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STRENGTH CHARACTERISTICS OF SELF CURING CONCRETE WITH INCORPORATING POLYCARBOXY ETHER

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Abstract : Concrete is the most widely used construction material due to its good compressive strength and durability. The imagination of a world without concrete is impossible as the concrete is a soul of infrastructures. Conventional concrete which is the mixture of cement, fine aggregate, coarse aggregate and water, needs curing to achieve strength. So it is required to cure for a minimum period of 28 days for good hydration and to achieve target strength. Lack of proper curing can badly affect the strength properties and durability of concrete. The strength and durability of concrete depends on the curing process of concrete. The ACI-308 Code states that "self-curing refers to the hydration process of cement with water." The extent to which this reaction is completed influences the strength and durability of the concrete. Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop.

Self-curing concrete is one type of modern concrete which cure itself by retaining its moisture content in it. The need for adequate curing of concrete cannot be overemphasized as it has a strong influence on the properties of hardened concrete. This study is investigating whether the use of self-curing concrete is economical for concrete compared to normal curing concrete in remote areas or other regions where there is scarcity of water without compromising the strength properties of concrete. In the present study, comparison of compressive strength, tensile strength and flexural strength of self curing concrete have been made; polycarboxyl ether compound has been used for internal self curing concrete. Experimental results indicated that self curing concrete has better mechanical properties as compared to conventional curing concrete.

Key words: Self-Curing concrete (SCC), Self-curing agents, Concrete strength characteristics, workability and polycarboxyl ether..

I. INTRODUCTION

Construction industry is growing day by day even in remote areas and desert regions. EvenIndia and other countries are facing lot of problems in supplying drinking water to their citizens. Hence construction industries are under pressure in finding out alternative curing methods of curing concrete**.** Curing of concrete is maintaining of satisfactory moisture content in concrete during its early stages in order to develop the desired properties of concrete. Concrete is the most commonly used construction material in the world. It is basically composed of two components which are paste and aggregates controlled by workability of fresh concrete, durability and strengthrequirements based on concrete curing process (Chikmagalur 2010).

The need for adequate curing of concrete cannot be overemphasized because curing has a strong influence on the properties of hardened concrete, proper curing will increase durability, strength, water tightness, abrasion resistance, volume stability, and resistance to freezing and thawing effect. Curing may be achieved in a number of ways and the most appropriate means of curing may be dictated by the site or the construction method by spraying while the concrete is wet. Self-curing is a technique used by construction industry that use lot of water in the name of curing to provide or promote indoor and outdoor construction activities in areas where there is scarcity of water. Self-curing concrete is the one which can meet the present and future requirements of concrete curing. As result of successful, recent tests and researches have recentlyput internal self-curing in the forefront of breakthroughs of ideas of how to make better concrete (R.Sundharam 2016).

Main objective

General objective of this study is to establish a correlation and comparison of concrete strength by internal self curing and conventional curing concrete in which equivalent curing methods for concrete specimens can accurately represent the curing conditions of concrete and also to reduce quantity of water required for concrete curing.

Specific objectives

The following objectives were determined

1. To study compressive, tensile and flexural strength of normal and self curing concrete for OPC mix.
2. To compare the strength characteristics for normal and self curing concrete.

METHODOLOGY

In this experimental work, the methodology conducted for this research work was determined and discussed. This investigation was carried out to study the behavior of normal and self-cured concrete within their ingredient materials. The followings are the methodologies adopted to achieve the objectives of this research project.

1.To conduct comprehensive literature review related to subject of self curing and normal curing concrete.

2. Selection of suitable ingredient materials required for concrete production including cement, aggregates, water and self curing superplasticizer.

3. Determine the relative quantities of these materials in order to produce concrete mix design.

4. Casting of concrete specimens and curing process by conventional curing and self curing.

5. Performing physical and mechanical laboratory tests on self curing and normal curing concrete.

LITERATURE REVIEW

The mechanism of self-curing can be explained as follows: continuous evaporation of moisture takes placefrom an exposed surface due to the difference in chemical potentials (free energy) between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reducethe chemical potential of the molecules, which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface. Self-cure concrete contains a chemical agent that reduces the evaporationof water from its surface, primarily by reducing the vapour pressure at the concrete pore solution surface. The self-curing agent developed at the Concrete Technology Unit also produces an alteration in cement hydration product microstructure, and it was considered that this might also contribute to the improved water retention properties (Abishek 2016).

A hydrophilic molecule or portion of a molecule is one that has a tendency to interact with or be dissolved by water. A pure hydrocarbon molecule is incapable of forming hydrogen bonds with water. The hydrogen bonds are partially reconstructed by building a water "cage" around the compound molecule, the water molecules that form the "cage" have substantially restricted mobilities(Ravikumar 2015).

Venkateswarlu et al.(2015), reported results of several durability tests conducted on ConventionalConcrete with PEG-600 as a self-curing compound for concrete specimens. It was found that initial surface absorption, chloride ingress, carbonation, corrosion potential, and freeze/thaw resistance characteristics were all the better in air cured self-cure concrete than in the air cured control concrete. This improvement appears to be dependent on the admixture dosage. It is possible to achieve durability properties with higher quantities of the self-curing chemical/compound. Concrete that is capable of retaining greater quantities of water, ordinary concrete when cured in the air has been developed by means of an addition of a self-cure chemical (SCC) which was a water-soluble polymeric glycol identified as the chemical(self-curing compound Polyethylene glycol (PEG)). The water retention leads to a greater degree of cement hydration and hence improved properties of concrete in comparison to control test specimens. The features of self- cure concrete provide good durability properties for concrete (Venkateswarlu et al 2015).

Methods used in self-curing concrete

Currently, there are two major methods available for self-curing of concrete. The first method uses saturated porous lightweight aggregate, super-absorbent Polymers and shrinkage reducing admixture (internal self-curing) in order to supply an internal source of water, which can replace the water consumedby chemical shrinkage during cement hydration. The second method uses curing compounds applied to theconcrete surface (external self-curing) which reduces the evaporation of water from the surface of concreteand also helps in water retention(Chikmagalur 2010).

The major methods available for self-curing concrete are the following:

- External self-curing of concrete
- Internal self-curing of concrete

Materials and Methodology

It is well known that the strength of the concrete is dependent on the properties of its ingredientmaterials. The present investigation was carried out to study the behavior of normal and self cured concrete and their ingredient materials. In this experimental work, concrete mix design was carried outfor M20 grade concrete. The following materials such as ordinary Portland cement (53 grade OPC confirming to Indian standard IS:12269: 1987), river sand as fine aggregate, quarried and crushed stoneas coarse aggregate, Self curing Admixture(Polycarboxyl ether) and potable water are used todetermine concrete strength while using different curing techniques.

Ordinary Portland cement (OPC)

Cement is defined as the bonding and binding material in concrete production having cohesive and adhesive properties which makes it capable of joining uniformly the different construction materials and compacted assembly. Ordinary/Normal Portland cement is one of the most widely used types of Portland cement. Ordinary Portland Cement (OPC) is the most commonly used cement in general concrete construction when there is no exposure to sulphates in the soil or groundwater as per IS: 8112- 1989.

S. No.	Test	Experimental Values	Suggested values as per IS12269-1987
1	Fineness of cement	3.0%	< 10%
2	Specific Gravity	3.05	< 3.15
3	Normal consistency	30%	--
4	Setting time in Minutes		

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. The water used for mixing and curing should be clean and free from harmful materials and substances that may be deleterious to concrete properties and steel. Portable water is generally considered satisfactory for concrete mixing process. The PH value of water to be used should not be less than six. The portable water available in the laboratory taps conforming to the requirements of water for concreting and curing as per IS: 456-2000 was used in this project work for concrete production process.

Aggregates

Aggregates are inert granular materials such as sand, gravel or crushed stones that are an end product in their own right. They are also the raw materials that are an essential ingredient in concrete production. For a good concrete mix, aggregates need to be clean, hard, strong particles free from absorbed chemicals or coating of clay and other fine materials that could cause the deterioration of concrete. Aggregates are broadly classified into two type's namely coarse aggregate and fine aggregate.

1. FINE AGGREGATE

Locally available sand conforming to zone II of Table 4 according to IS: 383: 1970 was used as fine aggregates for this present research work. The sand was tested as per IS: 2386:1963 (IS: 2386 Part I 1963).The specific gravity of natural sand was found according to Indian Standards and was used throughout in preparing the required mix of concrete.

2.COARSE AGGREGATE

The aggregates retained on 4.75 mm sieve (called coarse aggregates), which are generallycrushed stones aggregates having 20mm was used in the experimental work. The crushed stonesaggregates used were 20mm nominal maximum size and were tested as per Indian standards. The Coarse aggregates used in this study were tested as per IS Specifications IS: 383-1970.

Self curing Admixture (Polycarboxyl ether)

Self curing Admixture added during the mixing can reduce water evaporation from and within the set concrete, making it 'self-curing.' The Polycarboxyl ether should have abilities to reduce evaporation from solution and to improve water retention in ordinary Portland cement matrix. Internalcuring (IC) is a method to provide the water to hydrate all the cement, accomplishing what the mixingwater alone cannot do.

Polycarboxyl ether are linear polymers with a high molecular mass (Mr ≤ 100000) and withmany carboxylate groups. The experimental program was designed to investigate the strength of self- curing concrete by adding at 0.5%, 1%, 1.5%, and 2% by weight of cement of concrete. Perma plast pc – 304 is used in the present investigation.

CASTING OF CONCRETE SPECIMENS

The specimens were cast for testing the mechanical properties of concrete such as compressive strength, split strength and flexural strength. For compressive strength test, cubes of size 150mm×150mm×150mm were used. These cubes were filled with flesh concrete and compacted by using vibrating table. About 30 cubes were cast for compressive strength. For split tensile strength, cylinders of the size 150 mm diameter and 300 mm height were cast. A total of 15 cylinders were cast. Similarly for flexural strength beams of size 100mm×100mm×500mm were cast. A total of 15 beams were cast. The specimens were.

Curing of the concrete specimens

The concrete specimens were demoulded from the moulds and then immediately curing of the concrete specimens was done using the curing tanks in civil engineering laboratory of Nellore (India) for conventional curing and others specimens were placed out of water curing tank for internal self curing for the application of curing compound. After demoulding, the specimens reserved for conventional curing concrete were kept in water until the days of testing 7 and 28 days and those reserved for self curing concrete also tested at the same time interval as shown above.

MECHANICAL PROPERTIES OF CONCRETE

Tests were conducted on standard cubes specimens of 150 x 150 x 150 mm size, cylinders of 150 x300mm size and beams of 100 × 100 × 500 mm size, which were cast in Nellore (India) laboratory fortesting. The test specimens were marked, removed from the moulds and immediately submerged in clean fresh water for normal curing. For self curing concrete, specimens were placed outside the laboratory after removed from the moulds. Compression Testing Machine was used to conduct the test.From each type of curing condition 7 and 28 days compressive strength results were obtained as per IS:516-1959.

In the present investigation, three types of specimens namely cubes, cylinders and beams were cast. Cubes were used for compressive strength test and cylinders for split tensile strength test and beams for flexural strength test. The details of the standard specimens tests used in the investigation are shownbellow.

Compressive strength test of hardened concrete

Strength of concrete is the most important property of concrete, although other characteristic may also be critical and cannot be neglected. Strength is an important indicator of quality because strength is directly related to the structure of hardened cement pasted. Even though strength is not a directed measure of durability or dimensional stability, it has a strong relationship with the water

- **Compressive Strength of concrete**= Applied load /Cross-section Area of the Specimen(cube)

Split tensile strength test of hardened concrete

The split tensile strength test is well-known as indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test consists of applying a compressive line load along with the opposite generators of a concrete cylinder generally ofsize 150mm diameter and 300mm height placed with its axis horizontal between the compressive plates.Three cylinders from each batch of concrete mix are cast and cured for 28 days in order to determine split tensile strength of concrete for both conventional and self curing concrete. The split tensile test was conducted for 28 days. Testing to determine split tensile strength of all specimens was carried outas per IS: 516-1959.

- *Resultant Split Tensile Strength (f_{st}) =2P/πDL*

Where: **P**= Load at failure (maximum applied load)

L=Length of the cylinder

D=Diameter of cylinder

Flexural strength test of concrete mix

Flexural strength of concrete is defined as the ability of concrete to resist deformation under load. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measuredby loading 6 x 6 inch (150 x 150mm) concrete beams with a span length at least three times the depth.The flexural strength is expressed as modulus of rupture in MPa and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading).

$$R = PL/bd^2$$

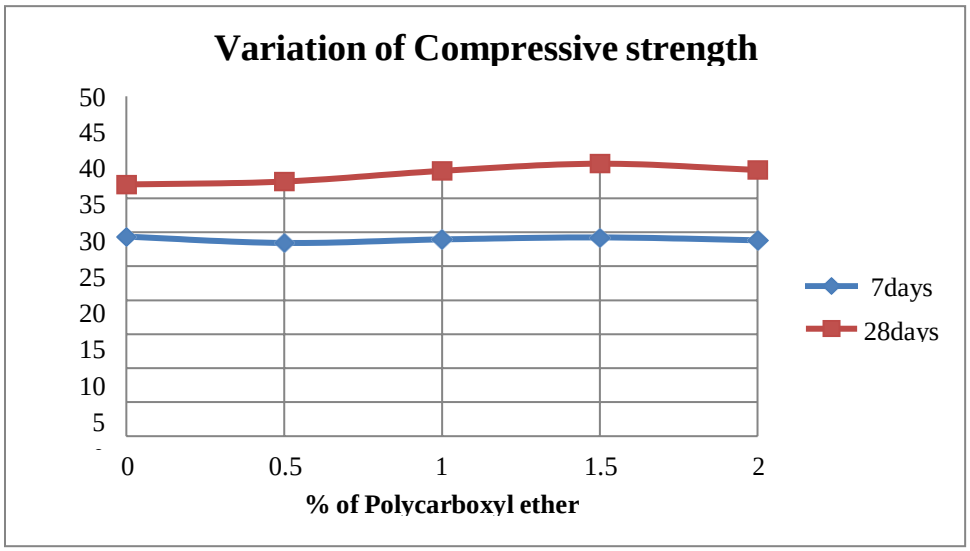
Where:

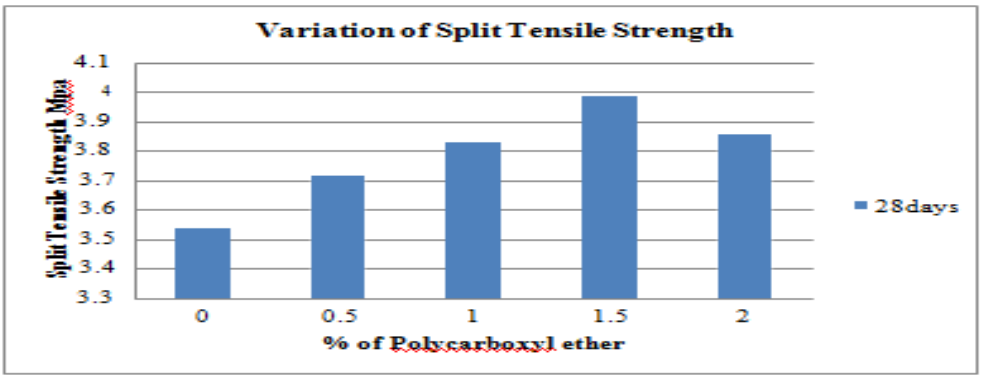
R = Modulus of rupture or flexural Strength

P= Maximum applied load indicated by the test machine (applied to the beam)

L = Length of the span on which the specimen was supported (Span length in cm)

Results and Discussion





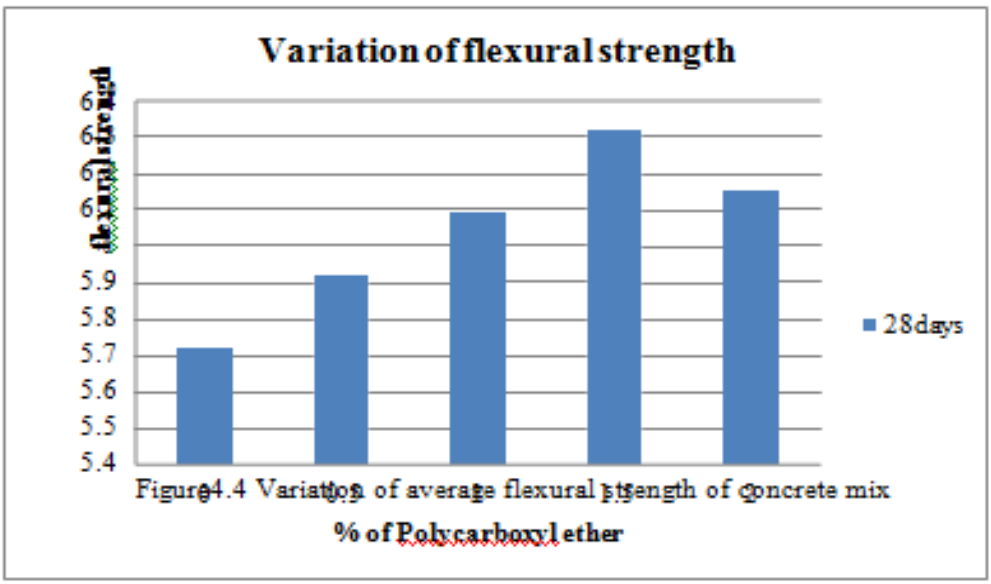


Figure 4.4 Variation of average flexural strength of concrete mix

S. No.	Nomenclature	Average 28 days strength (MPa)
1	M1	3.54
2	M2	3.72
3	M3	3.83
4	M4	3.99
5	M5	3.86

Table Average Split tensile strength of conventionally cured and self cured concrete mix

S. No	Nomenclature	Ultimate load in kgf	Flexural strength in MPa
1	M1	3280	5.72
2	M2	3396	5.92
3	M3	3490	6.09
4	M4	3621	6.32
5	M5	3528	6.15

Average flexural strength of conventionally cured and self cured concrete mix

: Percentage variation of 7 and 28 days compressive strength of conventionally curedand self cured concrete

S. No	Nomenclature	7Days compressive strength in MPa	28Days compressive strength in Mpa	% variation of 7 days strength with respect to reference	% variation of 28 days strength with respect to reference
1	M1	29.32	37.04	--	--
2	M2	28.42	37.56	3.24	1.12
3	M3	28.92	39.14	1.26	5.34
4	M4	29.21	40.82	0.34	10.40
5	M5	28.83	39.12	1.67	5.68

CONCLUSIONS

On the basis of the results obtained from the present study, the following conclusions can be drawn:

- For designed concrete mix, the 7days compressive strength of all self curing concrete mixes are lesserthan conventional curing concrete.
- For designed concrete mix, the 28days compressive strength, split tensile strength and flexural strength of self curing concrete are greater than conventional curing concrete about 10.50%, 12.71% and 10.48%at 1.5% of polycarboxyl ether.
- The concrete strengths for mix, it was observed that self curing concrete has greater results as compared to self curing concrete; also the strength of conventional curing concrete is good as they are greater than target mean strength designed.
- Self-curing concrete is the answer to the many problems faced in construction industries due to lack ofproper curing, lack of water in certain areas and it is an alternative to conventional curing concrete in desert regions where scarcity of water is a major problem.
- Self-curing concrete is more economical because it eliminates the curing charges and efficiently adapted in remote areas as well as in the areas where there is water scarcity problem.
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