THERMAL PERFORMANCE OF BUILDING MODELS WITH DIFFERENT ROOF VARIANTS

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ABSTRACT

The Cool roof coatings have great influences on lowering the warmth load on various building kinds, resulting in reduced cooling strength hundreds. A cool roof can be useful for a construction owner for several reasons. The use of cool roofs can reduce present-day bills. It decreases the roof operating temperature which can also increase the roof provider life. This examination seeks to recognize the quantity to which cool roof versions may be used as a residential demand-facet control strategy for a newly developed construction approach that regulates the temperature and humidity situations and provide a comfy residing environment for the occupants. As India is a tropical countryand has The prevailing temperature and humidity situations here are very excessive and have an incredible effect on the dwelling situations which causes discomfort. Increasing international power demands over years have also made sure that newly superior price-effective production substances bought to be developed to regulate using man-made cooling fabrics (i.E. Air conditioners, coolers, and exhausters). The use of roof cooling green dealers over the synthetic subordinates now not best reduces the effect of worldwide warming but also affords a thermal efficient environment for the occupants.

Cool roof variations are substances that reflect the sun's rays and emit heat extra successfully than warm or darkish roofs. In contrast, hot roofs absorb a lot greater solar strength than cool roofs, making them warmer sun reflectance and thermal emittance are such key cloth properties that decide a roof's temperature the bigger those values the cooler the roof will stay below the sun. Based on the above dialogue and handling the cutting-edge creation strategies we've studied the reflecting surface of different roofs the usage of common White acryl paint and Concrete tiles which had been positioned over the ACC block forged prototype structures and fly ash brick casted prototype structures. These temperatures of the roof surfaces were related to the regular roof solid surfaces of AAC blocks and fly ash bricks. Based on the research conducted, it is able to be concluded that concrete tiles have been able to reflect the maximum of the sun rays in contrast with the white cool coat. Among the manipulated and cool coat constructing prototypes, the coating showed a massive reduction in temperature as compared with the outside temperature.

KEY WORDS: FLY ASH BRICK MASONRY, AAC BLOCKS, MCU-Raspberry pi-3, DHT - 11

1. INTRODUCTION

1.1 GENERAL

Everyone spends more time underneath a roof and additionally day temperature is growing globally because of pollution within the environment. Due to this, indoor thermal comfort is becoming a main trouble and reasons inconvenience for humans, in phrases of comfort. Due to inconvenience, the performance of the painting force will decrease subsequently it results in the economic system and time and additionally impacts human health. This effect is greater in urban regions because maximum of the place is covered with roof and pavement surfaces with deficit vegetation which causes Heat Island Effect (HIE). For the sake of comfort air conditioners are being used and which consume greater strength.

One of the answers to lessen the air condition utilization is to undertake the insulation for diverse fabrics inside the building. Among them, the roof is the important material which takes a maximum of the direct warmness from the atmosphere. For the roof, one-of-a-kind kinds of roof cooling techniques may be followed. With this power, air-con preservation, pollutants, and expenditure will be saved. Why do need to we use roof cooling methods best?

High solar radiation has been absorbed and allotted via roof than other building additives. Here software of the cool variants to the overall additives of constructing turns into luxurious, so roof location is much less evaluate with overall components of building as a result price may be decreased. For this cool roof, versions are inexpensive and the performance of roof versions is good.

1.2. THERMAL COMFORT

A psychological feeling or a bodily sensation that feels the frame as a consolation depending upon the condition of the concern because of the thermal balance.

1.2.1 Comfort limits of Human frame

Temperature limits from 22degree Celsius to 26degree Celsius.

Humidity limits between 50% to 65%.

Those limits are relevant when someone is in ideal condition by way of sporting regular apparel.

1.3 TYPES OF COOL ROOF VARIANTS

1.3.1 FIELD APPLIED ROOF VARIANT

Field-implemented editions are implemented at once onto the roof floor, both on a brand new roof meeting or over a current roof surface, and may require the ideal primer or in a powder form.

1.3.2 FACTORY-IMPLEMENTED VARIANT

Factory-carried variants are implemented directly to products at the factory previous to distribution. Examples of factory-carried-out versions include coatings carried out to steel, and glazes that might be carried out to tiles.

1.3.2.1 SLATE OR TILE

These roofing merchandise are commonly used for residential buildings, or steeper-sloped buildings, and an increasing number of, commercial homes. Slate and tile merchandise are available with sun-reflective surfaces that provide a wide variety of cool colors. Concrete and clay tiles may be received in white, increasing the solar reflectance to approximately 70 percent (compared to the 20-30 percent range for purple tiles).

1.3.2.2 METAL

Metal roof products are available in special sizes with the utility of cool roof paint with the purpose to maintain indoor temperature.

1. 3.2.3 BROKEN CHINA MOSAIC TERRACING

Well-graded damaged pieces of smooth glazed tiles offer an inexpensive and conducive cool roofing alternative. Broken pieces of glazed tiles (ideally white) are embedded in wet mortar to offer a smooth floor that does not undulate. The joints have then grouted with the use of cement mortar.

1. 3.3 MODIFIED BITUMEN

Modified bitumen is a bitumen, modified with plastic and layered with reinforcing substances then topped with a surfacing cloth. The radiative houses of changed bitumen are decided through the surfacing fabric, so a fab changed bitumen product may be finished off with a cap sheet or coating to acquire excessive sun reflectance

1. 3.4 GREEN ROOFS

Green roofs protected with plant life they'll reduce indoor temperature and enhance the air best.

1.3.5 SOLAR PANELS

The roof is established with solar panels that may take in the solar radiation and produce electrical strength and continues the indoor environment cool, which is costly to evaluate with unique editions. In a long term, it will likely be beneficial in terms of economy and overall performance as a fab roof variant.

1.4 HOW COOL ROOF WORK

A cool roof reflects the sunlight and emits the absorbed heat in an excessive fraction into the atmosphere. Here surfaces with low solar reflectance and emissivity, soak up an excessive fraction of incident solar electricity which makes construction hot.

High solar reflectance and emissivity, absorb a small fraction of incident solar energy which makes the building cool than the outer temperature.

1.5 NEED FOR STUDY

The global warming phenomenon and its results are seen in changes in dwelling conditions. The use of air conditioners has become obligatory due to the boom in atmospheric temperature which causes the roofs or the fabric parts of construction to get heated up. To reduce the discomfort induced due to extended temperature outcomes without the use of energy sources one has to recognition on reducing the heat impact thru building fabrics. Hence one has to observe the temperature and humidity behavior in the construction by way of the usage of distinctive type wall and roof systems. Keeping the above facts in mind, an examination has been undertaken to understand the thermal consolation behavior of the version houses with numerous roof variants and variants in substances in-wall cloth

2. LITERATURE REVIEW

2.1 Building roof thermal testing with standard and 02 reflective coatings

In two test cells under various roof coverings in the semi-warm Cuernavaca, Mexico, climate, I. Hernández-Perez et al. discovered the following findings:

According to his research, white reflective roofs (WR1) had lower surface temperatures throughout the day than grey roofs (GR). When the sun was shining brightest, the WR1 was up to 10oC cooler than the GR. As a result, the air within the cell was up to 8 °C cooler than the air there when GR was present. They also discovered that WR1 gained 59 percent less heat than GR throughout the day.Similarly, WR2 was up to 14.6 °C cooler than the GR when the intensity of the irradiation was increased. It was good that the temperature dropped. Thermal Although the WR2 cell's air was up to 9°C cooler than the GR cell's air, it was comfortable. They determined that WR2 acquired 80% less heat than the GR when they calculated the daily heat acquisition during the day. The GR and RR are about the same temperature as the sun first reaches the roofs at midday. For the remainder of the day, up until the first rays of the following day's daylight reached the roofs, the RR (Red Roof) kept its temperature at around 3 degrees Celsius higher than the GR. The air within the RR cell reached a peak temperature that was 1°C higher than the air inside the GR cell. Finally, they discovered that RR gained 22% more heat per day.superior to the GR. In México, buildings often have dark roofs that are either grey from the concrete or red from the waterproofing coating. Based on the cost-effectiveness study, they learned that WR1 and WR2 generated net savings of 21.7 and 23.2 $/m2 during a multiyear life cycle, respectively. The RR produced negative net savings since this roof will gain more heat than the GR. Reflective coatings are a cost-effective method for lowering building energy demand in Mexico since the payback period is less than two years.

2.2 Passive cooling for air conditioning energy savings with new inexpensive radiative coatings.

When compared to roofs available in industrial (terra cotta tiles, TCT) or impoverished nations, Marc Muselli's study highlighted the relevance of innovative passive patented materials that were intended to minimise heat input from solar direct radiation (fibre cement FC, corrugated sheets CS, plate steel sheets PSS). These suggested substrates have competitive solar reflectance levels (Rvis 0.63 diffuse to 0.85 white opaque), and their computed IR emittances from specular and diffuse transmission spectra (Ei 0.92). These inexpensive materials (1-2 euros per m2) have the advantage of being offered as painted coatings (90 mm, 2 layers) or Low Density Polyethylene (LDPE) films (0.200 mm) for direct roof application. During periods of daylight, the surface temperature of standard roofing materials is greatly lowered by white opaque coatings (in the range of 18–34 percent for TCT/PSS and CS, and 25% for FC). White painted materials, according to simulations using a 48m2 trial roof prototype, can reduce and save air-conditioning electrical energy by 26 to 49 percent, depending on the roof composition cover.Buildings around the nation might utilise these materials extensively to reduce greenhouse gas emissions and energy demand from air conditioners. The LDPE films showed equivalent or comparable Solar Reflectance Indexes (SRIs) and IR emissivity attributes to referenced coatings examined by the National Berkeley Laboratory using a Kipp and Zone CNR1 radiometer.

3. METHODOLOGY:

In this study, six prototypes were constructed on the top of 5 storied Office building to know the thermal comfort behaviour. Following methodology was adopted in the experimental program. Fig 3.1 shows the methodology adopted.

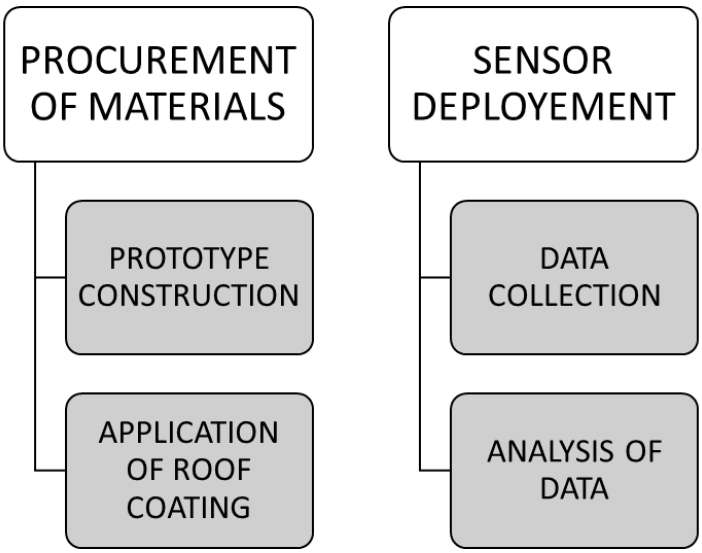


Figure 3.1 Methodology adopted.

3.1 PROCUREMENT OF MATERIALS

Materials used in the current study are Fly AshClay bricks, Autoclaved aerated concrete block (AAC block), Cement, Fine Aggregate, concrete tiles,Roof coatings, Sensors, Electric wires. All these materials are procured form the local market.

3.1.2 PROTOTYPE VARIANTS

(FP-1) Fly Ash brickPrototype + Concrete tiles used as roof variant (FP-1)

(FP-2)Fly Ash brick Prototype + White cool roof coating used as roof variant (FP-2)

(FP-3)Fly Ash brick Prototype + RCC slab as roof and without coating (FP-3)

(SP-1)Autoclaved Aerated Concrete block Prototype + Concrete tiles (SP-1)

(SP-2)Autoclaved Aerated Concrete block Prototype + White cool roof coating (SP-2)

(SP-3)Autoclaved Aerated Concrete block Prototype+ No Roof Coating (SP-3)

Before construction of all the prototypes, the material has been purchased from the nearby market. The materials are brought to the office premises and then transferred to the top roof of the building. Construction of prototype has been done as per the procedure. During construction measures are taken and checks have been done during the construction to avoid the errors. All the prototypes were built to achieve the equal volume inside the prototype for the comparison purpose.

3.1.2 APPLICATION OF ROOF COATINGS

- FP-3 and SP-3 were the building prototype models without any roof variants.
- The white cool roof coating is applied in two coats with a 0.8mm thickness. This was applied to the roofs of two prototypes, namely FP-2 and SP-2.
- Another roof variant was constituted by using concrete tiles of 6 mm thick. These were fixed with a 6mm thick cement mortar bond on the roof top of two models, SP-1 and FP1.

3.1.3 SENSOR DEPLOYMENT

Sensors were deployed on the project web page and temperature and humidity measurements had been taken for all the house fashions. A total of 7 sensors have been placed at specific locations in the house models. One sensor changed to measuring the outdoor temperature and humidity. Following hardware, tools have been used to take those measurements. The sensors were shifted in diverse fashions to have a comparison among them.

3.1.4 HARDWARE TOOLS:

MCU- Raspberry pi 3

Sensor- DHT 11

Electrical Wire- Double Stand

3.1.5 SENSOR CONNECTIVITY

Sensors were deployed on the project web page and temperature and humidity measurements had been taken for all the house fashions. A total of 7 sensors have been placed at specific locations in the house models. One sensor changed to measuring the outdoor temperature and humidity. Following hardware, tools have been used to take those measurements. The sensors were shifted in diverse fashions to have a comparison among them.

3.2 DATA COLLECTION

Data has been collected and saved with the aid of a cloud platform (server). Data can be accessed through the URL. All the information is, to begin with, saved in MCU (raspberry pi) and the identical is connected to the community to upload all of the recorded statistics by means of MCU. A front-end utility was created to see the accrued facts. The information is saved on a server. The information can be seen on the dashboard of the URL. To make all this happen, coding is the critical element on each platform. Such as to study and send the facts to the cloud, the MCU is fed with a code that runs automatically whilst the MCU is turned on. The MCU forwards the temperature and humidity records sensed by using the DHT11 sensor to the server. To keep the records on the server, a code has been run to make visible facts within the dashboard with a graphical illustration.

3.3 ANALYSIS OF DATA

Acquired data has been analysed and the comparison is made between different house models. The results and discussion was presented in the next chapter.

4. RESULTS AND DISCUSSION

Both temperature and humidity data was collected for all the four cases mentioned below. For each case, comparison has been made with the prototypes to know the performance among each other

Case-1: SP-1, SP-2, SP-3, FP-3 and Outdoor temperature and humidity.

Case-2: FP-1, FP-2, FP-3, FP-3 and Outdoor temperature and humidity.

Case-3: SP-2, FP-2, SP-3, FP-3 and Outdoor temperature and humidity.

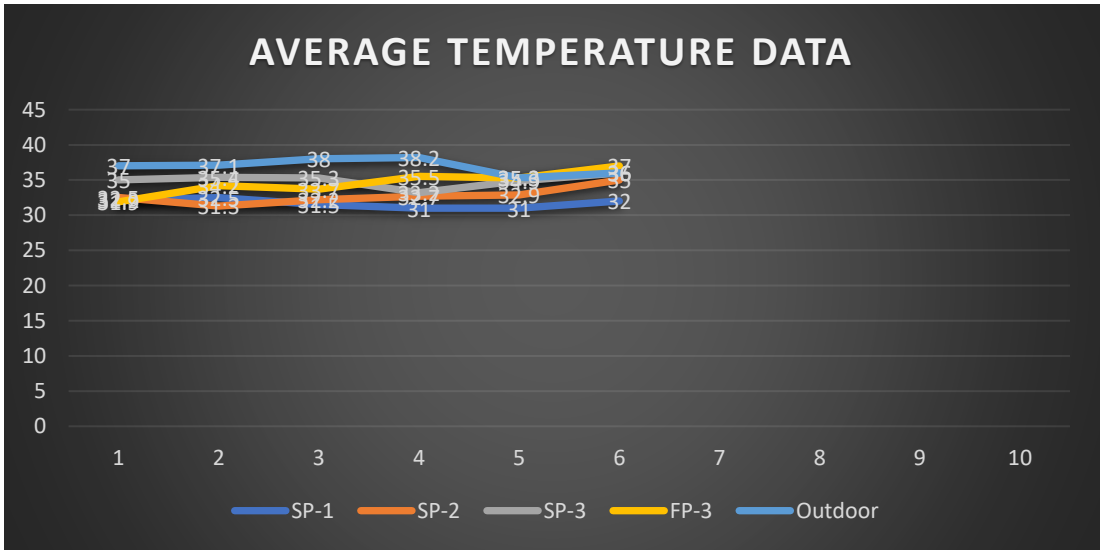
Case-4: SP-1, FP-1, SP-3, FP-3 and Outdoor temperature and humidity.

4.1 TEMPERATURE DATA

Table 4.1 to Table 4.4represents the average temperature data of various building models as per above cases. The sensor records the data for every five minutes from 10:00 to 16:55. In each table the comparison was made between four house models and with the outdoor temperature. The average temperature was mentioned for each of the model and reduced temperature was calculated in reference with the outdoor temperature.

Case-1	***Time***	***Temperature (°C)***				
Date		***SP-1***	***SP-2***	***SP-3***	***FP-3***	***Outdoor***
	11:00 to 11:55	*32.2*	*32.5*	*35*	*31.9*	*37*
	12:00 to 12:55	*32.5*	*31.3*	*35.4*	*34.2*	*37.1*
	13:00 to 13:55	*31.5*	*32.2*	*35.3*	*33.7*	*38*
	14:00 to 14:55	*31*	*32.7*	*33.2*	*35.5*	*38.2*
	15:00 to 15:55	*31*	*32.9*	*34.9*	*35.3*	*35.3*
15-05-2022	*16:00 to 16:55*	*32*	*35*	*36*	*37*	*36*
AVERAGE		*31.7*	*32.76*	*34.96*	*34.6*	*36.93*

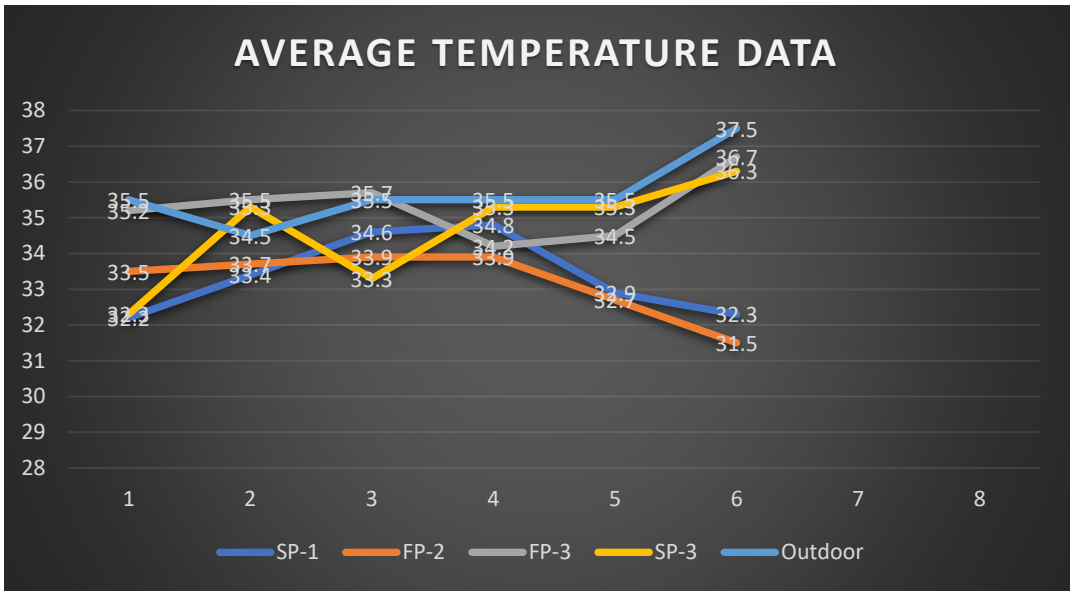
Table 4.1 Average temperature data of Case-1



Average temperature data of Case-1.It seen that SP-1has shown that the least temperature readings and SP-3. Between SP-3 and FP-3, SP-3 showed the better performance.

Case-2	Time	Temperature (°C)				
Date		SP-1	FP-2	FP-3	SP-3	Outdoor
	11:00 to 11:55	32.2	33.5	35.2	32.3	35.5
	12:00 to 12:55	33.4	33.7	35.5	35.3	34.5
	13:00 to 13:55	34.6	33.9	35.7	33.3	35.5
	14:00 to 14:55	34.8	33.9	34.2	35.3	35.5
	15:00 to 15:55	32.9	32.7	34.5	35.3	35.5
16-05-2022	16:00 to 16:55	32.3	31.5	36.7	36.3	37.5
Average		**33.36**	33.20	**35.3**	**34.63**	35.66

Table 4.2 Average temperature data of Case-2.



That FP-2 has shown the least temperature readings and SP-3 showed the highest amongst all. Between the ambient and SP-3 a difference 1 degree C was observed. Between SP-3 and FP-3, FP-3 showed the better performance.

CASE-3 shows that FP-2 has shown the least temperature readings and SP-3 showed highest amongst all. Between the ambient and FP-3 a difference 1degree C was observed. Between SP-3 and FP-3, SP-3 showed the better performance.

Case-4 shows that SP-3 has shown the least temperature readings and FP-3 showed highest amongst all. Between the ambient and FP-3 a difference 1.3 degree C was observed. Between SP-3 and FP-3, FP-3 showed the better performance. This should be validated by conducting more experiments.

4.2 HUMIDITY DATA

The Data represents the average humidity for every five minutes from 11:00 to 16:55. The humidity ranges for all the four cases were within the limit of 50%-60% for the prototypes constructed. Where the outdoor humidity ranges vary from 40%-55%. Here temperature is directly proportional to humidity i.e. when temperature increase percentage of humidity will be decreased and vice versa.

5. CONCLUDING REMARKS

•A 3m gap separates each of the six prototypes that have been constructed. Out of which, 3 prototypes were constructed using fly ash brick and 3 others using AAC blocks.

• White cool coat and concrete tiles were the cooling materials utilised within the inspection. These have been put to the roof floor in such a way that it deflects solar rays and preserves the cooler temperature, creating a secure environment.

• For the case study, DHT 11 sensors were deployed in each of the prototypes, and this connection was connected to a Raspberry Pi 3 so that temperature readings could be sent to the cloud storage.

• The findings conducted may lead one to believe that concrete tilescontrasted to the white cool coat, were able to reflect the majority of the sun's rays.

• The coating used in the manage and funky coat constructing prototypes demonstrated a significant drop in temperature when compared to the ambient temperature.

• However, the AAC block variant demonstrated a modest decrease in temperature when compared to Fly ash brick without a covering.

•For all of the prototypes that were built, the interior humidity levels were between fifty and fifty-five percent. a place where the outside humidity levels vary from 45% to 55%.

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