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Parametric Studies and CFD Analysis of PCM in Energy Efficiency Building for Thermal Management

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Abstract**: *This paper presents a simulated parametric study to investigate the thermal management of the roof panel using phase change materials (PCM). The warmth engrossing and expelling ability of PCM is utilized to regulate the warmth produced in the room. A single and double layer of the PCM was kept between the roof and concrete. The energy saving level has noted on particular time without PCM materials, the same method as performed with single layer PCM and double layer PCM. Along these lines, it's exceedingly important to improve the warm presentation, so as to accomplish the objective of vitality sparing. So the Thermal Energy Storage (TES) is perhaps the most ideal approaches to improve thermal execution of building. The major classifications of the heat energy storage are practical and dormant. This paper is focused on one point such as PCM materials with to reduce the heat generated inside the room. CFD is seen as a superior substitute in present day ventures and has the capacity of taking care of such difficult issues. From the assistance of CFD, relative examinations are produced to consider the accompanying cases, for example, Case 1: Concrete piece with rooftop top section off without PCM. Case 2: Concrete slab with roof top slab off with single layer PCM. Case 3: Concrete slab with roof top slab off with Double layer PCM. The relative temperature design inside the room is utilized to comprehend the warm solace in the room and the upsides of utilizing PCM.***

Keywords **: *PCM, Concrete, Roof slab and CFD.***

I. INTRODUCTION

With reference to the parametric studies, while the efficiency in buildings has been the focus in many studies[1]. Due to the environment the heat wave exposure has greater effort on inside the room.

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The phase change materials by using one dimensional conduction method in computational fluid dynamics can be chosen middle from two points of the roof slab and concrete to analysis the temperature effect during the environmental condition[2]. Comparative analyses are provided to go through the below cases such as, Case 1: Concrete slab with roof top slab off without PCM. Case 2: Concrete slab with rooftop finish piece with single layer PCM. Case 3: Concrete slab with rooftop finish piece with Double layer PCM[3].

II. MATERIALS AND METHODS

The tremendous warmth move during the condensing technique similarly as the setting strategy without enormous warmth varies makes PCM intriguing as a wellspring of warmth amassing product in convenient usage[4]. Exactly when degree extends, the PCM microcapsules acclimatized warmth and taking care of this essentialness in the dissolved stage transition products. Exactly while degree decreased, the microcapsule of PCM eject this set away warmth essentialness and along these lines PCM solidify [5]. Stage change mode changes to liquid to solid and the other route around is schematically showed up in fig.1.

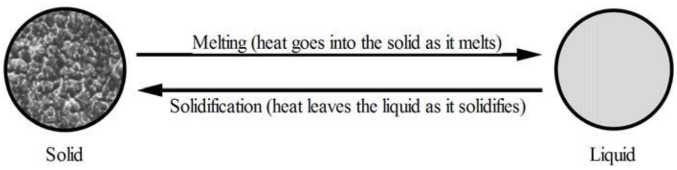

Fig. 1.Graphical description of phase.

For most part, stage change forms happen at almost steady temperatures. This makes them alluring for use in an assortment of uses. Hypothetically, the procedures may be utilized in three distinct strategies as pursues, Solid-fluid (liquefying and hardening) Liquid-gas (vanishing and buildup) Solid-gas (sublimation and re-sublimation) Solid-strong changes. Vitality sparing level relies upon the advantages and disadvantages of warm execution. In this way, it's exceedingly important to improve the warm presentation, so as to accomplish the objective of vitality sparing, Thermal Energy Storage (TES) is probably the most ideal approaches to improve warm execution of building. Phase change materials (PCMs) for TES are products providing warm guideline at specific stage varies temperatures by retaining and radiating the warmth of the medium. The principle kinds of TES are reasonable and dormant. A total TES process includes at any rate three stages: charging, putting away and releasing.

The articles are altogether centered around one point, for example, materials study [4]–[6], execution strength[7]–[9], position improvement, PCM-based structure heat recuperation, and vitality sparing impacts[10]. The principle climatic districts and scope scopes of PCM application in the building and the types of PCM application and the main physical properties in different climates locales the CaCl2•6H2O Calcium chloride hexa hydrate (PCM) has chosen.

III. COMPUTATIONAL FLUID DYNAMICS

CFD develop into an indispensable piece of the cutting edge factory and it stretches out its help to numerous specialists to comprehend and break down the issue all the more clearly. CFD systems will diminish the reliance on the more costly, tedious trial techniques. In late investigations the utilizations of PCM in warm vitality stockpiling framework and about different PCM materials were clarified tentatively and numerically utilizing CFD.

IV. MODELLING METHODS AND MATERIALS

Modelling external domain convenient to compute the transfer of heat coefficient and solar loading on the surfaces was a complex approach and thus a simpler way was adopted. In this method the Heat flux obtained from experimental results were given as input to the top surface of the roof top slab. The Heat flux variation for a span of 8 hours was The roof and concrete slab were modelled as 20x20x10CM and 20x20x12CM.This was considered as the domain for analysis. Concrete piece with rooftop top section off without PCM is shown in the fig.2.

Similarly the single layer PCM was designed as 20x20x10CM for roof and 20x20x12CM for concrete and 20x20x2.5 for single layer PCM domain as considered for analysis with same input temperature vs time is shown in the fig.3. For the Double layer PCM was designed as 20x20x10CM for roof shown in the fig.4 and 20x20x12CM for concrete and 20x20x2.5 for single layer PCM and 20x20x4 CM for next layer has designed on top of the 2.5CM PCM to considered for analysis.

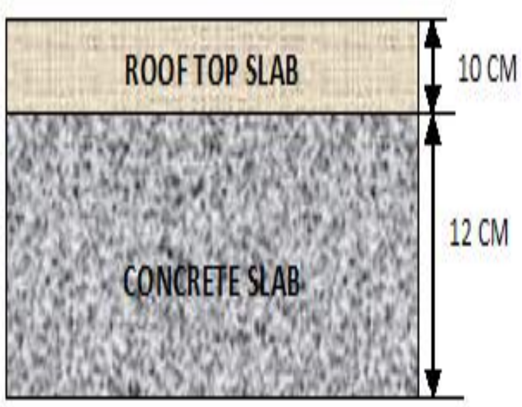

Fig. 2.Concrete piece with rooftop top section off without PCM.

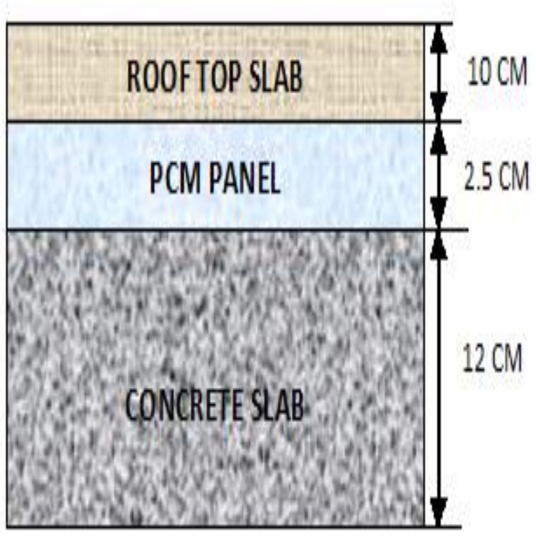

Fig. 3.Concrete slab with rooftop finish piece with single layer PCM.

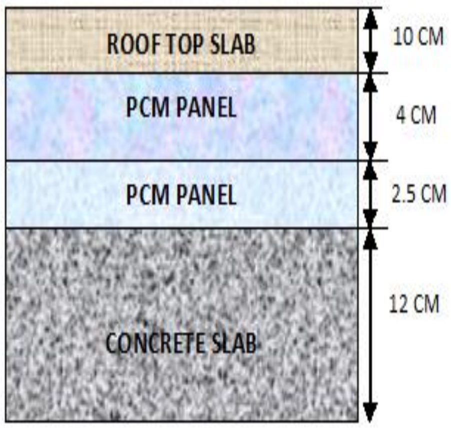

Fig. 4.Concrete slab with rooftop finish piece with Double layer PCM.

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Table- II: Material Properties

NAME	Material Type	Density (kg/m3)	CP (Specific Heat) –j/kg-k)	Thermal conductivity (w/m-k)
Concerete	Solid	2300	880	1.37
Roof top slab	Solid	2100	800	1.73
CaCl2·6H2O Calcium chloride hexahydrate (PCM)	Solid – liquid Liquid – Solid	1562 (liquid, 32ºC) 1802 (solid, 24ºC) 1710 (solid, 25ºC)	1440	0.540 (liquid, 38.7ºC) 1.088 (solid, 23ºC)

A Structured mesh was generated and the number of elements was found to be 540 is shown in the fig.5. For the transient case analysis the density of the rooftop slab was assumed as 2300 kg/m3 and the density of the concrete slab was assumed to be 2100 kg/m3, Similarly the Specific heat was considered as 880 j/kg-k and 800 j/kg-k for rooftop slab and concrete slab respectively. Thermal conductivity of 1.37 and 1.73 w/m-k was considered for rooftop slab and concrete slab respectively. The boundary conditions for the analysis was taken as transient heat flux taken for every 15 minutes for 8 hours from 9:00am to 5:00pm Convective heat transfer was considered at the base surface of the concrete slab. The thermal transfer coefficient was given as 1 W/m2K and 4 W/m2K.The free stream temperature was assumed to be 300K. For the transient case a step size of 60 seconds was taken and the analysis was done for 28800 seconds is shown in the fig.6.The temperature for top wall is shown in the fig.7 and for bottom wall is shown in the fig.8.

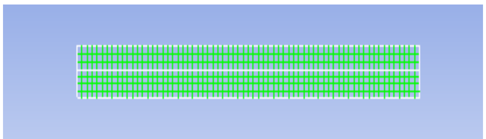

Fig. 5.Structured Mesh of 540 elements.

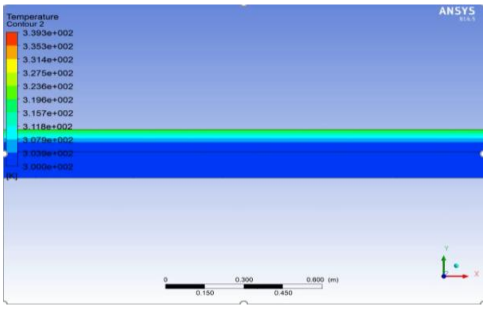

Fig. 6.Contour of Static Temperature at 28800 second.

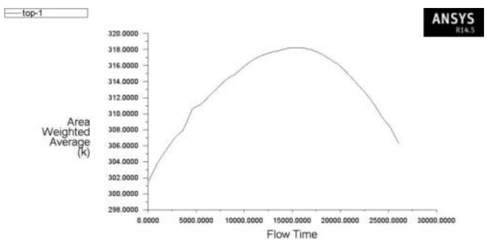

Fig. 7.Temperature distribution on Top wall.

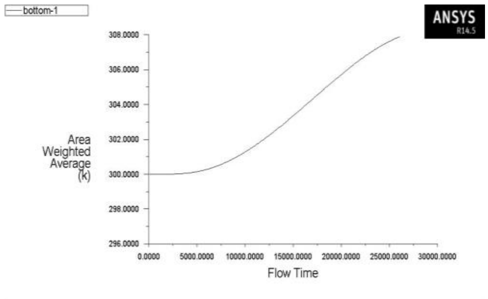

Fig. 8. Temperature distribution of Bottom wall.

The results were validated and for the next case the PCM was monitor in between the concrete and roof.single layer PCM is shown in the fig.9.

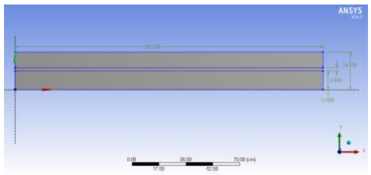

Fig. 9.Geometry of single layer PCM in cm.

Similarly Mesh for single layer PCM with 580 elements is shown in the fig.10.

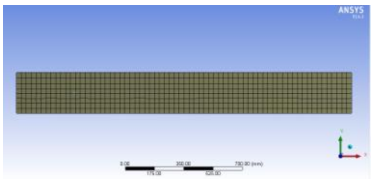

Fig. 10. Mesh for single layer PCM with 580 elements .

A structured mesh was generated for the above geometry. Similarly a double layer PCM was also Monitor shown in the fig.11 .

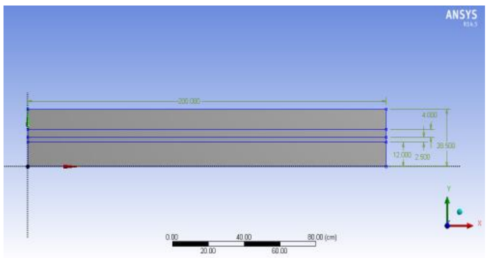

Fig. 11. Geometry for double layered PCM in cm.

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Similarly Mesh for double layered PCM with 1916 elements is shown in the fig. 12.

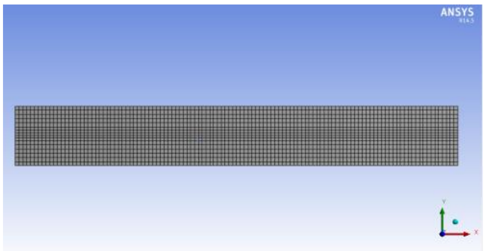

Fig. 12. Mesh for double layered PCM with 1916 elements.

V. RESULTS AND DISCUSSION

The Fig.13 shows the graph of temperature Vs time. Thechart unmistakably demonstrates that there is a huge ascent in temperature at the top surface of the rooftop piece at the 12:00pm. Also basement of the concrete portion piece remained unaffected to the heat flux provided. A point of 4cm apart from each other starting from the basement of the concrete portion was monitored for static temperature and plotted. The temperature effect at the ground surface of the concrete portion did not rise as expected to a 15k rise given in the literature. Also there the maximum temperature attained on the top surface of the rooftop slab was 66^{o}C where was the maximum temperature attained in the literature was only 53^{o}C. The material properties assumed were incorrect and for different properties the analysis was carried out. The Step size was reduced and second order time implicit method was used.

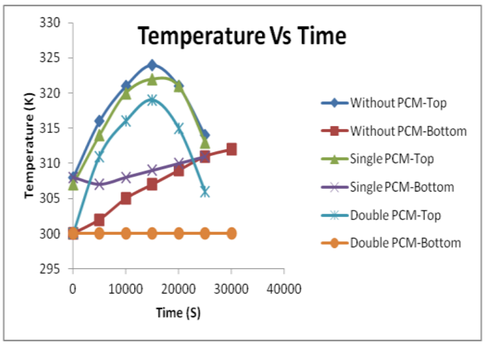

Fig. 13. Graph of Temperature Vs Time.

For the above properties the analysis was carried. Mixed ambit cases such as radiation and convection was given for the top surface as supposed to only convection taken in the previous case. The outside radiation temperature was determined utilizing the Stefan–Boltzmann law which denotes that the all out vitality emanated per unit surface zone of a dark body over all wavelengths per unit time (otherwise called the dark body brilliant emittance) is legitimately corresponding to the fourth intensity of the dark body's thermodynamic temperature. The solar heat flux obtained from the experiments was taken as the input to calculate the radiation temperature assuming black body radiation. Also the free stream temperature for convection was given as a time dependent input which varies from 27o C to 36oC on the roof top. A warmth move coefficient of 5 W/m2-k was taken for the rooftop top surface and 1 W/m2-k on the base surface which is the ceiling.{\display style j^{\star }=\sigma T^{4}.}

V. CONCLUSION

Subsequently a novel methodology utilizing Computational Fluid dynamics system is endeavored to analyze the benefits of PCM. The single and double layer has replaced the traditional storage middle from two points of the roof slab and concrete. In the future work the single and double layer PCM beneath the concrete will be analyzed and accordingly the PCM ceiling panels will be fabricated.

REFERENCES

1. A. O. Nayak, G. Ramkumar, T. Manoj, and R.Vinod , "Comparative Study between Experimental Analysis and CFD Software Analysis of PCM material in Thermal Energy Storage System" International Journal of Chemical Engineering and Applications, Vol. 2, No. 6, Dec. 2011,pp.400-407.
2. S. A. Memon, " Phase change materials integrated in building walls: A state of the art review", Renewable and sustainable energy reviews. Vol.31, Mar.2014,pp.870-906.
3. G. K. Pavlov ,B. W. Olesen , "Building thermal energy storage- concepts and applications", In12th Roomvent Conference 2011.
4. L. G. Socaciu "Thermal Energy Storage with Phase Change Material" Leonardo Electronic Journal of Practices and Technologies, No. 20, Jan. 2012,pp.75-98.
5. C. Amaral, R. Vicente, P. A. A. P. Marques, A. Barros-Timmons "Phase change materials and carbon nanostructures for thermal energy storage: A literature review" Renewable and Sustainable Energy Reviews, Vol. 79, Nov. 2017, pp. 212-1228.
6. R. Singh ,S. Sadeghi, B. Shabani." Thermal conductivity enhancement of phase change materials for low-temperature thermal energy storage applications", Energies,Vol.12,No.1,Jan 2019,pp.75.
7. T. Yan ,R. Z. Wang ,T. X. Li, L.W. Wang, I. T. Fred," A review of promising candidate reactions for chemical heat storage", Renewable and Sustainable Energy Reviews,Vol.43,Mar. 2015,pp.13-31.
8. B. Xu ,P. Li ,C. Chan ," Application of phase change materials for thermal energy storage in concentrated solar thermal power plants: a review to recent developments" Applied Energy,Vol.160,Dec.2015, pp.286-307.
9. N. Şahan ,M. Fois ,H. Paksoy ." Improving thermal conductivity phase change materials—A study of paraffin nanomagnetite composites", Solar Energy Materials and Solar Cells. Vol.137,Jun.2015.pp.61-67.
10. N. Senthil kumaran , M. Prabhahar ,L. Prabhu , S. Sangeetha, "CFD Analysis Of Heat Transfer And Flow Characteristics Of Silencer Of An Internal Combustion Engine ", International Journal of Chemical Sciences" Vol.14,No.(3) ,July. 2016.

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