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Observations on Thermal Responses of Buildings and Finishes

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A B S T R A C T

This paper presents the onsite thermal study observed over various residential buildings with several combinations of roofing, roof coverings and finishes in and around Perianaickenpalayam Coimbatore, Tamil Nadu in January 2022. The observations were made manually using Dry bulb and wet bulb thermometers. The variations considered in the studies are, RCC Flat Roof Vs RCC Taper roof, White wash Finish Vs Yellow Colour, Roof with Solid parapet Vs Roof Without parapet, Mangalore Tiled Roof Vs RCC Filler roof, AC Sheet Roof Vs Corrugated Iron Sheet Roof, AC Sheet Vs Bison Board and Aluminium Sheet Roof, Ceiling Height 3.0m Vs Ceiling Height 2.1m, AC Sheet with Tree Shade Vs AC sheet without Tree shade, AC Sheet Vs RCC Roof, AC Sheet without ceiling and with AC sheet ceiling, Mangalore Tile Vs Country Tile and Flat tile, Mangalore tiled roof Vs AC Sheet Roof, RCC Slab without WPC Vs RCC Slab With WPC, AC Sheet Vs Ground Floor RCC, First Floor RCC, Mangalore Tiled Roof and Comparison of orientation of Rooms in a building. The results made it clearly a various combinations of building components found to predict lower temperature at ceiling level of the various buildings and finishes. The results thus obtained will serve as preliminary information for many similar thermal researches in future. Moreover to consider the different design factors at panning and designing stage and to do selection of materials and finishes, the results will be of more beneficial.

Keywords: Ambient, Dry bulb, Finishes, RCC Roof, Temperature, Wet bulb,

1. Introduction

Anicet Vincent et.al.,2004, opined that the use of passive and active techniques well-coordinated gives a room for energy saving and protection of the environment. Although materials and design alone cannot be concluded to be the only way of attaining thermal comfort, light coloured roofing materials, light painted walls and lightweight building form are primarily the potential ways of saving energy. J Vijalakshmi, 2010 discussed the limitations of overall thermal transfer value (OTTV) standards, its significance and relevance, and concluded that OTTV is one of the means of achieving energy efficiency of air conditioned buildings. Mohammed Arif Kamal, 2012 discussed in detail various passive cooling techniques. He concluded stating that incorporation of these passive cooling techniques would certainly reduce our dependency on artificial means for thermal comfort and minimize the environmental problems due to excessive consumption of energy and other natural resources and hence will evolve a built form, which will be more climate responsive, more sustainable and more environmental friendly. Asif Ali 2013, examined various passive cooling techniques and locally available resources used in Mughal buildings in North India and concluded with the design elements of these buildings have evaluated on the basis of their suitability to the climate. Karam M. Al-obaidi 2014 discussed on different techniques to develop the understanding of pitched roof systems in the tropics. The research hypothesize that colour approach could change pitched roof angle more than material properties. The results of different roofing systems affirmed this theory and showed the significance of roof colour more than the roof area, angle and material. Furthermore, it was noticed that pitched roof sides have played a significant role to determine the heat gain. MuKtar Inusa 2017, based on the study made, it is apparent that the use of air conditioning in the residential buildings can be reduced tremendously to the minimum. We can now build houses that are environmentally responsible and are most comfortable to occupy with very little energy demand. The heat load of the buildings is reduced by the use of the above techniques. C V Subramanian et al., Various types of passive cooling techniques available can be appropriately incorporated in the building design for warm humid climate of Tamil Nadu region. The building interior can provide adequate comfort by incorporating such passive techniques and also reduces the artificial energy consumption. This reduces duration of overheated period of the building, dependence for air conditioner and other electromechanical devices. Architects and Engineers can incorporate such techniques in the modern construction, also during modifying and retrofitting of old buildings

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2. Materials and Methods

In view of collecting and analyzing thermal responses of different buildings and finishes, ambient air temperature and inside temperature at ceiling level is observed in various kinds of residential buildings. The ambient air temperature was measured in a shaded place in open atmosphere. The inside readings were taken at 300 mm lesser than the ceiling level. The temperatures were recorded directly using Dry bulb and Wet bulb thermometer. The size of the rooms were so selected that unless mentioned here in the particular study in this paper, otherwise it was 3000mm x 3000mm in plan and ceiling height 3000m.

The rooms were provided with 2 numbers of windows of each size 900 mm x 1200 mm located in two adjoining walls with a connectivity of right angled junction. Floor was in general made of mosaic finish over PCC concrete base. The windows were open during day time and closed during night hours and were not provided with any kind of screens. All the windows were capped with a sunshade at its top. The roof concrete was of 11o mm thick RCC slab, with brick jelly weather proofing of 75 mm thick over it. The rooms thus selected were having a 40 mm thick seasoned country wood paneled door or plywood 1 number with normal fastenings, kept closed both in day and night hours. No air conditioners or air coolers or none other active power operated equipment such air fans are used. Hence, all these study can very well be referred to be a study of passive thermal behaviour. The observed data are presented in graphical form in figure 1 to 15.

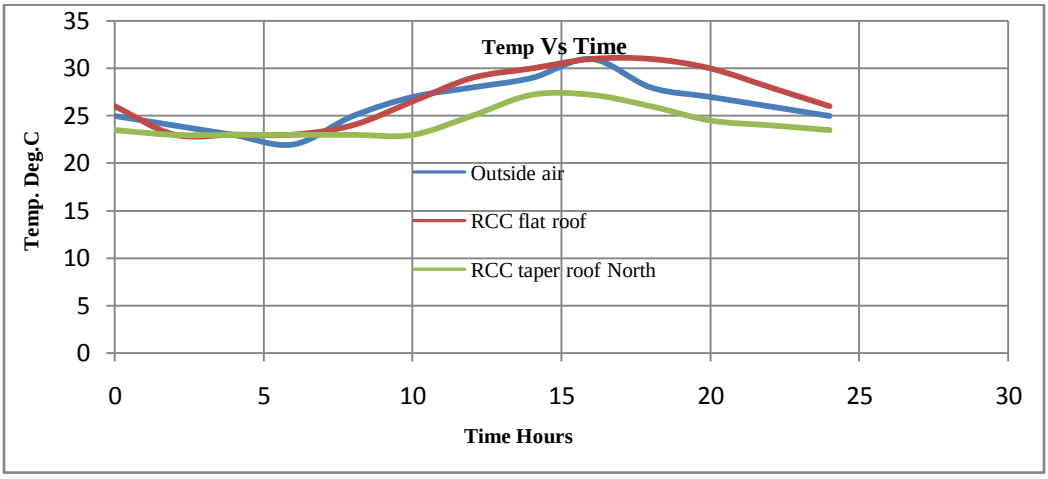

Fig. 1- RCC Flat Roof Vs RCC Taper roof

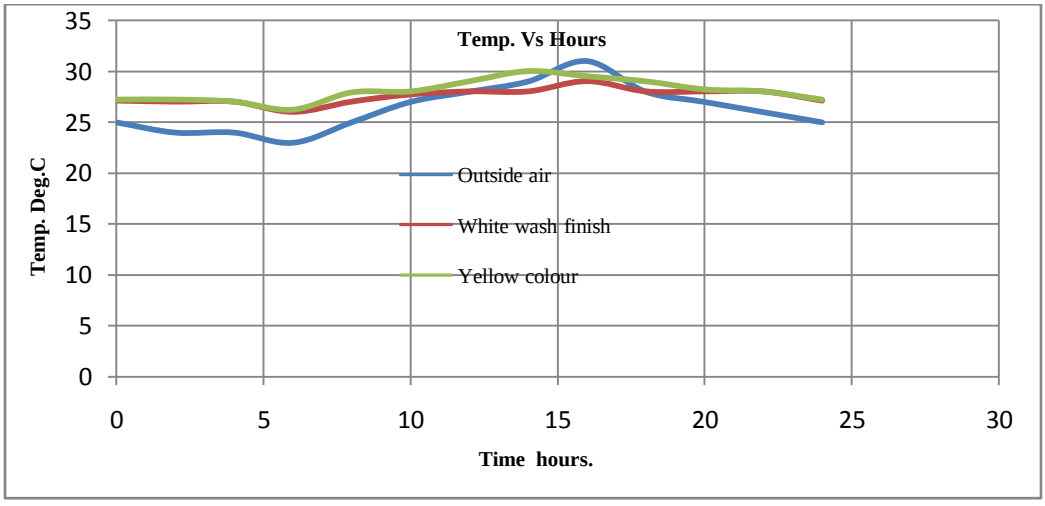

Fig. 2 -White wash Finish Vs Yellow Colour

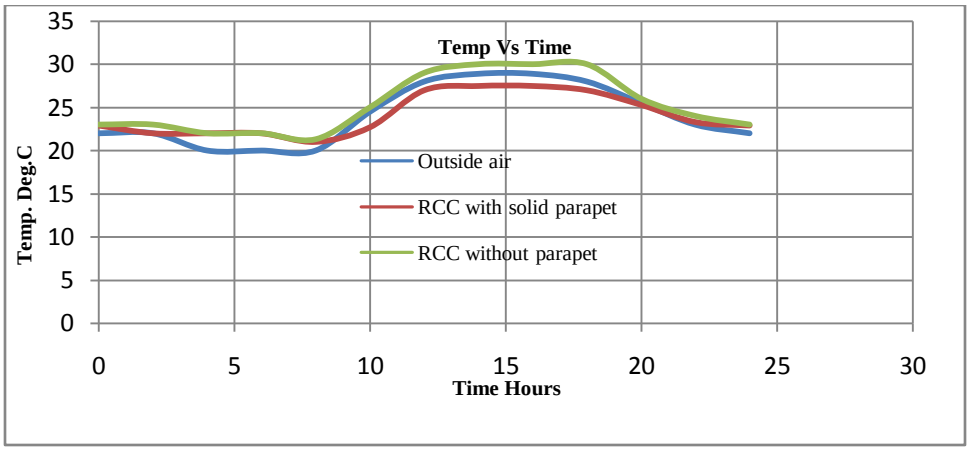

Fig. 3- Roof with Solid parapet Vs Roof without parapet.

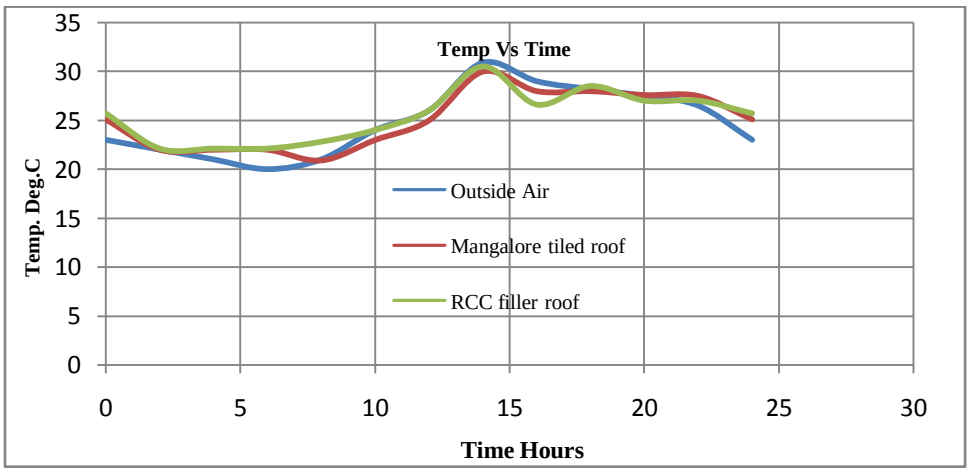

Fig. 4 - Mangalore Tiled Roof Vs RCC Filler roof

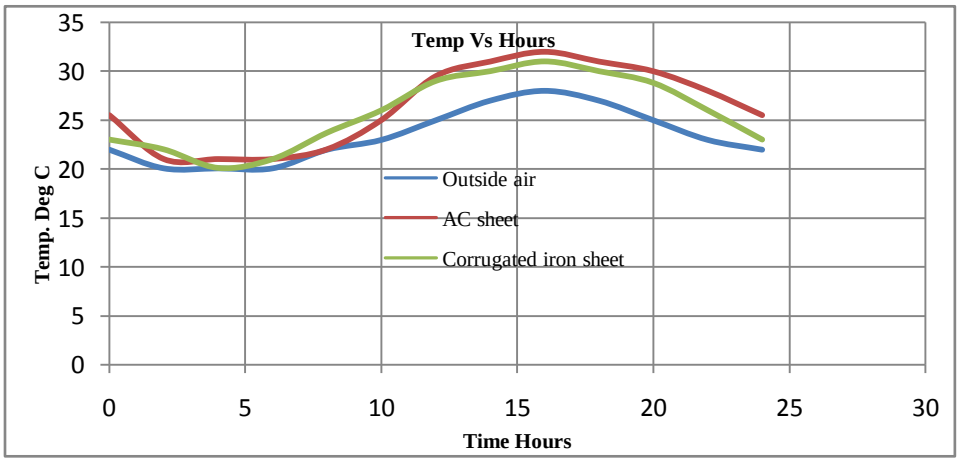

Fig. 5 - AC Sheet Roof Vs Corrugated Iron Sheet Roof

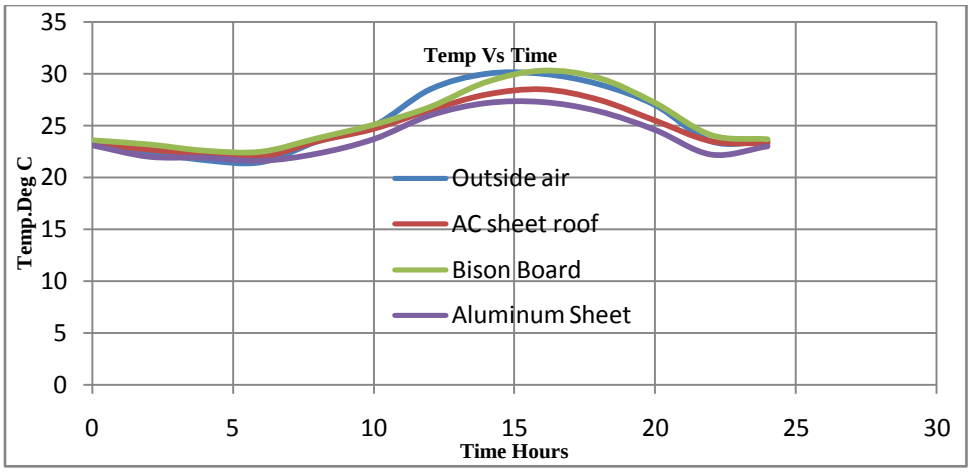

FIG. 6 -AC Sheet Vs Bison Board and Aluminium Sheet Roof

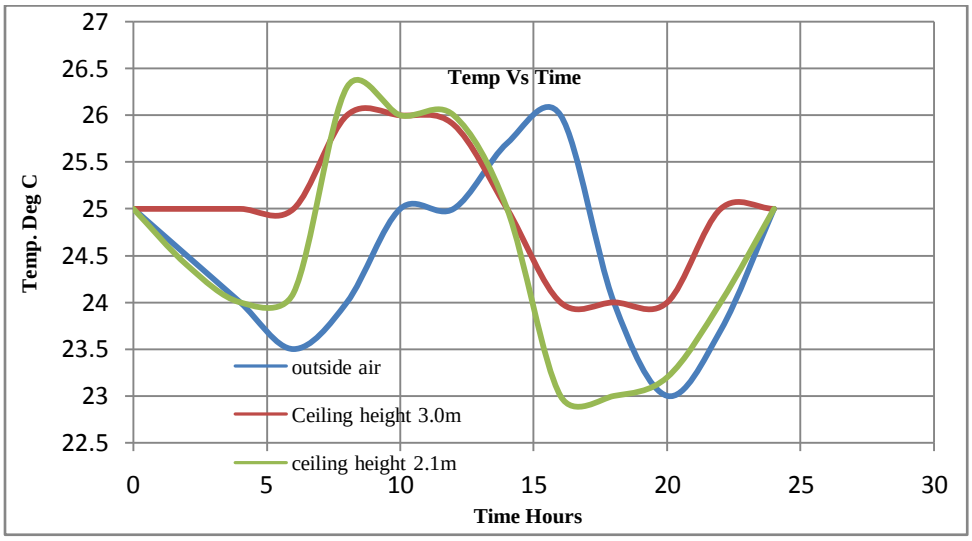

Fig. 7- Ceiling Height 3.0m Vs Ceiling Height 2.1m

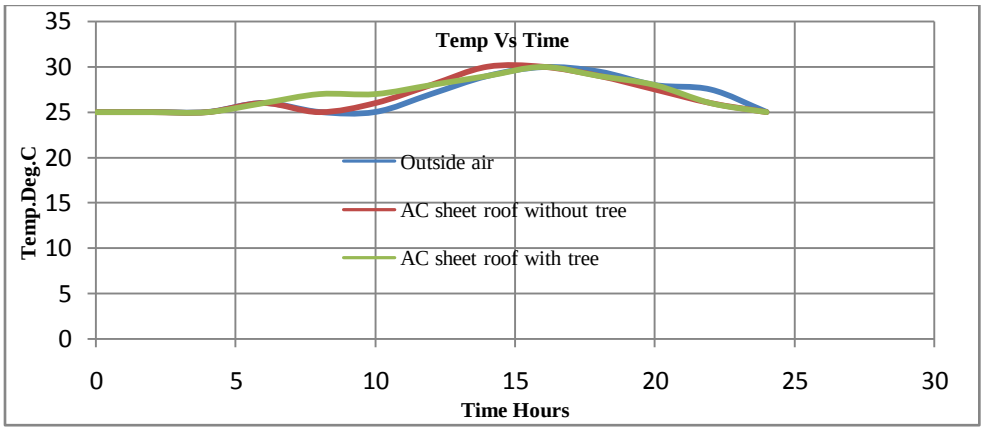

Fig. 8 - AC Sheet with Tree Shade Vs AC sheet without Tree shade

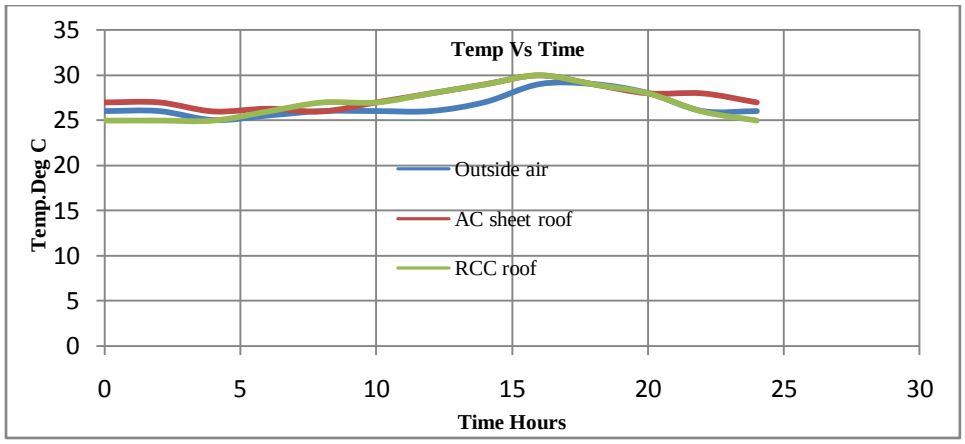

Fig. 9 - AC Sheet Vs RCC Roof

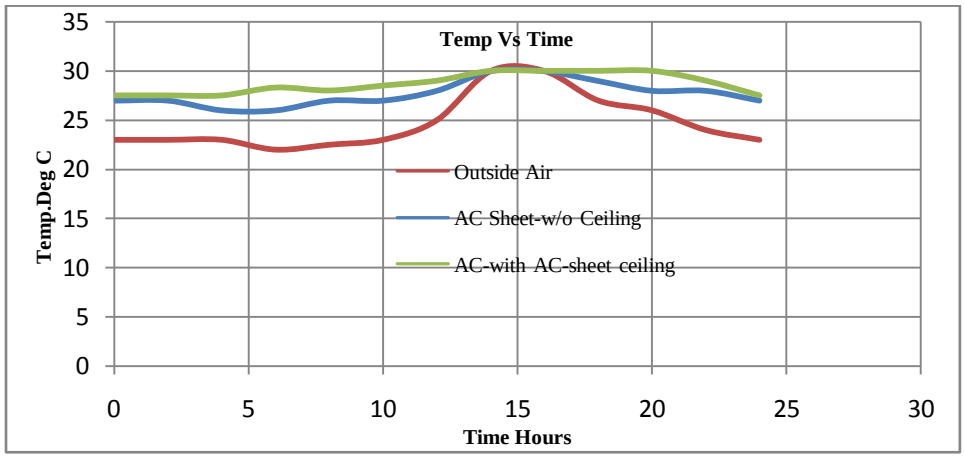

Fig. 10 - AC Sheet w/o ceiling and With AC sheet ceiling

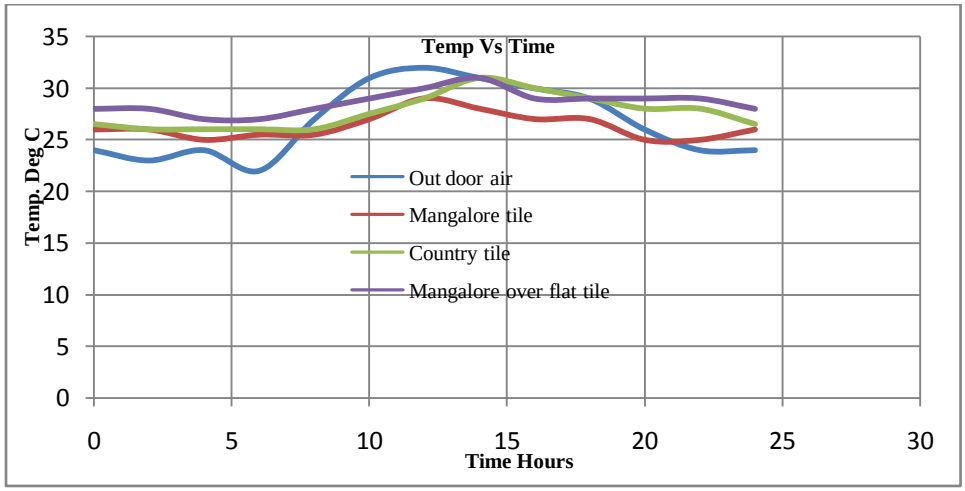

Fig. 11 - Mangalore Tile Vs Country Tile and Flat tile

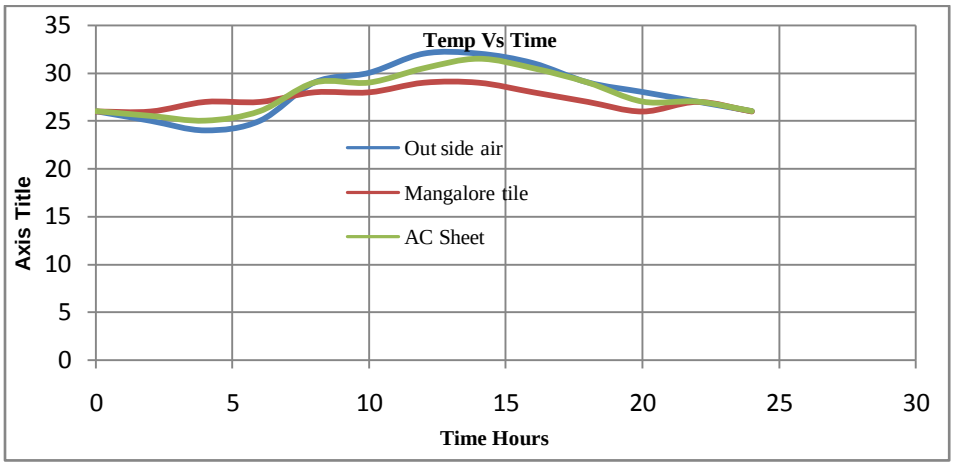

Fig. 12 - Mangalore tiled roof Vs AC Sheet Roof

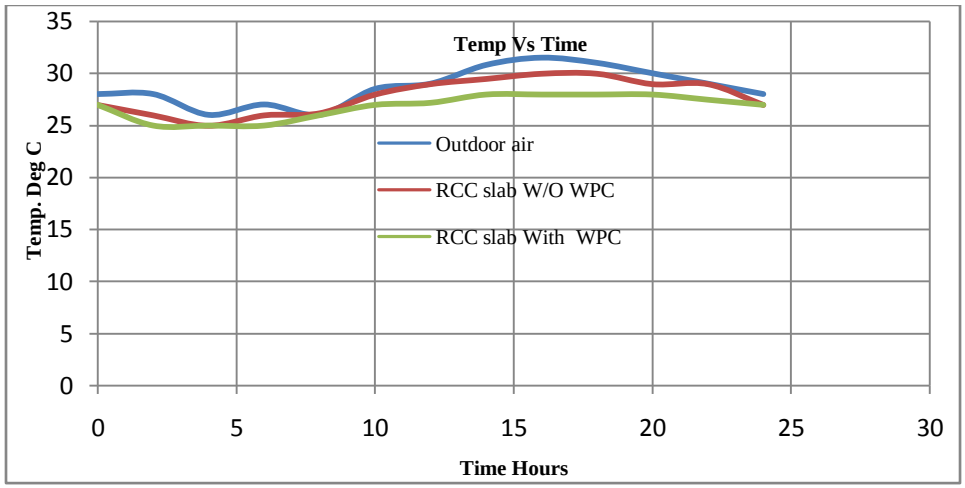

Fig. 13 - RCC Slab without WPC Vs RCC Slab with WPC

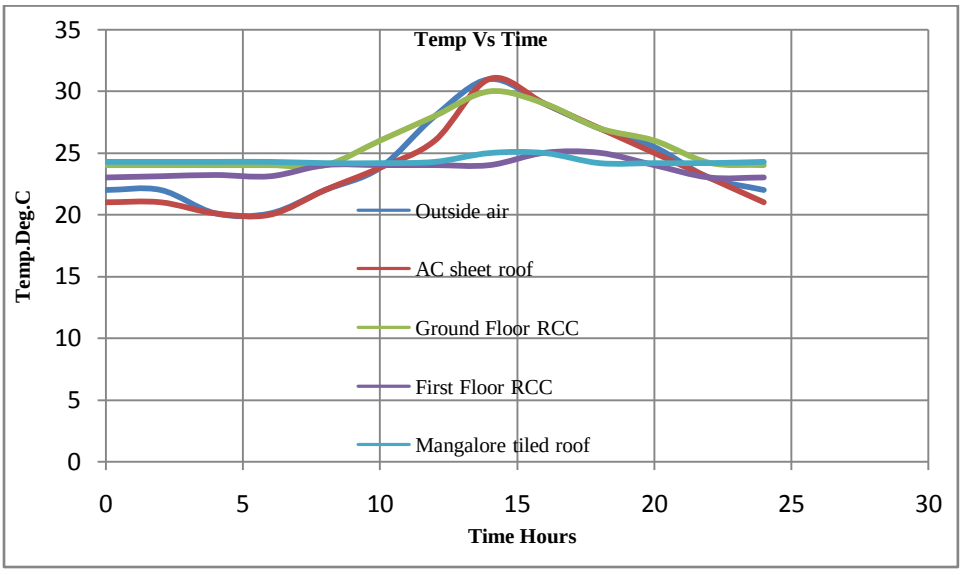

Fig. 14 - AC Sheet Vs Ground Floor RCC, First Floor RCC, Mangalore Tiled Roof

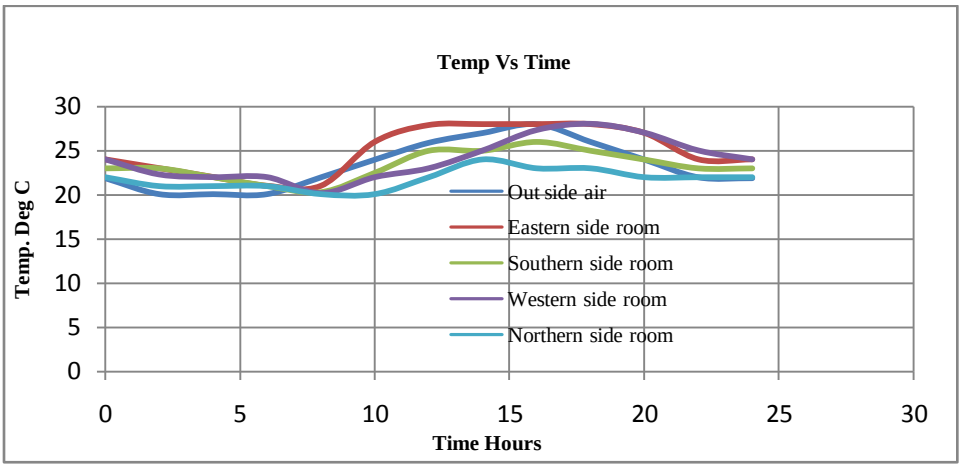

Fig. 15 - Comparison of orientation of Rooms in a building

Figure1 refers the comparison of RCC flat roof with RCC Taper roof of a residential building. From zero hours to 6.00 am, no much difference was recorded. After 6.00 am up to 3.00pm RCC flat roof steadily raised to peak temperature at 3.00 pm in line with ambient temperature. From 3.00 pm to next zero hours, the RCC flat roof continued to retain around 2.5 Deg in excess of ambient air temperature. In all, from 10.00 am to 10.00 pm RCC taper roof towards northern side predicted 3 to 4.5 Deg. lesser than the RCC flat roof.

Figure 2 refers the comparison of external finishes of White wash finish and Yellow colour wash finish of two nearby residential buildings. There was no change in early hours up to 6 am. Minor changes up to 12.00 noon; in peak 2.00 pm yellow colour wash gave rise of 2 Deg. Again in evening 6.00 pm the difference reduces to 1 Deg. In all, the yellow wash gives a difference of 1 to 2 deg.

Figure 3 refers the comparison of Roof with Solid parapet and Roof Without parapet of two similar residential houses. The presence and absence of parapet wall from early hours up to 8.00 am, there is no much difference. But, after 8.30 am, the roof with parapet brings down the temperature even below the ambient air temperature 1.5 deg to 2 deg. In the afternoon hours the RCC roof without parapet showed 1 deg. more than the ambient air temperature; and around 2.5 deg. more than the RCC roof with parapet.

Figure 4 refers the comparison of Mangalore tiled roof with RCC filler slab roof with Mangalore tile filler, from two nearby residential buildings. From early hours, up to 6 am, RCC Filler slab and Mangalore tiled roof behaves similarly. From 6.00 am to 12.00 noon, Mangalore tiled roof predicted around 1 Deg. lesser temperature; during this time outside ambient air temperature and RCC Filler slab roof were almost same. From 2.00 pm to 4.00 pm, by slowly deceasing, the RCC Filler slab predicted around 1 to 1.5 Deg. lesser. After 6.00 pm up to 8.00 pm the both the roofing were similar and in line with the ambient air temperature. From 9.00 pm onwards, the ambient air temperature reduced to 1 Deg. and at zero hours again further 1 Deg. lesser was noted in ambient air temperature than these two roofing.

Figure 5 refers the comparison of AC sheet roof with Corrugated iron sheet roof, from two nearby residential buildings. From zero hour to 5.00 am, AC sheet and Corrugated iron sheet both showed varied fluctuation of higher and lower temperature. But, from 5.00 am to 11.00 am corrugated iron sheet observed heat easily and rises its temperature around 1 deg. more than AC sheet. After 12.00 noon up to 6.00 pm, AC sheet temperature was 1 Deg. higher than Corrugated iron sheet. Thereafter, from 6.00 pm to next zero hours AC sheet predicted more than 2 Deg. higher temperature. So, it can be considered that the Corrugated iron sheet predicted lower temperature.

Figure 6 refers to the comparison of AC Sheet, Bison Board and Aluminium sheet. This study was made in a textile industry having three similar buildings of size 18300 mm x 9150 mm near Vedapatti, Coimbatore, Tamil Nadu, India. The height of the building at eaves was 4300 mm and at ridge level was 6400 mm. Up to 6.00 am all the three were behaving similarly. From 6.00 am onwards continuously Aluminium sheet predicts lower than AC sheet and Bison board. From 12.00 noon onwards Bison board predicted highest of all the three. From 3.00 pm onwards the bison board behaved similar to ambient temperature. However, during this post peak period of 3.00pm to 8.00 am there is a definite higher value of Bison board for 2.5 Deg. than that of aluminium sheet.

Figure 7 refers the comparison of 2.10 m ceiling height and 3.00 m ceiling height, of a two residential buildings compared with that of the ambient temperature. From zero hours to 6.00 am and again from 3.00 pm to next zero hours, 2.1 m ceiling almost follow the level of ambient temperature. From 6.00 am to 3.00 pm, both ceiling height behaves similar to each other, almost with no difference among them. From zero hours to 6.00 am and again 6.00 pm to next zero hours; there is a definite difference of 1 Deg. between, 2.1 m and 3.00 m ceilings. The 3.00 m ceiling predicted an overall difference of maximum and minimum of 2 deg. only. But, the 2.1 m ceiling predicted a difference of almost 3.5 Deg.

Figure 8 refers the comparison of AC sheet roof with tree shade and AC Sheet roof without tree shade, observed as two nearby residential buildings. Morning 6.00 am to 10.00 am the AC sheet without shade behaves in line with ambient temperature. During this time the AC sheet covered in shade had a higher temperature of 1 to 2 Deg. than the one without shade. From 12 noon to 3.00 pm, AC sheet without shade had a rise of around 1 Deg. Thereafter from 3.00 pm onwards both of them behaved similarly till next zero hours. However, during 10.00 pm, the both were having 1.5 Deg. lesser than the outside air.

Figure 9 refers to AC Sheet Vs RCC Roof of two nearby residential buildings. The AC sheet roof was sloping towards north and the RCC was flat roof. From zero hours to 6.00 am, AC sheet predicted higher for 1 to 2 Deg. than the RCC roof. From 8.00 am to 8.00 pm both behaved similarly; and the temperature was almost 2 Deg. higher than the ambient air temperature. Again, after 8.00 pm AC sheet predicted 2 Deg. higher than RCC flat roof and ambient air.

Figure 10 compares the AC sheet roofing without any ceiling with AC sheet roof with AC sheet itself provide as ceiling. These two were adjoining rooms of two row houses of a staff quarters. The both AC sheet roofing were sloping towards east. Both were selected as intermediate row houses, instead of being at end blocks. AC sheet roof without ceiling and AC sheet roof with ceiling both predicted more than that of the ambient air. The AC sheet roof with AC sheet ceiling predicted highest of all. Not only that the AC sheet roof with AC sheet ceiling defeated the purpose of ceiling for reduction of temperature; it retained the afternoon 3.00 pm highest temperature till around 9.00 pm, then slowly it got declined further to 2.5 Deg. at next zero hour. In all, AC sheet roof predicted 4 to 5.5 Deg. more than the ambient air temperature.

Figure 11 refers the comparison of Mangalore tile roof with Country tile roof and Mangalore tile over flat tile roofing. Each one is one of the staff quarters of intermediate row house. The ambient air temperature fluctuates from a minimum to maximum of 10 Deg. The Mangalore tile over flat tile predicted well with a least over all difference of only 2 Deg. Even when the peak temperature existed in ambient air, the Mangalore tile roof over flat tile predicted 2 deg. lesser than ambient air. But over all lower temperature was predicted by Mangalore tiled roof, in addition to that its temperature was lower for about 2.5 Deg. than the country tile roof and Mangalore tile over flat tile.

Figure 12 refers to the comparison of Mangalore tiled roof with AC sheet roof in two different residential buildings. Both were having same slope towards eastern side. Ambient air varies with a peak and lowest of eight Deg. The Mangalore tile roof had a variation of Peak to lowest of its range as three Deg. Whereas the AC sheet roof had a variation of six Deg. In all, the Mangalore tile roof predicted around 2.5 Deg. higher from zero hours to 6.00 am, and lower around 2.5 Deg. between 2.00 pm and 4.00 pm. Hence, the Mangalore tile is preferable than AC Sheet roof, for hot humid areas.

Figure 13 refers to the comparison of RCC slab with WPC made of brick jelly in lime mortar and RCC slab without WPC. These two are the similar nearby residential buildings. RCC Slab with WPC predicted 1 Deg. lower in early hours from zero to 6.00 am and one and half to two Deg. Lower in afternoon hours from 2.00 pm to 6.00 pm. Hence, a definite reduction of two Deg. was noted in RCC slab with WPC.

Figure 14 refers the comparison of AC sheet sloping I the eastern side with Ground floor RCC, First floor RCC and Mangalore tiled roof sloping in eastern side. Mangalore tiled roof and first floor RCC were behaving similarly. AC sheet and ambient air were similar in early morning hours and up to 10.00 am. From 12.00 noon onwards up to 8.00 pm, Ground floor RCC and AC sheet were in line with ambient air temperature.

Figure 15 refers to the comparison of orientation of rooms in an office building with RCC roof with respect to thermal behavior. It is obvious that the Eastern side room predicted with more temperature. Among the west and south the west behaves better in the 8.00 am to 12 noon. After evening 6.00 pm, Eastern side and Western side room behave similarly. In all the Northern side room continuously behave well with lowest prediction of temperature.

3. Result and discussion

From Fig.1, it can be concluded that where ever possible, RCC taper roofing towards northern side can be preferred than RCC Flat roof for maintaining internal thermal load of around 3 to 4 Deg. From Figure 2, it can be noted that white colour brings down the internal air temperature to the extent of 2 Deg. From Figure 3, RCC Roof with parapet predicted around 2.5 Deg. lesser than roof without parapet, between 10.00 am and 3.00 pm. This might be because of two reasons; one of them is the observation of heat by the parapet wall material as it is mainly made of mud brick and its thermal lag. The other reason might be the shadow cast by the parapet wall however small, it could have got its own effect. Any way this needs to be studied carefully in detail. From Figure 4, the RCC Filler slab behaves almost similar to that of the Mangalore tiled roof can be noted. Here, one can consider the advantage of the RCC filler slab, as it gives a boon of upper floor area for vertical rise with equal thermal comfort as that of Mangalore tile roof. Of course, the initial cost may be higher for RCC Filler slab, however, over all life cycle cost will be lesser, in addition to its thermal comfort. From figure 5, it can be decided that the Corrugated iron sheet predicted lower temperature. Form figure 6, it can be noted that during this post peak period of 3.00 pm to 8.00 am there is a definite higher value of Bison board for 2.5 Deg. than that of aluminium sheet. From figure 7, it can be concluded that the higher ceiling height, results with least difference between maximum and minimum inside air temperature. From figure 8, it can be observed that both AC sheet roof with shade and without behaved similarly in most of the hours; but in morning 8.00 am to 10.00 am, the one with shade predicted 1 to 2 Deg. higher. From Figure 9, it can be concluded that the AC sheet roof sloping towards northern side behaves in line with that of RCC flat roof from 8.00am to 8.00pm; from zero to 6.00am and from 8.00pm to next zero hours, the AC sheet roof predicted 2 Deg. higher. This means that for heat retaining capacity is more in AC sheet. Hence, it can be preferred, in hilly regions where more heat gain in required. From figure 10, it can be observed that AC sheet roof with AC sheet ceiling without any roof level ventilator can be adopted to hilly regions where heat gain is warranted rather than cooling down. From figure 11, it can be concluded that simple Mangalore tiled roof can be preferred than country tiled roof and Mangalore tile over flat tile roofing for over all cooling effect. From figure 12 also, it can be concluded that Mangalore tiled roofing is better than AC sheet roofing. From figure 13, it can be concluded that RCC roof WPC made of brick jelly in lime mortar is better than RCC without WPC for a reduction in temperature of 2 Deg. From figure 14, it can be seen that Mangalore tiled roof and first floor RCC can be considered predicting lower temperature. From figure 15, it can be concluded that the rooms oriented towards north predicted lower temperature.

4.Conclusion

The various combinations of Roofing and finishes were covered and the research observations were discussed and in the section of Result and Discussions. The study in general may look like the comparison showed a minimum variation of temperature such as 2 Deg. to 4 Deg. Those who have undergone the basics of thermal comfort with reference to age, climate, dressing, etc., one can understand that however minimum, the passive applications for heat reduction and heat gain in the appropriate regions in the specific type of building design would lead to a successful energy saving and cost reduction buildings. So, a various combinations of the results presented along with better orientation, material selection, proper planning and designing of building elements, considered with micro conditions would result for a more thermally comfortable, energy saving buildings.

5. Future Scope

Further research may be carried out in buildings having different types of masonry. Thermal response of different roofing of modern industries may be done. Computer simulations may be made with reference to the actual observed data. Double skinned walls, walls with and without insulation materials may be studied. Effect of with and without presence of solid parapet wall and Effect of solid parapet wall can be compared with that of parapet wall with

opposite openings in wind flow direction can be studied in detail. Thermal studies may be made with either the uniform thickness of roof covering and or the wall materials along with the uniform unit price of materials to simply the selection options.

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Conflict of Interest: The authors have no conflict of interest with anybody in publishing this paper.

References

[1] Anicet Vincent et.al., Effects of Rationalization of Active and Passive Techniques in the Building Industry, Plea2004 - The 21st Conf. on Passive and Low Energy Architecture. Eindhoven, The Netherlands, 19 – 22 Sep 2004 pp1-5

[2] J. Vijayalaxmi Concept of Overall Thermal Transfer Value (OTTV) in Design of Building Envelope to Achieve Energy Efficiency Int. J. of Thermal & Env. Engg.Vol.1, No. 2 (2010) pp 75-80

[3] Mohammad Arif Kamal, An Overview of Passive Cooling Techniques in Buildings: Design Concepts and Architectural Interventions, *Acta Technica Napocensis: Civil Engineering & Architecture Vol. 55, No. 1 (2012)*

[3] Asif ali, Passive Cooling and Vernacularism in Mughal Buildings in North India: A Source of Inspiration for Sustainable Development International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies,Vol.04,No.1, 2013 pp15-27

[4] Karam M. Al-Obaidi et al., 2014 , Investigation of Passive Design Techniques for Pitched Roof Systems in the Tropical Region, Modern Applied Science; Vol. 8, No. 3; 2014 pp 182-191

[5] Muktar Inusa, Application of Passive Cooling Techniques in Residential Buildings: A case study of Northen Nigeria.Int. J. of Engg. Research and Application , *Vol. 7, Issue 1, (Part -1) Jan 2017, pp.24-30*

[6] C. V. Subramanian et al., Solar Passive Architecture Cooling Techniques Int. Res. J. of Engg. and Technology, Vol: 03 Issue: 12 Dec -2016 pp 1388-1394.