Effect of Sonicated Graphene on Heat of Hydration of Cement Graphene Composites

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Abstract- *Cement composites are widely used today to improve the properties of concrete. Graphene being a material with high traction, tearing resistance has multiple advantages like enhancement in strength, crack resistance, water resistance, improved durability and so on when used as an additive in cement making a great graphene cement composite. Studies have shown that the main drawback in making full use of this material in concrete is its agglomeration property and difficulty in its uniform dispersion. Sonication process is extremely helpful in overcoming these limitations of graphene in concrete. Though this novel material has got much attention in the form of numerous studies on its strength and few mechanical properties, the rate of hydration is not much known. Hence in this study, the temperature is monitored to know about the heat of hydration pattern of this cement graphene composite. Sonication is done for 15 minutes and graphene proportions of 0.02%, 0.03%,0.04%,0.05% and 0.06% in the cement mortars are studied.*

Keywords- cement additives, compressive strength, durability, tensile strength, graphene oxide, sonication.

I. INTRODUCTION

The effects of temperature early in the life of concrete can strongly influence long term stability. In general, concrete temperature peaks at 48hours and remain constant for about 7 days. The larger is the concrete structure, the more is the likely heat to be generated. Differential temperature, air temperature, and mixing temperature are all important factors. Monitoring the temperature of concrete during is a critical factor in making sure the product sets to its full strength and knowing when it is safe to build on. Heat is generated during hydration and gets trapped which cannot escape quickly. The core continues to heat while the surface cools down. Large temperature differentials can form between core and surface leading to thermal cracks. This in turn may cause increased permeability for easy penetration of water and air, also reduced durability and structural integrity. Generally concrete needs to be maintained at a uniform temperature which is challenging at times. In high-temperature areas, there are higher chances of shrinkage forming cracks, decreased strength after 28 days, and a high potential for corrosion in reinforcements. Hot climates can speed up the curing process and lead to short term strength gains but excessive heat ultimately leading to weaker concrete. Low-temperature issues include - water freezing in concrete capillaries leading to cracks as the water expands when freezing, up to 50% decrease in strength if concrete freezes before reaching 500psi.

Concrete temperature monitoring is critical to ensure the long-term strength and stability of concrete structures. Monitoring is necessary to verify - Temperature differentials don't go beyond safe limits, Concrete did not cool more than 2.8°C per hour during the first 24 hours. The core temperatures at various stages, to determine any necessary temperature control strategies to put in place. The implications can also be long term structural integrity and having temperature records. Being alerted to cure temperatures outside safe parameters enables us to take corrective action while we have the chance.

A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record monitor or signal temperature changes. There are many different types of temperature sensors. Some of them require direct contact with the physical object that is being monitored, while others indirectly measure the temperature of an object. Noncontact temperature sensors are usually IR (infrared) sensors. They remotely detect the IR energy emitted by an object and send a signal to a calibrated electronic circuit that determines the object’s temperature.

Among the contact temperature sensors are thermocouples and thermistors. Today we have advanced concrete sensors that provide real-time insights to concrete temperature, maturity, evaporation rate, and strength along with full visibility into temperature differentials and relative humidity. They don’t require us to be on-site to know the status of concrete being worked upon. Sensor data is sent from the job site to mobile devices where we can access it from anywhere and at any time. These sensors can be used throughout the curing process easily.

The equipment is recoverable and reusable across multiple projects making them reduce the total monitoring costs. It optimizes schedules and enhances the efficiency of work. They can be secured to rebars with tie wraps making the installation process simple. The sensor can then be plugged into the transmitter hole for wireless connectivity. These sensors help us to set up customized notifications based on the status of concrete elements. They also notify us instantly once a certain condition has been met. They operate in harsh conditions- both cold and hot. The ruggedized IP68- rated enclosures are both dust and water-resistant. These sensors can be used for walls, girders, columns, floors, tanks, and hollow-core precast units. The accuracy is about 0.4°C with concrete strength data based on ASTM C1074 matching break results. These sensors can reveal a significant differential temperature across a mass concrete pour or effect of curing on concrete due to seasonal weather changes which cannot be captured even by concrete cylinder break tests.

Data loggers with thermocouple temperature sensors fitted are used to accurately monitor and record concrete temperature throughout the curing process. Type K thermocouple probes are embedded within the concrete so that the actual core temperature of the mixture is logged, rather than just the ambient air temperature. Entire kits are specifically designed for this purpose. Kits can be configured for remote web-based monitoring, or purely as standalone devices with their display screen. They are cost-effective and a simple way to take in-situ measurements in concrete as it cures. It enables around-the-clock measurement and reporting of temperature at critical locations. They also accept a wide range of thermocouple probes. Also, can be configured and installed in minutes. Display readout of current temperatures, visual alarms, etc . are offered in single and multi-channel form factors. Temperature sensor sample rates range from every 10 minutes to one hour (concrete pours in cold weather typically require more frequent sampling). The concrete temperature monitoring period usually lasts several days. For multi-channel logger applications, thermocouple sensors are often placed at the bottom, middle, and top of the concrete structure, with an additional channel for ambient air temperature. In this study sensors are embedded in cubes for finding temperature for 24 hours after mixing.

In this study we are using normal contact sensors which has a probe to be embedded in fresh concrete. The temperature is noted in every hour for 24 hours with the help of its digital display. A series connection of three batteries was made to complete the circuit and provide the sensors the right current required for functioning.

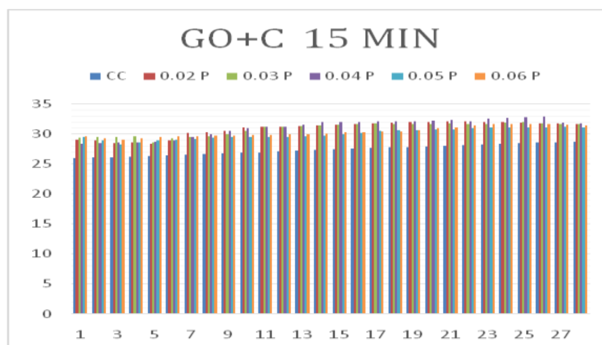
a) Materials used

Sand, cement, graphene powder, Class F flyash, superplasticizer and water were used to make the specimen mortars. The water-cement ratio of 0.5 was taken for all mortar cubes. Basic tests like consistency, initial and final setting time along with specific gravity was carried out and found to be in accordance with IS codes.

b)Sample preparation

The cubes were made using sonicated graphene in solution form by adding the graphene powder in calculated water content. Superplasticizer was also added to keep the dispersion of graphene stable in solution. The sonication was done for 15 minutes and graphene proportion of 0.02%, 0.03%, 0.04%, 0.05%, 0.06% was added to make specimen samples. Each proportion was connected to sensors with digital display and the temperature was constantly noted every 1 hour for 24 hours after mixing.

II. RESULT AND DISCUSSION



Graph showing comparison of heat of hydration values

Sensors in mortar cubes

The conventional mortar cube with no graphene, showed less temperature in the whole 24 hours of observation. Graphene in each proportion had increased the temperature showing that graphene powder facilitated hydration process of the specimens. Out of the five different proportions in this study, 0.04% showed the highest temperature which suggests that 0.04% is the optimum percentage of addition for faster hydration and gaining of strength in mortar cubes.

III. CONCLUSION

Sonicated graphene is better than conventional cement mortar cubes as they have faster and higher rate of hydration. Thus it can be used for applications requiring better initial strengths. 0.04% graphene oxide in mortar cubes give the optimum heat of hydration and thus can be slight accelerators.

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