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Experimental Investigation On Local Materials As Self-Curing Agents for Mortar And Concrete-Literature Review

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ABSTRACT

Curing, which is the application of water externally, to the concrete in normal/conventional concrete is done after mixing, placing and finishing are completed. On the other hand, self curing or internal curing involves providing additional moisture internally in addition to the surface moisture so that optimum hydration takes place and detrimental self desiccation/dehydration does not happen. In self curing, additional moisture acts as pool of water which can be used internally to satisfy the need of water for effective hydration. As per American Concrete Institute (ACI) the internal curing (IC) means "A technique in which cement hydration continues due to the availability of internal water that is not part of the mixing water." The idea behind the concept of self-curing is to lower the amount of water lost through evaporation from concrete and therefore, by using chemical curing agents, fine aggregates, superabsorbent polymers, or saturated wood fibers, the water retention of the self-curing concrete is increased as compared with conventional concrete. The strength and durability of concrete can be badly affected due to improper curing. The broad objective of this paper is to present the brief literature review about the self-curing. The paper discusses literature review, various water reducing agents and effect of self-curing agentson fresh and hardened properties of concrete.

***Keywords**:Curing Agents, Cement Hydration, Internal curing, Polyethylene Glycol, Self-desiccation*

I. INTRODUCTION

Curing has significance in the sense that development of concrete microstructure and pores depend upon it. Strength and durability are the functions of curing and highly bank upon its effectiveness. Effective curing of concrete is therefore an issue which must be dealt meticulously in the construction industry, particular in areas of hot climates or of scarcity of water [1, 2]. The main function of internal curing in concrete, is to decrease the water evaporation from concrete and therefore to maintain sufficient amount of moisture inside the concrete. The maintaining of moisture is essential for the persistent and prolonged hydration of cement. It is the most important factor for the development of concrete micro structure and pores' structure [3]. Owing to the chemical reaction of cement hydration, water is lost internally and it needs to be replaced by water from outside. Lack of curing causes the concrete surface to shrink and cracks form on top of it. This shrinkage cannot be managed by conventional curing methods. Therefore internal curing is a new technique, where the curing agents are added, minimizing the chemical potential of molecules. [4].According to 308 ACI code "A technique in which cement hydration continues due to the availability of internal water that is not part of the mixing water."In general, internal curing techniques are primarily divided into two elements, namely the technique of water addition and the technique of water retention [5].The technique of water addition typically consists of introduction of light weight aggregates and super absorbent polymers and the technique of water retention is accomplished by applying self-curing agents to the concrete mix. Adding light weight aggregates (LWA) and super absorbent polymers (SAP) will eliminate the key disadvantage of traditional concrete. [5, 6]. The main advantage of self-curing concrete is observed when compared to concretes which are not cured internally. Self-curing concrete gives superior hydration process with time under drying condition compared to conventional concrete. Evaporation of moisture content in self-curing concrete is lower than traditional concrete cured by air. With age, the continuation of cement hydration, sorptivity and permeability values decrease for self-curing concrete. [7] Now a day concrete curing is a big problem, particularly in areas that suffer from water shortages. When concreting work is carried out at high altitudes, sloped roof, vertical components and construction in remote regions where the supply of water is very difficult and when construction is in the hot zone, internal curing technique is essentially required.

1.1 Techniques of Curing

The selection of method depends on certain factors, such as the availability of curing materials, the size, shape and age of concrete, production facilities, aesthetic appearance and economics. [1]

1.2 External Curing Method

1. Continuously having ample moisture/water in the concrete during the early hardening period.
2. Reduce the loss of water from the concrete's surface.
3. By supplying heat and additional moisture, the strength of concrete increases.

1.3 Internal Curing Method

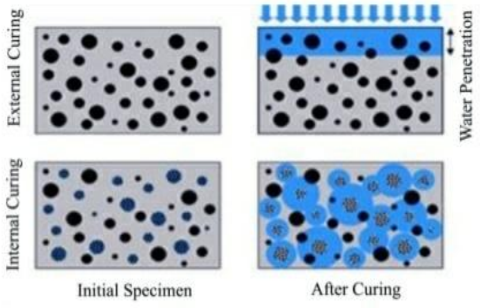
Now a day, two main methods are used for internal curing. The first approach requires the use of saturated lightweight aggregates that can serve as an internal water supply that can replace the water utilized during cement hydration through chemical reactions. The use of poly-ethylene glycol (PEG) is part of the second process. PEG decreases water evaporation from the concrete surface and thus improves the preservation of water. [2]

II. NEED FOR INTERNAL CURING

Internal curing or self-curing relates to the mechanism by which, due to the availability of additional internal water which is not part of the mixing water, cement hydration takes place. As minerals and admixtures react completely in cement system, demand of external and internal curing water increases tremendously as compared with that of a conventional ordinary Portland cement concrete. When water is not readily available, early-age cracking and autogenous shrinking can occur due to de-percolation of capillary porosity. [4]

III. MECHANISM OF INTERNAL CURING

Conventionally curing maintains the moisture condition in concrete from outside to inside. On the contrary, 'internal curing' does the curing 'from inside to outside' via internal reservoirs created by the PEG. Due to a difference in chemical potential (free energy) between the vapour and liquid phases, the continuous evaporation of moisture occurs from an exposed surface of conventional concrete. Polymer form hydrogen bonds with water molecules when they are introduced into the mix and thus reduce the chemical potential of the molecules, which consequently decreases the vapour pressure, thus reducing the rate of evaporation from the surface.[5]



Initial Specimen After Curing

Fig 1: Mechanism of Internal Curing

IV. Advantages Of Self-Curing

1. It decreases autogenous cracking.
2. It prevents autogenous shrinkage in large part.
3. It decreases permeability.
4. It protects steel reinforcement.
5. It provides greater durability.
6. It improves rheological properties.
7. It increases the early age strength.
8. It lowers maintenance.

V. Literature Review

K. Sumangala (2019) carried out literature survey regarding the research done in the field of self-curing concrete. The author studied and found that various chemical admixtures such as Poly Ethylene Glycol (PEG), Super Absorbent Polymer (SAP), Poly Vinyl Acryl (PVA), SodiumLignosulphonate and naturally available materials like Light Weight Aggregates (LWA), Light Expanded Clay Aggregate (LECA), wood powder and coco pith were used to make self-cured concrete. The author also concluded that using 1- 2% of polyethylene glycol (PEG) admixture in various grades of concrete gave strength equal to conventional concrete and also increased the strength up to 10-15%. When 0.3% of Superabsorbent polymer (SAP) was used, the physical properties were increased to 5%. [8]

Siddharth Nahar and Siddharth Pastariya (2018) experimented with the self-curing concrete that by retaining its moisture content, it can cure itself. In the this research, author added admixture Polyethylene Glycol (PEG 400) in concrete grade M20 and M25 mixes by varying the percentage by weight of cement from 0% ,0.8%,1.6%,2.4% & 3.2% and results were studied and observed the effect on compressive strength, split tensile strength, flexural strength and durability. It was concluded that 2.4 % of PEG 400 was optimal for M20 by weight of cement, while 1.6 % was optimal for M25 concrete to reach the optimum strength without losing workability.

Slump for M20 and M25 grades of concrete increased with increasing percentage of polyethylene 400 (PEG 400). [9]

Vikram M. B. at el., (2018) studied self curing concrete and used polyethylene 400 and polyethylene 600 as self curing agents in concrete. M25 grade concrete was used for investigation. The author added polyethylene 400 & polyethylene 600 varies from 0.5% to 2.0% by weight of cement for M25 grade concrete. For maximum compressive strength, the author calculated the optimum dosage of polyethylene 400 and it was 1.0% by cement weight and the optimum dosage of polyethylene 600 was also 1.0%. He also came to the conclusion that self curing concrete is less porous and more compact as compared to conventional concrete and is capable to withstand extreme environmental conditions and corrosion effects [10].

M. M. Kamal at el., (2018) investigated to find out effect of adding internal curing agents on the performance of normal and high-strength, self-curing, self-compacting concrete. The author adopted three types of self curing agents, namely, Polyethylene glycol 400 and Polyethylene glycol 600 & light expanded clay aggregates (LECA). The first stage of research consists of figuring out the effect of the curing agent on the main properties of normal-strength and high-strength self-compacted concrete in order to create the best self-curing self-compacting concrete. The second stage was to analyze the behavior of RCC beams which were cast using the two predetermined concrete types. The author found that using Polyethylene glycol 600 is more effective for normal-strength self-curing self-compacting concrete (N.S.SCSCC) than using Polyethylene glycol 400, followed by using LECA as the 'LWA' lightweight aggregate. It was advised to use light expanded clay aggregates (LECA) for high-strength self-curing self-compacting concrete rather than using chemical agents. The optimum values obtained for normal strength self-curing compacted concrete (N.S.SC-SCC) and high strength self-curing compacted concrete (H.S.SC-SCC), respectively, were 2% and 3% when using Polyethylene glycol 600. The optimum values of 3% and 2% for normal strength self-curing compacted concrete (N.S.SC-SCC) and high strength self-curing concrete (N.S.SC-SCC) were obtained while using LECA. The maximum deflectionvalues for reinforced Normal strength self curing-self compacted concrete (N.S.SC-SCC) were observed at mid point and quarter of the beams when using Polyethylene glycol 600 than using Polyethylene 400 and LECA and for reinforced High strength self curing-self compacted concrete (H.S.SC-SCC) beams, compared with the use of Polyethylene glycol 400 and Polyethylene glycol 600, the maximum reported deflection values obtained while using LECA. [11]

T. UdayaBanu at el., (2018) experimented with hydration which was done by locking the water content added for mixing from evaporation and by forming a thin film over it. M20 grade of concrete was adopted for investigation. The author added polyethylene 400 (PEG 400) in the ratios 0.5%, 1%, 1.5% and 2% of the weight of cement for M20 grade concrete. Due to solubility properties of polyethylene 400, it was added in water along with water during mixing process. The author found that optimum amount of polyethylene 400, for maximum compressive strength was found to be 1.5% of weight of cement for M20 grade concrete and by using this method; cost for concreting was also reduced [12].

G. Trinath (2017) studied self-curing concrete, and use of polyethylene Glycol (PEG 400) as self curing agents in concrete. M30 grade concrete was adopted for investigation. The author added polyethylene Glycol (PEG 400) varying from 0.0% to 2.0% by weight of cement for M 30 grade concrete. The author determined the optimum percentage of polyethylene Glycol (PEG 400) which was found to be 1% for compressive and Split Tensile Strength. If the dosage of polyethylene Glycol (PEG 400) increased to more than 1%, there was a decline in compressive and split tensile strength. However, the optimum percentage of polyethylene Glycol (PEG 400) for flexural strength was found at 0.5%. If we increase the dosage of polyethylene Glycol (PEG 400) more than 0.5%, there is reduction in flexural strength. [13]

Awham M Hammed at el., (2017) investigated the effect of polyethylene glycol (PEG) and Polyacralymide (PAA) addition, on the properties of ordinary cement and mortar. The author concluded that the addition of polyethylene glycol (PEG400) and (PEG/PAA) altered the physical and mechanical properties of cement mortar. The study demonstrated that polymer-modified mortar possessed higher strength compared to reference mortar. Mortar with 1 and 3% of polyethylene glycol (PEG400) and (PEG/PAA) dosage respectively gave higher compressive strength, as compared to conventionally cured mortar. This was because of reduction in porosity, with increment in rate of added substance. The organic polymer interspersed in the hydrated cement may lead to the formation of cross-links among the grains that have originally been solidified in free space. By the use of polyethylene glycol (PEG400) and (PEG/PAA) it was observed that the workability of mortar also increased, and mortar became flow able. Up to certain dosage of polyethylene-glycol 400 and (PEG/PAA), one can save water which is required for external curing. It had been observed during testing; internally cured mortar polyethylene glycol (PEG400) and (PEG/PAA) demonstrated lesser cracks than the normal mortar. Addition of polyethylene glycol (PEG400) and (PEG/PAA) effectively enhanced its tensile and flexural strength. However, the compressive strength decreased to some extent. [14]

A Ananthi et al., (2017) studied the effect of curing agent polyethylene glycol (PEG-400) in the performance of concrete. The author used polyethylene glycol as chemical agent and glenium Super plasticizer. M40 grade concrete was adopted for investigation. From result, it was observed that the optimum dosage of polyethylene glycol (PEG400) for maximum strength was found to be 2% for M40 grade. From the workability test, it was seen that an increase in glenium dosages increased the workability at the rate of 3.3%. An average increase in the compressive strength of 2.25% & 12% was found when self-curing concrete of polyethylene glycol (PEG 400) was used in curing than the conventional curing of concrete at the age of 7 days 28 days respectively. Self-curing concrete has 1.5% higher tensile strength than conventional concrete. [15]

Dr. U. B. Chouby, (2017) carried out the comparative study by using polyethylene glycol 400(PEG400) as internal self curing agent for various grades of concrete. The comparative results for compressive strength for conventional and self-cured concrete M20, M30 and M40 grade at saturated ages (7, 14 & 28 days) were analyzed. It was found that 1% dosage of polyethylene glycol 400 by weight of cement was optimum for M20 & M30 grade of concrete while 0.5% dosages of polyethylene glycol 400 were optimum for M40 grade concrete for achieving the maximum compressive strength. [16]

Sri Rama Chand Madduru., et al. (2016) found out that due to many reasons, if curing is not properly done, it renders the repairs useless. Self compacting mortar (SCM) is preferred for aging infrastructure for repairs especially in reinforced concrete structures. It was concluded that the use of self curing agents in self compaction mortars in optimum dosages benefited self compacting mortars in achieving better strength and durability performance. [17]

Alaa A Bashandy et al. (2016) studied the fresh and hardened properties of Recycled Aggregate Self-curing Concrete (RA-SCC). Polyethylene Glycol (PEG) is an amazing chemical agent which reduces the loss of water to the minimum and does continuous curing of concrete. Many of the recycled aggregates store an elevated amount of water which is not a part of the mixing water to set up water supply reservoirs in the concrete to get continuous hydration process. Water reducing admixture Polyethylene Glycol (PEG) and recycled aggregates as self-curing agent were used in concrete. The author concluded that the Using Polyethylene Glycol 400 (PEG 400) as a chemical curing agent the in Recycle Aggregate Concrete (RAC), compressive strength for self-curing concrete with crushed dolomite, crushed concrete and crushed brick increased by about 14.1%, 12% and 1.75%, respectively. The optimum dosage of Polyethylene Glycol 400 (PEG 400) was 0.25% of cement content for self-curing concretes with dolomite and crushed concrete, while it was equal to about 0.5% of cement for self-curing concrete with crushed red bricks. [18]

Amgoth Ram Kumar (2016) studied the fresh and hardened properties of self curing concrete. Polyethylene glycol (PEG) of molecular weight 4000 (PEG 4000) and 200 (PEG 200), Liquid Paraffin Wax light and liquid paraffin wax heavy for dosages ranging between 0.1 to 1% by weight of cement added to mixing water as self curing compound in concrete with different water ratio. The author concluded that decrease took place in compressive strength of self curing Self curing concrete (SCC) with the increase in percentage of curing compounds for higher grade but higher dosage of curing compound was required for lower grades of self-curing concrete (SCC). As the percentage dosage of self curing compounds increased, the resistance against acid attack decreased irrespective of grades of concrete. Sorptivity decreased with decrease in dosage of Polyethylene glycol (PEG) in both low and high molecular weights of Polyethylene glycol (PEG). [19]

K. Bala Subramanian (2015) experimental study found that, the strength development of high strength concrete is more if the replacement percentage of silica fume by weight of cement is 10%. On the other hand, permeability of the concrete decreases if the replacement percentage of silica fumes by weight of cement is 15%. Also the strength of the concrete improved significantly with the increase of self-curing agent. i.e., concrete with 0.4% of Polyethylene (PEG) gave more strength than that with 0.2%, and 0.3%. [20]

C Yoginatnantham and M Helen Santhi (2015) studied the fresh and hardened properties of Self Compacting Self Curing Concrete (SCSCC) consisting of 30% of class C fly ash for the replacement of cement and 100% of Manufactured sand(M sand) for river sand. Water reducing admixture of Glenium B233 and self-curing compound of Polyethylene glycol (PEG 400) were used for M25 grade concrete. The fresh properties of Self curing concrete (SCC) were determined as per “European Federation of National Associations Representing for concrete”(EFNARC) specification. The optimum dosage of the self-curing admixture Polyethylene-glycol 400 (PEG 400) was found as 1% by weight of cementations material for M 25 concrete. The compressive and split tensile strength of Self curing-Self compacted concrete (SCSCC) is found to be 3 % and 2 % higher than that of conventional concrete. The usage of industrial wastes such as fly ash and manufactured sand in Self curing-Self compacted concrete (SCSCC) found to reduce the demand for conventional concrete materials and also to make the concrete eco-friendly. [21]

Magada I. Mousa et al., (2014) studied the effect of two materials that were selected as self curing-agents and examined in order to compare them for optimizing the performance of concrete. The first one is the pre-soaked lightweight aggregate (leca) with different ratios; 0.0%, up to 20% of sand volume, and the second type is a chemical agent of polyethylene-glycol with different percentages; 1%, up to 3% of cement weight. The result demonstrated that the use of self curing agent (Ch.) in concrete factually enhanced the physical properties in comparison to conventional concrete. Up to 15% saturated leca was effective while 20% saturated leca was effective for permeability and mass loss but adversely affects sorptivity and volumetric water absorption. [22]

Ole Mejlhede Jensen (2006) carried out survey for various techniques to incorporate the internal curing water in concrete. Internal water curing can be used to reduce self-desiccation and shrinkage due to it. He concluded that some concretes may need 50 kg/m3 of internal curing water for this purpose. [23]

VI. CONCLUSION

Following conclusions can be drawn based on the literature review.

1. Fresh properties of concrete are improved with addition of polyethylene glycol as self curing agent.
2. Self curing concrete is an alternative to conventional concrete in areas especially where the scarcity of water is there and in hot region.
3. Self curing concrete minimizes the impact of the human errors in curing.
4. It is observed that there is less amount of percentage required by weight of cement of Polyethylene glycol for high grade of concrete as compared to low grade.
5. Strength of self curing concrete is relatively high when compared to conventional concrete.
6. Self curing concrete gives better hydration with time under dry condition compared to conventional concrete.
7. From the workability test results, it was observed that the self-curing agents improved workability.

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