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TECHNIQUES TO MINIMIZE HEAT TRANSFER IN CONCRETE ROOF STRUCTURES

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ABSTRACT

Throughout the course of civilization, there has been a significant shift in people's attitudes. The alteration in behavior is evident as individuals have actively contributed to the destruction of vegetative cover, initiated numerous industries, established housing units, and introduced various machines, among other developments. However, some of these innovations have negative repercussions on the environment. The emissions produced by machines and other equipment contribute to the depletion of the ozone layer, a crucial shield safeguarding humans, plants, animals, and other organisms from the harmful radiations of the sun. Nowadays there is a tremendous increase in the growth of various industries. Along with the development of industries, the heat of the sun reaching the ground also increased. This increase in the sun's radiation directly increases the heat on the all the structures. Most of the dwelling units such as flats, apartments, residential housing units etc. are made of concrete structures. Hence people may find difficulties of heat in their dwelling units. The needs of the people are increasing a lot resulting in providing more facilities and better living conditions. Many new concrete buildings are arising in the world day by day. Around 70% of total population is using concrete buildings in their day to day activities for fulfilling their various needs. Individuals rely on concrete structures for various purposes such as residential, commercial, and industrial use. Those residing in hot regions encounter significant challenges due to the thermal characteristics of concrete buildings. These structures absorb heat throughout the day and release it in the evening and night. Upon returning home after a day of strenuous activities, many people find it challenging to cope with the intense heat trapped in their residential units during the hot season. Therefore, a project has been initiated with the objective of addressing the theme "Mitigating Thermal Impact within Concrete Roof Structures for an Improved Indoor Environment," aiming to create a more comfortable atmosphere within these structures.

Keywords: Roof Structures, Residential, Commercial, and Industrial

1.INTRODUCTION

As the sun's heat and radiation intensify, there is a simultaneous surge in the construction of concrete buildings, seen as a lucrative investment by property owners. The concrete roofs, exposed to the sun, absorb and radiate heat into the structures, elevating the internal temperature. This thermal impact subjects' occupants to increased temperature stress, leading to reduced efficiency and diminished overall work output within these buildings. Prolonged exposure to such heat poses potential health hazards, necessitating medical care over time and potentially causing adverse effects on individuals' well-being. Concrete roof structures play a pivotal role in the construction landscape, serving as essential components in residential, commercial, and industrial buildings. The inherent durability and strength of concrete make it a popular choice for roofing, providing stability and longevity to structures. However, the thermal characteristics of concrete roofs can pose challenges, particularly in regions with high temperatures. The capacity of concrete to absorb and release heat can lead to increased indoor temperatures, impacting the comfort and efficiency of occupants. As the global climate evolves and temperatures rise, the need to address heat-related issues in concrete roof structures becomes increasingly crucial. This necessitates exploring innovative techniques and solutions to minimize heat transfer, enhance insulation, and create more comfortable living and working spaces. An understanding of these challenges and the implementation of effective strategies can contribute not only to improved thermal performance but also to sustainable and energy-efficient construction practices. This introduction sets the stage for a comprehensive exploration of techniques geared towards optimizing concrete roof structures in the face of thermal challenges.

2.AIM AND SCOPE

The aim of employing techniques to minimize heat transfer in concrete roof structures is to create a more thermally efficient and comfortable environment within these buildings. This involves reducing the absorption and retention of heat by the concrete roofs, thereby lowering the internal temperature. By implementing such techniques, the goal is to mitigate temperature stress on occupants, enhance overall comfort, and potentially contribute to increased energy efficiency by lessening the need for excessive cooling systems. This can lead to improved productivity, well-being, and a more sustainable use of resources in concrete-roofed structures.

3.LITERATURE REVIEW

A REVIEW OF ROOFING METHODS: CONSTRUCTION FEATURES, HEAT REDUCTION, PAYBACK PERIOD AND CLIMATIC RESPONSIVENESS BY MAJED ABUSEIF * AND ZHONGHUA GOU - The roofs of buildings play an essential role in energy efficiency because a significant amount of solar radiation is absorbed by roofs in hot weather and a significant amount of heat is lost through roofs in cold weather. This paper is a systematic literature review about roofing methods for flat roofs. Ten roofing methods are reviewed in this paper. They are concrete roof, cool roof, insulated roof, roof garden, photovoltaic panels' roof, biosolar roof, double-skin roof, roof ponds, skylight roof, and wind catcher. The review covers each roof's main features, heat flux reductions, payback periods, and the appropriate climate for its implementation. Moreover, cool pool, ventilated roof pond, and wind catcher can help stabilize a building's indoor temperature on hot days and they can reduce cooling loads up to 100%; roof gardens have the highest positive impact on the environment with passive heating on cold days and passive cooling on hot days; it can reduce the cooling loads up to 37%, and the reduction can be up to 80% if it is integrated with reflective material and ventilation; cool roof and uncovered pond have a reasonable heat gain reduction, which can be up to 33% and 55% respectively, with a short payback period; photovoltaic panels' roof is a sensible solution to reduce the fossil fuel energy consumption for a building and it also has a valuable heat reduction, which can be up to 63%. Finally, a skylight with thermal treatment is an ideal selection if the building has a deficit of natural light.

PASSIVE COOLING OF CEMENT-BASED ROOFS IN TROPICAL CLIMATES BYJORGE L. ALVARADO A, EDGARD MARTÍNEZ B - Intropical climates, dwellings are made of cement-based materials like concrete to be able to withstand tropical storms and severe weather conditions. However, cement-based materials exhibit undesirable thermal properties including low thermal conductivity and thermal diffusivity which make living conditions almost unbearable. The purpose of this research project was to investigate the impact of a newly designed passive cooling system which can minimize heat transfer through concrete roofs. The passive cooling system consists of a corrugated aluminum sheet with a unique orientation to promote heat dissipation. A layer polyurethane is also used to minimize heat transfer. This proof-of-concept study clearly demonstrates the significant impact of a simple and effective passive cooling system in reducing thermal loads in roofs. The experimental results demonstrate that the newly designed aluminum– polyurethane insulation system with an optimal orientation reduces the midpoint temperature of a cement-based roof significantly.

LOWERING EMISSIVITY OF CONCRETE ROOF TILE'S UNDERSIDE CUTS DOWN HEAT ENTRY TO THE BUILDING BY XUEJUNCHEN,1LEI WANG,1ZHIKUI LIU,1YINGHONG - Buildings in Southern China widely use a double-skin roof to reduce heat entry through the roof to the building interior during summertime. Concrete roof tiles are preferably installed as the outmost layer of the double-skin roof due to their resistance to hail and wind damages and their attractive price. Observations reveal that lowering the emissivity of concrete roof tiles could cut down the summer heat gain of buildings in tropical regions. The experiment validated that a concrete tile exhibiting a lower εb results in a reduced roof deck temperature and transmits a lesser amount of heat into the building interior, particularly during daylight hours.

A COMPARATIVE STUDY ON EFFECTS OF VARIOUS INSULATING LAYERS OF ROOF SYSTEM ON ENERGY USAGE OF BUILDING ENVELOPE A RAUT1, S KHATOON2 AND P GOUD13 - The roof system has been studied with their carbon emission and Embodied Energy to understand the sustainability aspect of the insulating layers in combination to provide a green roof system. The materials used for studying the insulating effects of roof system which were analysed in combinations were cork, gypsum board, expanded polystyrene, rock wool, fibre glass, PVC mesh, Polyurethane, etc.Due to the insulating layers the heat transfer is reduced through the roof system, which affects the cooling load of building envelope which reduces the energy consumption. The research successfully suggests the value-added function of insulation layers not only to provide thermal indoor air comfort by restricting the dissipation of heat through the exposed roof surface but also proves to be energy efficient for building envelope.

EXPERIMENTAL AND NUMERICAL STUDY OF THERMAL PERFORMANCE OF A BUILDING ROOF INCLUDING PHASE CHANGE MATERIAL (PCM) FOR THERMAL MANAGEMENT - MUSHTAQ T.H.1*, AHMED Q. M.2, HASANAIN M.H.3 - The energy required for heating and cooling of buildings plays an important role in all countries. In many countries heating/ cooling and air-conditioning systems are used in many commercial and residential buildings. Due to increase in energy demands of these systems, an appropriate insulation of buildings, such as walls, roofs and floors is important in reducing the rate of heat flowing to buildings in summer and winter. Selecting a proper insulation material by considering its thermal properties in each weather conditions should be expected to favor the economics of the buildings. In addition, to make a suitable lagging time to heat flux entering the buildings by storing energy is another way to control indoor air quality. The storage of energy can be done in the form of sensible and latent. The energy is stored in Phase Change Material (PCM) by latent form. Moreover, the thermal conductivity of PCM is usually less than bricks. Therefore, PCMs can play both as insulation and also as a storage material. Due to these advantages the use of PCM in building material is considered in the past decade. The characteristics of PCMs make them suitable for use in energy conservation.

4. EXPERIMENTAL PROGRAMME

The experimental programmed consists of testing the inside temperature of a room of a structure and outside prevailing temperature of the structure at that time with various methods adopted for minimizing the solar radiation as well as for limiting the heat of the sun. The structure for testing should be of concrete roofed in nature. Readings should be collected for reference during the peak timing of radiation ie. between the 12.00pm and 4. 00pm.This analysis help us to find out the better thermal insulation material and also how to minimize the room temperature close to normal temperature rather than to provide AC which is supplying cool air inside the room emitting heat to the outside premises. The main disadvantage of AC is that, it emits gases like ozone, carbon di oxide, etc. which are more harmful for the mankind and living society.

PROTOTYPE FOR TESTING

Outside dimension – 112cm x 82cm x 95cm
Inside dimension – 90cm x 60cm x 80cm
False ceiling bottom level is 10cm down from bottom level of roof

Figure 1–Prototype

4.1 BLANKETING

Blanketing is a technique of covering the structure or a part of the structure with a material. We are using aluminium foil as blanketing material. Aluminium foil is a thin material which is highly reflective in nature.

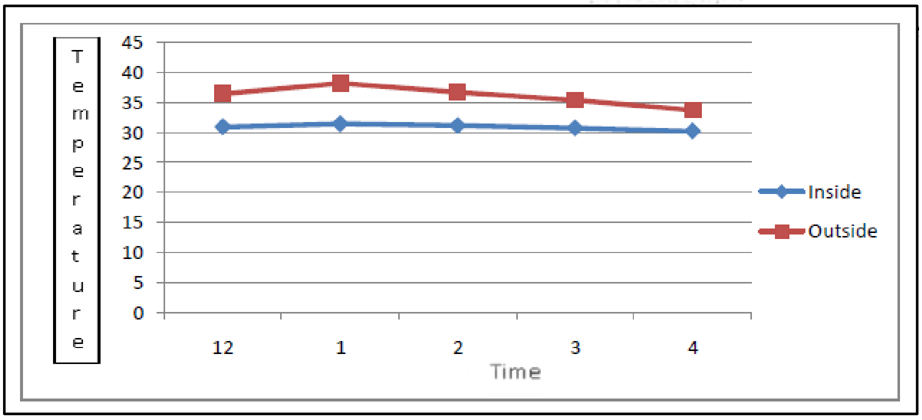
Roof blanketing
Wall blanketing
Combined roof and wall blanketing

4.4.1 ROOF BLANKETING

This is the technique of applying aluminium foil over the roof of the structure. Aluminium foil is used for roof blanketing in the project because it may reflect around 95% of sun radiation, so the building may get cool.

Figure: 2 -Prototype roof blanketed with Aluminum foil

Sl No.	Time (pm)	Internal temperature ◦c	External temperature ◦c
1	12	30.6	36.2
2	1	31.2	38
3	2	31.2	36
4	3	30.4	35.2
5	4	30	33.4



roof

Figure: 4 Inference: Inside temperature is 6.80C less than outside temperature.

4.4.2. WALL BLANKETING

This is the method of covering the outer wall surface with aluminium foil in order to reflect the sun radiation back, so that the building may get cool because of less affection of sun radiations on walls of structures.

Figure 5-Prototype wall blanketing with aluminum foil

Sl No.	Time (pm)	Internal temperature ◦c	External temperature ◦c
1	12	32.5	36.7
2	1	33.2	38.2
3	2	33	36.2
4	3	32.5	34.8
5	4	32	34.6

Figure 6-Wall blanketed with aluminum foil

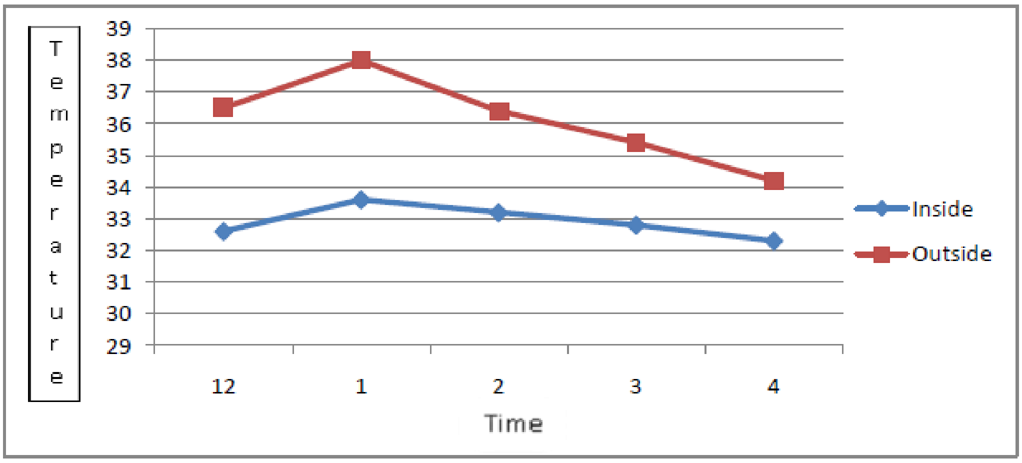


Figure 7 Inference: Inside temperature is 4.40C less than outside temperature

4.4.3. COMBINED ROOF AND WALL BLANKETING

In this method the top portion of the roof and outer walls are blanketed with aluminium foil. It is a combined method of roof blanketing and wall blanketing. The outer surface of the structure is fully covered with aluminium foil in order to protect the structure from the radiations of the sun.

Figure -8 Prototype with combined roof and wall blanketing

Sl No.	Time (pm)	Internal temperature °C	External temperature °C
1	12	30	37.6
2	1	30.5	38.8
3	2	30.5	37
4	3	30	36
5	4	29.8	34.8

Figure -9 -Combined roof and wall blanketing

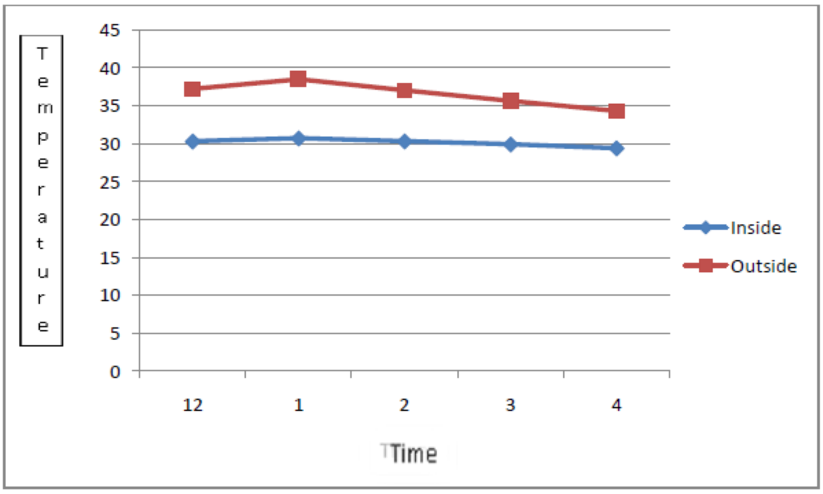


Figure -10 Inference: Inside temperature is 7.80C less than outside temperature

5.1 ALUMINIUM COMPOSITE PANEL (ACP)

The walls of the building can be covered or blanketed with ACP for reducing the impact of radiations from the sun. The ACP sheet consists of majority of aluminium and the same can attain good thermal protection from the radiations. Normally ACP work is done for providing good aesthetic value for the building. There are other reasons such as heat reduction on structures, Leak prevention on walls etc.

Sl No.	Time (pm)	Internal temperature ◦c	External temperature ◦c
1	12	32.4	36.7
2	1	33.7	38.4
3	2	33	36.4
4	3	32	35.2
5	4	31.5	33.8

Figure -11 ACP on the sides of structure

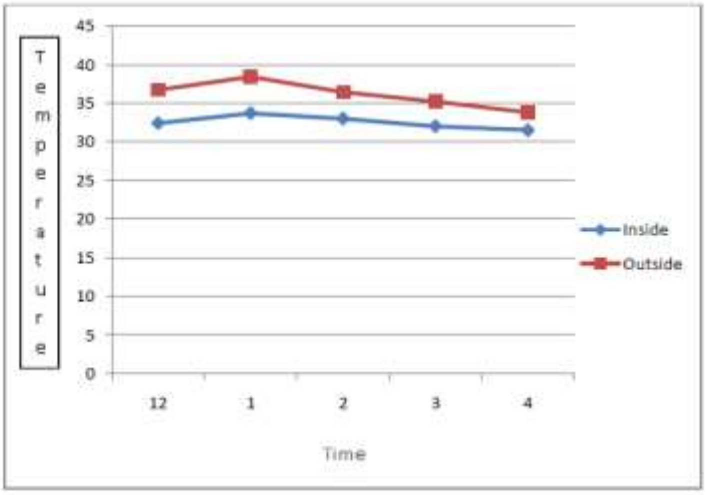


Figure -12 Inference: Inside temperature is 4.70C less than outside temperature

5.2. SOLAR PANELLING OVER THE ROOF STRUCTURE

Solar panel can be provided over the roof structure. Solar energy can be made useful for electrification of structures. The provision of solar panels drives two basic functions

Empowering solar energy for electrification

Heat reduction on concrete structures

Sl No.	Time (pm)	Internal temperature ◦c	External temperature ◦c
1	12	32.4	36
2	1	33	38.4
3	2	32.6	36.6
4	3	31.8	35.4
5	4	31.4	34.6

Figure -13 Solar panel above the concrete roof

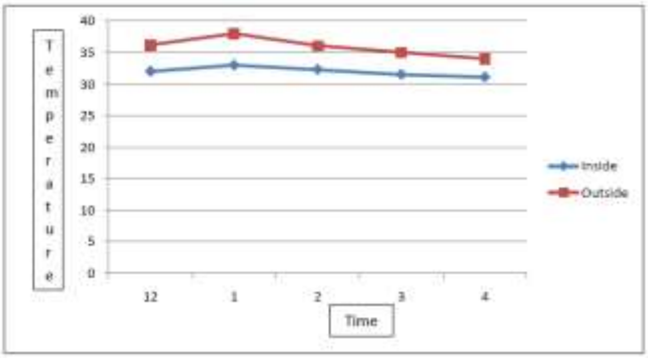


Figure -14 Inference: Inside temperature is 5^{0}C less than outside temperature.

5.3. PROVISION OF FALSE CEILING BELOW CONCRETE ROOF

By providing false ceiling below the existing roof, there creates a sufficient space for the air to occupy between false ceiling and existing roof. Thus, the hot air which is radiated through the roof is entrapped between the false ceiling and roof of the structure. A limited amount of heat and other radiations will enter to the inside of room as per the material used for the false ceiling work. It is also advisable to provide an air gap or ventilation for the space between false ceiling and roof for transferring overheats entrapped between this region.

5.4. FALSE CEILING WITH THERMOCOL SHEETS

False ceiling with thermocol sheets will give a good result for the reduction of heat and sound. The thermocol false ceiling prevents much of the radiations including heat from entering to the room. The major advantage of using thermocol is its thermal control. The same advantage of thermocols taken by people for keeping cool items such as ice cubes and ice creams without melting for a long time. Thus, it is a worth to provide a false ceiling with thermocol for preventing heat radiation from the roof.

Figure 15–Thermocol false ceiling below concrete roof in a building

Figure 16 - Prototype with thermocol false ceiling below concrete roof

Sl No.	Time (pm)	Internal temperature ◦c	External temperature ◦c
1	12	30	36.7
2	1	30.4	37.4
3	2	30	36.2
4	3	29.5	35.5
5	4	28.8	34.4

Figure 17 - Thermocol false ceiling below concrete roof

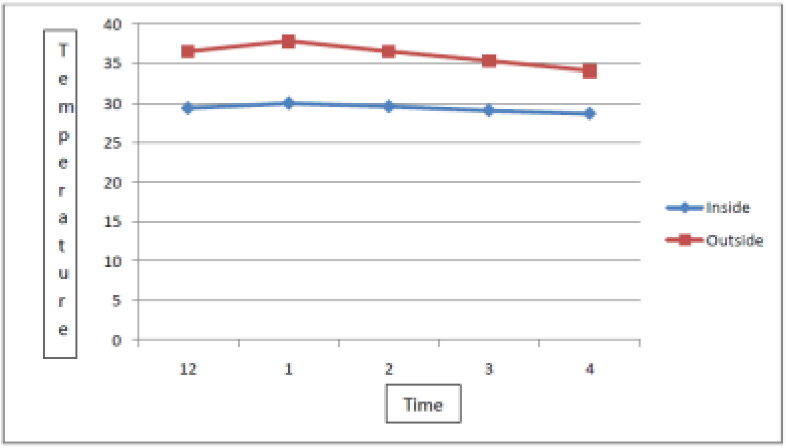


Figure 18 - Inference: Inside temperature is 7.8^{0}C less than outside temperature.

5.5 FALSE CEILING WITH PVC

False ceiling with PVC sheets can be provided for controlling over heating of space inside the room. The PVC sheets of various designs and various thicknesses are available in the market. Thus, the customer can choose PVC ceiling of their pattern. This type of ceiling is quite cheaper and easy in installation. This type of ceiling provides thermal control up to a certain limit and the rest of the heat may receive to the rooms. People may find this type of false ceiling for either of the above two major purposes.

Figure 19 - PVC false ceiling below concrete roof

Figure 20 – Prototype with PVC false ceiling below concrete roof

Sl No.	Time (pm)	Internal temperature ◦c	External temperatur e ◦c
1	12	31.4	36.4
2	1	31.8	37.8
3	2	31.6	36
4	3	30.8	35
5	4	30	33

Figure 21 - PVC false ceiling below concrete roof

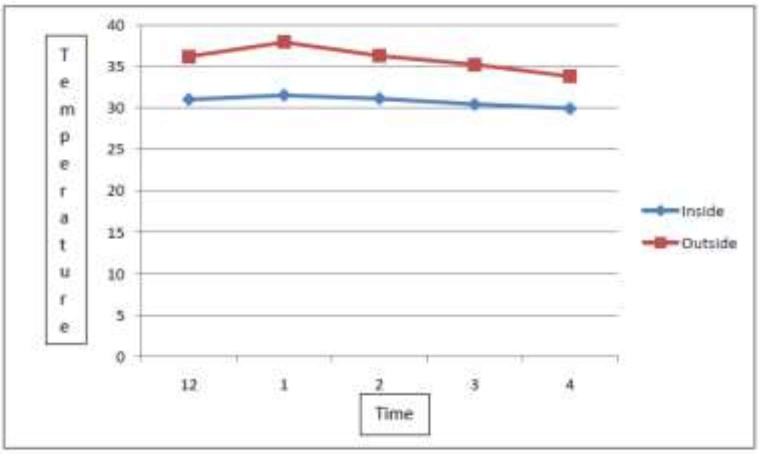


Figure 22 - Inference: Inside temperature is 6.4^{0}C less than outside temperature.

5.6 FALSE CEILING WITH GYPSUM BOARD

Now gypsum board is gaining a lot of market in false ceiling works. Gypsum boards are strong enough to carry weight of electrical light fittings and other light weight objects without any damages. These boards are screwed at various points to the supporting channel work and the same is putty painted to get aesthetic appearance similar to concrete roofs.

Figure 23-False ceiling with gypsum board in concrete roofed structure

Figure 24 – Prototype with gypsum board false ceiling

Sl No.	Time (pm)	Internal temperature °c	External temperature °c
1	12	30	36
2	1	30.2	38.2
3	2	29.8	36.6
4	3	29.6	35
5	4	29	34.2

Figure 25 – False ceiling with gypsum board

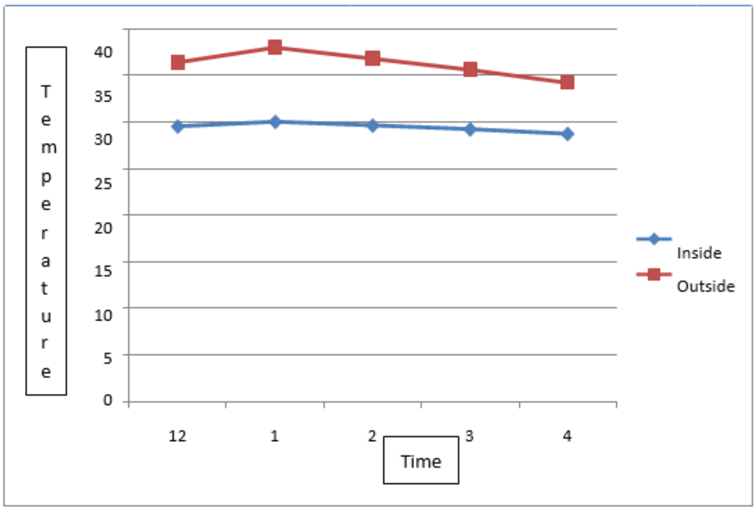


Figure 26 – Inference: Inside temperature is 8^{0}C less than outside temperature.

5.7. BONDING THERMO RESISTANT LAMINATES WITH CONCRETE

This method involves the lamination of thermo resistant materials with concrete. The thermo resistant materials are bonded at the bottom of the concrete roof. Thus, the heat inside the concrete roofed buildings gets reduced. By laminating the material at the bottom of concrete, we can effectively use the top portion of concrete surface.

Figure 27 – Bonding thermocol below concrete roof

Sl No.	Time (pm)	Internal temperature ◦c	External temperature ◦c
1	12	30	36
2	1	31	37.5
3	2	30.5	36.4
4	3	28.8	35
5	4	29	34.2

Figure 28 – Bonding thermocol below concrete roof

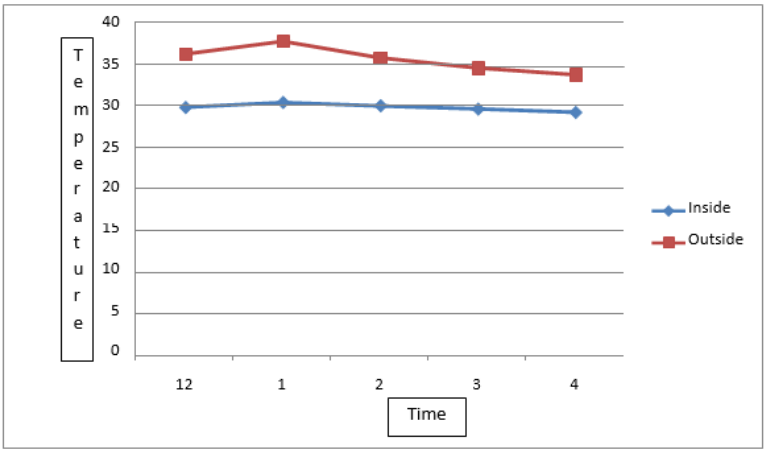
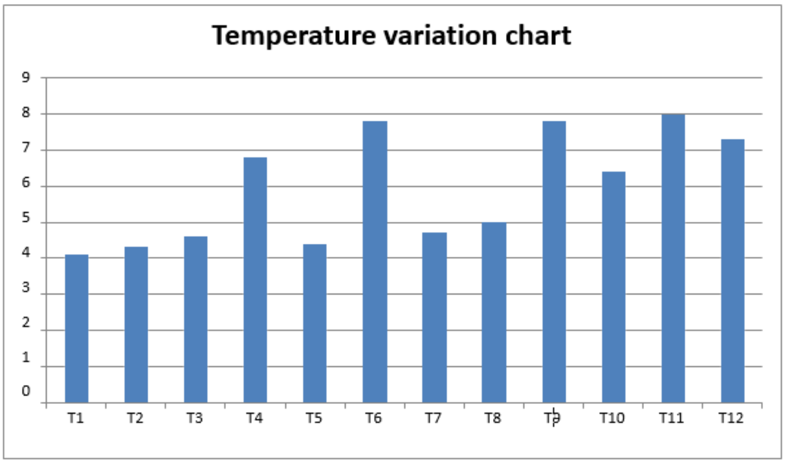


Figure 29– Inference: Inside temperature is 7.3^{0}C less than outside temperature.

6. RESULT AND DISCUSSION

T1. Orientation in wrong direction
Inside temperature is 4.10C less than outside temperature.
T2. Orientation in correct direction
Inside temperature is 4.30C less than outside temperature.
T3. Ventilation hole on top of wall
Inside temperature is 4.60C less than outside temperature.
T4. Roof blanketed with Aluminium foil
Inside temperature is 6.80C less than outside temperature.
T5. Wall blanketing with Aluminium foil
Inside temperature is 4.40C less than outside temperature.
T6. Combined roofs and wall blanketing with Aluminium foil
Inside temperature is 7.80C less than outside temperature.
T7. Sides of structure covering with ACP
Inside temperature is 4.70C less than outside temperature.
T8. Solar panel over the concrete roof
Inside temperature is 50C less than outside temperature.
T9. Thermocol false ceiling below concrete roof
Inside temperature is 7.80C less than outside temperature.
T10.PVC false ceiling below concrete roof
Inside temperature is 6.40C less than outside temperature.
T11. Gypsum false ceiling below concrete roof
Inside temperature is 80C less than outside temperature.
T12. Bonding thermocol below concrete roof
Inside temperature is 7.30C less than outside temperature.



7.CONCLUSION

By following the above said techniques the thermal radiation & heat inside the concrete roofed structurescan be reduced to a moderate extent. The reduction in temperature inside the concrete roofed structures can offer a better environment for human beings. The Air conditioners are costly and they consume more electricity. More over the gases like Freon etc. are very harmful to human beings and to environment. By providing the above-mentioned techniques, we can minimize the use of air conditioning.

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