International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

COST EFFECTIVE THERMAL REDUCTION TECHNIQUES FOR CONCRETE ROOF STRUCTURES

Jisha P M[1], Dr. A.G.Mohandas Gandhi[2], S.Janani[3]

[1]ME Construction Engineering and management, Department of Civil Engineering, RVS Technical Campus, Coimbatore -641402, India
[2]Head of Department I/C, Department of Civil Engineering, RVS Technical Campus, Coimbatore -641402, India
[3]Assistant Professor, Department of Civil Engineering, RVS Technical Campus, Coimbatore -641402, India

---***---

Abstract - *From the beginning of the civilization onwards there is tremendous change in the attitude of the people. People start destroying the vegetative cover, start many new industries and housing units, developed new machines, etc. Some of the inventions are in such a manner that they adversely affect the atmosphere and surroundings. Some of the emissions from the machines and other equipment's results in depleting the ozone layer which is the main layer that protects human beings, 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. People are depending on concrete structures for residential purposes, commercial purposes, industrial uses and many more. People in hot areas of the world face major problems due to heating of concrete buildings. Concrete buildings absorb heat during the day time and release the entrapped heat in the evening and night. After people reaching their homes with robust of activities carried out at workplace, most of the people find it very tough to cope up with the unbearable heat in their residential units during the hot season. Hence it's decided to take up a project based on the theme "Reducing the thermal impact inside the concrete roof structures for a conducive environment" which provides a better environment inside the concrete roofed structures*.

1. INTRODUCTION

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 The heat and other radiations from the sun are increasing day by day, whereas on the other hand, people are constructing concrete buildings to serve a valuable investment for the owners.

Building shape, location, materials, and elements of design, all play significant roles in energy performance inside a building, and consequently, the role of architects is to integrate them to produce a sustainable building and save energy usage. When designing a building, unfortunately roofs have not received much attention, yet the roof of building plays an essential role in building sustainability, as it absorbs thermal energy significantly in hot climates.

Concrete roof becomes hot due to sun and emit the heat inside the structure causing a rise in temperature inside the structure. This effect makes the people inside to bear lot of temperature stress resulting in low efficiency. Thus the total work output of the people inside the concrete buildings decreases. Over exposure to such heat may cause a variety of health hazards. This may gradually lead people to have adverse effects on their health and they are forced to take medical care over the time period.

In past years, much research has been conducted regarding different ways to deal with building roofs in order to improve thermal comfort, improve energy performance in buildings, and to reduce the negative impact on the environment. Many researchers have addressed different sustainable methods and treatments for building roofs to improve the energy performance in buildings.

1.1 Aim and Scope

This project aims at reducing the heat inside the concrete roofed structures without providing air conditioning. the basic principles for selecting appropriate roofing methods are discussed and future studies for integrating these roofing methods are suggested. Some of these methods can eliminate the need of installing HVAC (Heating Ventilation and Air-conditioning) systems and others can achieve a high percentage of heat reduction if they are the right choice and they are implemented in the right circumstances. An incorrect selection could result in mild to severe energy penalties. The review contributes to the increasing knowledge about sustainable roofing and helps designers to increase building energy efficiency by selecting the appropriate roofing method.

2. EXPERIMENTAL STUDY

The experimental programme 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.

Testing method

A small opening of size 20cm x 20cm is made at 20cm down from the top of wall. The same is covered using gypsum board for the testing of inside temperature.

The outside temperature is measured by placing the thermometer outside the structure for around 15 minutes.

Apparatus used

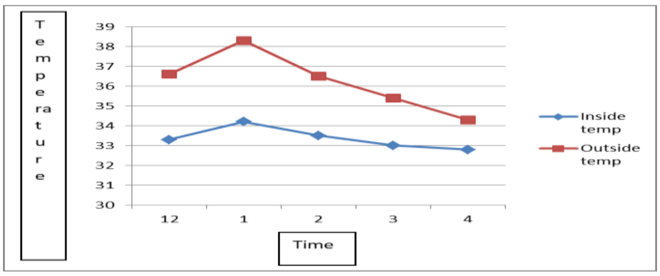
A mercury thermometer with measuring temperature ranging from -15^0c to 50^0c is used for measuring the inside and outside temperature.

2.1 ORIENTATION IN WRONG DIRECTION

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	33.3	36.6
2	1.00	34.2	38.3
3	2.00	33.5	36.5
4	3.00	33	35.4
5	4.00	32.8	34.3

Table 1-Orientation of structure in wrong direction

Figure 13-Prototype oriented in wrong direction

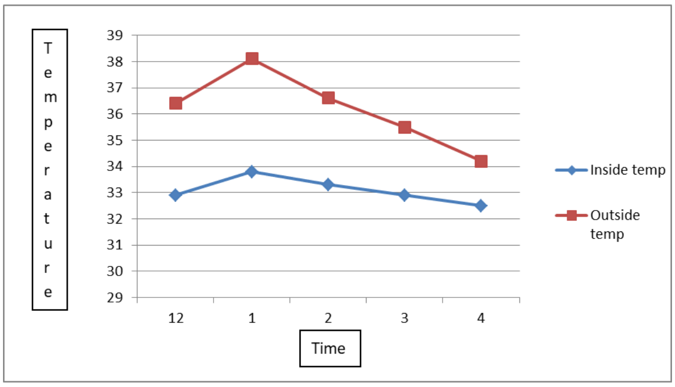


Graph 1- Inference: Inside temperature is 4.1^0C less than outside temperature.

2.2 ORIENTATION OF STRUCTURE IN CORRECT DIRECTION

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	32.9	36.4
2	1.00	33.8	38.1
3	2.00	33.3	36.6
4	3.00	32.9	35.5
5	4.00	32.5	34.2

Table 2 Orientation of structure in correct direction

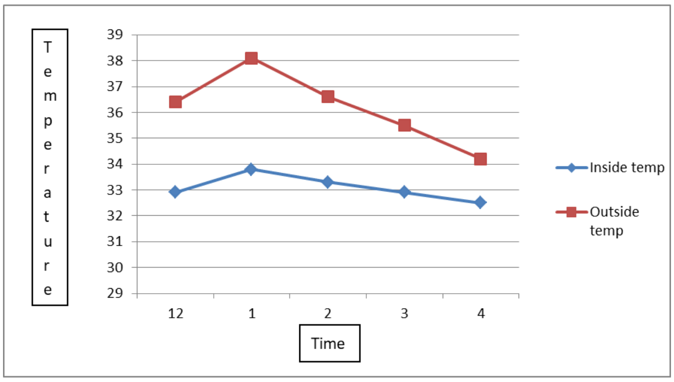


Graph 2- Inference: Inside temperature is 4.3^0C less than outside temperature

2.3 BUILDING WITH VENTILATION HOLE AT TOP OF WALL

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	32.6	36.7
2	1.00	33.4	38
3	2.00	32.7	36.5
4	3.00	32.1	35.5
5	4.00	31.5	34.00

Table 3-Ventilation hole on top of walls

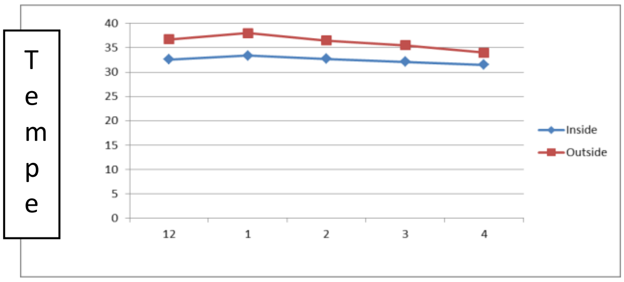


Graph 3- Inference: Inside temperature is 4.6⁰C less than outside temperature.

2.4 BUILDING WITH VENTILATION HOLE AT TOP OF WALL

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	30.9	36.4
2	1.00	31.4	38.2
3	2.00	31.1	36.7
4	3.00	30.7	35.4
5	4.00	30.2	33.7

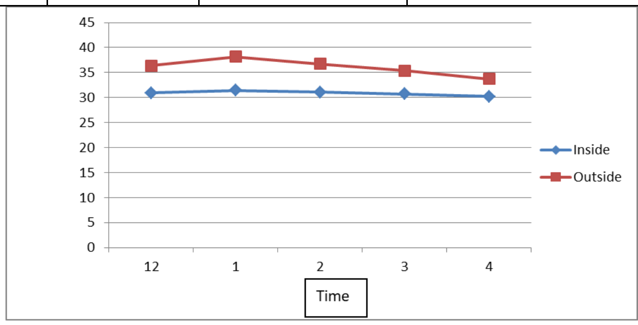
Table 3-Ventilation hole on top of walls



Graph 3- Inference: Inside temperature is 4.6⁰C less than outside temperature.

4.04 ROOF BLANKETING

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	30.3	37.2
2	1.00	30.7	38.5
3	2.00	30.3	37
4	3.00	29.9	35.6
5	4.00	29.4	34.3

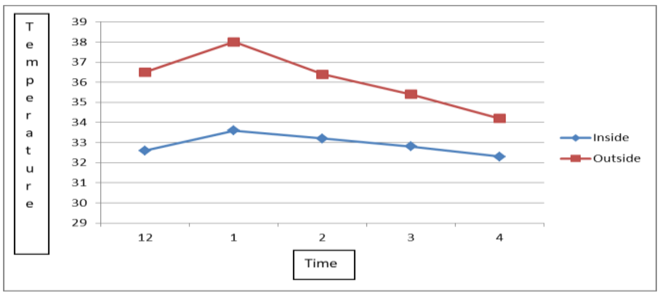


Graph 4- Inference: Inside temperature is 6.8⁰C less than outside temperature.

4.05 WALL BLANKETING

Sl No.	Time (pm)	Internal temperature ∘c	External temperature ∘c
1	12.00	32.6	36.5
2	1.00	33.6	38
3	2.00	33.2	36.4
4	3.00	32.8	35.4
5	4.00	32.3	34.2

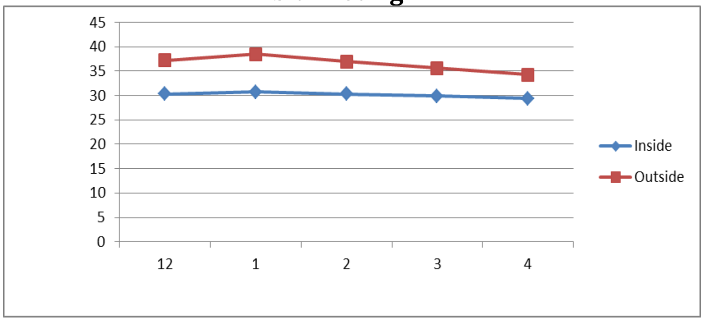
Table 5-Wall blanketed with aluminium foil



Graph 5- Inference: Inside temperature is 4.4⁰C less than outside temperature.

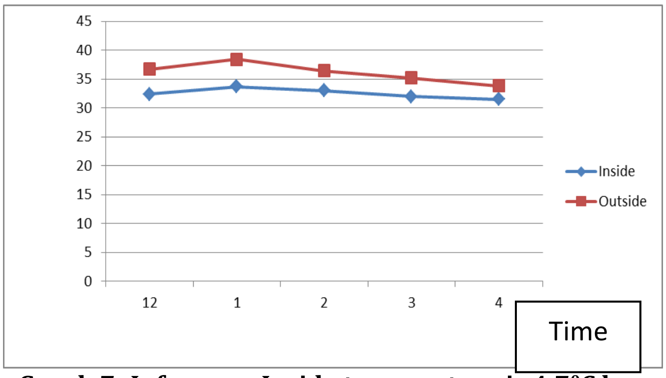
4.06 COMBINED ROOF AND WALL BLANKETING

Table 6-Combined roof and wall blanketing



Graph 6- Inference: Inside temperature is 7.8^{0}C less than outside temperature.

4.07 ALUMINIUM COMPOSITE PANEL

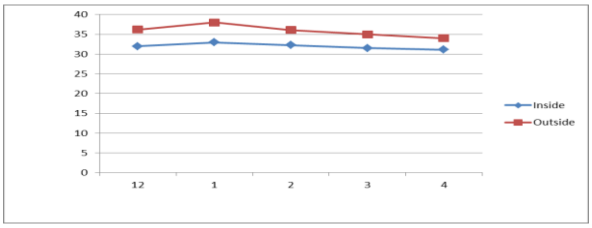


Graph 7- Inference: Inside temperature is 4.7^{0}C less than outside temperature.

4.08 SOLAR PANELING OVER THE ROOF STRUCTURE

Table 8 – Solar panel above the concrete

Sl No.	Time (pm)	Internal temperature °c	External temperature °c
1	12.00	32	36.2
2	1.00	33	38
3	2.00	32.3	36.1
4	3.00	31.5	35
5	4.00	31.1	34



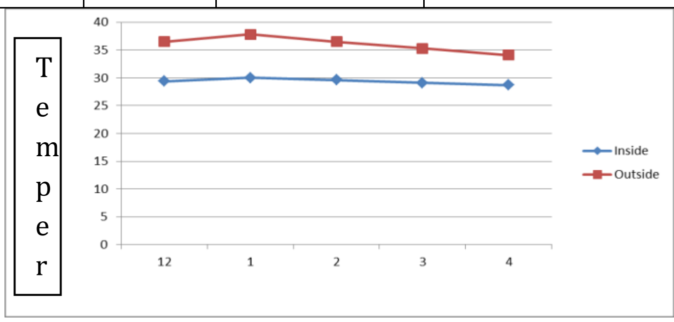
Graph 8- Inference: Inside temperature is 5^{0}C less than outside temperature

4.09 PROVISION OF FALSE CEILING BELOW CONCRETE ROOF

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	29.4	36.5
2	1.00	30	37.8
3	2.00	29.6	36.5
4	3.00	29.1	35.3
5	4.00	28.7	34.1

Table 9-Thermocol false ceiling below concrete Roof

Sl No.	Time (pm)	Internal temperature °c	External temperature °c
1	12.00	32.4	36.7
2	1.00	33.7	38.4
3	2.00	33	36.4
4	3.00	32	35.2
5	4.00	31.5	33.8

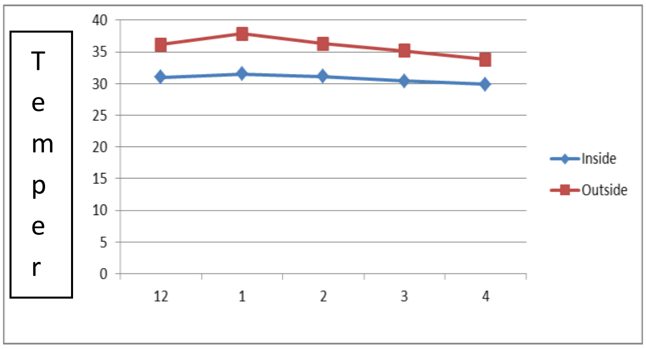


Graph 9- Inference: Inside temperature is 7.8^{0}C less than outside temperature.

4.10 FALSE CEILING WITH PVC

Sl No.	Time (pm)	Internal temperature ˚c	External temperature ˚c
1	12.00	31	36.2
2	1.00	31.5	37.9
3	2.00	31.1	36.3
4	3.00	30.4	35.2
5	4.00	29.9	33.8

Table 10 - PVC false ceiling below concrete roof

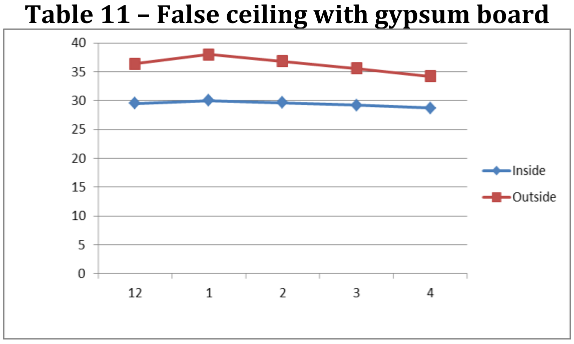


Graph 10- Inference: Inside temperature is 6.4^{0}C less than outside temperature.

4.11 FALSE CEILING WITH GYPSUM BOARD

Sl No.	Time (pm)	Internal tempera ture ˚c	External temperature ˚c
1	12.00	29.5	36.4
2	1.00	30	38
3	2.00	29.6	36.8
4	3.00	229.2	35.6
5	4.00	28.7	34.2

Table 11 – False ceiling with gypsum board

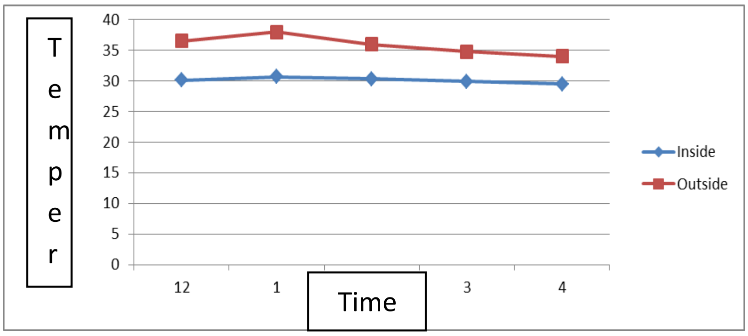


Graph 11- Inference: Inside temperature is 8^{0}C less than outside temperature.

4.12 BONDING THERMO RESISTANT LAMINATES WITH CONCRETE

Sl No.	Time (pm)	Internal temperatur e ˚c	External temperature ˚c
1	12.00	30.1	36.5
2	1.00	30.7	38
3	2.00	30.3	36
4	3.00	29.9	34.8
5	4.00	29.5	34

Table 12 – Bonding thermocol below concrete roof



Graph 12- Inference: Inside temperature is 7.3^{0}C less than outside temperature

RESULT AND DISCUSSION

T1. Orientation in wrong direction
Inside temperature is 4.1^{0}C less than outside temperature.

T2. Orientation in correct direction
Inside temperature is 4.3^{0}C less than outside temperature.

T3. Ventilation hole on top of wall
Inside temperature is 4.6^{0}C less than outside temperature.

T4. Roof blanketed with Aluminium foil
Inside temperature is 6.8^{0}C less than outside temperature.

T5. Wall blanketing with Aluminium foil
Inside temperature is 4.4^{0}C less than outside temperature.

T6. Combined roofs and wall blanketing with Aluminium foil
Inside temperature is 7.8^{0}C less than outside temperature.

T7. Sides of structure covering with ACP
Inside temperature is 4.7^{0}C less than outside temperature.

T8. Solar panel over the concrete roof
Inside temperature is 5^{0}C 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

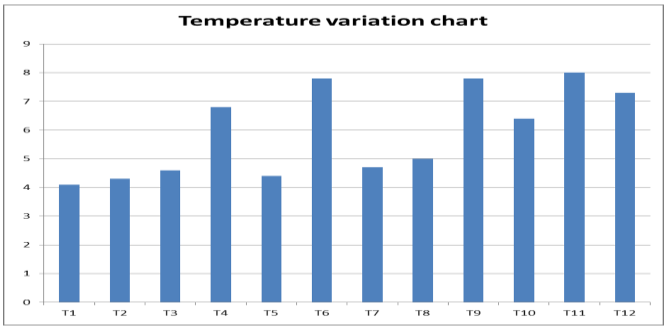
Inside temperature is 6.4⁰C less than outside temperature.

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.



Graph 13- Temperature variation chart

CONCLUSIONS

- 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.

REFERENCES

- The effects of Orientation, Ventilation, and Varied WWR on the Thermal Performance of Residential Rooms in the Tropics- Nedhal Ahmed M. Al-Tamimi, SharifahFairuz Syed Fadzil,Wan Mariah Wan Harun
- Indoor climate as a function of building orientation- International Journal of Ambient Energy-Volume 8, Issue 1, 1987
- http://en.wikipedia.org/wiki/Building insulation
- http://www.primebondindia.com/acp-sheets.html
- http://theinteriorconcepts.blogspot.in/2013/01/false-ceilingdropped-ceiling-and-its.html
- http://www.aluminumfoils.com/aluminum-foil/aluminum-properties.html
- Mind the roof over your head-PrabhakarSinha (The Times of India)
- Su, B.; Aynsley, R. Roof Thermal Design for Naturally Ventilated Houses in a Hot Humid Climate. Int. J.Vent. 2009, 7, 369–378. [CrossRef]
- Omar, A.I.; Virgone, J.; Vergnault, E.; David, D.; Idriss, A.I. Energy Saving Potential with a Double-Skin RoofVentilated by Natural Convection in Djibouti. Energy Procedia 2017, 140, 361–373. [CrossRef]
- Kreith, F.; Manglik, R.M.; Bohn, M.S. Principles of Heat Transfer; Cengage Learning: Stamford, CT, USA, 2010.
- Level. Passive Design. In How Insulation Works; BRANZ Ltd.: Porirua, New Zealand, 2017.
- Heat Loss from Homes. Available online: https://www.haringey.gov.uk/environment-and-waste/goinggreen/green-home-improvements/heat-loss-homes (accessed on 10 December 2018).
- Stay Warm. Available online: https://www.actsmart.act.gov.au/quick-tips/energy_saving/stay_warm(accessed on 10 December 2018).
- Yesilata, B.; Isiker, Y.; Turgut, P. Thermal insulation enhancement in concretes by adding waste PET and rubber pieces. Constr. Build. Mater. 2009, 23, 1878–1882. [CrossRef]
- Najim, K.B.; Fadhil, O.T. Assessing and improving the thermal performance of reinforced concrete-based roofing systems in Iraq. Energy Build. 2015, 89, 213–221. [CrossRef]
- Shi, G.Z.; Li, L.P.; Song, C.F.; Cheng, S.M.; Tao,W.Q.; He, Y.L. 3D numerical thermal optimization of the roofs constructed with cast-in-situ hollow concrete floor system by finite volume method. Energy Build. 2016, 131,142–152. [CrossRef]
- Xaman, J.; Cisneros-Carreno, J.; Hernandez-Perez, I.; Hernandez-Lopez, I.; Aguilar-Castro, K.M.;Macias-Melo, E.V. Thermal performance of a hollow block with/without insulating and reflective materialsfor roofing in Mexico. Appl. Therm. Eng. 2017, 123, 243–255. [CrossRef]
- Alawadhi, E.M.; Alqallaf, H.J. Building roof with conical holes containing PCM to reduce the cooling load:Numerical study. Energy Convers. Manag. 2011, 52, 2958–2964. [CrossRef]
- Alqallaf, H.J.; Alawadhi, E.M. Concrete roof with cylindrical holes containing PCM to reduce the heat gain.Energy Build. 2013, 61, 73–80. [CrossRef]
- Thiele, A.M.; Jamet, A.; Sant, G.; Pilon, L. Annual energy analysis of concrete containing phase changematerials for building envelopes. Energy Convers. Manag. 2015, 103, 374–386. [CrossRef]
- Han, J.; Lu, L.; Yang, H.X. Investigation on the thermal performance of different lightweight roofing structuresand its effect on space cooling load. Appl. Therm. Eng. 2009, 29, 2491–2499. [CrossRef]

- Oleson, K.W.; Bonan, G.B.; Feddema, J. Effects of white roofs on urban temperature in a global climate model.Geophys. Res. Lett. 2010, 37. [CrossRef]
- Zhang, Z.J.; Tong, S.S.; Yu, H.B. Life Cycle Analysis of Cool Roof in Tropical Areas. Procedia Eng. 2016, 169,392–399. [CrossRef]
- Androutsopoulos, A.V.; Stavrakakis, G.M.; Damasiotis, M. Cool Roof Impacts on a School-Building Thermaland Energy Performance in Athens, Greece. Procedia Environ. Sci. 2017, 38, 178–186. [CrossRef]
- Scherba, A.; Sailor, D.J.; Rosenstiel, T.N.; Wamser, C.C. Modeling impacts of roof reflectivity, integratedphotovoltaic panels and green roof systems on sensible heat flux into the urban environment. Build. Environ.2011, 46, 2542–2551. [CrossRef]
- Kumar, A.; Suman, B.M. Experimental evaluation of insulation materials for walls and roofs and their impacton indoor thermal comfort under composite climate. Build. Environ. 2013, 59, 635–643. [CrossRef]
- Nandapala, K.; Halwatura, R. Design of a durable roof slab insulation system for tropical climatic conditions.Cogent Eng. 2016, 3. [CrossRef]