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RESEARCH ARTICLE

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AN EXPERIMENTAL STUDY ON THE STRENGTH AND DURABILITY PROPERTIES OF CONCRETE USING WATER SOLUBLE SELF-CURING AGENT

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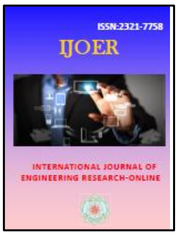

ABSTRACT

The aim of this investigation is to study the strength and durability properties of concrete using water-soluble Polyethylene Glycol as self-curing agent. The function of self-curing agent is reduces water evaporation and increase the water retention capacity of concrete compared to the nominal concrete. The use of self-curing compounds is saving water, it is a necessity everyday (for each cubic meter of concrete requires 3m3 of water in a construction, most of which is used for curing). In this study, compressive strength and split tensile strength of concrete containing self-curing agent is investigated and compared with those of nominal concrete.

1. INTRODUCTION

Now a day's many techniques are introduced and rapid improvement in the concrete technology. As per survey the usage of cement rapidly increases from 1.5 to 2.2 billion tons from 1995 to 2010 (Malhotra, 1999). The durability and strength characteristics of concrete is depends on curing, optimum strength is reached by proper curing. Moisture content, humidity and temperature conditions are influence the curing. The minimum curing time for concrete is 28 days; it gives good hydrations and good strength results. If proper curing is not take place we could not reach the desired strength results. Water/cement ratio place important role in curing. We need proper water/cement ratio to hydrate cement particles of cement and for good bonding in between particles. The water/cement ratio will also be effect the strength of concrete structures. The water/cement ratio of range 0.35-0.45 is give better results.

Self-curing technique is one of the techniques, used in less water resource areas. In concrete structures proper curing is required to get good strength results and durability properties. For nominal concrete curing process is done externally. After mixing, placing and casting of specimens curing is applied. Self-curing process is used to give additional moisture content to the concrete structures to get effective hydration process, also reduces the self-drying of specimens. If concrete specimens are exposed to the atmosphere evaporation of water takes place and reduces moisture content. The loss of moisture content reduces the initial water-cement ratio also effects the hydration process. Due to this quality and strength properties of concrete may affect. Shrinkage and early-age cracking occurs due to evaporation at initial stages. Drying shrinkage and cracking occurs at final stage of setting. Curing temperature have important role in strength developing of concrete structures. The nominal concrete losses its strength at higher temperature conditions due to the formation of cracks between two different natured ingredients, cement paste and aggregates. If concrete is cured at high temperature it devolves high early strength than the nominal concrete and cured at lower temperature, but strength is generally lowered at 28 days and later stage.

2. MATERIALS USED

1. ordinary portrland cement.
2. sand.
3. coarse aggregate.
4. polyethylene glycol.
5. water.

2.1 Properties of Portland cement: These properties are taken from the various standard books, journals and some standard codes as reference.

Table No 2.1 Chemical analysis of Portland cement

S.NO	Constituent	Percentage
1	Cao	64
2	Sio_2	22
3	Al_2o_3	4.1
4	Fe_2o_3	3.6
5	Mgo	1.53
6	So_3	1.9

2.2 Sand: Sand is natural material, it occurring from finely divide rock and mineral particles. We are using the locally available river sand is conforming to Zone II of IS: 383- 19707 was used as fine aggregate with specific gravity 2.89.

2.2.1 Sieve Analysis of sand: The Sieve Analysis of sand is carried out to know the zone of the sand, the fineness of sand give good compaction of mix. The results of sieve analysis are given in Table No. 2.2.

Table No. 2.2. Sieve Analysis of sand

Sieve size	Weight Retained in gm	% passing
4.75 mm	20 gm	97.8
2.36 mm	13gm	96.4
1.18 mm	74 gm	91.2
600 micron	391 gm	50.7
300 micron	416 gm	8.9
150 micron	86gm	1.6
Total	1000 gm	-

2.2.2 Physical properties of sand: Before going to the experimental work we have to find the physical properties of sand like specific gravity and water absorption. The physical properties of sand are given below in Table No 2.3.

Table.2.3.Physical properties of sand

Fine aggregate	Specific gravity	Water absorption in %
Sand	2.71	0.7

2.3 COARSE AGGREGATE: The coarse aggregates are naturally occurring material from divided rock material and crushed granite stone. The shape of coarse aggregate may also influence the strength characteristics of concrete structure. These are available in different shapes; mainly angular shape aggregates may give better compaction of mix and reducing the void pores. In this project we are using angular shaped coarse aggregates having maximum size is 20mm are tested as per IS: 383-1970. It is crushed granite stone obtained from the local quarry having specific gravity is 2.69.

2.4 POLYETHYLENE GLYCOL: Polyethylene-glycol is a liquid state polymer of ethylene oxide and water, having general formula H(OCH2CH2)nOH, here n refers average number of repeated oxyethelene groups, it ranges from 4 to 180. The abbreviation of poly ethylene glycol is a combination with a numeric suffix which represents the average molecular weights. Main feature of polyethylene glycol is water-soluble nature.

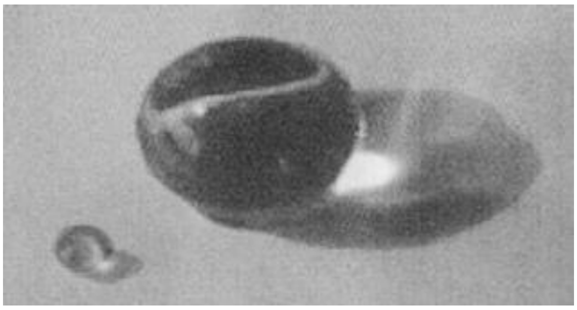

Figure 2.1 POLYCTHYLENE GLYCOL

2.4.1 Chemical properties of PEG: PEG 400 is strongly hydrophilic. The partition coefficient of PEG 400 between hexane and water is 0.000015 (log P = -4.8), it indicates that when PEG is mixed with water and hexane, it divided into 15 parts of polyethylene glycol in hexane layer for 1 million parts of polyethylene glycol in water layer. PEG 400 is soluble in water, acetone, alcohols, benzene, glycerine, glycols, and aromatic hydrocarbons, and is slightly soluble in aliphatic hydrocarbons. These are main chemical properties.

2.4.2 Physical properties of PEG: Depending on the molecular weight of polyethylene glycol the physical properties like solubility, hygroscopic, vapour pressure, melting or freezing point and viscosity are variable: Solubility- Increasing the molecular weight of PEG results in decreasing solubility in water & solvents. PEG is also soluble in many polar organic solvents such as acetone, alcohols. Hygroscopic- PEGs are hygroscopic, it means they are grasping the moisture from the atmosphere and holds the moisture. Hygroscopic decrease as molecular weight increases. Viscosity- PEGs can be considered Newtonian fluids, so the kinematic viscosity of PEGs decreases as temperature increases. Stability- PEGs have low volatility and are thermally stable for a limited period of time below 300°c and without O2.

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

3. EXPERIMENTAL PROCEDURE

The experimental program was designed to investigate the strength of self-curing concrete by adding poly ethylene glycol PEG400. The experimental program was aimed to study the durability, compressive strength, split tensile strength and stress-strain curves. To study the above properties mix M25 is considered. The scheme of experimental program is given below

Stage 1: Cubes having size 150 x 150 x 150mm and cylinders having size 150 x 300mm were casted for the determination of the strength of nominal concrete.

Stage 2: Cubes having size 150 x 150 x150mm and cylinders having size 150 x 300mm were casted for the determination of the strength of self curing concrete by adding poly ethylene glycol PEG400.

Stage 3: Experimental works were conducted on conventional concrete mixes by using different binder mix modified with different proportions polyethylene glycol. This experimental investigation was carried out for three different proportions of PEG-400 @ 0.5%, 1%, and 1.5% by weight of cement to the concrete. Then the optimum percentage of chemical mix was found. Similarly experimental work is conducted for different proportions of chemical mix. Hence analyze concrete mixed with PEG-400 and results were tabulated.

Stage 4: Here cubes and cylinders are prepared with three different dosages of PEG-400 with concrete.

4. CONCRETE MIXING AND CASTING

4.1 MIXING: Mixing is place an important role in concrete structures. Proper mixing gives uniform and high quality concrete. The proper mixing gives better strength results. The concrete mix is obtained by combination of Portland cement, specified fine and coarse aggregate. The proper mixing of these materials gives uniformity.

Separate paste mixture has shown that the mixture of cement and water into paste before combining each material with aggregates can increase the compressive strength of concrete. It is normally mixed in high-speed, shear-type mixers with water/cement ratio of 0.30 to 0.45 by mass. The cement paste pre mix may contain admixtures like super plasticizers, pigments, or may be silica fume. The pre designed mixed paste is then blended with aggregates & any remaining batch water and final mixing is completed. High-energy mixed concrete is produced by high-speed mixing of cement, water and sand with the net specific energy consumption of at least 5 kJ/kg of the mix. Now we are adding super plasticizer to the mix, later it can be mixed with aggregates in a nominal mix concrete. In this process, sand gives consumption of energy, it results high-shear conditions on surface of cement particulates. This results in the full volume of water interacting with cement. The liquid activator mixture can be useful by itself or foamed for lightweight concrete. High-energy mixed concrete hardens in low and sub zero temperature conditions and possesses an increase volume of gel, which drastically reduce capillarity in solid and porous materials.

In this we required normal conventional mixing and chemical mixing. First we make the mixing for M25 grade conventional concrete with water/cement ratio of 0.45. Another mixing is self-curing concrete mix. In this we are adding self-curing agent PEG-400 to the conventional concrete mix. In these we are adding polyethylene glycol at different dosages @ 0.5%, 1% and 1.5%. For each dosage mixing is takes place having water/cement ratio of 0.45.

Figure.4.1. Concrete mixing

4.2 CASTING: Casting of the specimens placed as per IS: 10086-1982, material preparation, requirement of materials and casting of cubes and cylinders. The mixing, compacting and curing of concrete are done according to IS 516: 1959. After casting, cube and cylinder specimens were placed in water for 7days and 28 days and the specimens casting with self-curing compound were placed in dark place for curing at room temperature. Chemically made specimens are not exposed to sunlight. The casting details are given below

Figure.4.2 Casting of specimens

4.2.1 CASTING DETAILS: The casting details of conventional concrete and self-curing concrete cube and cylinder specimens are given below:

S.No.	Nature	M25 mix concrete	
		Cubes	Cylinders
1	Plain concrete	8	6
2	0.5% PEG	8	6
3	1.0% PEG	8	6
4	1.5% PEG	8	6

5. EXPERIMENTAL INVESTIGATIONS AND RESULTS

In this project concrete of mix proportion 1 : 1.25 : 3.01 will be prepared by using OPC, is mixed with self-curing compound PEG-400 and conventional concrete, sand as fine aggregate and kankar as coarse aggregate. According to this mix proportion different samples (cubes and cylinders) are done. After testing we compare the test results of conventional concrete with the self-curing concrete (PEG-400). The concrete mix samples will be tested to find properties of concrete as follows:

- Compressive strength after 7 days, 28 days.
- Split tensile strength after 7 days, 28 days.
- Durability test after 7 days and 28 days.
- Stress-strain curves after 28 days

5.1 COMPRESSION STRENGTH TEST:

Fig.5.1. Compressive strength testing

These results are obtained by testing the total 4 specimens for 7 days and 28 days by considering the average of the test results for conventional concrete and for each dosage of self-curing concrete. The results are tabulated below:

Table 5.1 Compressive strength of concrete at 7 days

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Compressive Strength at 28 d (N/mm^2)
1	Conventional concrete	M25	0	29.89
		M25	0.50%	32.81
		M25	1%	36.55
2	Self-curing concrete	M25	1.50%	35.11

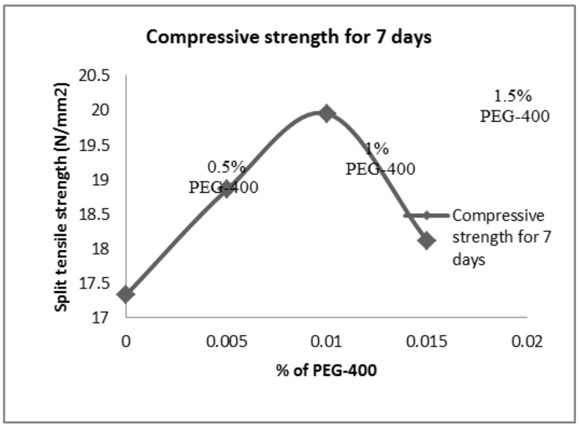

Figure 5.2. Graph for 7 days Compressive strength

Table 5.2 Compressive strength of concrete at 28 days

S.No	Type of concrete	Grade of Mix	% of PEG 400	Average Compressive Strength at 7 d (N/mm^2)
1	Conventional concrete	M25	0	17.34
		M25	0.50%	18.85
		M25	1%	19.95
2	Self-curing concrete	M25	1.50%	18.11

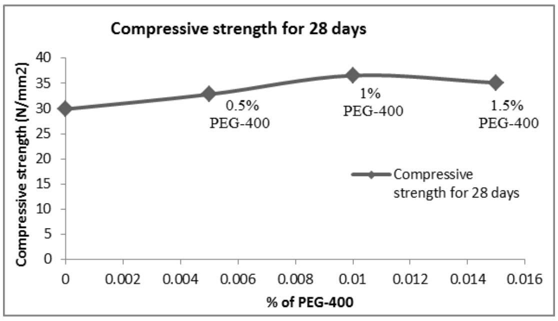

Figure 5.3. Graph for 28 days Compressive strength

5.2 SPLIT TENSILE STRENGTH RESULTS:

These results are obtained by testing the total 4 specimens for 7 days and 28 days by considering the average of the test results conventional concrete and for each dosage of self-curing concrete. The results are tabulated below:

Table 5.3 Split tensile strength of concrete at 7days

S.No Type of concrete

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Split tensile Strength at 7 d (N/mm^2)
1	Conventional concrete	M25	0	1.78
		M25	0.50%	1.7
		M25	1%	2.12
2	Self-curing concrete	M25	1.50%	2.05

Table 5.4 Spilt tensile strength of concrete at 28days

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Split tensile Strength at 28 d (N/mm2)
1	Conventional concrete	M25	0	2.12
		M25	0.50%	2.34
		M25	1%	2.69
2	Self-curing concrete	M25	1.50%	2.9

5.3 DURABILTY RESULTS:

These results are obtained by testing the total 2 specimens for 7 days and 28 days by considering the average of the test results for conventional concrete and for each dosage of self-curing concrete. The results are tabulated below:

Table 5.5 Cube specimens cured in 1N H_2SO_4 solution at 7 days

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Compressive strength of concrete at 7 d (N/mm^2)
1.	Conventional concrete	M25	0	15.5
2.	Self-curing concrete	M25	0.5%	15.5
		M25	1%	17.7
		M25	1.5%	16.5

Table 5.6 Cube specimens cured in 1N H_2SO_4 solution at 28 days

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Compressive strength of concrete at 28 d (N/mm^2)
1.	Conventional concrete	M25	0	24.40
2.	Self-curing concrete	M25	0.5%	27.00
		M25	1%	29.60
		M25	1.5%	29.66

5.4 STRESS-STRAIN CURVE: The Stress-strain curve is obtained by testing the cylinder specimens for 28 days by considering the average of the test results for conventional concrete and for each dosage of self-curing concrete.

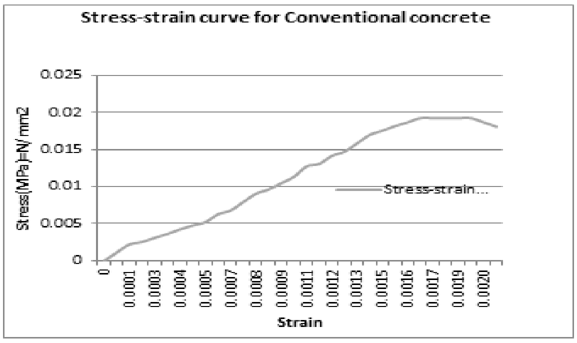

Figure 5.4.1 Stress-strain curve of Conventional concrete at 28 days:

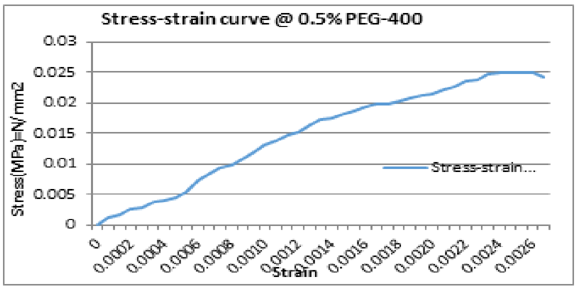

Figure 5.4.2 Stress-strain curve of Self-curing concrete of 0.5% PEG-400 at 28 days:

6. CONCLUSIONS

Based on the experimental investigations, mechanical properties of concrete like compressive strength, tensile strength, durability aspects and stress-strain behavior of Self-curing concrete (with PEG-400). The following conclusions are drawn.

- Addition of PEG-400 as increase the compressive strength of Self-curing concrete by 15% at 1% dosage for 7 days when compared to the conventional concrete.
- Addition of PEG-400 as increase the compressive strength of Self-curing concrete by 22.3% at 1% dosage for 28 days when compared to the conventional concrete.
- Addition of PEG-400 as increase the split tensile strength of Self-curing concrete by 19.1% at 1% dosage for 7 days when compared to the conventional concrete.
- Addition of PEG-400 as increase the split tensile strength of Self-curing concrete by 36.8% at 1% dosage for 28 days when compared to the conventional concrete.
- Addition of PEG-400 as increase Durability values of Self-curing concrete by 14.2% at 1% dosage for 7 days when compared to the conventional concrete.
- Addition of PEG-400 as increase Durability values of Self-curing concrete by 21.5% at 1.5% dosage for 28 days when compared to the conventional concrete
- From the above points it is observed that the optimum dosage of PEG-400 for M25 mix concrete is 1%
- The Stress-strain behavior for conventional concrete and Self-curing concrete with different dosages PEG-400 is observed to be similar. This shows that addition of PEG-400 to conventional concrete at lower dosages does not affect the Stress-strain behavior.
- The peak stress values for Self-curing concrete are more by 25% for 0.5% dosage, more by 35% for 1% dosage and more by 25% for 1.5% dosages of PEG-400. This shows that addition of small dosages of PEG-400 increases the peak stress values when compared to conventional concrete.
- The stain corresponding to peak stress for all dosages of PEG-400 is 0.0025 (approximately). This shows that addition of different dosages of PEG-400 does not vary stress-strain behavior corresponding to peak stress.
- Modulus of elasticity of Conventional concrete is 27MPa and for Self-curing concrete is 30MPa for M25 mix concrete.
- Self-curing compound (PEG-400) may be responsible for the above advantages when compared to conventional concrete. Thus Self-curing concrete reduces conventional curing problems and improves mechanical properties and durability aspects.
- For complex shapes where wrapped or membrane curing is difficult, there the Self-curing technique shows an alternative to improve the mechanical properties.

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