

Strength Characteristics of Self Curing Concrete With Different Self Curing Agents

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ABSTRACT: Concrete is most widely used as a construction material due to its good mechanical properties and durability. Depending upon the nature of work the 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 strength and durability of the concrete depends on curing. The cement hydration problem due to improper curing, which can be successfully overcome by using self curing concrete. Hence no traditional way of curing is required in self curing concrete. Self curing concrete can be used where curing is a constraint because of inadequacy of water, fluoride content in water which affects concrete characteristics and where structures cannot be accessed for curing. The present study self curing agents such as Super Absorbent Polymer (SAP) and Poly Vinyl Alcohol (PVA) were used in concrete which helps in self curing and helps in better hydration and strength. Effect of these agents on strength properties of concrete such as compressive strength, split tensile strength, flexural strength were studied. M25 grade concrete is considered as reference mix and strength properties of reference mix were determined. Self curing agents SAP (0.25%, 0.5%, 0.75%, and 1%) and PVA (0.25%, 0.5%, 0.75%, and 1%) by weight of cement were added separately in the reference mix and their strength properties were studied and compare with reference mix.

KEYWORDS: Self curing concrete, SAP, PVA.

I. INTRODUCTION

General

The desired properties in concrete can be obtained by proper curing if concrete is in the initial stages. 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 curing of concrete structures is important to meet performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. But, curing is not possible in all occasions because of some barriers and negligence. 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. Self-curing agents mainly help in the retention of water in concrete by reducing evaporation because of hydration of concrete. When compared to conventional concrete self-cured concrete holds water from evaporation.

Water soluble alcohols such as Poly Ethylene Glycol (PEG), Poly Vinyl Alcohol (PVA) can be used as self curing agents in self-curing concrete. Super Absorbent Polymer is also one of the self curing agent. Most SAPs are cross linked polyelectrolyte. They absorb large quantity of water without dissolving because of their ionic nature and interconnected structure. Self curing admixtures play a vital role in today's condition where water is becoming an important asset which cannot be wasted for curing. For example 1m³ of concrete requires 3m³ of water.

Curing is done mainly to retain the moisture in concrete, by preventing evaporation from the concrete during the period in which it is attaining strength.

Curing can be done in many other ways and the best way will be dictated at site based on conditions at site.

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Self Curing Concrete

As per IS: 456-2000 “Curing is the process of preventing the loss of moisture from the concrete”. Self curing concrete is the one which can cure itself by retaining its moisture content. A concrete can be made to self cure by adding curing admixtures or by the application of curing compounds.

Methods Of Self-Curing

Self-curing concrete has two major methods. They are

- i) Light weight aggregate (LWA)
- ii) Shrinkage reducing admixtures (Propylene glycol)

Mechanism Of Internal Curing (IC)

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 vapours 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 vapours pressure, thus reducing the rate of evaporation from the surface.

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 are:

- a) Lightweight Aggregate (natural and synthetic, expanded shale).
- b) Super-absorbent Polymers (SAP).
- c) SRA (Shrinkage Reducing Admixture) such as Propylene glycol type i.e. polyethylene- glycol/polyvinyl alcohol.

II. LITERATURE REVIEW

Marianne Tange Hasholt, et al. [1] studied the effect of superabsorbent polymer on the mechanical strength of concrete by optimizing the dosage and internal water added. The authors arrived at the conclusion that “Addition of SAP does not lead to decrease in mechanical strength and while one has to be very patient and careful, it is possible to not only retain the same strength but also to increase it while preventing self-dessication.

M. Manoj Kumar, et al. [2] studied the effects of addition of using different ratios of superabsorbent polymer on the various mechanical properties of concrete, like Compressive Strength, Splitting Tensile Strength and Flexural Strength and compared them to conventional concrete.

The following conclusions were drawn from their study

1. Water retention for the concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time.
2. The optimum dosage is 0.3% addition of SAP leads to a significant increase of Compressive and Splitting tensile strength and decrease in flexural strength.

Ole Mejlhede Jensen, et al. [3] observed the mechanism of superabsorbent polymer and determined how it will affect long term shrinkage and reduces autogenous shrinkage. They also explained the possible problems which were associated with the usage of superabsorbent polymer.

Patel Manishkumar Dahyabhai, et al. [4] studied the use of Poly Ethylene Glycol in conventional concrete as an admixture helps better hydration and hence the strength of concrete. In this research paper, the individual effect of admixture PEG600 & PEG1500 on strength properties of concrete by varying the percentage of PEG600 and PEG1500 by weight of cement 0.5%, 1.0%, 1.5% and 2% were studied. The study shows that PEG600 and PEG1500 could help in gaining the strength of conventional curing. It was also found that 1% of both PEG600 and PEG1500 by weight of cement was optimum for M25 grade concrete for achieving maximum strength without compromising workability. The test result indicates that use of water soluble polymers in concrete has improved performance of concrete.

They concluded that the compressive strength of self curing concrete was increased by applying the self-curing admixtures such as PEG 600, PEG 1500 by 37% and 34% respectively.

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M.V.Jagannadha Kumar, et al. [5] studied that the optimum dosage of PEG400 for maximum strengths (compressive, tensile and modulus of rupture) was found to be 1% for M20 and 0.5% for M40 grades of concrete. As percentage of PEG400 increased slump increased for both M20 and M40 grades of concrete. Strength of self-curing concrete is on par with conventional concrete. Self-curing concrete is the answer to many problems faced due to lack of proper curing. **A.Aielstein Rozario, et al. [6]**, studied that the sulphate attack measurement on self curing concrete at ages 28 days, and 56 days. The main investigation in this study is variation of water soluble polymer dosage of 0.05% and 0.1%. They said that the permeability of concrete decreases with an increase in the replacement of fly ash with cement and in addition of P.E.G.

III. EXPERIMENTAL PROGRAMME

MATERIALS USED

Cement

Ultratech 53 grade cement is used in the present experimental study. The cement is free from lumps uniform colour. Results of various tests on cement conducted are summarised in table 1.

Sand

The sand used for this experimental investigation is locally available river sand and it conforms to Indian Standard Specifications IS: 383-1970 and their by confirms zone II. The sand was primarily sieved through 4.75 mm sieve to separate any particles greater than 4.75 mm.

Aggregates

Crushed granite was used as coarse aggregate and it conforms to Indian Standard Specification IS: 383-1970 was used. Maximum size of coarse aggregate in the present study was 20 mm. The properties of fine aggregate and coarse aggregate are shown in table 2.

Table 1: Properties of Cement

S. No.	Characteristics	Values obtained	Standard values
1	Normal Consistency	35%	-
2	Initial Setting time	48 min	Not less than 30 min
3	Final Setting time	240 min	Not greater than 600 min
4	Fineness	4%	Less than 10%
5	Specific Gravity	3.1	3.1-3.15

Table 2: Properties of Fine Aggregate and Coarse Aggregate

S. No.	Characteristics	Fine Aggregate	Coarse Aggregate
1	Specific Gravity	2.66	2.86
2	Fineness Modulus	3.1	6.29
3	Grading Zone	II	-

Self Curing Agent (Polyvinyl Alcohol)

Commercially Polyvinyl alcohol is produced from polyvinyl acetate by a continuous process. The acetate groups are hydrolysed by ester interchange with methanol in the presence of anhydrous sodium methyl ate or aqueous sodium hydroxide. Polyvinyl alcohol is an odourless and tasteless, translucent, white or cream coloured granular powder.

It helps to retain water in concrete. It is soluble in water, slightly soluble in ethanol, but in soluble in other Organic solvents. Typically a 5% solution of polyvinyl alcohol exhibits a PH in the range of 5.0 to 6.5 Polyvinyl alcohol has a melting point of 180⁰ to 190⁰C.

Polyvinyl alcohol is a water soluble synthetic polymer. Polyvinyl alcohol has excellent emulsifying and adhesive properties.PVA is fully degradable and dissolves quickly.

Super Absorbent Polymer

The SAPs are covalently cross-linked. They are Acrylamide/acrylic acid copolymers. One type of SAPs are suspension polymerized, spherical particles with an average particle size of approximately 200 nm; another type of SAP is solution polymerized and then crushed and sieved to particle sizes in the range of 125–250 nm. The size of the swollen SAP particles in the cement pastes and mortars is about three times larger due to pore fluid absorption. The swelling time depends especially on the particle size distribution of the SAP. It is seen that more than 50% swelling occurs within the first 5 min after water addition.

Super Absorbent Polymers hydrate in contact with liquids leading to formation of swollen polymer gel. When their three-dimensional networks with chemical cross- links come in contact with fluid, the water molecules diffuse into the voids inside the polymer network and hydrate the chains, as this process is reversible i.e., the removal of water results in collapsing of SAP as shown in Fig. 1.



Fig. 1. Schematic representation of SAP network in collapsed and swollen state.

Preparation and casting of specimens

The standard size of specimens such as cubes (150 mm × 150 mm × 150 mm) to determine compressive strength, cylinders (150 mm diameter and 300 mm length) to determine split tensile strength and beams (100 mm × 100 mm × 500 mm) to determine flexural strength were cast. All the inner surfaces and base plates of moulds were coated with oil for easy removal of form and smooth finish. At-most care was taken while batching, mixing and casting operations were done. The specimens were de-moulded after 24 hours and kept at ambient temperature as shown in Fig. 2.

Experimental procedure

Experimental investigation was carried out with reference to the M25 grade concrete mix. Self curing agents such as PVA and SAP were used in this study. Different concrete mixes were cast using PVA and SAP at different percentages 0.25, 0.5, 0.75 and 1. Mix proportions of reference mix M25 grade concrete are shown in table 3.

Table 3: Mix Proportions Of M25 grade concrete (Kg/m³)

Mix	Cement	Fine Aggregate	Coarse Aggregate	Water
M25	399.125	680	1209	191.58

IV. EXPERIMENTAL RESULTS

Compressive Strength Test

Cube specimens were tested for compression and the ultimate compressive strength was determined from failure load measured using the compression testing machine as shown in Fig. 3. The average values of compressive strength of 3 specimens for each category at the age of 28 days are shown in table 4. From these values it was observed that the increase in strength of M25 grade concrete with the addition of 0.25% and 0.5% of PVA was 5.64% and 1.7% respectively, and the remaining mix strengths were decreased.

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The compressive strength of M25 grade concrete with the addition of 0.25%, 0.5%, 0.75% and 1.0% of SAP was decreased. The strength variations of each category are shown in Fig. 6.

Split Tensile Strength Test

It is a common test used to determine the tensile strength of concrete indirectly when the cylindrical specimen is kept horizontally and loaded in compression, the specimen is subjected to tensile stress along the plane perpendicular to the line of loading the cylinder. The experimental setup was shown in Fig. 4. The average values of specimens for each category at the age of 28 days are shown in table 5.

From these values it was observed that the increase in strength of M25 grade concrete with the addition of 0.25% PVA was 5.26%, and the remaining mix strengths were decreased.

The split tensile strength of M25 grade concrete with the addition of 0.25%, 0.5%, 0.75% and 1.0% of SAP was decreased. The strength variations of each category are shown in Fig. 7.

Flexural Tensile Strength Test

Flexural tensile strength test for 28 days was carried out on concrete beams. The experimental setup was shown in Fig. 5. The average values of specimens for each category at the age of 28 days are shown in table 6.

The strength of M25 grade concrete with the addition of PVA for 0.25% was observed to be equal, and the remaining mix strengths were decreased.

The flexural tensile strength of M25 grade concrete with the addition of 0.25%, 0.5%, 0.75% and 1.0% of SAP was decreased. The strength variations of each category are shown in Fig. 8.



Fig 2: Cast specimens



Fig 3: Compressive Strength Test



Fig 4: Split Tensile Strength Test



Fig 5: Flexural Tensile Strength Test

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Table 4: Compressive Strength Values For PVA and SAP

Mix	Compressive Strength in MPa				
	0.0%	0.25%	0.50%	0.75%	1.00%
PVA	34.22	36.15	34.81	33.92	31.70
SAP	34.22	31.63	29.48	26.22	22.37

Table 5: Split Tensile Strength Values For PVA and SAP

Mix	Split Tensile Strength in MPa				
	0.0%	0.25%	0.50%	0.75%	1.00%
PVA	3.04	3.16	2.76	2.61	2.59
SAP	3.04	2.58	2.44	2.19	2.12

Table 6: Flexural Tensile Strength Values For PVA and SAP

Mix	Flexural Tensile Strength in MPa				
	0.0%	0.25%	0.50%	0.75%	1.00%
PVA	3.02	3.04	2.86	2.81	2.52
SAP	3.02	2.53	2.47	2.24	2.02

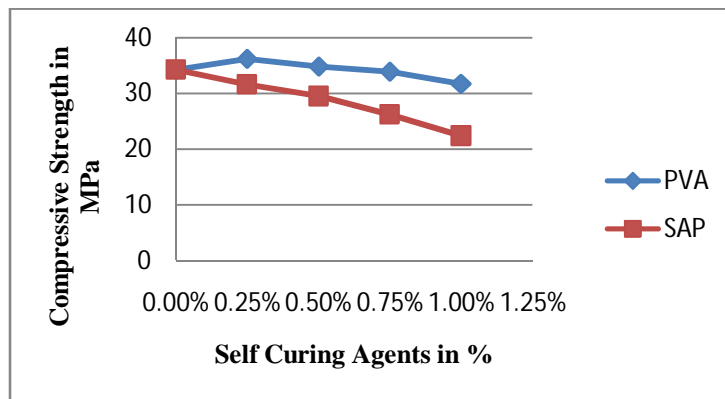


Fig 6. Variation of Compressive strength

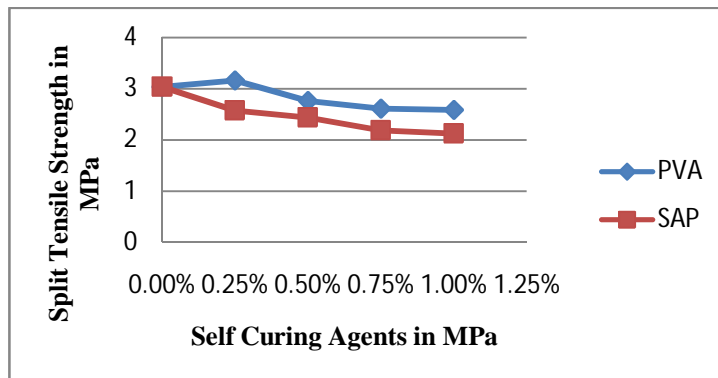


Fig 7. Variation of Split tensile strength

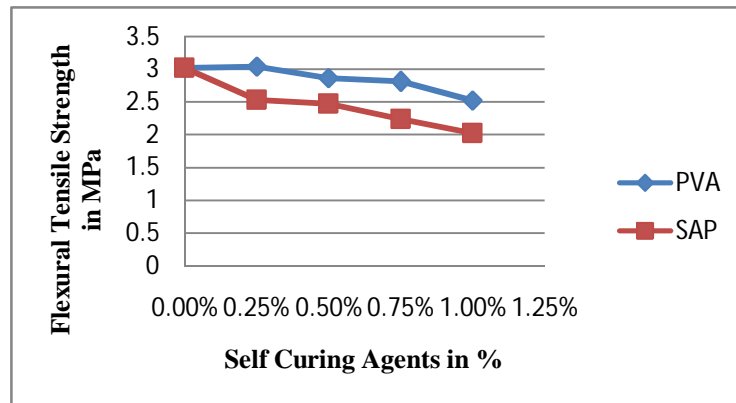


Fig 8. Variation of Flexural tensile strength

V. CONCLUSION

1. From the experimental work, it can be concluded that, concrete with self curing agent PVA attained strength equal to normal curing concrete where as self curing concrete with self curing agent SAP did not.
2. The optimum dosage of Poly Vinyl Alcohol for maximum strength properties was found to be 0.25% for M25 grade of concrete.
3. The compressive strength of concrete increased by 5.63% with PVA over M25 grade normal cured concrete.
4. The split tensile strength of concrete increased by 5.26% with PVA over M25 grade normal cured concrete.
5. The flexural tensile strength was attained with PVA.
6. Mechanical properties are decreased, when Super absorbent polymer is used as a self curing agent for M25 grade of concrete.
7. Strength of self curing concrete is on par with conventional concrete.
8. In desert countries and in high rise structures improper curing can be prevented by adopting Self Curing Concrete.

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