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Influence of Fibres on Fresh and Hardened Properties of Self-Curing Concrete

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Abstract: Concrete is the most widely used construction material owing to its good compressive strength and durability in this present scenario. Depending upon the nature of work, cement, fine aggregate, coarse aggregate and water are mixed in specific proportions to produce plain concrete. Plain concrete needs a congenial atmosphere of moisture for a minimum period of 28 days for good hydration and desired strength. Any laxity in curing will badly affect the strength and durability of concrete. Self-curing concrete is one of the special concretes that mitigate insufficient curing due to human negligence. Paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the water is contaminated by fluorides will badly affect the characteristics of concrete. The present study involves the use of super-absorbent polymer admixture in concrete which helps in self curing and assists in attaining better hydration and strength. Here, the effect of admixture SAP and fibre on compressive strength, split tensile strength and modulus of rupture by varying the percentage of admixture by weight of cement is found. The grade of concrete selected for this study was M40. It was found that SAP could help in self curing by providing strength on par with conventional curing. The dosage of self curing agent is 0.3% by weight of cement and polypropylene fibre varying from [0.1%-0.5%] by weight of cement. It was found that 0.3% of SAP and 0.3% of polypropylene fibre by weight of cement was optimum for M40 grade concrete for achieving maximum strength without compromising workability.

Keywords: *Curing, Self-curing Concrete, Self-curing Agent, Fibrous Self-curing Concrete, super-absorbent polymer, Polypropylene Fibre*

Introduction:

Curing of concrete is an important process during the first hours after casting to maintain optimal conditions for cement hydration and for assuring the required durability and strength of the hardened concrete, thus enabling a high performance of the structure during its service life. Therefore, to maximize the degree of hydration of cement and possibly that of the supplementary cementitious materials [SCM] and to reduce early shrinkage cracking [autogenous shrinkage, plastic shrinkage, and drying shrinkage], it is important to apply effective curing techniques during an extended period of time. 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. 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. The ACI-308 Code states that "internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing Water."Conventionally, curing means creating conditions such that water is not lost from the surface i.e., curing is taken to happen 'from the outside to inside'. In contrast, 'internal curing' is curing 'from the inside to outside' through the internal reservoirs (in the form of saturated lightweight fine aggregates, superabsorbent polymers, or saturated wood fibres) created. 'Internal curing' is often referred as 'Self–curing.

Significance of Self-Curing:

When the mineral admixtures react completely in a blended cement system, their demand for curing water [external or internal] can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, significant autogenous deformation and [early-age] cracking may result [4]. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may Super-adsorbent polymer: GFP- 1605

Materials Used:

A. Cement

Portland Pozzolana Cement, 53 Grade conforming to IS 12269 – 1987

B. Fine Aggregate

Locally available sand conforming to grade zone II of IS 383 –1970

C. Coarse Aggregate

Crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS 383 – 1970

D. Super plasticizers

Conplast Sp 430

Table I. Superplasticizer Properties

Specification	Values
Colour	Brown
Specific Gravity	1.22 to 1.225
Chloride Content	Nil
Solid Content	40%

E. Fibre: Polypropylene

Table II. Polypropylene Properties

Specification	Values
Specific gravity	0.9
Length	38mm
Diameter	0.1mm
Aspect Ratio	380

F. Super-absorbent polymer: GFP- 1605

Table III. SAP Properties

Specification	Values
FORM-dry	white powder
FORM-wet	Transparent gel
Particle size	0-1 mm
Absorption in distilled water	800 g for 1 g
Absorption in sea water	40 g for 1 g
pH of absorbed water	Neutral
Density	1.08
Particle size	0-1 mm
Absorption in distilled water	800 g for 1 g
Absorption in sea water	40 g for 1 g
pH of absorbed water	Neutral
Density	1.08

F. Water

Water used was fresh, colorless, odourless and tasteless potable water that was free from cause early-age cracking organic matter of any type.

Mix Design:

The mix proportions were carried out based on IS 10262-[2009] to achieve M40 grade. Mix design can be defined as the process of selecting ingredients of concrete and determining their relative proportions with the objective of producing concrete of certain minimum strength and durability as economically as possible in plastic and hardened states. The mix proportions of different mixes are shown in Table 4. SAP particle absorbs water in fresh concrete, as long as there is water in the SAP reservoirs [2], the concrete does not desiccate and thereby it is possible to mitigate autogeneous shrinkage.

Table IV. Mix Proportion of Concrete Developed

Mix	Cement kg/m^3	FA kg/m^3	CA kg/m^3	SAP %	Fibre %	Water lit/m^3	S.P [lit/m^3]
C M	395	715.28	1150	----	-----	158	4.7
SCC	395	715.28	1150	0.3	-----	211.3	4.7
FSC C1	395	715.28	1150	0.3	0.1	211.3	4.7
FSC C2	395	715.28	1150	0.3	0.2	211.3	4.7
FSC C3	395	715.28	1150	0.3	0.3	211.3	4.7
FSC C5	395	715.28	1150	0.3	0.5	211.3	4.7

CA = Coarse aggregate, FA = fine aggregate, SAP = Super absorbent polymer, SP = Super plasticizer

V. Method of experiment:

It is important that the constituent material of concrete remain uniformly distributed within the concrete mass during the various stages of handling and that full compaction is achieved, and making sure that the characteristics of concrete which affect full compaction like consistency, mobility and compatibility are in conformity with relevant codes of practice.

The tests were carried out in accordance with relevant IS Standards. The aggregates were tested for physical properties such as: specific gravity and particle distribution test.

The fresh concrete was subjected to the slump test followed by casting of concrete in moulds for further investigations. All the mixes were prepared by mixing the concrete in laboratory mixer along with water and super plasticizer. For compressive strength studies 36 cube specimens of size 150 mm x 150 mm x 150 mm, for flexural strength studies, 36 prism specimens of size 100 mm x 100 mm x 500 mm and 36 cylinder specimens of size 300 mm height and 150 mm diameter for split tensile strength studies were prepared. All the specimens were cast and cured for 28 days as per standard curing methods.

VI. Research program:

The experimental program was designed to investigate the strength of Self Curing concrete by adding super absorbent polymer [GFP-ABSORB 1605] and Polypropylene fibre at 0.1%, 0.2%, 0.3%, and 0.5% by weight of cement to the concrete. It was aimed to study the workability, compressive strength, split tensile strength and modulus of rupture.

A. Slump Test

Adequate workability is required for proper placement, consolidation and finishing of concrete. The workability has been investigated at varied volume of fibre and SAP as constant.

B. Compressive Strength

The cube specimens were tested on compression testing machine of capacity 3000KN as per IS 516-1959 (1959).The bearing surface of machine and specimen was wiped off clean. The specimen was placed in machine in such a manner that the load was applied to opposite sides of the cubes as casted that is, not top and bottom. The axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. fc = P/A , where, P is load & A is area.

C. Splitting Tensile Strength

The cylinder specimens were tested on compression testing machine of capacity 3000KN IS 5816-1999 [1999]. The bearing surface of machine and specimen was wiped off clean. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded fsplit =2 P/πDL, where P=load, D= diameter of cylinder, L=length of the cylinder.

D. Modulus of Rupture

The prism specimens were tested on universal testing machine for two-point loading to create a pure bending as per IS 9399-1979 [1979]. The bearing surface of machine and specimen was wiped off clean. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained.

VII. Results and Discussion:

E. Slump test

Table V Slump Cone Test Result

Mix	Slump Values[mm]
CM	82
SCC	115
FSCC1	124
FSCC2	132
FSCC3	146
FSCC5	118

F. Compressive strength

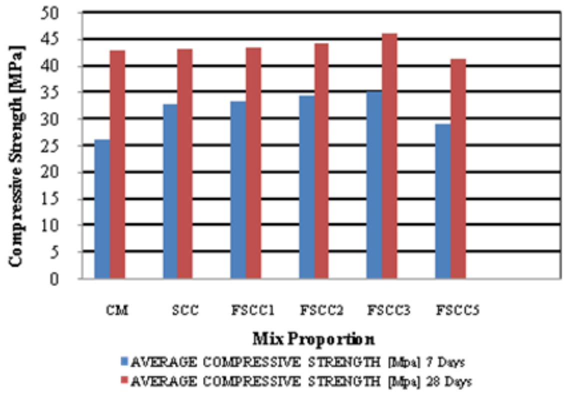

Fig 1. Compressive Strength of Concrete Specimens

G. Split tensile strength

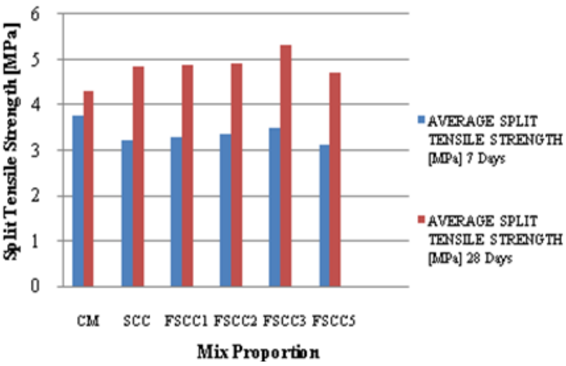

Fig 2. Split Tensile Strength of Concrete Specimens

H. Modulus of Rupture

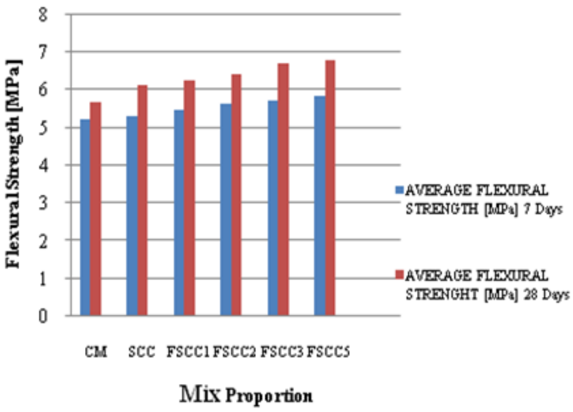

Fig 3. Modulus of Rupture of Concrete Specimens

VIII. Conclusion:

Super-absorbent as an internal curing agent and polypropylene fibre is used for the investigation. Based on the experiment work carried out, the following conclusions were determined. By addition of SAP and fibre, significant increase in Compressive, Split tensile and flexural strength was found. The effectiveness of internal curing by means of SAP applied to concrete is the highest if 45 kg/ m3 water is added by means of 1 kg/m3 SAP. Compressive strength of fibrous self curing concrete was higher than conventionally cured concrete and self curing concrete. Split tensile strength of fibrous self curing concrete was higher than conventionally cured concrete and self curing concrete. Flexural strength of fibrous self curing concrete was higher than conventionally cured concrete and self curing concrete. The optimum dosage of super-absorbent polymer is of 0.3% of cement content. The optimum dosage of polypropylene fibre is of 0.3% of cement content. There was a gradual increase in the strength for dosage from 0.1 to 0.3% of fibre content but later, it is gradually reduced.

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