Comparative Analysis of Conventional and Energy Efficient Materials for Residential Bungalow with respect to the Hot and Dry Climate.

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Abstract - *Energy-efficient buildings have expanded more popularity in the last few years, due to the increased emphasis on energy conservation. The main aim of energy-efficient buildings is to minimize environmental impacts such as greenhouse gases due to the use of conventional materials in construction. It results in achieving thermal comfort and minimizing artificial cooling loads indoors. This initiative takes one step forward saving the globe from an energy crisis. Comparative analysis is done based on case studies performed between conventional and energy-efficient bungalows.*

Key Words: Conventional materials, energy efficient materials, hot and dry regions, residential bungalows, thermal comfort, and passive cooling strategies.

1. INTRODUCTION

A study of residential buildings in Solapur city shows that most occupants of the buildings have persistent and growing problems with the indoor environment due to high indoor temperature. Most buildings are characterized by poor design in relation to the climate, which requires a great deal of energy for cooling during climatic extremes. It also helps to reduce the usage of air conditioners and the period for which it is highly required. The ideal method is to work in harmony with the local climate. (1)

In terms of thermal comfort, traditional and contemporary buildings have different demands. Traditional buildings accomplish most of their comfort by passive methods, without the use of HVAC, but old levels of thermal comfort do not reach today's standards, despite the fact that their passive thermal performances are exceptional for modern building designs. In this regard, the current study attempts to evaluate the feasibility of comparing the construction approaches of traditional and contemporary buildings in order to attain comfortable conditions from an architectural perspective. (2)

It is seen that one-third of the world's energy is consumed by the building out of which 60% is through air conditioning systems. The building sector consumes a large amount of energy to provide thermal comfort to its occupants in India. It can be seen that 29% of the overall energy is used by the building out of which 20% by residents and 9% by commercial. (3)

2. METHODOLOGY

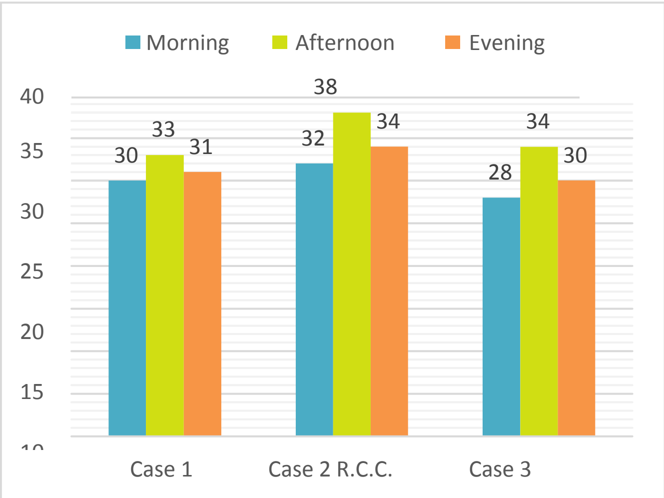
The method adopted for the study is exploratory, where 3 live case studies of residential units in Solapur have been considered for a quantitative field survey of temperature and relative humidity in May-June 2022. Based on this case study a comparative analysis of conventional and energy-efficient building materials can be done. And then selecting material that has a low heat transfer coefficient (U) value and (R) value.

3. ANALYSIS

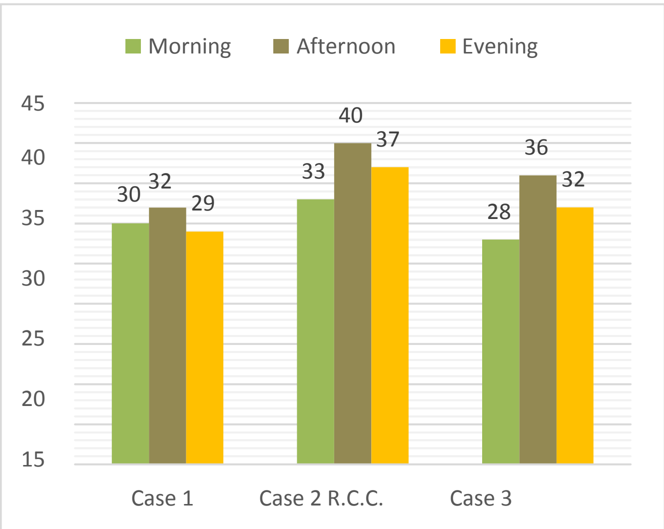
Out of 3 live case studies, one is the conventional residential unit to have a better comparison with the other two passive design residential units. Indoor and outdoor temperature and indoor and relative humidity have been recorded during the field survey. A survey has been performedin the month of May-June, 2022 at three intervals of time in the day i.e. morning, afternoon, and evening (9 am, 12 pm, and 4 pm). The temperature has been measured with the help of calibrated thermometer i.e. psychrometer instrument of both Dry bulb and Wet bulb temperature has been recorded and then with help of psychrometric chart relative humidity hasbeen calculated.

3.1. INDOOR AND OUTDOOR TEMPERATURE

Both indoor and outdoor temperatures of all 3 case studies have been recorded. In case 1 during morning time, both indoor and outdoor temperatures are the same; in the afternoon and evening, the outdoor temperature is higher by 1-2°C than the indoor temperature. In this case, passive cooling strategies have been applied such as inverted earthen pots used for coba on terrace and whitewash which has eventually reflected in reducing indoor temperature and achieving thermal comfort. The second case is of the conventional building (R.C.C.) in which any of the passive strategies hasn't been implemented that's why the indoor temperature is higher than the outdoor by 3-4°C. Case 3 also has the same readings as case 1 with outdoor temperatures higher than the indoors. In this case, ground floor is thermally comfortable because of applying passive cooling strategies such as cavity walls, water body and landscaping but first floor is not comfortable in comparison with ground floor. In the evening time room gets heat radiation due to which up to some extent mechanical cooling devices are used for thermal comfort. (4)



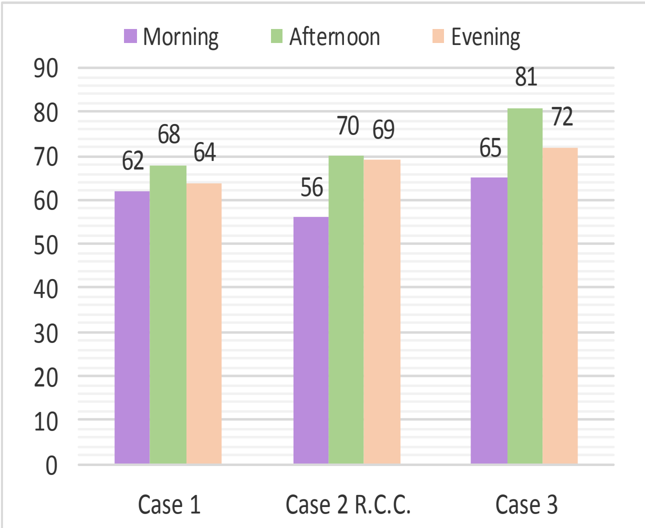
Graph 1.0 shows the mean Outdoor temperatureduring peak periods of the day



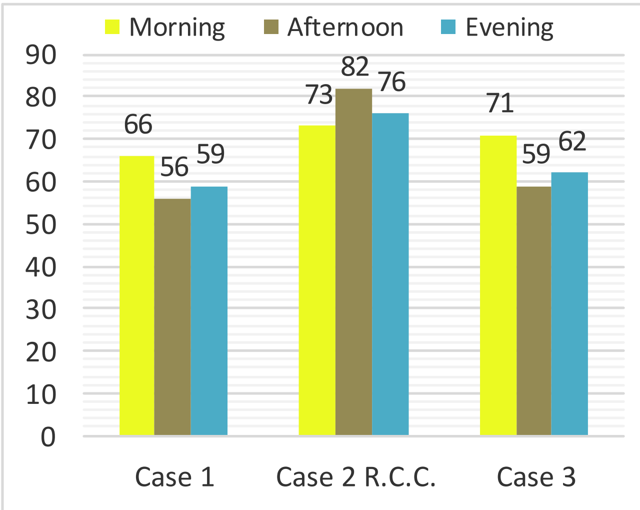
Graph 2.0 shows the mean Indoor temperatureduring peak periods of the day

3.2 INDOOR AND OUTDOOR RELATIVE HUMIDITY

Both outdoor and indoor relative humidity has been recorded and is very important for further analysis. In case 1 in the morning time, indoor humidity is higher than the outdoor while in the afternoon and evening it is reversed. In case 2 during all 3 peak periods of the day indoor relative humidity is higher than the outdoor by 10-12%. This case is conventional with no implementation of passive cooling strategies. Lastly, in case, 3 morning indoor humidity is higher than the outdoor while in the afternoon and evening outdoor is higher than the indoor. In both cases, 1 and 3 passive cooling strategies have been efficiently applied to achieve thermal indoor comfort and make it an energy-efficient house. The suitable indoor relative humidity should be between the range of 40-60% while designing or proposing any residential model we need to design accordingly to achieve an indoor comfortable environment without any use of mechanical devices for cooling but naturally ventilating and cooling.



Graph 3.0 shows mean outdoor relative humidity during peak period of the day.



Graph 4.0 shows mean outdoor relative humidity during peak period of the day.

4. DISCUSSION

Table 1 : Comparative analysis between conventional and energy efficient bungalow

Sr. No.	Items	Conventional Bungalow	Energy Efficient Bungalow
1	Wall Masonry	230 mm thick brick wall with plaster on both sides	200 mm thick AAC blocks with plaster on both sides
2	Roof	RCC slab	Filler slab
3	Glass	Plain single-layer glass	Insulated double-layer glass
4	Door	Teak Wood	Salvaged door
5	Flooring	Vitrified Tiles	Porcelain tiles, Kota stone
6	Painting	Plastic VOC	Light color coating
7	Solar Panels	Not provided	3.0 KW capacity
8	Solar Water heater	Electrical Geyser	Solar Water Heater
9	Lighting	CFL bulb and tube lights	Low Watt LED bulb and tube lights
10	Water proofing	Normal waterproof	Cool Roof (white coating)

4.1. Energy Efficient material application on building components

1) **Wall assembly** - 200 mm thick AAC blocks with 15mm thick plaster on both sides with U-value -0.77 W/m^{2}K, R-value -1.29 W/m^{2}K, and the cost is 56/ piece.

2) **Roof assembly** - 125 mm thick filler slab with 25 mm thick inverted earthen pots laying below and cost 245/sq. ft

3) **Window** - Double glazing with Low E coating filled gap in between with Argon gas, VLT- 77% , SHGC- 62% ,U-value -1.6 W/m^{2}K ,R-value -0.6 W/m^{2}K and cost is 225/ sq. ft

4) **Waterproof** - Cool roof reflects up to 97% of sun rays and reduces air conditioning costs by up to 19.2%, it has a 0.98% water absorption rate and prevents leakage and even dampness. Reduce the surface temperature by 24°C and costs 13/ sq. ft (star cool shield).

5) **Paint** - Light color coating paint with 61% spectrum reflectance.

6) **Flooring** - 25 mm thick Kota stone is used in site surroundings and inside the building envelope 10mm thick porcelain tiles and 18 mm Kota stone tiles both are used for flooring. Kota stone costs 20/ sq. ft and porcelain costs 40/ sq. ft

7) **Solar Panel** - Solar PV panels of capacity 3.0 KW have been provided on rooftop system in 300 sq. ft facing south direction. Installation charges 2,00,000/- including fabrication. (5)

Table 2: Comparative analysis of U-value of Conventional and Energy-Efficient Bungalows (6)

Sr. No.	Category	Conventional building	Energy-efficient building
1.	U value for the roof (W/m^{2}K)	2.93	0.064
2.	U value for the wall (W/m^{2}K)	0.54	0.123
3.	U value for Floor (W/m^{2}K)	0.25	0.09
4.	U value for Windows (Glazing)	1.96	0.6

5. Conclusion :

According to this study, the energy consumption and internal environmental conditions of conventional and energy-efficient buildings are considerably different. This study only looked at only one building plan and one climate condition. Only those strategies have been studied and applied which are applicable to the hot and dry climate of Solapur city. Graphical analysis has been done based on the ambient temperature and relative humidity of both indoor and outdoor selected case studies. Further comparative analysis between conventional and energy-efficient building materials shows that adopting an energy-efficient model with passive cooling strategies for hot and dry regions will help achieve indoor thermal comfort and reduce the use of artificial means of energy.

However, the current study demonstrates that energy-efficient buildings are less expensive than conventional buildings when an integrated strategy is adopted. The Energy-efficient building performance is outstanding and remarkable.

REFERENCES

[1] Jadhav, T. (2021). Comparative Analysis of Initial Cost Between Conventional and Energy Efficient Building using BIM as A Tool: A Case Study Approach. *INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY*, 1-7.

[2] Hançer, P. L. (2019, June 28). A Comparative Study of Traditional and Contemporary Building Envelope Construction Techniques in Terms of Thermal Comfort and Energy Efficiency in Hot and Humid Climates. *11*(3582), 1-22. DOI:doi:10.3390/su11133582

[3] Taleb, H. M. (2014, January 22). Using passive cooling strategies to improve thermal performance and reduce the energy consumption of residential buildings in U.A.E. buildings. *Frontiers of Architectural Research, Elsevier, 3*(2), 154-165. doi:10.1016/j.foar.2014.01.002

[4] *Passive design strategies for residential buildings in Nigeria's hot, dry climate.* **Akande, O. K.** Nigeria: s.n., March 2010, WIT Transactions on Ecology and the Environment, Vol. Vol 128, p. 12. 1743-3541.

[5] Xinrui Lu, A. M. (2019). Comparative Analysis of Energy Performance for Residential Wall Systems with Conventional and Innovative Insulation Materials: A Case Study. *Scientific Research Publishing*, 240-261.

[6] Liang, X. (2017). Comparison of building performance between Conventional House and Passive House in the UK. *ScienceDirect Elsevier*, 1823-1828.