Enhancing the Compressive Strength of Thermal Energy Storage Concrete by Using Paraffin Wax and Waste Copper Slag

Sidharath Bardhan and Khuspreet Singh

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ENHANCING THE COMPRESSIVE STRENGTH OF THERMAL ENERGY STORAGE CONCRETE BY USING PARAFFIN WAX AND WASTE COPPER SLAG

Sidharath Bardhan[a], Khushpreet Singh[b]

[a]ME Scholar, Civil Engineering Department, Chandigarh University, Mohali, Punjab, India

[b]Assistant Professor, Civil Engineering Department, Chandigarh University, Mohali, Punjab, India

Abstract- :- Concrete, as we all know, is used in a variety of applications such as construction, roadways, and so on. We create concrete to meet the needs of the project, and qualities such as compressive strength, durability, and fire resistance vary between structures and roadways. We strive to use the cheapest material that is readily available around the construction sites to improve the qualities of concrete.

When the concrete is poured, several processes (both endothermic and exothermic) occur. When Concrete is brought into the environment, the temperature has a significant impact on it, causing cracks in the concrete, a loss of compressive strength, and concrete bleeding, among other things. When concrete is brought into the environment, it undergoes an endothermic reaction, which means it absorbs heat from the environment. As a result, the temperature inside the building rises, and various studies are being conducted to manage this.

We will employ paraffin wax and waste copper slag in our experiments in this study article, and we will look at the thermal characteristics and compressive strength of concrete.

Phase Change Material-

Phase change materials (PCM$_s$), used for latent energy storage as their behaviour with temperature shows the solid to liquid phase change depends upon temperature of Environment like in summer they absorb energy and in cold times they release energy meant to be better comfort inside the building. Internal structure of the PCM$_S$ changes when phase change materials goes from liquid to solid or solid to liquid that is one state to another state.

PCM Heat Exchange Mechanism

Phase change material, introduced to the heat source for the physical change will be seen in the phase change material when chemical bonds breaks means their state change from solid to liquid which leads to heat absorption, known as endothermic reaction or process. As more phase change materials absorb heat, more breaking of chemical bonds takes place until its phase change temperature reached that is process of melting. During the process the Stored Heat refers to latent heat.

When PCM$_S$ introduced in concrete they absorb Heat and phase change material start melting means absorbing of energy take place. The releasing of stored heat energy into the environment then phase change material again solidifies. This storing and releasing heat energy process is Heat Exchange mechanism.

There is releasing of heat energy into environment when phase change material solidifies. Phase change process is known as latent heat when heat is stored and released.

Most of the researcher agreed for a major reason for performance of phase change material into concrete as it;

a) Improved thermal heat storage

b) Control cracking

c) Environment friendly

d) cost effective

Copper Slag

Copper Slag is the by-product of manufacturing copper. 40 million metric tons of copper slag is generated across the world while in India 6.5 tons of slag is generated yearly.There are three major copper producers **HINDUSTAN COPPER, BIRLA COPPER and STERLITE COPPER** produce around 6 to 6.5 tons of slag at different sites per year. Mechanical properties of copper slag satisfy the needs of material which is used in the concrete for the partial replacement of aggregate. Replacement of aggregate with copper slag meets the needs like elimination cost of disposal, low concrete cost and enhancing the compressive strength of concrete.

Paraffin wax

Paraffin wax is used in concrete as phase change material when the paraffin is introduced in concrete it enhances the thermal properties of concrete up to some extent. Properties like tasteless, waxy solid, density 900kg/m^3 and melting point between 46 and 68^{o}c. Paraffin wax is good heat storage material when it changes from liquid to solid or solid to liquid that is changing of phase.

Literature review

(Bentz and Turpin, 2007) This research paper was done to study the use of Phase change Materials (PCM$_S$) in the building. Different Test methods for PCM$_S$ was shown. PCM$_S$ are capable to store energy when the temperature is increased further given back at certain temperatures. Only few materials are known to store energy and release energy inside the building for comfort.

(Sharma *et al.*, 2009)This research was done to check the available PCM$_S$ for heat energy storage and PCM$_s$ incorporating or use in different application. The main significance was the enhancement of thermal performance of different PCM$_S$. Different applications were analyzed on PCM$_S$ which can be used in the building.

(Kuznik *et al.*, 2011)This Research gives the review of the PCM incorporation in building walls. All the phase change materials which are reviewed are being capable for enhancing building of the building envelop further increase in phase change material in walls of building, thermal conductivity can enhance the thermal storage capacity. More attention can be paid to the convective heat transfer coefficient, numerical modelling assumptions and use of phase change diagram

(Tyagi *et al.*, 2011) This research is about the different methods for incorporating the microcapsule technology as the PCMs in the building applications. Their results show that the method which can be used for the microencapsulation is in situ polymerization method and the wallboard with phase change material shows promising results for temperature fluctuation.

(Wang *et al.*, 2012)They studied the properties of energy stored concrete by paraffin wax as their phase change transition temperature was 26^{o}c in order to check the ability of energy stored concrete in both cooling and warming system. For adsorbing the paraffin wax fly ash lightweight aggregate was used and the adsorb quantity was 10%, 15% and 20%. Results shows that in both cooling and heating process the energy stored concrete were slower than that of blank sample.

(Vaz *et al.*, 2012) Researchers aim is to develop the new phase change composite material that can be microencapsulated in plastering mortar, numerical and experimental investigation of that material. Two tests were conducted one is with phase change material plastering mortar and another one is with recourse to conventional mortar. Results show that up to 25% thermal enhancement of mortar gives good results

(Xu and Li, 2013) The main focus of this research is on the development of composite PCM by incorporating paraffin through vacuum impregnation in buildings. By using the self-designated heating system the Thermal performance was evaluated of the cement composite PCM. Paraffin can be added up to 18%, and 9% and shows that phase change material improves the human comfort zone, capable of storing and releasing heat. Also, components of the chemical base phase change material are compatible with each other as it prevents the leakage of paraffin wax during its phase of transition that is from solid to liquid. PCM can be used to decrease the loads of air conditioning in building and to provide better comfort.

(Chen *et al.*, 2013) They studied the microencapsulation of Paraffin Microcapsule with the phase change material that is shells of silicon dioxide. Stability of microcapsule and thermal properties was Analyzed and the result shows the melting point of Microcapsules was were57.96oc with 156.86 kj/k as latent heat and solidified at 55.78◦C with 144.09 kJ/kg as latent heat at 82.2% microencapsulation ratio.

(Ling and Poon, 2013) This research was done to check the Phase Change Materials different types and thermal performance influence on phase change material concrete at hardened stages and fresh stages. The addition of PCM into concrete lowers strength, and low fire resistance if appropriate PCM is incorporated, can be minimized. Different PCM material has different properties like immersion process take several hours, for impregnation the effective technique is vacuum impregnation, if the PCM used is encapsulated and inflammable the fire resistance can be improved.

(Soares *et al.*, 2013) this study presents an overview of different PCM_s use in passive heat and heat energy storage system. Different types of PCMs were shown as the main methods for incorporation of PCMs and to measure the PCM_S properties in building. Economic and environmental factors were discussed also Heat transfer modelling and different techniques of incorporation were discussed. This review shows the reduction in the heat energy consumption and load reduction in cooling, for better comfort due to temperature fluctuation indoors.

(Choi *et al.*, 2014) this research was done to select the desirable and economic PCM_S to control the hydration heat in the concrete structures. From different inorganic phase change materials 7 types are taken out and used in cement mortar. 5 experimental tests were conducted is micro conduction, simplified adiabatic temperature rise, compressive strength, and heat tests. Results show good latent heat properties in the mortar which can prevent the volume change in the micro cracks.

(Cellat *et al.*, 2015) This research show enhancement of thermal concrete by the addition of fatty acids (bio-based) as Phase Change Materials (PCMS). They tested binary mixtures of myristic acids, Capric acids, and lauric acids for different use in building. The liquefy point of the fatty acids is adjusted further for better human comfort zone temperatures and according to that compositions can be regulated. The thermal test shows that both PCMs are chemically and thermally stable. At 120oc degradation started and less compressive strength of concrete was shown at 12% yet stayed within desired limits. However, the PCMs content was increased by 2wt% compressive strength was reduced.

(Ramakrishnan *et al.*, 2016) they studied the feasibility form of stable phase change material composites into cement was investigated. Paraffin showed good results of PCM_S leakage during integration of PCM_S into cementitious composites. The composite phase change material shows a higher contact than 90oc and successfully prevents the PCMS leakage in cementitious composites which is due to the counter-water affinity properties.

(Dakhli, Chaffar and Lafhaj, 2019) Researchers investigated the thermal enhancement, physical and mechanical enhancement of phase change material concrete. Results show that when the integrated PCM increases the thermal performance decreases. Addition of PCM to the cement dropped the thermal performance to 0.6 W/Mk as compared to pure cement thermal performance was found to be 0.7 W/Mk. With 20% thermal performance dropped to 0.56W/Mk. With 30% thermal performance dropped to 0.53W/Mk.

(Raza*k et al*>, 2020) This research was done to optimize the percentage of PCM in the concrete to achieve high thermal performance concrete which is affected by time and to enhance the mechanical properties at different percentages. Replacement of aggregates with Ground Granular Blast Slag (GGBS) was done at various percentages that are 0%, 5%, 10%, 15%, and 20% Results showed that of Phase Change Material incorporation into concrete with partial replacement of Ground Granular Blast Slag (GGBS) shows thermal storage energy effective. There is a decrease in Compressive strength, density measurement, and water absorption decreases with an increase in the amount of PCM. Up to 5% of the compressive strength and thermal storage give good results.

(Suhaib, Kaur and Goyal, 2020) studies the experimental work of phase change material effect on the Recycled Aggregate Concrete. Water absorption is tested on recycled aggregates and phase change materials shows higher than natural concrete. An increase of PCMs in cement increases the porosity. Addition of PCMs reduces the thermal conductivity 0.7 W/mK.f on 0%, 0.6 w/mk on 10% addition, and 0.56 w/mk for 20% after on addition of 30% give the lower value which is 0.532 w/mk.

(Khordehgah *et al.*, 2020) this article presents different methods of heat energy storage like sensible heat storage, thermochemical energy storage, and storage of latent heat, and the main focus was on phase change materials as a suitable solution for energy utilization between demand and supply to improve the system of heat energy storage. The methods of enhancing the performance of PCM were Nano capsules, micro and macro were discussed.

(Kulkarni and Muthadhi, 2021) they studied Organic and Inorganic materials by the direct incorporation in to the cement mortar. Partial replacement of cement is done with PCMs up to 15%, 3 organics, 2 inorganics directly incorporated into the cement. Different tests were performed on the thermal heat storage cement mortar like acid and Sulphate attack, flexural strength test, and compressive strength. Result shows the organic PCM$_{S}$ decreased compressive strength of mortar whereas up to 10% of the inorganic mortar gives equal strength as that of conventional mortar.

Compressive strength reduces at 90 days is shown when an acid attack test is performed on the mortar. The temperature variation is same in both cases that is in organic PCM and normal mortar.

Conclusion

- 10-15% replacement of cement with paraffin wax can give best results for heat storage in building
- 10-30% replacement of aggregate with waste copper slag can give best results for compressive strength in concrete.
- Use of paraffin wax and copper slag is cost effective and can help in solid waste management.

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