulation material use in building for thermal comfort for its occupants. Insulation reduces unwanted heat loss or gain can decrease the energy demands of heating and cooling systems. Insulation material in buildings prevents the transmission heat from exterior buildings wall which capture the heat energy from the sun. Some major building insulation materials used in buildings are cellulose, glass wool, rock wool, polystyrene, wood fiber, vermiculite etc and also some insulation materials made from agricultural wastes like coconut husk, rice husk, bagasse, corn cobs, palm oil leaves etc, also used in building insulation to reduced energy consumption. Function of building insulation is as below

- Maintain a comfortable and hygeienic indoor cliamte at low temperature
- The main aim of thermal insulation in winter is enrgy conservation leading to decrease heating demand and hence the protection of environment.
- Protect the atmoshphere through reduction of CO_2 , NO_x and green house gases.
- Reduce the heat loss or heat gain to achieve energy conservation.

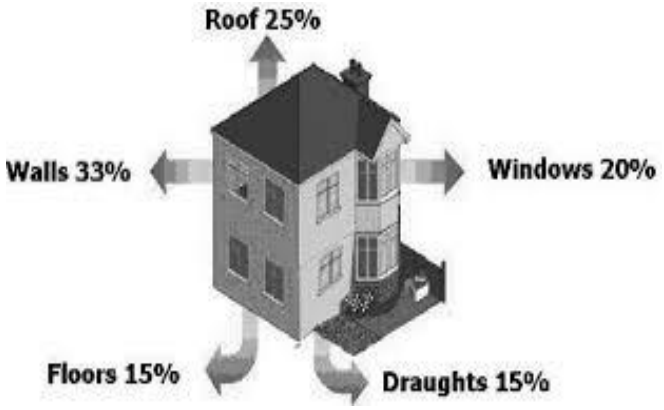

Figure 1. Heat loss from residential buildings

II. COCONUT AS AN INSULATIUON

India is the third largest producer of coconut in the world producing 9.4 million tons from this about 50% coconut husk is 4.2 million tons per year produced. Coconut husk have thermal conductivity K in range 0.054-0.143 W/m K and average density of coconut husk is 386 Kg/m^3. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Coconut fibers are commercial available in three forms, namely bristle (long fibers), mattress (relatively short) and decorticated (mixed fibers). The physical, chemical and mechanical properties of coconut fiber are presented in table 1. In this study from literature review the thermo physical properties of environmentally friendly biodegradable agricultural by-products such as oil palm, coconut, and sugar cane were investigated to ensure its ability for use for building thermal insulation. Experimental investigation of agro wastes materials were done using ASTM C518 standard which is normally use for measure the thermal conductivity of material under the steady state one dimensional test conditions with heat flow. In this experimental testing condition four parameters fiber mean diameter, density; Fiber length and thermal conductivity have measured for selected three materials oil palm, coconut, and sugarcane.

Figure 1. Coconut husk

Coconut husk has been used as a raw material for making building insulation boards using the hot pressing method have low thermal conductivity, varying between 0.054 and 0.143 W/mK. . Hot pressing is the process in which heat and pressure is applied to a mattress composed of fibers and resin to mould the final product In this study, binder less insulation boards made from coconut husk and bagasse were manufactured using hot pressing with pressure .

Table 1. Coconut husk properties

Sr no	Properties	
1	Thermal conductivity	0.054-0.143 W/mK so it has high thermal resistance
2	Density	Coconut husk having high density 250-380 kg/m^3
3	Tensile strength	15-327 Mpa for coconut husk fibers
4	Production	Coconut husk is most abundant materials available in our country produce 4.5 million tonnes per year than other agricultural wastes like corn cobs, palm oil ,durian peel etc
5	Water absorptivity	80 -90% water absorption
6	Fire resistance	It provides excellent insulation against temperature and sound due to its good flame-retardant properties than other agricultural wastes.
7	Toxicity	No chemical additives are added lead to ecofriendly and non toxic performance
8	Cost	Coconut husk is agricultural waste materials easily easily available from natural with very low cost which is negligible so manufacturing insulation material cost is low
9	Moisture content (10%)	It is very tough and durable and unaffected by moisture and dampness.

(A) Experimental set up

Figure2. Closed space volume room model

Figure 3. Inside view of closed space model

Figure 4.Heater on condition in room

Figure 5.Digital temperature meter

(B) Testing procedure

- Select the fixed volume space made from wooden box having dimension As shown in fig(a) square wooden box with fixed volume having 1.21 m×0.9 m ×0.9 m dimensions is fitted with window A.C.
- Inside view fig (b) of closed spaced shows four heater coils is connected to achieve the temperature of space and one small fan is put in the room, thermo coal sheet with 1.5 cm thickness is implemented on all walls of inside space which consider as wall of wood.
- As shown in fig (a) four separately switches are available on the board for on/off individual heater coil inside the room spaced and display shows heater current.
- In this set up, three temperature level wants to achieve are 50°C, 45°C and 35°C by using heater in closed space respectively
- First put the multi digital temperature meter or thermometer inside the closed space for taking temperature readings inside room and closed the door of room as shown in fig (d)
- Now, switch on as fig(c) of all heaters to achieve the temperature of closed space first 50°C , once digital temperature meter indicate temp of space 50°C than off all switch of heaters and start stopwatch for taking reduction timing for closed space to reach up to 40°C
- Find the heat loss without insulation.
- Energy consumption and CO_2 emissions for particular this closed system is calculated as per below

From the testing obtained following result

Table 2. Experiment readings

Sr .no	Achieve temperature of the room		Time require for temperature reduce
	Set Tmp (°C)	Reduce temp up to (°C)	
1	50	40	3.19 min
2	45	35	5.55 min
3	35	28.1	59.45 min

III THEORATICAL CALCULATION

- $Q = UA\Delta T$
- $U = \frac{1}{\frac{1}{hi} + \frac{x}{k} + \frac{1}{ho}}$
- For h_i , Forced convection correlation equation use
- $Re = \frac{\rho V L}{\mu} = \frac{VL}{\upsilon}$

Where, ρ = density of air kg/m^3 and $V = \frac{\pi dn}{60}$
L = length of closed space, m
μ = dynamic viscosity, kg/m s
υ = kinematic viscosity, kg/ms

Where, d = rotor diameter =80 mm ,
n = speed of fan = 1400 rpm,

$$V = \frac{3.14 \times 0.08 \times 1400}{60}$$

= 5.8 m/s

- Now, $Re = \frac{VL}{\upsilon} = \frac{5.8 \times 1.21}{1.896 \times 10^{-5}} = 3.70 \times 10^5$
- $Nu = 0.036 \left(Re\right)^{0.8} \left(Pr\right)^{1/3}$

$$\left(\frac{2.136 \times 10^{-5} \times 1005}{0.027}\right)^{1/3}$$

$= 0.036 (3.70 \times 10^5)^{0.8}$

but, $Nu = \frac{hiL}{k}$

so, hi = $\frac{0.036 \times (3.70 \times 10^5)^{0.8} \times (0.795)^{1/3} \times 0.027}{1.21}$

hi = 21.27 W/m^2 K

- For outside natural convection is done so, find h_o
- Rayleigh number Ra = $\frac{g\beta(Ts - T\infty)L^3}{\upsilon^2}$

$= \frac{9.81 \times (50 - 28.1) \times (1.21)^3 \times (0.795)}{312.05 \times (1.896 \times 10^{-5})}$

Where, $\beta = \frac{1}{(\frac{Ts + T\infty}{2}) + 273}$

- Ra = 0.2697×10^{10}

Nu = {0.825 + $\frac{0.387 Ra^{1/6}}{[1 + (\frac{0.492}{0.795})^{9/16}]^{8/27}}$ }^{2}

= 169.80

- Now, Nu = $\frac{hoL}{k}$

so, 169.80 = $\frac{ho \times 1.21}{0.027}$

ho = = 3.78 w/m^{2}K

- Now, Q = UAΔT
- U = $\frac{1}{\frac{1}{21.27} + \frac{0.027}{0.17} + \frac{1}{3.78}}$

$= \frac{1}{\frac{1}{21.27} + \frac{0.027}{0.17} + \frac{1}{3.78}}$

= 2.12 W/m^{2}K

For walls loss

1) Q =2[UAΔT]
   = 2 × [2.12× (1.21×0.9) × (50-28.1)]
   = 101.12 W

2) Q = 2×[UAΔT]
   = 2× [2.12× (0.9×0.9) × (50-28.1)]
   = 75.2 w

Top and bottom loss

3) Q =2[UAΔT]
   = 2 × [2.12× (1.21×0.9) × (50-28.1)]
   = 101.12 W

- Total heat loss= 101.12 W + 75.2 W + 101.12 W
  = 277.44 W or J/s

- Energy consumption and CO2 emissions

- As per calculate above heat loss accurse for given exiting condition is 277.44 joule per second. For calculating heat loss during 12 months is below

  Q = 12×30×24×3600×277.44
  = 8629493760 joule
  = 8629493.760 kJ

  - Calorific value of coal as per
    Indian government=4541 kcal/kg

= 4.186×4541
= 14822.62 kj/kg

- Total fuel consumption in kg= $\frac{Heat\ loss\ during\ 12\ month\ in\ kj}{Calarofic\ value\ of\ coal\ in\ kj/kg}$

= 582.18 kg

- Now , 1 kg coal burning produce 2.38 kg CO_2 emissions

- So, total CO_2 emissions = 2.38 × 582.18
= 1385.58 kg

(A) Data interpretation and Analysis

- For the same fixed volume space developed insulation material from coconut husk and implement it inside the space wall.
- As above procedure again readings taken now with insulation and find heat loss and energy consumption from space.
- Compare heat loss analysis and energy consumption in both cases.

IV CONCLUSION

- From literature review conclude that, Coconut coir has low thermal conductivity and the coconut husk insulation manufacturing process is benign as coconut coir board does not require chemical binders.
- Heat loss calculation done on fixed volume room without insulation will consume the energy over 12 months is 582.18 kg which is equivalent to coal use in produce electricity for this space closed volume.
- After implement coconut husk made insulation on fixed volume room approximately 30 to 40% heat loss will be reduced which will reduce the energy consumption up to 20 to 30 %.
- Total CO_2 emissions for this closed system 1385.58 kg yearly and after implementing coconut husk insulation on room wall it reduces the yearly CO_2 emissions.
- From this experiment, we can conclude that using coconut as insulation on residential building is most efficient and economic way for residential electricity consumption and reduces CO_2 emissions form atmosphere.

Future scope:

Future scope of this study can help world wide for energy consumption from residential buildings by using coconut husk as an insulation and reducing 40 % CO_2 emissions from the world and maintain carbon credit of the nation.

Acknowledgements

I would like to sincerely thank all my mentors and guide who helped for the collection of very minor details during my work. My guide Prof. Harshal Oza and co-guide Prof. Jyotin Kateshia without whom the hierarchical structure would not have been possible. I would thank to him for giving motivation, cooperation, constant support with encouraging me for making this paper and providing their best of knowledge for complete work.

REFERENCES

[1] Satta panyakaew, Steve Fotios, "Agricultural Waste Material as Thermal Insulation", PLEA 25th Conference on passive and low Energy Architecture, October 2008
[2] Krishpersad , "Experimental Investigation of Building Thermal Insulation from Agricultural By-products", British journal of Applied Science & Technology, May 2012, 2(3); 227-239
[3] Majid Ali, "A versatile material and its application in engineering", second international conference on sustainable construction material and technology, June 30

[4] Joseph Khedari, Sarocha Charoenvai, Jongit Hirunlabh, "Insulation particleboards from durian peel and coconut coir",January 2002, www.elsevier.com/locate/buildenvEnergy and Buildings
[5] H.J.Darby, A.A Elmualim, F. Kelly, "A case study investigates the life cycle carbon emissions and carbon storage of a cross laminated timber multi storey residential building"

WEBSITES

[1] Bureau of Energy Efficiency", www.beeindia.in/guide/1Ch1

