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Self-Curing Concrete with Shrinkage Reducing Admixture

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Abstract —*Concrete is most widely used construction material due to its good compressive strength and durability. Depending upon the nature of the work cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain concrete. Plain concrete needs congenial atmosphere by providing moisture for a minimum period of 28 days for good hydration and to attain desired strength. The properties of hardened concrete, especially the durability, are greatly influenced by curing since it has a remarkable effect on the hydration of the cement. Any laxity in curing will badly affect the strength and durability of concrete. Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete. The present study involves the use of shrinkage reducing admixture i.e. polyethylene glycol (By adding 1% & 1.25% of PEG-4000 by weight of cement) in M40 grade of concrete (Grade ratio = 1:2.23:3.08) which helps in self-curing with better hydration which reduces shrinkage cracks and hence increases strength and is compared with that of conventional cured concrete of the same grade.*

Keywords: *Self-Curing concrete, Self-Curing agent, PEG-4000, Water reducing admixtures, shrinkage, Special concrete.*

1. INTRODUCTION

Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80% [1]. With insufficient water, the hydration will not proceed and the resulting concrete may not possess the desirable strength and impermeability. The continuous pore structure formed on the near surface may allow the ingress of deleterious agents and would cause various durability problems. Moreover due to early drying of the concrete micro-cracks or shrinkage cracks would develop on surface of the concrete [2]. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Curing temperature is one of the major factors that affect the strength development rate. At elevated temperature ordinary concrete losses its strength due to the formation of the cracks between two thermally incompatible ingredients, cement paste and aggregates. When concrete is cured at high temperature conventionally develops higher early strength than concrete produced and cured at lower temperature, but strength is generally lowered at 28 days and later stage [3]. A uniform temperature should be maintained through the concrete section to avoid thermal cracking. Laboratory tests show that concrete in dry environment can lose as much as 50 per cent of its potential strength compared to similar concrete that is moist cured. Curing of the concrete is also governed by the moist-curing period, longer the moist-curing period higher the strength of the concrete assuming that the hydration of the cement particles will go on. American Concrete Institute (ACI) Committee 301 recommends a minimum curing period corresponding to concrete attaining 70% of the specified compressive strength [4].Curing has a strong influence on the properties of hardened concrete; proper curing will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing [5].

A durable concrete is one that performs satisfactorily under the anticipated exposure condition during its designed service life. In addition to the conventional concrete mix some additional compounds in proper dosage and materials such as fly ash are used to increase the durability and strength of the concrete mix.

Curing techniques and curing duration significantly affects curing efficiency, various degree of Efficiency can be achieved by various in situ-curing methods. The effectiveness of the concrete curing method depends on the material used, method of construction and the intended use of the hardened concrete. Techniques used in concrete curing are mainly divided into two groups namely, Water adding techniques and Water- retraining techniques. Reliability and effectiveness of such curing methods are still under debate. This study presents the working comparison and the effectiveness of curing methods on several hardened property of concrete such as compressive strength.

2. REVIEW OF LITERATURE

There are numerous studies have been reported in the literature in respect of self-curing concrete. Some of the significant contributions are briefly mentioned in the literature.

Swamy *et. al.* (1990) presented a simple method to obtain a 50 MPa 28-day strength concrete having 50 and 65 percent by weight cement replacement with slag having a relatively low specific surface. The compressive and flexural strengths and the elastic modulus of these two concretes as affected by curing conditions are then presented. Without any water curing, concrete with 50 percent slag replacement reached nearly 90 percent of its target strength of 50 MPa at 28 days 14 and continued to show modest strength improvement up to 6 months.

Dhir *et. al.* (1996) worked on self-curing concrete using two computer models, at low dosages, good strength and improved permeability characteristics were observed. At high dosages it appears that the admixture has a detrimental effect on the concrete’s compressive strength.

Hans W. Reinhardt *et. al.* (1998) they demonstrated on self-cured high Performance concrete that a partial replacement of conventional weight aggregates by prewetted lightweight aggregates leads to an internal water supply for continuous hydration of cement. Despite water loss by evaporation there is continuous strength gain up to 25% more strength after 1 year compared to standard compressive testing after 28 days.

Gowripalan *et. al.* (2001), the mechanism of self-curing can be explained as follows: The polymer added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure. This reduces the rate of evaporation from the surface” Self-Curing concrete is the newly emerging trend in the construction industry.

Barrita *et. al.* (2004) evaluated high performance concrete mixtures that can be used successfully in hot dry climates. A series of concrete mixtures were prepared and moist cured for either 0, 0.5, 1 or 3 days, or by using a curing compound, followed by air drying at 38°C and 40% relative humidity. To accomplish this, 11% by volume of the total aggregate content was replaced with lightweight aggregate. Type I white Portland cement and quartz aggregate plus the lightweight aggregate were all selected for their low iron content to minimize adversely affecting the MRI measurements. The concrete mixtures were low strength concrete (W/C=0.60), self-consolidating concrete (W/C=0.33 containing 30% fly ash), and high strength concrete (W/ C=0.30 containing 8% silica fume).

Tarun R. Naik *et. al.* (2006) Influence of microstructure on the physical properties of self-curing concrete Potential benefits from concrete using lightweight aggregate include: Better thermal properties, Better fire resistance, improved skid-resistance, reduced autogenous shrinkage, reduced chloride ion penetrability, improved freezing and thawing durability, an improved contact zone between aggregate and cement matrix and less micro-cracking as a result of better elastic compatibility.

Md. Safiuddin *et. al.* (2007) carried out experiments to study the effect of this type of curing on the properties of Micro silica Concrete with a water binder ratio of 0.35. Dry-air curing produced 15.2%, 6.59% and 3.36% reduction in compressive strength, dynamic modulus of elasticity and ultrasonic pulse velocity respectively, thus the formation of major reaction product Calcium silicate hydrate the major strength providing and porosity reducer stops before the pores are adequately blocked by it. Also, it caused 12.4% and 46.53% increase in initial surface absorption after 10 and 120 minutes respectively.

N. Yazdani *et. al.* (2008) presented a study on accelerated curing of silica fume concrete. Accelerated curing has been shown to be effective in producing high-performance characteristics at early ages in silica-fume concrete. Hence dehydration takes place, which may cause shrinkage problems. An experimental study was undertaken to determine the feasibility of steam curing of FDOT concrete with silica fume in order to reduce precast turnaround time.

C.Selvamony *et. al.* (2010) investigated on self-compacted self-curing Concrete using limestone powder and clinkers. In this study, the effect of replacing the cement, coarse aggregate and fine aggregate by limestone powder (LP) with silica fume(SF), quarry dust(QD) and clinkers respectively and their combinations of various proportions on the properties of SCC has been compared.

Ravi Kumar M.S. *et. al.* (2011), an experimental investigation was conducted to make a comparative study on the properties of High Performance Concrete with kiln ash (25% and 50% replacement) and without kiln ash (control concrete) in conventional and aggressive environment using self-curing instead of water curing.

Raghavendra *et. al.* (2012), Using Membrane curing and Self-Curing methods one can achieve 90% of efficiency as compared to Conventional Curing method. Membrane curing compounds are most practical and widely used method it is most suitable in water scarce area.

Vilas *et. al.* (2012) carried out an experimental study to investigate the use of water soluble polyvinyl alcohol as a self-cutting agent. He concluded that Concrete mixes incorporating self-curing agent has higher water retention and better hydration with time as compared to conventional concrete.

Mateusz Wyrzykowski *et. al.* (2012), analyzed the modeling of water migration during internal curing with superabsorbent polymers. The SAP are supposed to be uniformly distributed in the concrete and act as internal water reservoirs, which first absorb water during mixing and release it to the surrounding cement paste By adding SAP, it is possible to provide water curing in low water-to-cement ratio (w/c) mixtures.

John Roberts *et. al.* (Jan, 2013) demonstrated internal curing improves flexural and compressive strength of pervious concrete. The internally cured sections did not receive poly protection or any special curing, other than internal curing by using light weight aggregate (LWAS).

Sathanandham T *et. al.* (Nov 2013, 2014) preliminary studies of self-curing concrete with the addition of polyethylene glycol (PEG). They studied due excess of hydration in plain concrete shrinkage occurs which affect the durability hence introduced shrinkage reducing admixture polyethylene glycol (PEG 4000) which results in self-curing and helps in better hydration and hence good strength.

Nirav R Kholia *et. al.* (2013) found out the effect on concrete by different curing method and efficiency of curing compounds. Primary requirement of fast-track construction is high early strength in concrete. Early age concrete strength without costly heat treatment is of greater significance in the construction industry.

Amal Francis k *et. al.* (2013) the scope of the research included characterization of super absorbent polymer for use in self-curing. Experimental measurements were performed on to predict the compressive strength, split tensile strength and flexural strength of the concrete containing Super Absorbent Polymer (SAP) at a range of 0%, 0.2%, 0.3%, and 0.4% of cement and compared with that of cured concrete. The grade of concrete selected was M40.

Ya Wei *et. al.* (2014) investigated on internal curing efficiency of prewetted LWFAS on Concrete Humidity and Autogenous Shrinkage development.

Magda I. Mousa *et. al.* (2014) the mechanical properties of concrete containing self-curing agents are investigated in his paper. In this study, two materials were selected as self-curing agents with different amounts, and the addition of silica fume was studied. The self-curing agents were, pre-soaked lightweight aggregate (LECA) and polyethylene-glycol PEG (CH). The result shows that concrete used polyethylene-glycol as self-curing agent, attained higher values of mechanical properties than concrete with saturated LECA.

Based on the afore-mentioned literature review, an effort is made in the present investigation to compare the conventional cured concrete with self-curing concrete by adding Shrinkage reducing admixture "polyethylene glycol" (PEG-4000, 1% & 1.25% weight of cement) in M40grade of concrete (grade ratio = 1:2.23:3.08) which helps in self-curing and in better hydration which reduces shrinkage and hence increases strength.

3. EXPERIMENTAL INVESTIGATION

A. Materials

1. Cement: PPC of 53 grades.

2. Fine Aggregate: Crush aggregate (Zone-II).

3. Coarse Aggregate: Locally available quarry stone in good strength passing through 20 mm and retain in 10mm sieve.

4. Water: Ordinary potable water without acidity and alkanity available in the laboratory was used.

5. Fly ash: Ultra tech C-type.

6. Super Plasticizer: Guppi enterprises is used to reduce water up to 20-30%.

7. Polyethylene glycol-4000: PEG-4000 are added at rate of 1% & 1.25% weight of cement.

B. Mix Design of Self-Curing Concrete

Using the properties of materials as listed above the mix design has been adopted from IS 10262:2009 to design grade ratio = 1:2.23:3.08 of concrete. Based on the various design stipulations the mix ratio was obtained for all the specimens and the following table shows the results obtained.

Table I: Concrete Mixes Formulation

Mix	Cement (kg/m3)	FA (kg/m3)	CA (kg/m3)	Water (kg/m3)	Fly ash (kg/m3)	SP (kg/m3)	PEG-4000 (kg/m3)
Conventional	366	817	1128	140	19	7.7	Nil
PEG 1%	362.34	817	1128	140	19	7.7	3.66
PEG 1.25%	361.425	817	1128	140	19	7.7	4.575

4. RESULTS AND DISCUSSION

The strength parameters of self-cured concrete were compared with conventional cured concrete at 3days, 7days, 14 days and 28 days.

Concrete cured internally using 1% and 1.25% PEG-4000 attained more compressive strength than conventional cured concrete.

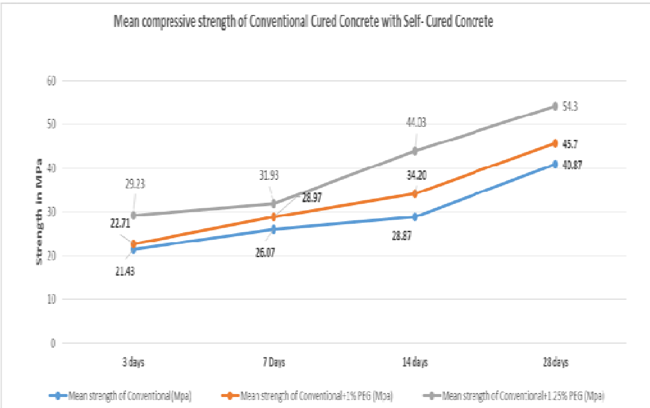

Fig. 1: Compressive Strength for self-curing and conventional mixes

5. CONCLUSION

PEG-4000 was used as self-curing agent. M40 Grade of concrete (Grade ratio = 1:2.23:3.08) is adopted for the investigation. Based on the experimental investigation carried out, the following conclusions were drawn:

- Compressive strength for the concrete mixes incorporating 1% & 1.25% self-curing admixture is higher compared to conventional concrete mixes.

Days	Mean strength of Conventional (MPa)	Mean strength of Conventional+1% PEG (MPa)	Mean strength of Conventional+1.25 % PEG (Ma)
3 days	21.43	22.71 (6%)	29.23 (27%)
7 Days	26.07	28.97 (10%)	31.93 (19%)
14 days	28.87	34.20 (17%)	44.03 (35%)
28 days	40.87	45.7 (12%)	54.3 (25%)

- Hence it can be concluded from above results that the strength obtained at 14 days from conventional mix can be obtained at 7 days using 1% PEG-4000 and the same can be obtained at 3 days by using 1.25% PEG-4000 with conventional mix.
- The compressive strength of conventional concrete at 28 days can be obtained in 14 days by using 1.25% of PEG-4000 with conventional concrete.
- It has been observed during testing, cubes of Conventional Mix +PEG-4000 shows less crack and doesn't break down even after throwing from almost 1m of height which is not observed in case of Conventional Mix.
- There is less shrinkage and good bonding observed in concrete with shrinkage reducing admixture which is not observed in case of conventional mix.

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