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A study of review of literature on internal curing concrete made using various internal curing agents

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Abstract

This paper aims to give overview on self-curing concrete made by means of various self-curing agents by using different water-cement ratios and various dosages of self-curing agents. Water consumption is huge for the process of preparing concrete and also during the process of 28 days of curing. It is said that the construction industry is the second largest industry to use huge quantities of water. For the constructions in the desert regions or in the places where water scarcity is available, it is difficult to manage the required quantity of water and hence the water which is available in the small water bodies like ponds and rivers are being used for the construction activities. This leads to the depletion of water in the water-scarce zones. Pertaining to this, the demand has raised in the construction industry to prepare concrete that consumes less amount of water but with desirable properties. Self-curing or internal curing concrete is a type of modern concretes that doesn't require any amount of water throughout the development of curing concrete members. The self-curing nature for concrete is attained by using different self-curing agents like polymeric glycol, lightweight aggregates, polyethylene glycol, etc., This paper provides a detailed review of literature on various researches which were conducted on self-curing concrete at varied conditions. Self-curing concrete can be seen as an alternative to conventional concrete in the near future.

Keywords: *Internal Curing Concrete, Polyethylene Glycol, Self-curing Agent, Concrete Materials, Mechanical Properties.*

1. Introduction

1.1 Curing – Importance

The term curing can be well-defined as the process of monitoring the frequency and degree of moisture loss from concrete throughout the hydration process of cement. Curing process controls the ambient temperature of hydrating concrete as it disturbs the hydration rate. Drying shrinkage is possible when the water in the concrete gets dried. The durability of concrete is majorly affected by permeability and absorptivity, which is a result of improper or lack of proper curing. These are identified with the porosity of the concrete and whether the capillary pores are discrete or interconnected. While the number and size of the pores in paste are connected straightforwardly to its water-cement proportion, they are additionally related in a roundabout way to the degree of water curing. Curing for Long time relieves prompt hydration products to fill the capillary pores present either mostly or totally thus to diminish the porosity of the cement paste. Curing is planned principally to keep the concrete sodden by keeping the deficiency of dampness from the concrete during the period in which it is acquiring strength. Curing should be accomplished for a sensible timeframe if the concrete is to accomplish its expected strength and durability.

1.2 Internal curing

An electronic The properties of concrete such as the mechanical and durability will be enhanced by the curing process concrete. To get 99% of strength results it is mandatory to cure the concrete members for 28 days, wherein a high quantity of water will get wasted during the process of curing. Generally, the two methods of curing are the external curing and the internal curing. External curing involves the supply of water during the 28 days curing period. Internal curing is defined as the curing which happens within the concrete using the water that is used during the concrete mixing process. Self-curing concrete can also be called Internal curing concrete. Different internal curing agents can be used to achieve the internal curing property of concrete. Among the various types of self-curing agents available it was noted from the literature that Polyethylene glycol shown better self-curing nature besides the mechanical properties. This type of concrete is advantageous to use in the places where water is scarce.

1.2 Internal curing compounds

To accomplish the nature of internal curing to the concrete following are the possible materials that can be used.

- Polyethylene glycol (of different molarities)
- Lightweight aggregates
- Polymeric glycol
- Polyvinyl alcohol
- Shrinkage reducing admixtures

2. Literature review

(Basil M Joseph, 2016) conducted experimental studies on self-curing concrete made with Polyethylene Glycol – 400 solution then made the comparative studies between conventionally cured concrete and self-cured concrete. M25 grade of concrete is prepared by using 0-1.5% replacement of PEG-400 solution by weight of cement. It was found that at 1% replacement of PEG-400 the concrete shown better mechanical properties of hardened concrete. It was also found that with an increase in PEG solution the slump and compaction factor were also increased.

(Kastro Kiran V et.al, 2020) studied self-curing concrete made with PEG – 400 at various dosages viz. 0-3% by cement weightiness. M30 grade of concrete was aimed to prepare and the comparative study was made between the conventional concrete and self-cured concrete. It was found that for reference mix the compressive strength was 32 MPa and at 2% of PEG – 400 replacement the compression strength was increased to 36.5 MPa. Similarly, the flexural and split tensile strengths were observed at 1.5% PEG – 400 replacements viz. 2.9 MPa and 1.38 MPa. It was concluded that self-cured concrete shown better performance than conventionally cured concrete. The effect of salts like NaCl and $CaCl_2$ on self-cured concrete was also studied. The mix which gave the maximum compressive strength in the initial trial was adopted to assess the effect of salts. It was found that self-cured concrete specimens got deteriorated when exposed to salts and the results shown a decreasing trend. The compressive strength was decreased to 29 MPa and 26 MPa when exposed to NaCl and $CaCl_2$ solutions from 36.6 MPa. Similarly, flexural and split tensile strength results were also decreased. Overall, the authors concluded that self-cured concrete could be the best possible alternative to conventionally cured concrete.

In a work carried by (Magda I. Mousa et.al, 2015) self-cured concrete is prepared using pre-soaked lightweight aggregate at dosages ranging between 0-20% by volume of sand and polyethylene glycol solution at dosages between 1-3% by weight of cement. Physical properties such as volumetric water absorption, permeability, and water sorptivity were evaluated by using three different cement contents (300, 400, and 500 kg/m^3) and water-cement ratios (0.3, 0.4, and 0.5). Silica fume was used at two different dosages viz. 0% and 15% by weight of cement. It was observed that physical properties were greatly increased when self-curing concrete was prepared by using polyethylene glycol solution. It was also noted that 15% lightweight aggregate showed better results where on the other hand 20% replacement of lightweight aggregate shown better results for loss of mass and permeability capacity but the water absorption by volume and sorptivity of concrete were greatly affected. It was concluded that the optimum dosages of polyethylene glycol and lightweight aggregates were observed at 2% and 15% replacements. It was also noted that an increase in cement quantity gives better results but at a lower water-cement ratio. Physical properties were enhanced by the usage of Silica fume in self-curing concrete.

Two different cement contents viz. 350 and 450 kg/m^3 were used at two water-cement ratio viz. 0.3 and 0.4 both for self-curing concrete and conventionally cured concrete (El-Dieb, 2017). The sizes of the crushed stone aggregate used in the study were 5-20 mm and 10-25 mm and the slump value was maintained constant for all the mixes, 90-120 mm. 0.02% of PEG is replaced with the cement weight throughout the study. The conventional concrete can be cured under two curing conditions, moist curing and air curing. To understand the behavior of self-curing in concrete, tests like water retention, hydration, water sorptivity, and water absorption were conducted. It was observed that the water retention capacity is good for the concrete prepared using a self-curing agent than related to conservative concrete. The hydration parameter of self-curing concrete shown better performance alongside the conventional concrete. The perviousness and sorptivity nature of self-cured concrete shown a decreasing trend concerning the age of the specimen.

The effect of corrosion on self-curing concrete was studied by (A.S. El-Dieb et.al, 2018). Polyethylene glycol and polyacrylamide were adopted to prepare the self-curing concrete to assess the corrosion behavior. The protection to reinforcement studies was then interrelated to durability features such as electric resistivity, chloride ion permeability, and water perviousness. Mixes were prepared in conjunction with PEG and PAM at various dosages. Self-cured concrete specimens gave better performance against corrosion potential and current. The studies on the micro-structure of self-cured concrete also indicated that durability and corrosion protection was enhanced. The self-cured concrete shown lower permeability as compared to the conventional concrete.

(Pericles et.al, 2018) studied the increased temperature effects on self-curing concrete made using highly-absorbing normal weight aggregates and normal weight crushed aggregates. Three different cast temperatures were used viz. 220C, 300C, 350C, and 400C for both air curing and water curing specimens. 62 MPa and 51 MPa of compressive strength were observed for concrete cured under air and concrete cured with water. It was also noted that during 3 and 7 days tests the mixes prepared using normal-weight aggregates shown a little greater compressive strength besides the concrete cured with water but on the other hand by the end of 28 days this was reversed. The mixes cast at 400C gave poor results and also the behavior was unpredictable.

A work carried by (Semion et.al, 2012) conducted studies on durability factors of internally cured concrete in high performance concrete. Pre-saturated lightweight aggregates were used to prepare internally cured concrete at three dosages of super-plasticizer (4.2%, 3.4%, and 2.6%) at water to cement ratios of 0.33, 0.25, and 0.21. Slump value shown a peak point when 2.6% of super-plasticizer was used. The sorptivity at 1 day was about 20% higher than when compared to the reference mix of all the three different water-cement ratios. On the other hand, it was observed that at 0.25 and 0.21 water-cement ratios the increase in sorptivity was increased to 44% and 54%. The air permeability of concrete cured internally is higher than the reference mix at day 1 and thereafter the air permeability showed a decreasing trend. For high performance internal cured concrete, diminution in water-cement ratio had a positive result on drying shrinkage.

A study highlighted on the influence of lightweight aggregate and polyethylene glycol solution on various mechanical properties of concrete cured internally. (BR VT, 2016). The lightweight fine aggregate having the size 0.3-4.75 mm was used along with PEG-600 solution, along with coarse aggregate of size ranging from 20-4.75 mm. Six mixes were cast at 10%, 20%, 30% replacement of lightweight fine aggregate along with 1%, 2%,3%, and 4% of PEG solution at 20% lightweight fine aggregate replacement. The slump values weren't altered much by the usage of lightweight aggregate but an increase in slump values was observed with an increase in PEG solution. The maximum compressive strength, 44.1 MPa, was observed at 20% replacement of lightweight fine aggregate. On the other hand, 49.1 MPa of compressive strength was observed for concrete made with 20% lightweight fine aggregate and 2% of PEG solution. The values have shown a decreasing trend after the optimum ranges. The optimum dosage for compressive strength was found when 20% of lightweight aggregate was used as a replacement, 44.1 MPa, and when 20% lightweight aggregate is used in conjunction with PEG solution at a dosage of 2%, the higher compressive strength was obtained, 49 MPa. A similar passion of results was found for flexural and split tensile strengths. However, a decrease in strengths was observed with further increase after the optimum dosages.

(Lura et.al, 2007) identified the primary and secondary consequences of internal curing of concrete. Degree of hydration, internal water movement, and autogenous shrinkage are observed as primary consequences whereas mechanical properties, pores and distribution of pore size, interfacial transition zone and self-induced stress and cracking were identified as secondary consequences.

A work carried by (Zaheer et.al, 2019) used light expanded clay aggregate which were water dipped for 24 hours to prepare self-curing concrete. Replacement of lightweight aggregate were made between 5-20% with an interval of 5% under the curing and non-curing conditions. It was observed that at 5% replacement maximum compressive strength was attained both for curing and non-curing conditions.

(Semion et.al, 2017) used saturated lightweight aggregate at water-cement ratios of 0.33, 0.25, and 0.21 and evaluated the cracking sensitivity, sealed shrinkage and drying shrinkage along with mass loss. It was noted that crack potential was unaffected when 0.33 w/c ratio was used and for the lower w/c ratio the crack potential was decreased from high to low based on typical criteria of rate of stress at the place of cracking and remaining time to crack. The shrinkage property of self-cured concrete decreased with rise in w/c ratio.

Conclusions

The following conclusions are derived from the literature;

1. Self-curing concrete made using polyethylene glycol shown better performance against mechanical and durability properties.
2. An optimum water-cement ratio was found in between 0.33 and 0.38 for the concrete to have better durability characteristics.
3. Concrete made using lightweight aggregates also shown better efficiency for low strength concretes but the durability of such concretes is unpredictable.
4. Addition of admixtures like silica fume and polyvinyl alcohol enhanced the strength properties.
5. Corrosion nature of self-cured concrete yielded better results than the conventional concrete along with crack resistance.
6. Overall, self-cured concrete can be seen as an alternative among many other special concretes which saves the natural water bodies for efficient consumption.

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