An Experimental Study on Mechanical Properties of Self Curing Concrete

Akshara O.S, DivyaSasi

Abstract— Today concrete is the most widely used construction material due to its good compressive strength and durability. The use of self-curing admixtures is very important from the point of view that saving of water is a necessity everyday (for each cubic meter of concrete requires 3m3 of water in a construction, most of which is used for curing). The aim of this investigation is to study the mechanical and durability properties of concrete using water-soluble Poly ethylene glycol (PEG-400) as self-curing agent. In this study, the mechanical properties of concrete containing self-curing agent is investigated and compared with those of conventionally cured concrete. The dosage of self curing agent is varying from 0.5% - 2.0% by weight of cement. Experimental results show that the self-curing gives better results as compared to conventionally cured concrete. The optimum dosage of PEG-400 for maximum strengths was found to be 1%.

Index Terms—Chloride resistance, Compressive strength, Modulus of elasticity, Poly ethylene glycol-400, Self curing, SEM analysis,Sulphate resistance.

1 Introduction

AS water becoming a scare material day-by-day, there is an urgent need to do research work pertaining to saving of water in making concrete and in constructions. Curing maintain satisfactory moisture content during its early stages in order to develop the desired properties. However, good curing is not always practical in many cases. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. Internal curing implies the introduction of a curing agent into concrete that will act as an internal source of water.The role of self-curing agents is to reduce the water evaporation from concrete, and henceincrease the water retention capacity of the concrete compared to conventional concrete.

1.1 Mechanism of Self Curing

The mechanism of internal curing is holding the preserved water content of concrete structures within it. So concrete structures are not required any additional water for curing purpose. Continuous evaporation of moisture takes place from 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 reduce the chemical potential of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.

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1.2 Methods of Self Curing

Self-curing concrete has two major methods. They are
i) Light weight aggregate (LWA)
ii) Shrinkage reducing admixtures (SRA)

1.3 Objective of the Project

The main objective of this project is;
To compare the fresh, hardened and durability properties of self curing concrete with conventional concrete of same grade with varying % of self curing agent.

1.4Sope of the Project

The scope of the project is to study the effect of poly ethylene glycol (PEG- 400) on strength and microstructure of self-curing concrete.

2 Materials And Properties

2.1 Ordinary Portland Cement

For the study Dalmia, Ordinary Portland cement (OPC-53 grade) has been used. The specific gravity of cement is 3.12. Standard consistency of the cement used is 33%.

2.2 Fine Aggregate

In this project M- sand was used as fine aggregate with specific gravity 2.67.

2.3 Coarse Aggregate

The coarse aggregates are naturally occurring material from divided rock material and crushed granite stone. In this project we use angular coarse aggregates of maximum size is 20mm having specific gravity is 2.73.

2.4 Poly ethylene glycol-400

PEG-400is a condensation polymer of ethylene oxide and water with the general formula $H(OCH_2CH_2)nOH$, where n is the average number of repeating oxyethylene groups.

2.5 Water

Potable water is used in the experimental work for both mixing and curing purposes of concrete.

3 Mix Design

The mix design is carried out as per IS 10262-2009. The mix proportion of the M20 concrete is shown in Table 1.The conventional concrete, self curing with 0.5%, 1%, 1.5% and 2% are designated as NC-MS, SC0.5, SC1, SC1.5 and SC2 respectively.

TABLE 1
MIX PROPORTION

Cement	Fine Aggregate	Coarse Aggregate	Water
383 kg	604.033 kg	1190.77 kg	191.6 litre
1	1.57	3.12	0.50

4 Experimental Programme

Weigh batching is done for all materials. All aggregates used in the mix were weighed under surface dry conditions. Laboratory mixer is used for mixing the components of concrete. Coarse aggregate, fine aggregate and cement were added to the mixer and they are mixed thoroughly. Water is then added and is mixed for 5 minutes. Standard cubes, cylinders and beams were cast for all mixes in concrete. The cubical mould used for casting concrete cubes was of size 150mm x150mm x150mm.The cylindrical mould used for casting concrete cylinders for conducting splitting tensile strength was 300mm height and 150 mm diameter. The beam cast for flexural test of concrete is of size 100mm x100mm x500mm. The specimens were kept under laboratory environment for 24 hours and they were demoulded. The conventional concrete samples were cured for 28 days in water pond and the specimens with PEG400 were cured for 28 days at room temperature by placing them in shade until taken out prior to test. The details of test conducted are explained below.

4.1 Tests for Fresh Properties of Concrete

Slump test and compaction factor test were conducted to measure the workability IS specification.

4.2 Tests for Hardened Properties of Concrete

4.2.1 Compressive Strength Test

The compressive strength test was conducted as per IS 516 – 1959 on three cubes of size 150mmx150mmx150mm using a compression testing machine. The test was conducted on conventional concrete and self curing concrete with different % of PEG-400.

4.2.2 Split Tensile Strength Test

This test is carried out by placing a cylindrical specimen of 300mm height and 150 mm diameterhorizontally between the loading surface of the compression testing machine and load is applied without shock and increased continuously at a nominal rate until failure of the cylinder along the vertical diameter. The test was conducted as per IS 516 – 1959.

4.2.3 Flexural Strength Test

Flexural strength was determined by using a beam of size 100mmx100mmx500mm made with conventional concrete and self curing concrete.3 numbers of specimens were tested for each type of concrete by applying three point loading.

4.2.4 Modulus of Elasticity Test

Cylinders of 150mm diameter x 300mm long specimens were cast and tested at the age of 28days in a compression testing machine. Deformation was measured using 250mm gauge length compressometer fixed on the surface of the cylinder. Readings were taken at regular intervals of load increment. Modulus of elasticity was determined from stress-strain graph.

4.3 Tests for Durability Properties of Concrete

4.3.1 Water Absorption Test

To determine the water absorption of specimens, specimens was oven dried for 24 hours and its dry weight is determined as initial weight (W1). The specimens were then immersed in water for 24 hours and its saturated surface dry weight was recorded as the final weight (W2). Water absorption of specimens is reported as follows.

$$\text{Percentage water absorption} = \frac{W2-W1}{W1} \times 100$$

4.3.2 Sulphate Resistance Test

Initial weight of the specimens is determined as W1.The Conventional concrete cubes as well as self cured cubes (curing period of 28 days) were immersed in H_2SO_4 solution. The % of H_2SO_4 used was 2% by weight of water. Cubes were cured in salty water for 28 days. After 28 days weight of the specimens is determined as W2. Percentage of weight loss is reported as follows.

$$\text{Percentage of weight loss} = \frac{W2-W1}{W1} \times 100$$

4.3.3 Chloride Resistance Test

The Conventional concrete cubes as well as self cured cubes (curing period of 28 days) were immersed in salty (NaCl) water. Percentage of weight loss is reported.

4.3 Micro Stucture

Scanning Electron Microscopy was used to determine the micro structure of concrete.

5 Results And Discussions

5.1 Fresh Properties of Concrete

The results of the Slump & Compaction factor test were shown in Fig.1. As the % of PEG-400 is increased the slump and compaction factor is found to increase. This may due to PEG-400 which reduces the evaporation of water from the surface of concrete and also helps in water retention

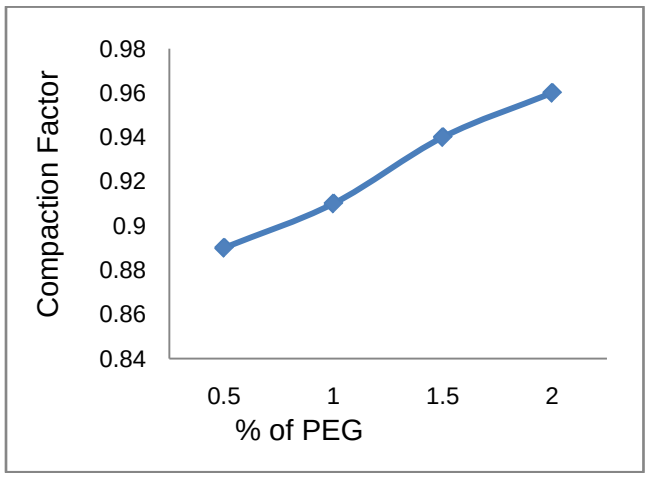

Fig 1Variation of Compaction Factor

5.2 Hardened Properties of Concrete

5.2.1 Compressive Strength Test

The results of the Compressive Strength test were represented in Fig2.By increasing the percentage of PEG-400, compressive strength of concrete goes on increasing up to 1% addition of PEG-400. This is due to the fact that, polyethylene-glycol is to reduce water evaporation from concrete, and hence increase the water retention capacity of concrete compared with conventional concrete which leads to improved compressive strength. Further addition of PEG-400, decreases the compressive strength of the concrete.

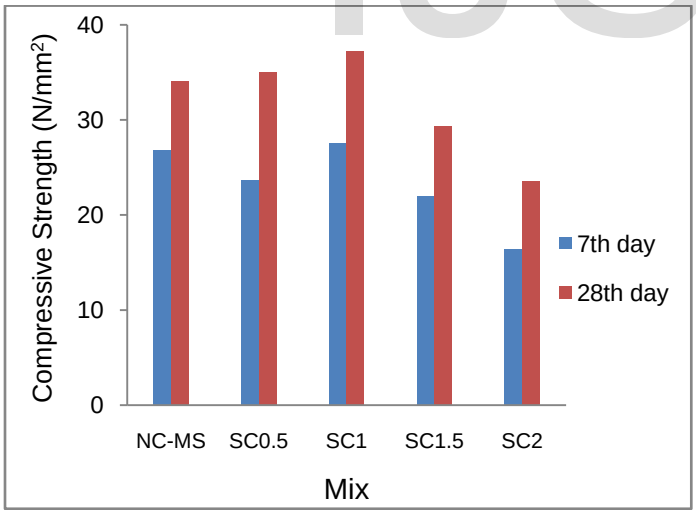

Fig.2 Compressive Strength Vs Mixes

5.2.2 Split Tensile Strength Test

The results of the split tensile strength, flexural strength and modulus of elasticitytest were represented in Fig 3. By increasing the percentage of PEG-400, split tensile strengthof concrete goes on increasing up to 1% addition of PEG-400. Further addition of PEG-400, decreases the split tensile strengthof the concrete..

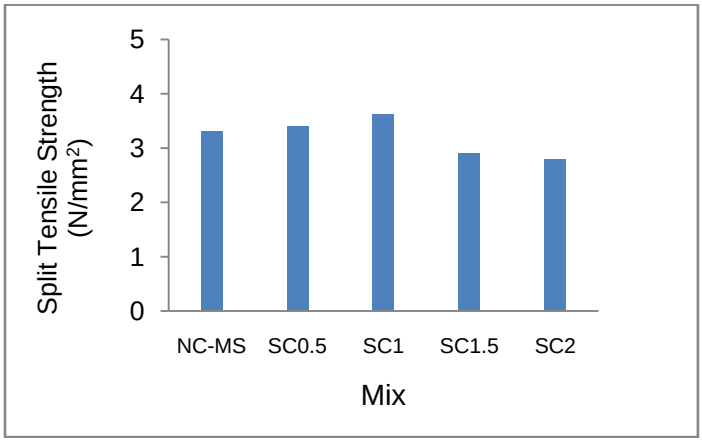

Fig.3Variation of Split Tensile Strength

5.2.3 Flexural Strength Test

The results of the flexural strengthtest were represented in Fig.4. The flexural strength was found to increase up to 1% PEG400. Further addition of PEG-400, decreases the flexural strength of the concrete.

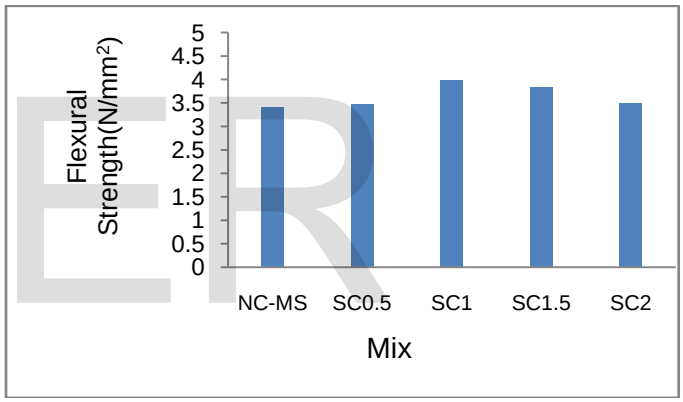

Fig.4Variation of Flexural Strength

5.2.4 Modulus of Elasticity Test

The results of the modulus of elasticitytest were represented in Table 4. The modulus ofelasticitywas found to increase up to 1% PEG400 and then decreased and is shown in Fig.5

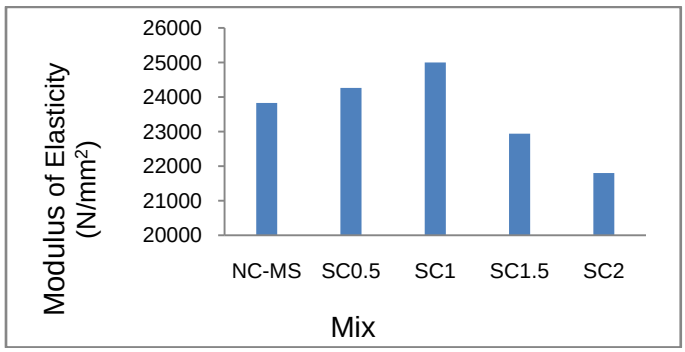

Fig.5 Variation of Modulus of Elasticity

5.3 Durability Properties of Concrete

5.3.1 Water Absorption Test

Water absorption test results were shown in Table 5.Water absorption of both NC and SC1are found to be less. Water absorption of SC1 is less compared to NC.

4.3.2 Sulphate Resistance Test

A sulphate resistance test result were represented in Table 5.The weight loss of the specimen increases with time and is more for NC compared to SC1.By the visual examination it is clear that the degree of deterioration is high when exposed to sulphate environments.

TABLE 5.
WEIGHT LOSS (%)

Mix	Water Absorption (%)	Weight Loss After 56 Days (%)	
		Sulphate Attack	Chloride Attack
NC	3.7	1.2	0.36
SC1	2.47	0.82	0.21

4.3.3 Chloride Resistance Test

Theweight loss of the specimens after 56 days when subjected chloride attack is presented in Table5.The chloride resistance test also shows the same trend of weight loss as sulphate resistance. But the deterioration is less for specimens subjected to chloride attack compared to sulphate attack.

5.4 Micro Structure of Concrete

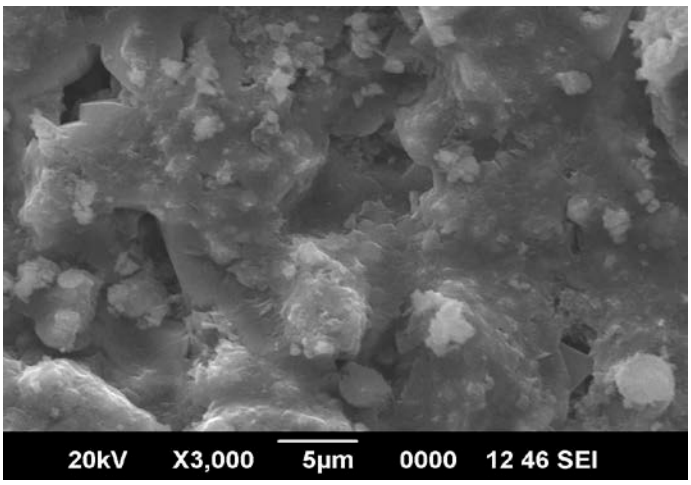

Fig.4 SEM image of Conventional Concrete

SEM analysis results of NC and SC1 is shown in Fig.4 and Fig.5.The microstructure of SC1is exhibited denser microstructure with a smaller width of microcracks and reduced size of crystalline hydration products compared to NC.

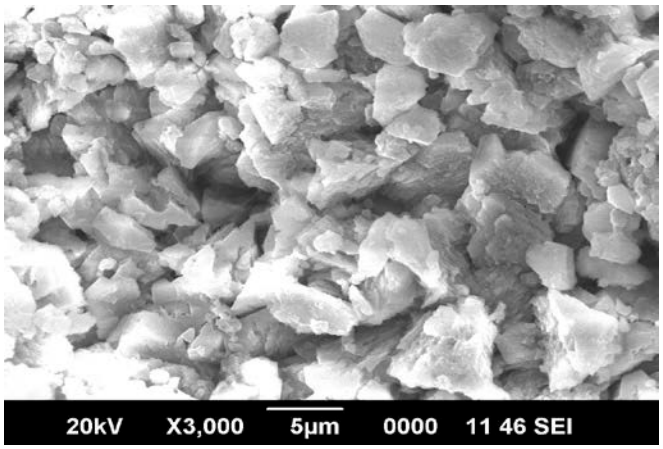

Fig.5 SEM image of Self Curing Concrete

6 Conclusions

- PEG-400 is added to the concrete the workability of the concrete is increases.
- The mechanical properties of self curing concrete are higher compared to normally cured concrete up to a certain % of PEG-400 and the optimum mix of self curing concrete is obtained when 1% of PEG-400 is added.
- Durability properties of self curing concrete (water absorption, sulphate resistance and chloride resistance) are found to be better compared to conventional concrete.
- The microstructure of self curing concrete indicates that the pore sizes are small compared to conventional concrete which may be due to the presence of hydrogen bonds.

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