IJFEAT
INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

Experimental Study of a Cement Concrete Block Filled With PCM to Improve the Thermal Inertia

Mr. Pawan R. Ingole[*],
Master of Engineering
Mechanical Engineering Department
IBSS College of Engineering
Ghatkhed,Amravati, Maharashtra.
[*]pawaningole5@gmail.com

Prof. S. S. Dandge
Head of Department
Mechanical Engineering Department
IBSS College of Engineering
Ghatkhed,Amravati, Maharashtra.
shreesdandge@rediffmail.com

***Abstract*— PCMs are viewed as a conceivable answer for decreasing the vitality utilization of structures. For raising the building dormancy and balancing out the indoor atmosphere, PCMs are more helpful in view of its tendency of putting away and discharging heat inside of a specific temperature range. Stage change material (PCM) is a substance with high warmth of combination which, on dissolving and hardening at a specific temperature, is fit for putting away and discharging a lot of vitality. In this paper, joining of PCM in solid piece and its impact on the warmth exchange through a solid square is concentrated on. The outcomes demonstrated that the PCM presented in a hole of solid square can enhance significantly the warm dormancy of piece and a mix of the sorts of PCM, its area in the divider and its sum, is critical for enhance lessening of warmth increase before it achieves the indoor space.**

***Index Terms*—Phase Change Material, Paraffin wax, Latent heat, Eutectic.**

I. INTRODUCTION

In the overall vitality emergency, vitality sparing has turned into a centering minded theme by each district over the world. Since antiquated times, man has attempted to enhance its solace inside of structures by enhancing the warm inactivity and minimize the proportional warm conductivity of the envelope of building. He expanded the thickness, changed the geometry of the external divider and attempted a few building materials to lessen temperature vacillation for indoor environment in both summer and winter. [1] The establishment of warming and aerating and cooling to look for health in homes, workplaces and open spots has made high vitality utilization and thusly, expanded earth contamination. The fundamental property of stage change materials is the capacity of warmth vitality in a dormant structure, prompting more prominent warmth stockpiling limit per unit volume than that of traditional building materials. At the point when the encompassing temperature rises, the compound obligations of the material will separate whereby the material will change from strong to fluid. This stage change is an endothermic procedure and accordingly will ingest warmth. [2] As the surrounding temperature drops once more, the PCM will come back to the strong state and radiate the retained warmth. The motivation behind this study is to enhance the warm dormancy of the external mass of structures situated in hot parched zones. The change of the warm latency of the solid piece is acknowledged by the insertion of a Phase Change Material (PCM) in a cavities gave in the square. [3] Nowadays, the building part is expending 40 % of the worldwide vitality in the European Union, and 66% of this vitality utilization is because of the HVAC frameworks. [1]

II. LITERATURE SURVEY

Test investigation of Jiapeng Sun demonstrated that the solid empty block with the four rectangles depressions minimizes the warm conductivity with the change of 21.69%. [4] A hypothetical model was proposed by Ammar Bouchair to examine the consistent state warm conduct of let go mud empty blocks for upgraded outer divider warm protection. After electronic demonstrating and counts, it was reasoned that the general warm resistance enhances by the request of 18–20%. It might increment to 88.64% and 93.33%, if the blocks utilized are infused with the protecting material and if the hole surface emissivity is brought down to 0.3, the change will be 72.73–78.33%. [5] Lin Qiu, et al. (2012) investigated the truth softening and hardening of PCM set up the PCM heat exchange model which considering fluid stage common convection in this paper and adventures CFD programming to complete numerical reenactment. Mario A Medina, et al. (2013) exhibited consequences of the potential warm improvements in building dividers got from utilizing stage change materials. For the edge dividers, the PCM typified inside intelligent foil sheets yielded the most astounding decreases of 52.4% (top) and 35.6% for a PCM convergence of around 15%, creating steadier divider temperatures. [8]

In course reading of "Unit Operation of Chemical Engineering" by Warren L. McCabe, Julian C. Smith and Peter Harriott, McGraw Hill International Edition, New York, 2001, expressed the distinctive properties of stage change materials and how to use high inactive warmth of combination of various stage change materials to lessen the temperature, by retaining the warmth through the liquefying process when it is presented to the sun based radiation. A creator Manish Goel displayed the trial study utilizing a suspension of n-eicosane microcapsules in water was led with a specific end goal to assess the warmth exchange attributes of stage change material suspensions, under a title "Laminar constrained convection heat move in small scale capsulated stage change material suspensions". The warmth fluxes decided for the tests were commonplace of low temperature applications (underneath 60°C). Results demonstrate that utilization of stage change material suspensions can diminish the ascent in divider temperature by up to half when contrasted with a solitary stage liquid for the same non-dimensional parameter.

Guohui Feng, , et al. (2013) demonstrated that contrasted with ordinary natural air framework, the stage change sun based vitality outside air warm capacity framework has a noteworthy change in vitality sparing and indoor solace level and will assume an imperative part in the vitality reasonable improvement. [11] M.R. Anisur et al. (2013) underscored those open doors for vitality investment funds and green house-gas outflows diminishment with the usage of PCM in TES frameworks. It was reasoned that around 3% of aggregate CO_2 emanations by fuel, anticipated in 2020 could be lessened with PCM applications in working for warming and cooling. [25] Jisoo Jeon, et al. (2013) highlighted that the correct configuration of TES frameworks utilizing a PCM requires quantitative data and information about the warmth exchange. He inspected the improvement of accessible inactive warmth warm vitality stockpiling advances and examines PCM application techniques for private building utilizing brilliant floor warming frameworks. [26]

III. PROPERTIES OF PHASE CHANGE MATERIAL AND CONCRETE BLOCK

TABLE NO.I PROPERTIES OF PARAFFIN WAX

Melting Point	Start melting at 37 °C (99 °F)
Specific Heat Capacity	2.14–2.9 J/g K
Heat of Fusion	200–220 J/kg
Appearance	White & colorless soft solid
Density	900 kg/m3
Resistivity	1013 and 1017 ohm metre
Boiling Point	Less than 370 °C (698 °F)

Fig No.1 *Paraffin Wax*

TABLE NO.II PROPERTIES OF CONCRETE BLOCK

The concrete block of dimensions 400mm X 200mm X 100mm is taken which is made by the mixture of cement, water and concrete. Following are some of the properties of the concrete block.

Parameter	Description
Size of the Block	400mmX200mmX100mm
Water absorption Capacity in 24 hr.	9-10 % by weight of Block
Thermal Conductivity	1.7 W/mk
Heat of fusion	150 KJ/kg
Average Compressive Strength at 28 Days	50-110 Kg/sq mm

IV. EXPERIMENTAL SETUP

A plywood box of size (410mm X 210mm X 110m) is fabricated, which is sealed from three sides. One side is kept open to get the concrete block placed inside. The electronic thermo sensor kit with the digital display screen is mounted on one of the side of the wooden box which will display the temperature of outer side, cavity and inner side of concrete block. Now a concrete block of (400mmX200mmX100mm) dimension is filled with the molten paraffin wax where cavity is provided in the block. Now allow the paraffin wax to get solidify and put concrete block with paraffin wax filled in the cavity, inside the plywood box and seal all the side of the box with thermal insulation so that no heat should be entering or leaving through the concrete block.

Fig No.2 *Concrete Block with cavity*

By exposing one of the sides of the block to the solar radiation, readings are taken as T_1, T_1 (Temperature of side of the block exposed to the sun), T_2 (Temperature of middle cavity of the concrete block filled with the paraffin wax) and T_3 (Temperature of inner side of the concrete block insulated from all sides). These readings are taken in sequence for hollow concrete block and concrete block with the paraffin wax filled inside the cavity for every hour of the day continuously from 10am to 6 pm every day for the period of fifteen days in the month of May in summer. The variations in the temperatures are noted and results are drawn from those readings. Average T_1, T_2 & T_3 for a particular time (10am to 6pm) is calculated for the sequence of 15 days.

TABLE NO.III OBSERVATION FOR HOLLOW CONCRETE BLOCK

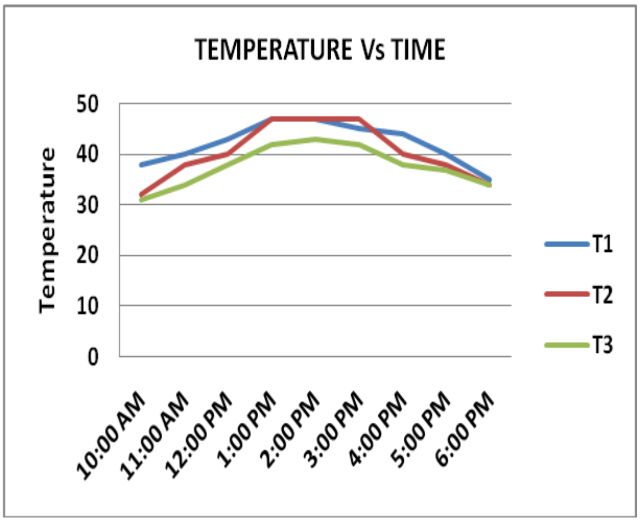
Time (Hr.)	Average T_1 (^{0}C)	Average T_2 (^{0}C)	Average T_3 (^{0}C)	$\Delta T_H = T_1 - T_3$ (^{0}C)
10 am	38	32	31	7
11 am	40	38	34	6
12 pm	43	40	38	5
1 pm	47	47	42	5
2 pm	47	47	43	4
3 pm	45	47	42	3
4 pm	44	40	38	6
5 pm	40	38	37	3
6 pm	35	34	34	1

TABLE NO.IV OBSERVATION FOR CONCRETE BLOCK WITH PARAFFIN WAX

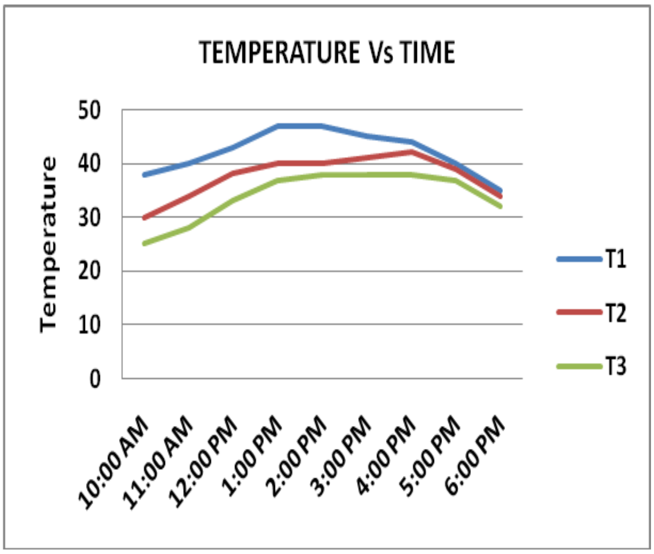
Time (Hr.)	T_1 (^{0}C)	T_2 (^{0}C)	T_3 (^{0}C)	$\Delta T_P = T_1 - T_3$ (^{0}C)
10 am	38	30	25	13
11 am	40	34	28	12
12 pm	43	38	33	10
1 pm	47	40	37	10
2 pm	47	40	38	9
3 pm	45	41	38	7
4 pm	44	42	38	6
5 pm	40	39	37	3
6 pm	35	34	32	3

V. RESULT AND DISCUSSION

Experimental results show that $\Delta T_P > \Delta T_H$ for same time of the day for the period of 15 days. That means there is a reduction in the temperature when heat passes through the concrete block hollow or filled with paraffin wax. But concrete block with paraffin wax filled inside shows the maximum temperature decrement when heat passes through the block in sun.

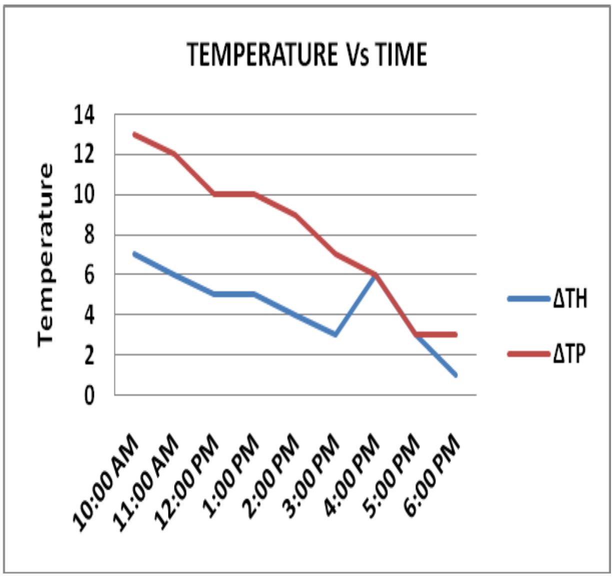


Graphical representation of temperature against time is shown for the hollow concrete block on an average of fifteen days during various times of the day. It indicates that T_3 curve shown in the green shade obviously has the lowest temperature.



Graph shows the effect of phase change material (Paraffin Wax) on the behavior of the curves especially the T_3 curve which indicates more decremented nature. The reduction in the temperature for inner most side of the concrete block with paraffin wax filled inside is more than that of hollow concrete block.

The comparison between ΔT_H for hollow concrete block & ΔT_P for concrete block with the paraffin wax is shown below:



The difference in the range of the ΔT for hollow concrete block and concrete block with the paraffin wax shows that the block with the paraffin wax filled inside, absorbs more heat than hollow one, ultimately causing the reduction in the heat flow to inner side of the cement block.

VI. CONCLUSION

There is a reduction in the temperature when heat passes through the concrete block which is hollow or filled with paraffin wax. This will help in discovering the temperature variety through the Solid Square and utility of PCM in building applications. This investigation idea is trailed by number of looks into for their application. Yet at the same time part numerous work stays to be done later on. This gives the foundation of utilization of stage change materials used in cement to complete further research work in future. The distinction in the scope of the ΔT for empty solid piece and with the paraffin wax demonstrates that the piece with the paraffin wax filled inside, assimilates more warmth than empty one, at last bringing about the diminishment in the warmth stream to internal side of the bond square

REFERENCES

[1] Necib Hichema,*, Settou Noureddineb, Saifi Nadiab, Damene Djamilab J. “Experimental and numerical study of a usual brick filled with PCM to improve the thermal inertia of buildings” Terra Green 13 International Conference 2013 – “Advancements in Renewable Energy and Clean Environment Energy Procedia” 36, 766 – 775, 2013.

[2] Pawan R. Ingole[1], Tushar R Mohod, Sagar S Gaddamwar **“**Use of Phase Change Materials in Construction of Buildings: A Review” International Journal of Engineering Research and General Science Volume 2, Issue 4, June-July, pp 624-628, 2014.

[3] Lidia Navarroa, Alvaro de Garciaa, Cristian Soléa, Albert Castella, Luisa F. Cabezaa* “Thermal loads inside buildings with phase change materials: Experimental results Energy Procedia” 30,342 – 349, 2012.

[4] Jiapeng Sun, Liang Fang, Jing Han b. “Optimization of concrete hollow brick using hybrid genetic algorithm combining with artificial neural networks” International Journal of Heat and Mass Transfer; 53: 5509–5518, 2010.

[5] Ammar Bouchair. “Steady state theoretical model of fired clay hollow bricks for enhanced external wall thermal insulation” Building and Environment; 43: 1603–1618, 2008.

[6] Dariusz Heim, Joe A. Clarke, “Numerical modeling and thermal simulation of PCM–gypsum composites with ESP-r” Energy and Buildings, vol. 36, pp. 795–805, 2004.

[7] Lin Qiu, Min Yan, Zhi Tan, “Numerical Simulation and Analysis of PCM on Phase Change Process Consider Natural Convection Influence” The 2nd International Conference on Computer Application and System Modeling 2012.

[8] Mario A Medina, Kyoung Ok Lee, Xing Jin, Xiaoqin Sun, On the use of phase change materials in building walls for heat transfer control and enhanced thermal performance, APEC Conference on Low-carbon Towns and Physical Energy Storage, Changsha, China,25-26 May, 2013.

[9] Amarendra Uttam, J. Sarkar, “Performance Analysis of Phase Change Material based Air-Conditioning System” 2nd International Conference on Emerging Trends in Engineering & Technology, College of Engineering, Teerthanker Mahaveer University, 12-13April, 2013.

[10] Ruben Baetensa, Bjørn Petter Jelle, Arild Gustavsen, “Phase change materials for building applications: A state-of-the-art review” Energy and Buildings, vol.42, pp.1361–1368, 2010.

[11] Guohui Feng, Lei Zhao, Yingchao Fei, Huang Kailiang, Shui Yu, “Research on the phase change solar energy fresh air thermal storage system” APEC Conference on Low-carbon Towns and Physical Energy Storage, Changsha, China, May 25-26, 2013.

[12] Dominic Groulx and Wilson Ogoh, “Solid-liquid phase change simulation applied to a cylindrical latent heat energy storage system” COMSOL Conference, Boston, 2009.

[13] Tung-Chai Ling, Chi-Sun Poon, “Use of phase change materials for thermal energy storage in concrete: An overview” Construction and Building Materials, vol.46, pp.55–62, 2013.

[14] M. Marinkovic, R. Nikolic, J. Savovic, S. Gadz\uric, I. Zsigrai, “Thermochromic complex compounds in phase change materials: Possible application in an agricultural greenhouse” Solar Energy Materials and Solar Cells, vol.51, pp.401-411, 1998.

[15] Shankar Krishnan, Suresh V. Garimella, and Sukhvinder S. Kang, “A novel hybrid heat sink using phase change materials for transient thermal management of electronics” IEEE Transactions on Components and Packaging Technologies, vol. 28, pp.281-289,June 2005.

[16] Murat M. Kenisarin, “High-temperature phase change materials for thermal energy storage, Renewable and Sustainable Energy Reviews” vol.14, pp.955–970, 2010.

[17] T. Siegrist, P. Jost, H. Volker, M.Woda, P. Merkelbach, C. Schlockermann and M.Wuttig, "Disorder-induced localization in crystalline Phase-change materials" Published online, DOI: 10.1038/nmat2934, 9 January 2011.
[18] I. Krupa, G. Mikova´, A.S. Luyt, "Phase change materials based on low-density polyethylene/paraffin wax blends" EuropeanPolymer Journal, vol.43, pp.4695–4705, 2007.
[19] Dale P. Bentz, Randy Turpin, "Potential applications of phase change materials in concrete technology" Cement & ConcreteComposites, vol.29, pp.527–532, 2007.
[20] Xiaoming Fang, Zhengguo Zhang, Zhonghua Chen, "Study on preparation of montmorillonite-based composite phase change materials and their applications in thermal storage building materials" Energy Conversion and Management, vol.49, pp.718–723, 2008.
[21] Jessica Giro-Paloma, Gerard Oncins, Camila Barreneche, Mònica Martínez, A.Inés Fernández, Luisa F. Cabeza, "Physicochemical and mechanical properties of microencapsulated phase change material" Applied Energy, vol.109, pp.441–448, 2013.
[22] Doerte Laing a, Thomas Bauer, Nils Breidenbach, Bernd Hachmann, Maike Johnson, "Development of high temperature phasechange-material storages" Applied Energy, vol.109, pp.497–504, 2013.
[23] Camila Barreneche, M. Elena Navarro, A. Inés Fernández, Luisa F. Cabeza, "Improvement of the thermal inertia of building materials incorporating PCM: Evaluation in the macro-scale" Applied Energy, vol.109, pp.428–432, 2013.
[24] Servando Álvarez, Luisa F. Cabeza, Alvaro Ruiz-Pardo, Albert Castell, José Antonio Tenorio, "Building integration of PCM for natural cooling of buildings" Applied Energy, vol.109, pp.514–522, 2013.
[25] M.R. Anisur, M.H.Mahfuz, M.A.Kibria, R.Saidur, I.H.S.C.Metselaar, T.M.I.Mahlia, "Curbing global warming with phase change materials for energy storage" Renewable and Sustainable Energy Reviews, vol.18, pp.23–30, 2013.
[26] Jisoo Jeon, Jung-Hun Lee, Jungki Seo,Su-Gwang Jeong, Sumin Kim, "Application of PCM thermal energy storage system to reduce building energy consumption" J. Therm Anal Calorim, DOI 10.1007/s10973-012-2291-9, pp.279–288, Budapest, Hungary, 15 February 2012.
[27] Dong Zhanga, Zongjin Lib, Jianmin Zhoua, Keru Wu, "Development of thermal energy storage concrete" Cement and Concrete Research, vol.34, pp.927–934,2004.
[28] J. Kosny, D.W. Yarbrough, K.E. Wilkes, D. Leuthold, A.M. SyEd, "PCM enhanced cellulose insulation in lightweight natural fibers" http://intraweb.stockton.edu/, 2005 (retrieved 13.10.08).