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COST EFFECTIVE GREEN BUILDING CONSTRUCTION STRATEGIES FOR TROPICAL REGIONS

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Abstract – Global warming & greenhouse effects has considerably changed the scenario of environment & world in recent years. Main causes of these are increasing industrialization & urbanization. These things, in reverse, affect the life of people. It causes an increase in temperature in cities more than bearable, causing an increased use of cooling systems by consumers. Therefore, this paper focuses on green & sustainable strategies, using which the energy need for cooling are reduced considerably. First, an existing building in Akola city is selected for experimentation works, as it lies in hot & dry tropical region. Its two models are created in Google SketchUp namely Traditional Building Model with construction materials like burnt clay brick, RCC roof etc. & Green Building Model with construction materials like fly ash brick cavity wall, RCC roof, & a layer of weatherproof heat insulating paint over slab etc. Then, the simulation of both the building is carried out in Energy Plus. The results shows a considerable decrease in room temperatures & required cooling energy with payback period of nearly 2.5 years for increased cost of construction.

Keywords- Global Warming, Cost Effective

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INTRODUCTION

Urbanization & industrialization is increasing rapidly with increasing population as people in villages are approaching the nearby city for education as well as for employment. The constructions are also increasing day by day. Construction of residential buildings is on large scale. The normal and traditional construction methods using burnt clay bricks masonry, RCC roofing is adopted now also for construction. Use of finishing items varies widely with living standards.

Green Building is a new concept for many cities & not yet applied in many cities of India. The reasons behind it are lack of knowledge about the new concept in common people & those people who know this concept, ignore & avoid it because of its greatest myth, i.e. it is costly. The concept of 'Green Building', has more initial cost but proves to be beneficial for its entire service life, in terms of savings & comfort, affecting minimum to the environment.

Middle class people contribute more than half population of any city and so construction of their houses is a major part of the residential buildings construction. Therefore, this paper focuses on affordable energy saving construction techniques, which will help & prove to be beneficial for them.

The concept of Green Building, being beneficial in all its aspects cannot totally apply to the residential houses because of various limitations like space available for construction, availability of green materials, and crucial factor is economy. So, such construction methods, which would be easily adaptable & materials, which are locally & readily available, must be used for construction.

METHODOLOGY

Firstly, one existing residential building is selected for the experimentation work. Its two models are then created in Google Sketch Up software namely 'Traditional Building Model' and 'Green building Model'. In the traditional building model, the materials used are clay bricks, cement mortar, & RCC. On the other hand, in the 'Green building Model', materials used are fly ash cavity wall, RCC, cement mortar with fly ash & heat insulating paint over roof slab etc. Various properties of materials required are taken from CBRI's Building Research Note. In both the models, the geometry of building, location of building, schedules of operation of lights, fans & air conditioning system in various rooms is same.

Then the simulation is carried out in the Energy Plus software. Weather file of Akola city is downloaded from US Department of Energy's website. Results of both the models are derived

in the form of Zone Mean Radiant Temperature, and Cooling Energy Required Monthly in each Zone. Difference in energy requirement, temperature, and heat transfer rate shows the savings in 'Green Building Model'. Similarly, the cost comparison of construction of clay brick masonry & fly ash wall masonry is done. Total increase in cost because of use of heat insulating paint & cavity wall construction is also calculated.

EXPERIMENTAL WORK & MODELLING

For experimentation & simulation purpose, an existing residential building is selected, as shown in fig (a). It is located in Khadki, Akola. It is modeled in Google Sketch Up & the images of model are shown in fig (b), (c). The plan of house is shown in fig (d).

The house is divided into zones namely HALL for hall & kitchen, MASTER BED for master bedroom, STUDY for study room, UTILITY for WC, Bath & Passage. For simulation purpose, only lights & fans are considered. The power of various appliances like TV, refrigerator, washing machine, sound systems etc is not considered, as their electricity consumption will remain same in both the situations. In case of their heat energy release capacity, it does not cause that much increase in the temperature of room.

Input of schedules of various equipments like lights, fans, and cooling systems are as per discussions with the house owner & their using habits. Air conditioner is provided only in master bedroom and fans are provided in rest of the house.

Monthly results are produced for a year from both the models for parameters zone mean radiant temperature & cooling energy required.

Fig. (a) - Existing Building at Akola

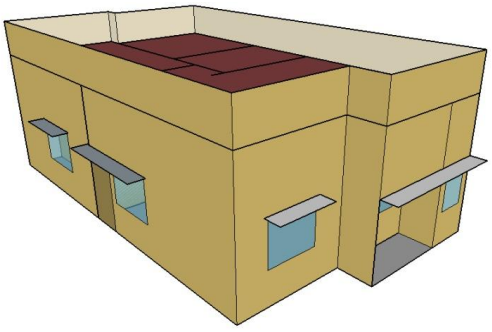
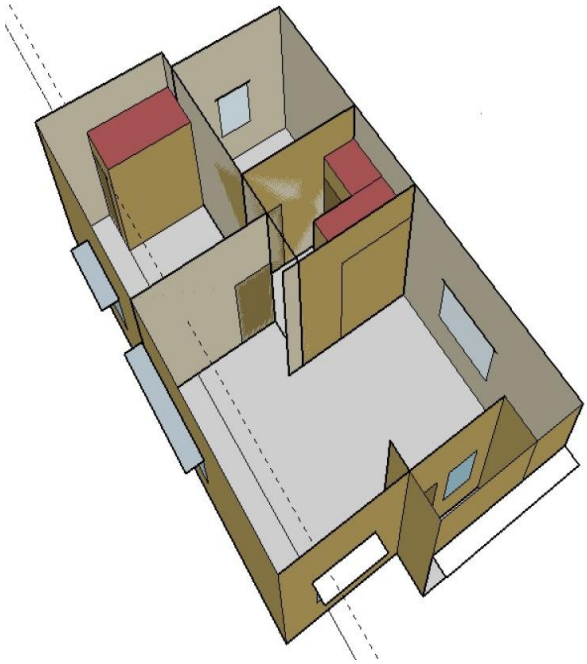


Fig. (b) - Model Created in Google SketchUp



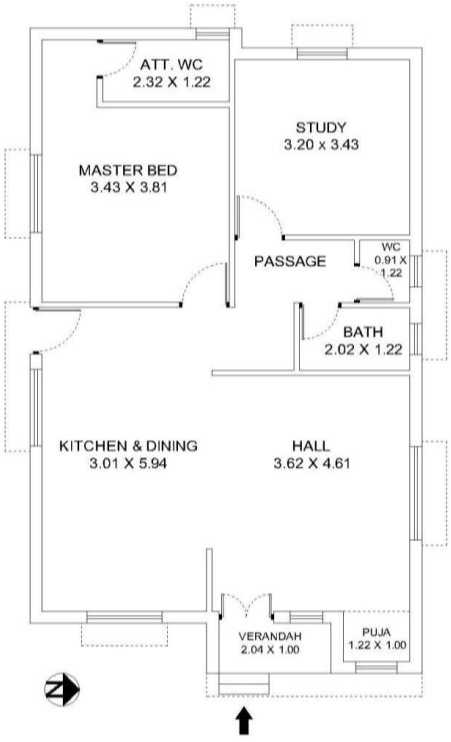


Fig. (c) - Model Created in Google SketchUp **Fig. (d) - Plan of Existing House**

BSERVATIONS

Table 1 - Values of Zone Mean Radiant Temperature (°C) for various zones in Traditional Building Model

Month	Outdoor Air Temperature	Master Bed	Study	Utility	Hall
January	22.28	23.47	24.35	24.11	24.01
February	24.67	24.31	26.65	26.39	26.50
March	28.96	25.94	28.49	28.14	28.72
April	33.27	27.89	31.07	30.64	31.61
May	35.01	28.54	31.62	31.32	32.57
June	30.33	26.63	28.79	28.60	29.57
July	27.43	26.13	26.88	26.62	27.39
August	26.41	25.50	26.17	25.89	26.58
September	28.39	26.60	27.90	27.50	28.00
October	26.84	25.79	27.15	26.78	27.02
November	23.91	24.27	25.42	25.07	25.03
December	21.59	23.12	24.16	23.94	23.71
Average Monthly Temperature	**27.42**	**25.68**	**27.39**	**27.08**	**27.56**

Table 2 - Values of Zone Mean Radiant Temperature (°C) for various zones in Green Building Model

Month	Outdoor Air Temperature	Master Bed	Study	Utility	Hall
January	22.28	20.84	21.02	20.83	21.51
February	24.67	21.06	21.79	21.55	22.70
March	28.96	21.69	22.46	22.12	23.72
April	33.27	22.31	23.29	22.84	24.91
May	35.01	22.59	23.49	23.13	25.50
June	30.33	22.02	22.54	22.30	24.23
July	27.43	22.27	22.04	21.79	23.44
August	26.41	21.98	21.76	21.51	23.02
September	28.39	22.25	22.28	21.88	23.19
October	26.84	21.97	22.09	21.73	22.84
November	23.91	21.41	21.55	21.24	22.02
December	21.59	20.97	21.09	20.89	21.48
Average Monthly Temperature	**27.42**	**21.78**	**22.12**	**21.82**	**23.21**

Table 3 - Cooling Energy Requirement Values for Master Bed Zone in Traditional & Green Building Model

Month	Zone Air System Sensible Cooling Energy [kWh]	
	Traditional	Green
January	39.76	0.34
February	390.17	84.73
March	621.21	141.35
April	846.69	187.89
May	957.21	220.09
June	679.45	162.61
July	284.08	43.84
August	231.30	33.72
September	312.27	40.85
October	259.24	33.07
November	141.37	15.19
December	85.27	4.89
Average Monthly Value	404.00	80.71
Difference	323.29	
% Decrease	8002%	

Table 4 - Cost Comparison in Construction Rates of Brick & Fly Ash Masonry (According to the CSR rates of Amravati Division)

Item	No.	Length	Width	Height	Unit	Quantity	Rate (in Rs.)	Amount (in Rs.)
Brick masonary	1	1	0.23	1	Cu. M	0.23	4500	1035
FA Brick masonary	2	1	-	1	Sq. M	2	725	1450

The difference in construction rates of both masonry is Rs. 415 / Sq. m, which is about 40 % increase in cost of masonry construction.

ESTIMATE OF BUILDING

In the estimate done below, only calculation of quantities & amount (Rs.) of masonry construction is done, as the remaining items of construction viz., RCC work, PCC work, plastering, woodwork, etc. will remain same in both the buildings.

Traditional Building

Item of Construction	Unit	No.	Length	Width	Height	Quantity	Rate/Unit	Amount (Rs.)
Brick masonry	Cu. M	1	39.70	0.23	3.66	33.42	4500.00	150387.57
Total Centreline Length = 38.71 + 0.99 = 39.70 m								

Green Building

Item of Construction	Unit	No.	Length	Width	Height	Quantity	Rate/Unit	Amount (Rs.)
Fly Ash Masonry	Sq. m	2	39.80	--	3.66	145.67	725.00	211218.60
East wall Length = 6.96								
West wall Length = 6.96								
North wall Length = 12.00								
South wall Length = 11.40								
Additional walls Length = 0.99 + 1.10 + 0.39 = 2.48								
Total Length = 39.8								
Applying Weather Proof Paint	Sq. m	1	--	--	--	77.39	145.00	11221.55
Area1 = 3.43 x 0.39 = 1.35								
Area 2 = 10.78 x 6.73 = 72.58								
Area 3 = 3.49 x 0.99 = 3.46								

RESULTS

For the particular building, the difference in monthly mean zone temperature & cooling energy is found to be as follows:

Model Type	Average Monthly Temperature (°C)				Sensible Cooling Energy	District Cooling (J)
	Master Bed	Study	Utility	Hall		
Traditional Building Model	25.68	27.39	27.08	27.56	404	1.48E+09
Green Building Model	21.78	22.12	21.82	23.21	80.71	3.03E+08
Difference	3.9	5.27	5.26	4.35	323.29	1.18E+09
% Decrease	1519%	1924%	1942%	1578%	8002%	7953%

The monthly mean decrease in temperature for the building is 4.70°C, which is considerable difference. The difference in power required for cooling is 323.29 kWh, which is about 80% less as compared with Traditional Building Model. However, the increase in construction cost of masonry is Rs. 415/Sq. m of Exterior Wall masonry construction. Therefore, the increase in construction of Green Building Model will be as follows:

Increase in Cost of Construction

Difference in cost of Masonry construction	60831.03
& Increase in cost of Masonry construction	4045%
Total Increase in Cost of Construction = Difference in cost of Masonry construction + Cost of Applying Weatherproof Paint	72052.58

Energy Savings for Cooling

Average Savings in Electric/Month	Yearly Savings	Rate of Electricity (Rs./Unit)	Savings/Year (Rs.)
323.29	3879.48	8.00	31035.84

Payback Period Calculation

$$\text{Payback Period} = \frac{\text{Total Increase in Cost}}{\text{Saving per Year}} = \frac{72052.58}{31035.84} = 2.32 \cong 2.50\ Years$$

CONCLUSION

From the temperature decrease results, it can be said that the average monthly temperature of Green Building model is 22.42°C. So, basically there is no need of proving cooling systems & the provision of fans in all rooms can suffice the needs. Moreover, after providing cooling system in master bed room, the average monthly cooling power saving is 323.29 kWh, which is 80 % less as of traditional building.

In case of construction & its cost, even though it is more in Green Building Model i.e. Rs. 72052.58 are required more, it is having a payback period of 2.50 years because of the energy savings in cooling master bedroom. The temperature decrease of the green building is 4.70°C,.

So, it can be concluded that by using locally available materials & a slight change in construction techniques we can decrease the cost of cooling our house & thus become more efficient.

REFRENCES

1. CBRI, Building Research Note 90, Data Bank on Thermal Insulating Materials.
2. Weather File Download - www.energyplus.gov.
3. Energy Plus Documentations.
4. CSR 2014-15 Amravati Region.