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Prospects of Using Super Absorbent Polymer in High Strength Concrete

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Abstract

Superabsorbent polymers (SAP) are compounds that are able to absorb water increasing their mass and volume, resulting in mass exceeding the initial value by hundreds times or more. In terms of concrete technology, the laboratory tests results indicate that the SAP absorption capacity in tap water is about ten times higher than in the environment of liquid solution of alkali content which is to simulate the cement paste environment. Curing of concrete is the process of maintaining the temperature and moisture conditions of concrete for hydration reaction so concrete develops hardened properties over time. However, proper curing isn't always attainable in several cases. Curing of concrete plays a serious role in developing the concrete micro-structure and pore structure and hence improves its durability and performance. By considering relevancy of curing, an attempt has been made to develop self-curing concrete by using Super Absorbent polymer as self-curing agent. Compressive strength of concrete containing SAP is investigated and compared with convention concrete. SAP will increase the water retention capability of the concrete by reducing evaporation of water from concrete.

Keywords: *Super Absorbent polymer, Curing, Compressive strength, split tensile strength*

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INTRODUCTION

Superabsorbent polymers (SAPs) have the interesting feature to absorb up to 500 times their own weight in aqueous solutions due to osmotic pressure, resulting in the formation of a hydro gel. Nowadays, they are used in the hygiene and medical industry as care articles or smart pills, and they can also be used for fire fighting or food packaging [1]. The main SAPs are based on cross-linked Poly (Acrylic Acid) (PAA) containing long chains of linear polymers which are interconnected at several points. Due to osmotic pressure, water is absorbed and the space in between the chains and the cross links (free volume) thus expands.

It is this expansive action which makes the polymer interesting and it took only a matter of time until this polymer also found its way as an additive in cementations materials [2]. SAPs can be used in cementations materials for reducing the autogenously shrinkage [3–6] for changing the reality of the fresh material [5–7] for increasing the freeze/thaw resistance [8, 9] for self-sealing [10–12] and even to promote autogenous healing [13, 14]. During preparation of a concrete mixture, the SAPs will take up mixing water. This swelling capacity is dependent on the composition of the mixture and the composition of the SAPs as the osmotic pressure force is dependent on the external fluid composition and the chemical structure, length and cross linking degree of the SAP. The SAPs will thus form water-filled inclusions, useful for internal curing [3].

The water present in the SAP will hereby be released into the cementations matrix due to the drop in relative humidity. In this way, the internal relative humidity is maintained. The SAP particles shrink and an empty macro pore remains as shown by means of neutron tomography measurements [15].

EXPERIMENTAL PROGRAM

Materials

Cement: Ordinary Portland cement (OPC) conforming to Grade 53, is used in the proposed work. Cement used conforms to IS: 8812-1989 & IS: 12269-1987 respectively.

Fine Aggregate: It is the aggregate most of which passes through a 4.75 mm IS sieve and contains only that much coarser material as is permitted by specifications. Sand is generally considered to have a lower size limit of about 0.07 mm. The

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sand used in this investigation is ordinary river sand obtained from the banks of Tungabhadra River. The sand is free from clayey matter, silt and organic impurities etc. The sands are commonly isolated into various zones as indicated by the rates passing the IS: 600 micron strainer. IS: 383-1970 groups the sand into four zones, I, II, III and IV with the goal that the scope of rate passing the 600 micron sifter in each zone doesn't cover. The sand utilized for the current examination falls in zone-II according to as far as possible.

Coarse Aggregate: The aggregates most of which are held on 4.75 mm IS sifter and contain only that much of fine material as permitted by the specifications are termed as coarse aggregates. 20 mm nominal size of coarse aggregate was utilized in the experimentation. A graded aggregate of nominal size 20 mm means an aggregate most of which passes the 20 mm IS sifter. Since the aggregates are formed due to natural disintegration of rocks or by the artificial crushing of rock or gravel, they derive many of the properties from the parent rocks.

The physical properties have been determined in accordance with the guidelines mentioned in IS: 2386-1963.The coarse aggregate was free from clayey matter, silt and organic impurities etc. The specific gravity of the coarse aggregate was 2.71 and fineness modulus was 3.79.

Water:

Potable water free from suspended solids and organic materials was used. The water utilized for both blending and curing of concrete was free from polluting influences, damaging measures of acids, antacids, oils, salts, natural issue or different substances that might be malicious to cement or steel. The presence of chlorides and sulfates are injurious to reinforcing bars as they may be corroded. The general requirements of water for blending and curing of concrete shall be as per guidelines of IS 456- 2000.

Super Absorbent Polymer:

Sodium polyacrylate polymer of medical grade is being utilized as SAP in the current experimental work. The particle size of which varies from 410 to 300 microns. The specific gravity is found to be 1.08 and it has a capacity of absorbing water up to 300 – 400 times. The water mixed with cement may absorb up to around 70 to 80 times.

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Mix Proportions

Table- I: Mix Proportions for M60 grade of concrete

Cement	428 kg/m^3	1
SCM	102 kg/m^3	0.27
Fine Aggregate	694.82 kg/m^3	1.39
Coarse Aggregate	20 mm – 815.28 12.5 mm – 198.75	2.11
Water	149 kg/m^3	0.28
SP	58 kg/m^3	0.12

Methods

This exploration was led in the laboratory to decide the conduct of the concrete in terms of mechanical quality and durability properties. The extent of work covers the mechanical and physical properties of high strength concrete with the addition of SAP.

The mechanical properties of solidified concrete were attempted through the compressive strength test with cubes 150mm × 150mm × 150mm shape. The cube samples were tested at the ages of 7 and 28 days after the wet curing process at the restoring tank in agreement to strategies of IS 9013: (1978). The split tensile strength was carried out on the standard test cylinder of concrete specimen of 150 mm diameter and 300 mm height. This test was carried out as per IS: 5816-1970.

The fresh properties of the green concrete are resolved through the slump test for the best workability, it is done as per IS 1199 - 1959, for sampling at site and at the lab. The chemical admixture utilized in this examination was SP 430 Conplast super plasticizer. It is required because of the lower use of water to deliver high strength GGBS concrete that would influence the workability of new concrete. Modification was being made to guarantee the best usefulness acquired with best flow slump without endangering the concrete quality.

It is utilized at a measurement rate, 2% of the cement by weight. The cementations materials were mixed for 4 to 5 minutes in a mechanical blender at a speed of 80 rpm to ensure homogeneous blending. Water was then included and mixed with all the supplementary cementations materials for 5 minutes, followed by 2 minutes resting period to scratch off any unmixed powders from the paddle sides of the blender and

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including them into the mixing bowl. The mixing was continued for an additional time of 5 minutes before placing the fresh concrete in 3D shaped molds. After complete mixing, the fresh paste was placed into 150 mm cube moulds and vibrated for 1 minute to expel air bubbles. Immediately after casting the moulds were covered with a polyethylene sheet to dodge any evaporating of water from the surface of the samples.

Table- II: Compression & Split Tensile Test Results

Mix	Mixture	Compressive Strength (N/mm^2)		Split Tensile Strength (N/mm^2)	
		28-D	90-D	28-D	90-D
M-1	0	61.12	62.54	5.02	5.79
M-2	0.1	61.78	63.87	5.39	5.53
M-3	0.2	63.32	65.37	5.46	6.01
M-4	0.3	65.62	68.82	6.33	6.41
M-5	0.4	63.13	62.86	5.21	5.45

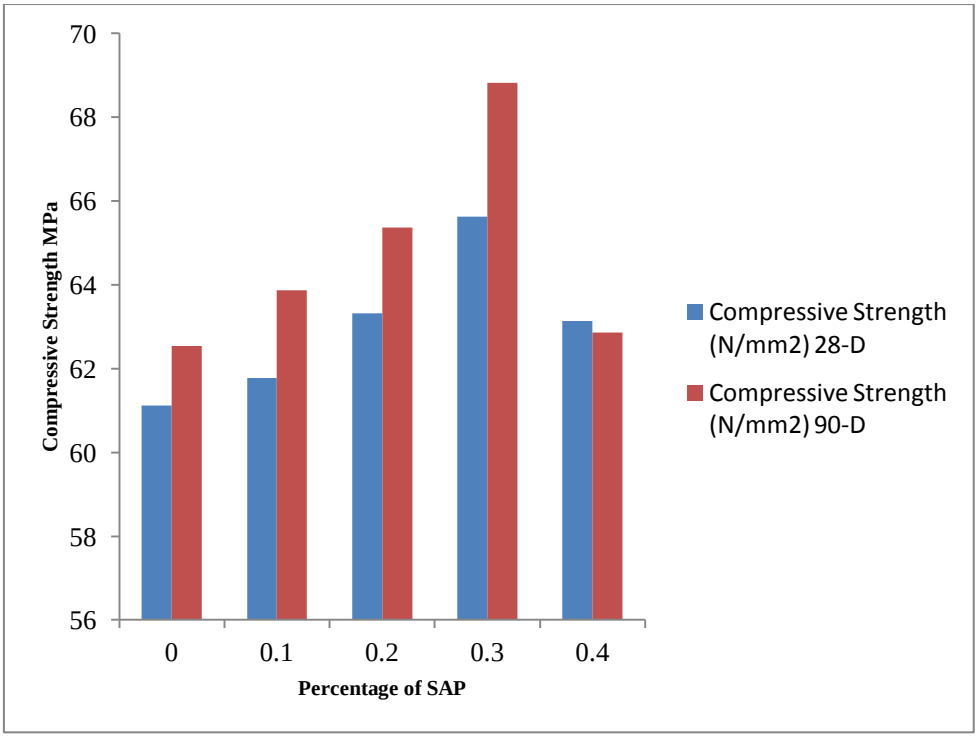


Fig. 1 Variation of Compressive Quality with %age of SAP

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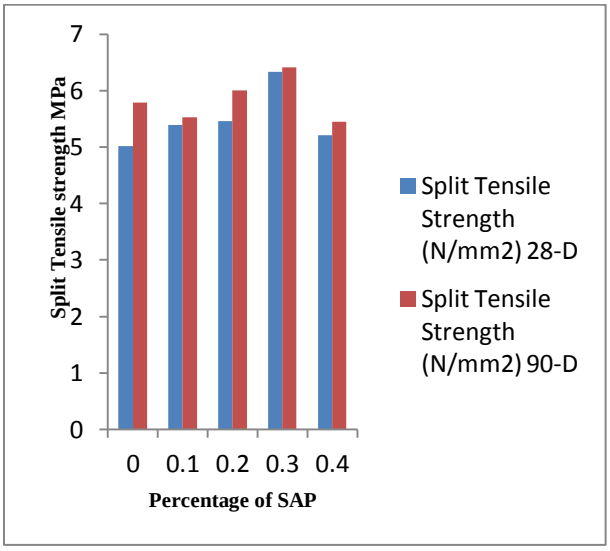


Fig. 2 Variation of Split Tensile Strength at Different Ages



Fig.3 Testing of cube specimen



Fig.4 Testing of cylindrical specimen

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RESULTS AND DISCUSSION

It may be noted that the pore structure of concrete tends to be refined when SAP is added. This is because the addition of SAP can improve the water distribution in the concrete and optimize the hydration process of the cementitious material. Especially during the middle and later ages of the development of cement matrix, it is more favorable for SAP to release water; to promote the pozzolanic reaction which leads to the development of calcium silicate hydrate gel. This can explain the reasons for the increase of compressive strength and durability. The hydration reaction is facilitated by the internal curing effect, and the hydration product fills the existing pores.

Additionally, the initial micro-cracks of the cement mortar are reduced and the autogenous shrinkage of the cement matrix is relieved. The compressive strength and split tensile strength of the SAP curing concretes at 28 days and 90 days are basically higher than referral mix, which indicates that the internal curing effect of SAP has been effectively worked. Although the early water absorption of SAP results in larger voids, which exerts negative effect on strength, the internal curing water is better stored and is beneficial to release water in the later stage of SAP to meet the second hydration reaction when SAP is added in concrete. And the compressive strength is further improved effectively. This trend keeps on growing with the advancement of the age.

CONCLUSIONS

- High strength concrete can be produced by using super absorbent polymers
- Long term mechanical attributes are more effective than instant effects due to the addition of SAP
- Compressive strength gradually increased with the advancement of age. The same trend is also noticed with respect to split tensile strength
- The most suitable percentage of SAP was found to be 0.3
- The above conclusion gives clear picture that there is no damage in using SAP in production of high strength concrete
- Still, more tests should be carried out in order to prove the quality of concrete containing super absorbent polymers.

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