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A Comparative study of mechanical properties of M25 grade self-curing concrete (using PEG-400) with conventional concrete

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Abstract
Today concrete is most widely used construction material due to its good compressive strength and durability. 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 to reduce the water evaporation from concrete, and hence they increase the water retention capacity of concrete compared to the conventionally cured concrete. 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). In this study, compressive strength and split tensile strength of concrete containing self-curing agent is investigated and compared with those of conventionally cured concrete.

Keywords: Self-curing concrete; Water retention; Relative humidity; Hydration; Poly-ethyleneglycol-400

1. Introduction
Now a day's many techniques are introduced and rapid improvement in the concrete technology. Self-curing technique is one of the techniques, used in less water resource areas. Many researches are concerned to identify effective self-curing agent. Therefore, several researchers are attracted towards identifying the self-curing agent. Polyethylene-glycol which decreases the surface tension of the water and minimizes the water evaporation from concrete and hence increases the water retention capacity of the concrete. It has been found that water-soluble polymers (Polyethylene Glycol) can be used as self-curing agents in concrete.

1.1. Methods of Self-Curing
Self-curing concrete has two major methods. They are
i) Light weight aggregate (LWA)
ii) Shrinkage reducing admixtures (Propylene glycol)

i) Light weight aggregate (LWA)
In the first method we are using saturated porous lightweight aggregate (LWA) in order to supply an internal source of water

ii) Shrinkage reducing admixtures (SRA)
In the second method we are using shrinkage reducing admixtures (SRA). Propylene glycol i.e. poly-ethylene glycol (PEG) or polyvinyl alcohol are the SRA materials. Which reduces the evaporation of water from the surface of concrete and also helps in water retention.

1.2 Significance of Self-Curing
The self-curing technique is more significant in water lacked areas or low water resource. Due to this chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, its leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking. So it is very useful in when water is readily not available. Due to control the water evaporation we use light weight aggregate and polyethylene glycol etc.

1.3 Mechanism of Internal 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 vapors 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 vapors pressure, thus reducing the rate of evaporation from the surface.

1.4 Potential Materials for Internal Curing (Ic)

Self-curing is also referred as Internal- Curing. Some of the special type of materials used in the internal curing process. They are as follows

The following materials can be providing internal water reservoirs:

a) Lightweight Aggregate (natural and synthetic, expanded shale)
b) Super-absorbent Polymers (SAP) (60-300 mm)
c) SRA (Shrinkage Reducing Admixture)

(Propylene glycol type i.e. polyethylene- glycol/ polyvinyl alcohol)

1.5 Advantages of Internal Curing

The Self-curing or Internal curing process has following advantages.

- Internal curing (IC) is a method to provide the water to hydrate all the cement, accomplishing what the mixing water alone cannot do.
- Provides water to keep the relative humidity (RH) high, keeping self-desiccation from occurring.
- Furnished as a ready-to-use, true water-based compound. Produces hard, dense concrete, minimizes hair cracking, thermal cracking, dusting and other defects.

1.6 Polyethylene Glycol

In this project we are using Polyethylene glycol as self-curing agent. Polyethylene-glycol is a condensation polymer of ethylene oxide and water with the general formula H (OCH2CH2) nOH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights.

Literature Survey

Wen-Chen Jau stated that self-curing concrete is provided to absorb water from moisture from air to achieve better hydration of cement in concrete.

Aielstein Rozario, Dr. C Freeda Christy, M Hannah Angelin said that the permeability of concrete decreases with an increase in the replacement of fly ash with cement and in addition of PEG dosages.

Ole and Hansen describe a new concept for the prevention of self-desiccation in hardening cement-based materials using fine, super absorbent polymer (SAP) particles as a concrete admixture.

A.S. El-Dieb investigated water retention of concrete using water-soluble polymeric glycol as self-curing agent. Concrete weight loss and internal relative humidity measurements with time were carried out, in order to evaluate the water retention of self-curing concrete.

3.1 Scope and Object of Self-Curing

Some specific water-soluble chemicals such as poly-ethylene glycol is added during the mixing can reduce water evaporation from and within the set concrete, making it "self-curing." The scope of the paper is to study the effect of polyethylene glycol (PEG 400) on strength characteristics of Self-curing concrete.

- The objective is to study the mechanical characteristic of concrete i.e., compressive strength and tensile strength by varying the percentage of PEG from 0.5%, 1% and 1.5% by weight of cement for both M25 grade of concrete.
- The dosage of polyethylene glycol is taken as 0.3% of total weight of cement used in mix.
- In this project we also study the stress-strain relation curves at different proportions like 0.5%, 1% and 1.5%.

Materials and Their Properties

4. Materials

4.1 Ordinary Portland cement

In this project we are used Ordinary Portland cement (OPC-53 grade) conforming to IS: 8112-198986. The specific gravity of cement is 3.15.

4.1.2 Sand

In this project 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.

4.1.3 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 are tested as per IS: 383-1970 and having specific gravity is 2.69.

4.1.4 Polyethylene Glycol

Polyethylene glycol is a condensation polymer of ethylene oxide and water with the general formula H (OCH2CH2) nOH, where n is the average number of repeating oxyethylene groups typically from 4 to about 180. The abbreviation (PEG) is termed in combination with a numeric suffix which indicates the average molecular weights. It is water-soluble in nature.

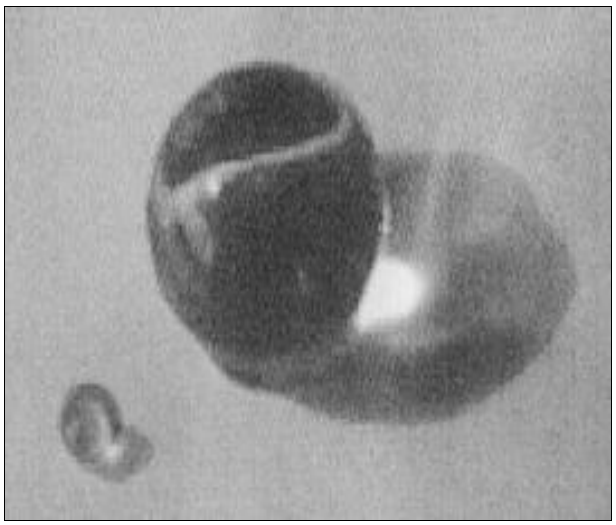

Fig 4.1: Polycthylene Glycol

4.1.4.1 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), indicating that when PEG 400 is mixed with water and hexane, there are only 15 parts of PEG 400 in the hexane layer per 1 million parts of PEG 400 in the water layer. PEG 400 is soluble in water, acetone, alcohols and is slightly soluble in hydrocarbons.

4.1.4.2 Physical properties of PEG

Depend on molecular weight the wide range of the physical property such as solubility,

Hygroscopic, vapour pressure, 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. Stability- PEGs have low volatility and are thermally stable for a limited period of time below 300°c and without O2.

4.1.5 Water

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

5. Experimental Programing

5.1 Compression Strength Test

a) Remove the specimens from water after specified curing time and leave the specimen in the atmosphere (keep outside) for 24hours before testing.
b) Place the specimen in the testing machine and the load shall be applies to the opposite sides of the specimen cast.
c) The specimen is must be placed at center to the base plate of the machine for a cubic or cylindrical specimen.
d) Rotate the loading arm gently by hand till the loading plate touches the top surface of the specimen.
e) Apply the load gradually without any sudden jerk and continuously applying load at the rate of 100kg/cm^2 minute till the specimen fails. Increase the load until failure and falls down. Note down the maximum load.

5.2 Split Tensile Strength

a) Remove the specimens from water after specified curing time and leave the specimen in the atmosphere (keep outside) for 24hours before testing.
b) Place the specimen in the testing machine and the load shall be applies to the opposite sides of the specimen cast.
c) The specimen is must be placed at center to the base plate of the machine for a cubic or cylindrical specimen.
d) Rotate the loading arm gently by hand till the loading plate touches the top surface of the specimen.
e) Apply the load gradually without any sudden jerk and continuously applying load at the rate of 100kg/cm^2 minute till the specimen fails. Increase the load until failure and falls down. Note down the maximum load.

5.3 Durability of Concrete

A long service life is considered synonymous with durability. According to ACI Committee 201, durability of Portland cement concrete is resist weathering action, chemical attack, abrasion, or any other process of deterioration. The self-curing concrete cubes are placed with the self-curing agent polyethylene glycol-400. We cast cubes @ 0.5%, 1% and 1.5% proportions of polyethylene glycol. The specimen is placed in the acid and base solutions. The cubes are placed in these solutions for 7 days and 28 days.

Experimental Results

6.1 Final Test Results

6.1.1 Compressive 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 for conventional concrete and for each dosage of self-curing concrete. The results are tabulated below:

Table 6.1: Compressive strength of concrete for 7 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
2.	Self-curing concrete	M25	0.5%	18.85
		M25	1%	19.95
		M25	1.5%	18.11

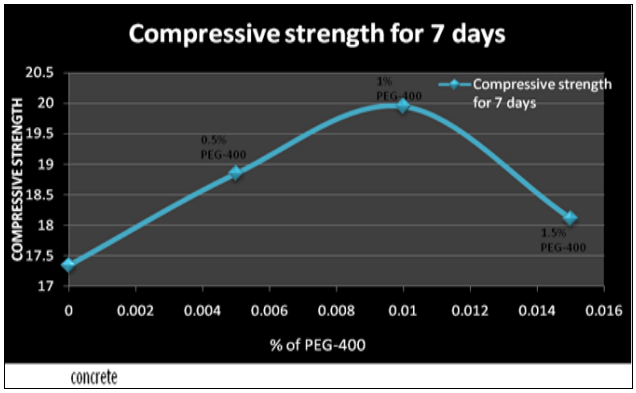

Fig 6.1: Graph for 7 days Compressive strength

Table 6.2: Compressive strength of concrete for 28 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
2.	Self-curing concrete	M25	0.5%	32.81
		M25	1%	36.55
		M25	1.5%	35.11

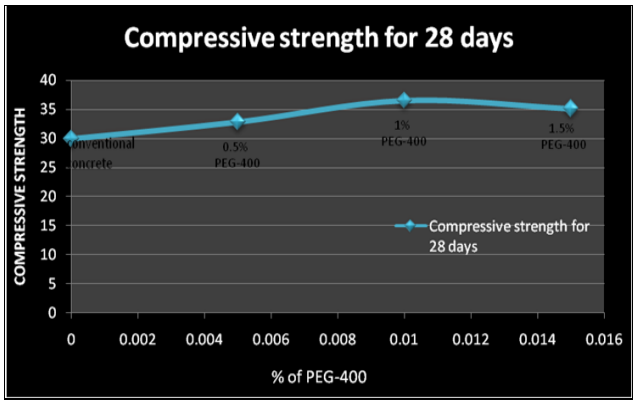

Fig 6.2: Graph for 28 days Compressive strength

6.2 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 6.3: Split tensile strength of concrete for 7days

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
2.	Self-curing concrete	M25	0.5%	1.70
		M25	1%	2.12
		M25	1.5%	2.05

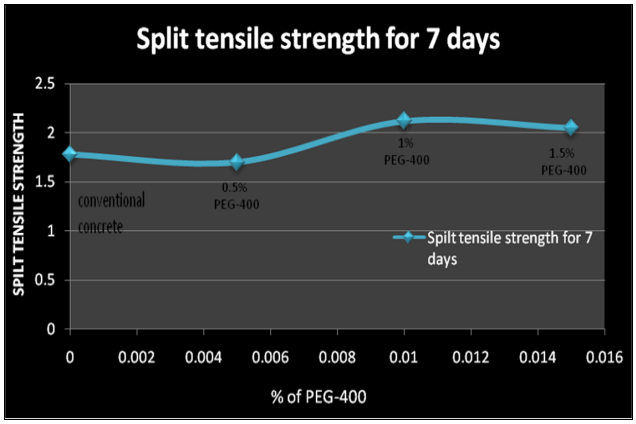

Fig 6.3: Graph for 7 days Spilt tensile strength

Table 6.4: 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/mm^2)
1.	Conventional concrete	M25	0	2.12
2.	Self-curing concrete	M25	0.5%	2.34
		M25	1%	2.69
		M25	1.5%	2.90

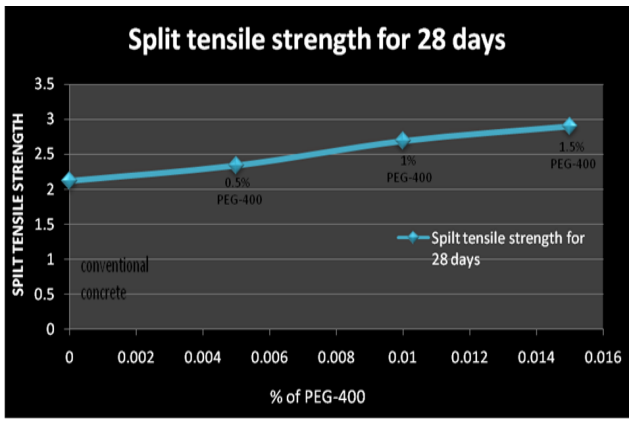

Fig 6.4: Graph for 28 days Spilt tensile strength

6.3 Durability 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 6.5: Durability of concrete for 7days

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Durability of concrete at 7 d (N/mm^2)
1.	Conventional concrete	M25	0	15.75
2.	Self-curing concrete	M25	0.5%	16.00
		M25	1%	17.55
		M25	1.5%	16.64

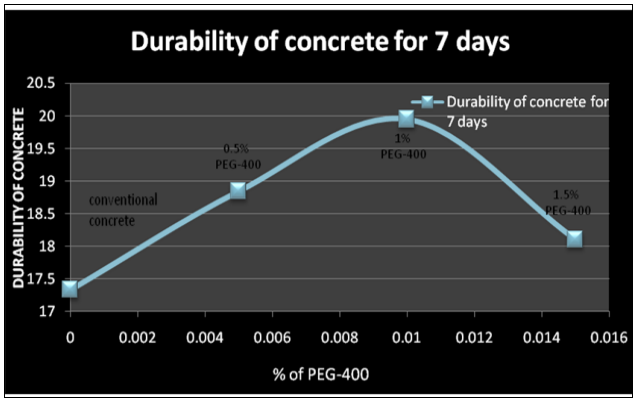

Fig 6.5: Graph for 7 days Durability

Table 6.6: Durability of concrete for 28days

S.No	Type of concrete	Grade of Mix	% of PEG-400	Average Durability of concrete at 28 d (N/mm^2)
1.	Conventional concrete	M25	0	25.00
2.	Self-curing concrete	M25	0.5%	27.00
		M25	1%	29.11
		M25	1.5%	29.66

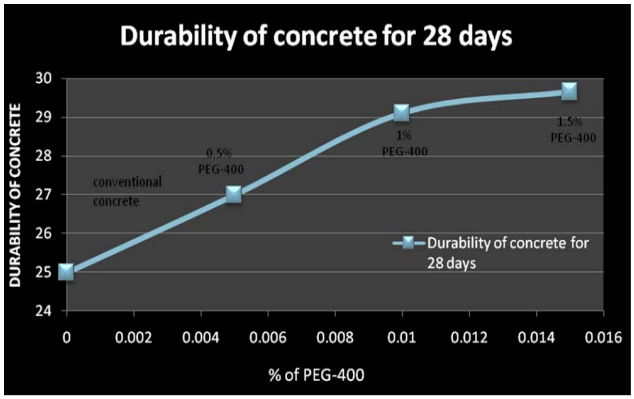

Fig 6.6: Graph for 28 days Durability

7. Conclusions

Based on the experimental investigations, "Engineering properties of concrete" such as Compressive strength, split tensile, durability and stress-strain curve.

1. Strength of self-curing concrete is high when compared with conventional concrete.
2. Self-curing concrete is reducing the improper curing problems.
3. Self-Curing concrete is an alternative method to conventional concrete in desert regions where scarcity of water is a major problem.

4. The optimum dosage of PEG-400 for maximum Compressive strength was found to be 1.0% for M25 of concrete.
5. Wrapped curing is less efficient than Membrane curing and Self-curing it can be applied to simple as well as complex shapes.
6. In compression strength aspect the incremental change in the strength was observed and it is more than 1.25 times than the conventional concrete.
7. In the split tensile strength aspect we observed the incremental change which is 1.1times more than the conventional concrete.

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