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Analysis of "Solar Radiant Heat Flux" Through Concrete Slab

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Abstract - *The project work has been undertaken during the day the earth's atmosphere is warmed by solar radiation from the sun, providing the energy that we need to sustain life. But this solar energy flow needs to be kept in balance, and in simplistic terms, the earth does this by re-radiating part of the energy received from the sun back to the sky at night. In this way a balance can be achieved between the solar warming from the sun and solar cooling from the night sky.*

By utilizing the advantages of night sky radiation the temperature of human residential place is to be control by following method.

When in the day the roof of the house will be cover by combined tarpaulin and aluminium insulation sheet from 6am to 6pm every day from sunup to sundown this flexible cover, with a very shiny bottom is drawn over the slab. It shades the slab of house while its low emissivity (0.01) due to the shiny surface prevent any radiant heating of the slab so the slab gains some heat from the ambient air, and its bottom still remains human comfort at least five degrees below the body so it feels cool in a day.

During the night, the slab remains open to the sky. This allows radiant heat transfer from the slab to surface that is 30 Degree Celsius to the sky. The rate depends on the difference in the fourth powers and the emissivity of the slab (0.85). So the slab bottom cools down to human comfort in the night.

To analyze one dimensional heat conduction through slab. To obtain maximum heat transfer at night time from concrete slab to atmosphere. To obtain maximum temperature drop during day of the concrete slab compared to ambient.

Key Words*:* Heat transfer; Aluminimum film; Human comfort; concrete cealing; Low emissivity; Radiant barrier.

1.INTRODUCTION

1.1 Problem Statement:

For every person using air conditioner or air cooling, there are many more who can't afford either and have to suffer extreme discomfort when their house turns into virtual oven in the summer, resulting in sickness and even death.

These problem is overcomes by experiment on an extremely simple roof cooling system which involves to cover the roof during the day by a low emissivity cover and withdrawing it at night, exposing the roof for cooling by radiation to the sky.

1.2 General Introduction

During day we are using radiant barrier. Radiant barrier is a shiny panel or flexible membrane used in construction. They can be used as part of assembly for example, an assembly made up of a radiant barrier to slow heat transfer. By definition, a radiant barrier has a low emissivity (0.1 or less). Radiant barriers reduce radiant heat transfer across the space which they face. The lower a material's emissivity, the more effective it is at reducing radiant heat transfer.

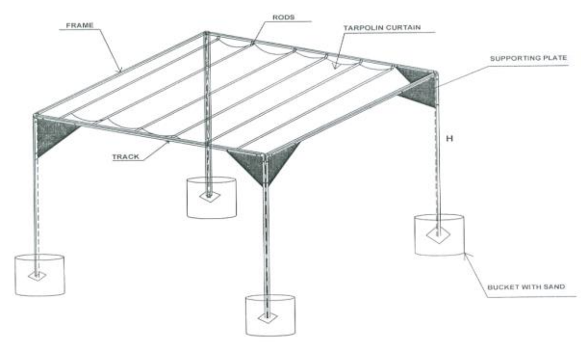
During nights with a clear sky a strong surface cooling of objects oriented towards the sky is observed. The large radiation heat flux of about 40 – 75 W/m^2 (watt per meter square) in clear-sky nights can be much larger than the convective heat flux, leading to measurable consequences in the thermal signature of buildings.

The surface temperature of objects directed to the sky with a large angle of view is often decreased below the temperature of the surrounding air. This radiant cooling can cause a significant change of the thermal signature of object surfaces depending on the effective background temperature of the night sky, the radiation distribution within the field of view (influencing the net radiation flux) and the tilt angle of the object.

2. CONSTRUCTION

2.1 Design of frame:

Frame is an important property of every project. Roof frame is designed in Creo 2.0
Refer the Figure No.1



FRAME SIZE			
FRAME.	L	W	H
MM.	2362	2362	2134
FT.	7'9"	7'9"	7"

Fig -1: Frame Design

2.2 Frame:

The material used for the construction of roof frame is aluminium. The frame will be constructed by the welding operation of aluminium rod. The length of the frame is 3'ft (915mm), width of the frame is 3'ft (915mm) and the height of the frame is 2'ft (610mm). The frame is use to install the combined tarpaulin and aluminium insulation sheet on the top of the slab. Refer the Figure No.2

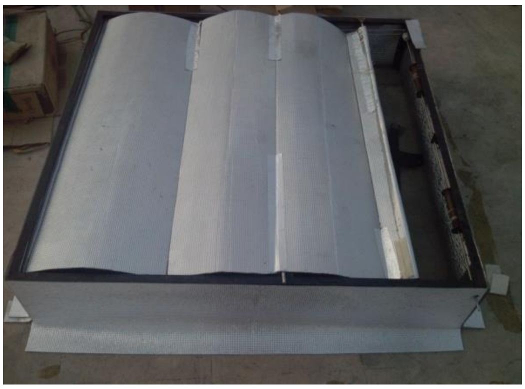


Fig -2: Covered Frame

2.3 Aluminium Insulation Sheet :

Aluminium foil is a new environmentally-friendly heat insulation material, which is soft, light weight and easy to install. This material not only has good insulation, heat reflection & anti-radiation functions but also has good moisture barrier.

Without a radiant barrier, concrete slab radiates solar generated heat to the insulation below it.

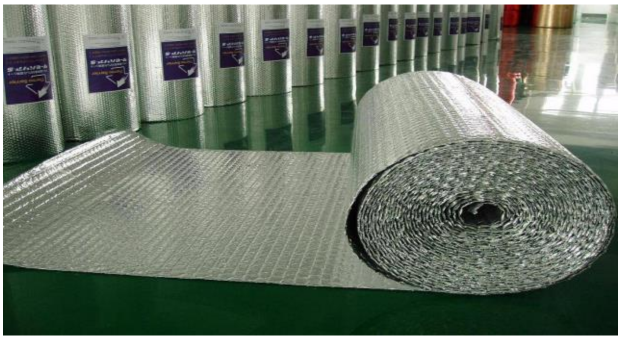


Fig -3: Curtain (Aluminium Sheet)

The insulation absorbs the heat and gradually transfers it to the material it touches, principally the ceiling. A concrete radiant barrier stops almost all of this downward heat transfer so that we can stay comfortable without air conditioning during mild weather. Refer the Figure No.3.

2.4 Concrete Slab:

As we all know that the terrace of the buildings ai always constructed with concrete which is a mixture of sand, cement and grit. A similar slab is constructed for experimentation purpose with the following dimensions.

Dimensions of slab: Length: 457mm, Width: 457mm, Height: 203mm

2.5 Final Structure:

- The slab is covered with the tarpaulin and aluminium sheet (curtain) on the top of the frame of aluminium which is installed on the ground in the bucket of the sand by fixing the aluminium bar into the sand.
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  - **Fig -4**: Opened Cover Frame
- This bar is welded with the frame by supporting plate. The curtain is installed in the portable manner by the by the pulley rope mechanism as shown in the figure no.4.
- The opening and closing will be done by hand with help of pulley rope mechanism. The mechanism includes frame, concrete slab, aluminium insulation sheet (sheet), temperature indicators are explained as follows.

3. PROCEDURE

Fig -4: Procedure

1. Constructing the slab and frame.

2. The slab is covered with the tarpaulin and aluminium sheet (curtain) on the top of the frame of mild steel which is installed on the ground in the bucket of the sand by fixing the mild steel bar into the sand. This bar is welded with the frame

3. The curtain is installed in the portable manner by the pulley rope mechanism as shown in the figure 2. The opening and closing will be done manually with help of the pulley rope mechanism.

4. The three Digital Temperature sensors are located as at top of slab, bottom of slab and at atmosphere.

5. Take the temperatures at three locations as said above with data logger unit. Temperatures are taken from sun up to sun down (approximately from 10 am to 6 pm) when slab is covered by aluminium sheet and after uncovering the slab during remaining time (i.e. 6 pm to 10 am).

6. Repeated this procedure for next 7 to 8 days.

4. ANALYSIS

During the night, the slab bottom starts getting warmer compared to the slab top due to the heat which gets trapped in it and starts emitting it to the clear sky by conduction.
Thermal conductivity of concrete (k) = 1.7 W/m°C.
Volume of the slab= 720mm X 720mm X 175mm.
If we consider a condition in 2nd April at night
Convective heat transfer coefficient (h) = 30 W/m² C
Then by Newton's law of Cooling,

$$Q_{conv} = h\,A\,(T_{amb} - T_{top})$$
$$= 30*0.72*0.72*(25.1-23.4) = 37.32 \text{ W}$$

By Fourier's Law of Conduction

$$Q_{cond} = K\,A\,d_T/d_x$$
$$=1.7*0.72*0.72*(30-23.4)/0.175 = 33.23\text{W}$$

Therefore the total heat content will be,

$$Q_{total} = Q_{conv} + Q_{cond} = 70.55\text{W}.$$

As this total heat will be absorbed by the slab and then emitted into the sky By Stefan Boltzmann's Law,

$$Q = 5.678*10^{-8}*A*e*(T_{top}^4 - T_{atmo.}^4)$$
$$70.55 = \varepsilon*5.678*10^{-8}*(0.72*0.72)*(7.686-4.784)*10^9$$

Therefore, the emissivity of the slab **ε = <u>0.82</u>**

5. RESULT

On the basis of measured temperatures at the three locations i.e. slab top, slab bottom and ambient, a graph time verses temperature is plotted. The graph shown in figure-5 is plotted on the basis of readings measured on 11th March 2017 and figure-6 for 14th March 2017 and following observations are done.

1. The dominative mode of heat transfer within the slab is Conduction. During the day, the slab is covered with the curtain and there is a drop in temperature within it, owing to its thickness and the insulation provided.
2. During the day, the slab reaches a maximum of 45 degrees and then onwards, fluctuations occur in the slab top temperatures. This is because there is a slight gap between the curtain and the slab top which allows Convection to take place effectively.

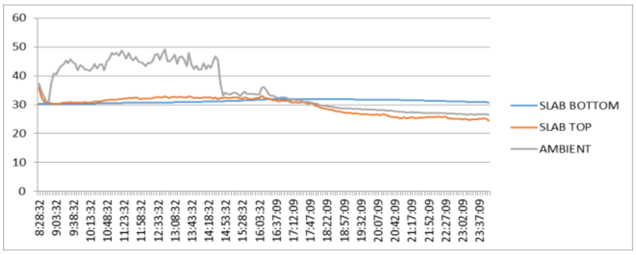

Fig -5: Temperature of top and bottom of slab with respect to time.

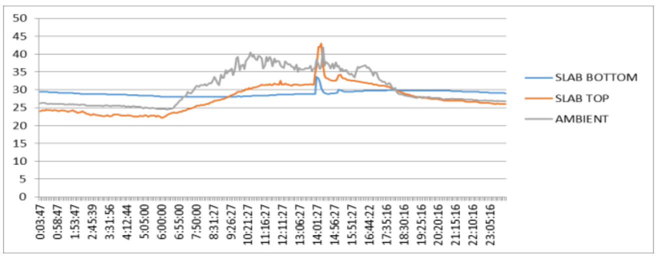

Fig -6: Temperature of top and bottom of slab with respect to time.

3. Also since the insulation is provided at the bottom of the slab and at the sides, there is some amount of temperature drop as well
4. Towards the end, i.e. at the 16th hour of the day, the slab starts emitting its heat to the sky thereby, initiating night sky radiation
5. Night sky radiation carries on for a process of an estimated 15.5 hours
6. The minimum temperature to which the slab can be brought down to is 27 degrees in this case.

6. CONCLUSIONS

1. From the results analysed above, it is sufficient to say that the structure will cool at a faster rate at night when the slab is covered by the curtain in the day and left exposed to the sky as soon as sunset starts.

2. The optimum mean radiant temperature (MRT) which can be achieved can be 25 degrees which is almost 3-5 degrees lesser than the ambient. This not only favours the structure cooling but will also result in further temperature drop within the structure's thickness as a result of conduction.

3. The MRT can also be achieved temperatures even lesser than 25 degrees. This is not possible because of the ambient effects such as cloudy skies, Haze's factor consideration, abrupt changes in climate, pollution etc. However, these MRTs can be achieved in villages, where a clear sky is visible which increases the radiant heat losses.

7. REFERENCES

1. "DR.D.S.Kumar, Heat and Mass Transfer,Delhi,2001,sixth edition,[PP (1.1,1.6),(8.1,8.10)]"
2. "Er.R.K.Rajput, Heat and mass Trasfer,new delhi,2012,[PP(1,15),(714,723)
3. "http://www.sciencedirect.com/science/article/pii/S2095263514000399"
4. "http://www.panasiaengineers.com/"
5. "http://environment.nationalgeographic.com/environment/green-guide/buying-guide/air-conditioner/environmental-impact/"
6. "http://www.ametherm.com/thermistor/what-is-an-ntc-thermistor"
7. "https://en.wikipedia.org/wiki/Air_conditioning#Power_consumption"
8. "https://www.quora.com/How-much-electricity-units-is-used-by-1-5-ton-split-AC"
9. "https://en.wikipedia.org/wiki/Greenhouse_effect#/media/File:The_green_house_effect.svg"
10. "http://www.sciencedirect.com/science/article/pii/S1876610212015755pdf1 sicvesesience direct"
11. "http://www.sciencedirect.com/science/article/pii/S2095263514000399?np=y
pdf 2 passive colling tech"