Self-Curing Concrete by using Super Absorbent Polymer

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***Abstract*— The use of super absorbent polymer (SAP) in concrete is proven to have many positive effects on the properties of concrete in its both stages; fresh concrete and hardened concrete. This study focuses on the use of an optimum amount of Sodium Polyacrylate as a super absorbent polymer in ordinary plain concrete. One of the major improvements that the SAP can contribute to the concrete is by providing internal water source. This internal water source acts as internal curing agent after the final setting of concrete. At the same time the SAP releases water at relatively slower rate at the fresh concrete stage. The SAP also provides additional voids in the concrete mass. These voids affect the concrete strength negatively at the same time improve the concrete performance by improving the concrete workability and placeability, reducing the concrete susceptibility to freezing thawing cycles, and improving concrete stability. The main focus of this study will be on the effect of the SAP on the fresh concrete as well as the hardened concrete. Several batches were prepared to determine the effect of the SAP on concrete when subjected to compressive, tensile and flexural stresses.**

Keywords – Concrete Curing, Concrete Strength, Gel, Super Absorbent Polymer, Voids.

I. INTRODUCTION

The SAP absorbs water and converts it into gel, then releases it slowly with time. This property was very useful when it comes to watering plants over time. This study showed similarity between concrete and plants when it comes to the need of continuous water supply. Excess amount of SAP will leave the concrete with large amounts of voids, which in turn reduces the concrete strength and durability. Small amount of SAP, on the other hand, will have negligible effect on the concrete performance. The amount of water added to the fresh concrete is one of the most important key factors that affect the concrete properties, including durability and strength. The water is an essential ingredient needed for the hydration process in the fresh concrete and for the curing process in the hardened concrete at its early stages.

Excessive amount of water added in the fresh concrete improves the concrete workability in general, reduces the concrete strength, and increases the drying shrinkage of the hardened concrete. Different admixtures were used to reduce the amount of water demand in the fresh concrete without jeopardizing the workability. Water reducer admixtures were used extensively in the ready mix plants. The most common admixture used nowadays is the superplasticier which is water reducer and at the same time retarder. The water gel created in concrete by the use of SAP provides cushioning and lubrication in the concrete mass which in turn improves the concrete workability as well as concrete stability. Jensen (2013) used superabsorbent polymers in concrete. His study focused on the strength and shrinkage of concrete. He concluded that the shrinkage of concrete dueto loss of water to the surroundings is the cause of cracking both in the plastic and in the hardened stage. This type of cracking can effectively mitigated by slowing down the water loss. The superabsorbent polymers use in concrete has the potential to reduce concrete cracking. Jensen and Hensen (2001) studied the autogenous shrinkage phenomena in concrete. They concluded that the autogenous shrinkage may lead to cracking and affect concrete strength and durability, which is also, can be considered as technological challenge of high performance concrete. Addition of superabsorbent polymer in the ultrahigh- performance concrete can be used to control the autogenous shrinkage. They also conducted tests that show that the shrinkage reduction due to superabsorbent polymer is related to a corresponding increase in the internal relative humidity of the cement paste. In addition, the use of superabsorbent polymer in concrete resulted in a reduction or elimination of stress build up and related cracking during restrained hardening of these high-performance cementitious systems (Jensen and Hensen 2002). Al-Nasra (2013) studied the use of Sodium Polyacrylates as SAP in concrete. His study focused on determining the optimum amount of SAP to be added to the concrete in order to maximize the strength and durability of concrete. Al-Nasra concluded in his study that the optimum amount of SAP is 0.11 percent of cement by weight, which he showed to be the most effective amount to be used in concrete.

The use of superabsorbent polymer in concrete is also useful in frequent freeing-thawing cycles environment, by providing the concrete frost protection. The superabsorbent polymers particles shrinks during the hydration process leaving voids in the concrete similar to the voids created by adding air entrainment agent to the concrete. The air bubbles left in the concrete are critical to absorb the hydraulic pressure due the water freezing. Water expands upon freezing about ten percent in volume generating hydraulic pressure in the concrete that has the potential to cause the concrete to crack. Providing voids in the concrete absorb the hydraulic pressure and provide addition space for the water to expand. The same can be said about the osmotic pressure in the concrete. The osmotic pressure is usually generated due to the difference in salt concentration in the water. This difference in salt concentration can be created by adding deicer to the concrete top surface, for the purpose of melting the ice on the concrete. Also these voids can be useful to absorb other kinds of internal pressures inconcrete including alkali reactivity pressure. Snoeck et al (2012) studied the use of superabsorbent polymers as a crack sealing and crack healing mechanism in cementitious materials. Their research focused on the use of the superabsorbent polymer to seal concrete cracks. As concrete cracks due to its low tensile strength and as harmful unfriendly chemicals may migrate into these cracks, the durability of concrete is endangered if no proper treatment or manual repair is applied. The first stage focused on hindering the fluid flow by swelling of superabsorbent polymers after they are exposed to a humid environment. The sealing capacity was measured by means of water permeability tests and through visualization of permeability tests by neutron radiography. They also concluded that the use of superabsorbent polymers is able to seal cracks and thus allow a recovery in water-tightness as a decrease in permeability is noticed. The second stage focused on healing of small cracks by the use of fiber reinforced cementitious materials that have the ability to restore the mechanical properties. These mechanical properties were analysed by four-point-bending tests and the crack closure was microscopically monitored. Cracks close through the combination of further hydration of un hydrated cement particles, precipitation of calcium carbonate and activation of the pozzolanic reaction of fly ash. Also they concluded that the desorption of superabsorbent polymers triggers healing in the vicinity of crack faces and cracks up to 130 μm were able to close completely in wet/dry cycles due to the precipitation of calcium carbonate. The process of curing involves maintaining satisfactory moisture content and temperature after concrete is placed in order to hydrate the cement particles and produce the desired hardened concrete properties. Proper curing can improve strength, durability, abrasion resistance, resistance to freeze-thaw cycles, deicer scaling resistance and reduce concrete shrinkage. Traditionally, concrete has been cured externally either through the use of water curing or sealed curing. Curing either supplies additional moisture from the original mixing water or minimizes moisture loss from the concrete. Water may be bonded directly on the concrete surface or may use other methods like wet burlap bags or fogging near the surface of the concrete to prevent evaporation of water from the fresh concrete. Sealed curing is accomplished by applying some sort of sealant to the surface of concrete in order to prevent moisture loss. Internal curing can be divided into two categories. The first category is internal water curing in which an internal curing agent stores water during mixing which is gradually released as hydration processes. The second category is internal sealing which is very similar to external sealed curing in that its goal is to prevent the loss of moisture from the concrete (RILEM, 2007).

II. LITERATURE REVIEW

K. Nithya et al., [1] examined that the strength variations in concrete by using Super Absorbent Polymer and polyvinyl alcohol as shrinkage reducing admixtures. Super Absorbent Polymer concrete has excellent compressive strength and is suitable for structural application. It was the establish the compressive strength, flexural strength, tensile strength. The compressive and tensile strength of self-curing concrete for 7 and 28 days is found out and compared with conventional concrete of similar mix design. S.Rajeswari et al., [2] This paper explained Super absorbent polymer is able to absorb a significant amount of liquid from its surroundings and will retain the liquid with its structure without dissolving. SAP's are added at rate of 0-0.6 wt% of cement. M 30 grade if concrete was produced using Super Absorbent Polymer from 0.1 to 0.4% by weight of cement as an internal curing agent and studied the characteristics of self-curing concrete with addition of 2% steel fibers by volume if concrete. this paper from studies it was concluded that the strength increases at different proportions of polyethylene glycol that is 1% is optimum for M20 and M25 grade 0.5% for M40 grade. M.Srihari et al., [3] This paper explained compressive, tensile and flexure strength tests were conducted at the 7 and 28 days. Mix is used to produce concrete with 0.5%, 1%, 1.5%, 2% PEG and 0.1%, 0.2, 0.3% and 0.4% SAP. The common Super Absorbent Polymers are added at rate of 0-0.6 wt% of cement. It has been observed that the compressive, tensile and flexure strength is maximum at 1% PEG and 0.3% SAP. Super absorbent polymer gives better results than polyethylene glycol and more economical than PEG. Vinayak vijapur et al., [4] This explained about the to produce M30 grade of concrete using super absorbent polymer as an internal curing agent in Self curing Technique and to study the characteristics of self-curing concrete with addition of steel fibers that 2% by volume of concrete. To promote the rate of hydration of cement using SAP to achieve higher strengths. From this paper the effect dosage of super absorbent polymer ranges from 0.1% to 0.4% by weight of cement mechanical properties of concrete that compressive strength, split tensile strength, flexure strength shear strength and impact strength. Finally concluded that the workability of steel fiber reinforced concrete at an optimum dosage of 0.3% of super absorbent polymer. Then the compressive, tensile, flexure strength of steel fiber reinforced concrete has increased with increase in various percentage dosages of addition of super absorbent polymer.

T.Mazur et al., [5] This paper presents the relationship between compressive strength, modulus of elasticity, water and chloride permeability with water cement ratio for internal curing concrete. Generally harden concrete is characterized by its compressive strength and density. The Super plasticizer was used to increase \workability of polymer used concrete mix. Conclusion of this paper is less than 10% or more than 30% replacement by burnt clay chips can be considered as not necessary for internally cured concrete. Also from the equations of SAP expected results of strength and durability can be calculated for any water cement ratio.

Kenneth Sequeira et al., [6] this paper explained the compressive strength of material with super absorbent polymer is lesser than that of reference mix in general. The optimum dosage of 0.15% by weight of cement and 30kg/m3 of internally cured water it has a slightly higher value The compressive strength carried out at 3,7, and 28 days with the average of three samples being taken at the above dates. Its is found that the compressive strength of the sample with optimum dosage of SAP is found to be greater than that without SAP if only marginally

Rajiv Chandak et al., [7] In the present study, the effect of super absorbent polymer on compressive strength by varying the percentage of SAP by weight of cement from 0.2%, 0.3% and 0.4% were studied for both mixes M20 and M30 and it is compare with same grade of concrete which is made by conventional method. It was found that sap could help in self-curing by giving strength on par with conventional curing. The common SAPs are added at rate of 0.3, 0.3 and 0.4 wt % of cement. It is seen that more than 50% swelling occurs within the first 5 min after water addition. The conclusion of this paper the self cured concrete using SAP was more economical than conventional cured concrete and the optimum dosage is 0.3% addition of SAP leads to a significant increase of compressive strength.

Fazhou Wang et al., [8] This paper investigates the application of SAP as an internal curing agent in high-strength concrete. It is indicated by optimizing the dosage of SAP, a trade-off can be reached to maintain a desired internal curing effect without seriously undermining the mechanical strength of high-strength concrete and the related mechanism is illustrated by the water release process of SAP in cement paste using a cracking viewer. This work will offer a fresh look on the application of SAP in high-strength concrete. the conclusion of this paer water entrained by SAP is almost exhausted within hydration of cement paste for 7 days numerous pores will be left during the water-release process of SAP and the pre structure is influenced by SAP dosage and the entrained water. The former mainly influences porosity of cement paste, and the latter mainly influences pore size and its distribution in cement paste.

B. Vijaya Rangan et al., [9] examined that the SAP-based g concrete has excellent compressive strength and is suitable for structural applications. The salient factors that influence the properties of the fresh concrete and the hardened concrete have been identified. The paper has identified several economic benefits of using SAP based geopolymer concrete.

III. MATERIALS

4.1 Super Absorbent Polymer

Super absorbent polymer is a group of polymeric material. SAP is a new method for prevention of self-desiccation Most SAPs are cross-linked polyelectrolytes. SAP is able to absorb a significant amount of liquid from its surroundings and will retain the liquid within its structure without dissolving. Commonly SAPs are added at rate of 0-0.6 wt % of cement. They are covalently cross-linked and are Acrylamide/acrylic acid copolymers. The swelling time depends especially on the particle size distribution of the SAP. SAPs are non-toxic and non-corrosive materials which have capacity of absorption of water up to 250-300 times of its own weight.

In the present work Super Absorbent Polymer was used for the Investigation and their properties are tabulated as quoted in table 4.1

4.3 Coarse Aggregate

In this present investigation, locally available crushed granite aggregate was used, as per IS 383-1970, coarse aggregate in sieve size 20mm passing and 4.75mm retaining in saturated surface dry (SSD) condition were used.

Table 4.1. Physical Properties of Super Absorbent Polymer

S.NO	Types of Test	SAP
1.	Particle size	1 mm(average)
2.	Water absorption	150g for 1g of SAP
3.	pH of absorbed water	Neutral
4.	Density	1.08
5.	Hydration/Dehydration	Reversible
6.	Bulk density	0.85
7.	Decomposition in sun light	6 months
8.	Available water	95% approx..

Figure 4.1 Super Absorbent Polymer

Figure 4.3 Coarse Aggregate

4.4 Fine Aggregate

The locally available river sand was used as fine aggregate in the present investigation. The sand was screened at site to remove deleterious material and tested as per procedure given in IS: 383-1970.

Figure 4.4 Fine Aggregate

IV. EXPERIMENTAL PROCEDURE

Constituents of Super Absorbent Polymer concrete are as shown below based on mix design of B.V.Rangan.

Table 5.1:Mix ratio of the materials used for 1m^3 as per the code IS 10262:2009

Materials	Water	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
Quantity	425	763.65	1018.48
Ratio	0.45	1.75	2.39

5.1 Casting of specimens

Before casting of specimens the moulds were tightened by using screw and then it is oiled.

5.1.1Batching

In batching concrete, the quantity of fly ash, fine aggregate and coarse aggregate shall be determined by mass and sodium silicate and sodium hydroxide solution measured in volume or mass.

5.1.2Mixing

Mixing can be done by following two process in geopolymer concrete using pan mixer.

Dry Mixing

The fly ash, coarse aggregate and fine aggregate were mix together. The mixing time shall be at least 3 minutes.

Wet Mixing

Then the sodium silicate and sodium hydroxide solution was mixed with dry solid for 3minutes water would be added if any necessity (3% of water).

5.1.3 Moulding , Compaction and Surface finishing

- After the wet mixing the moulding process was done by following two methods
- Super Absorbent polymer concrete was compacted in mould of three layers with 25 manual strokes. For each layer is compacted by the tamping rod. The Compacted mould surface was finished by trowel.

5.1.4 Curing of specimens

- After 24 hours, the specimens were demoulded and the specimen was kept at respective curing condition.
- Curing is the process of preventing the loss of moisture from the concrete while maintaining a satisfactory temperature regime.
- The Casted moulds are being in free place at the room temperature.

V. TEST CONDUCTED

A strength test were conducted for geopolymer concrete such as

(i) Compressive strength test for 7,14 and 28 days
(ii) Split tensile test for 28 days
(iii) Flexural strength test for 28 days

(i) Compressive Strength

It was found that the compressive strength for control mix is 40.3 MPa at 28 days.

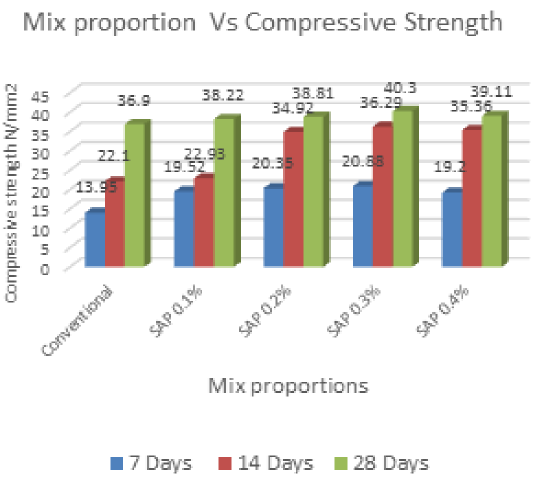

Fig 6.1 Avg. Compressive strength of SAP polymer concrete with adding different %

(ii) Split tensile test

Split tensile test was carried out for control mix and optimum percentage for the age of 28 days.

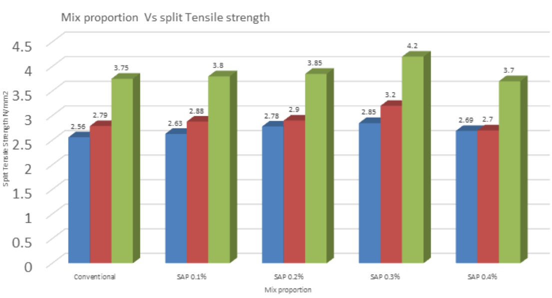

Fig 6.2 Average Split tensile strength of SAP polymer concrete

(iii) Flexural strength test

A Flexural strength test was carried out for control mix and optimum percentage for the age of 28 days.

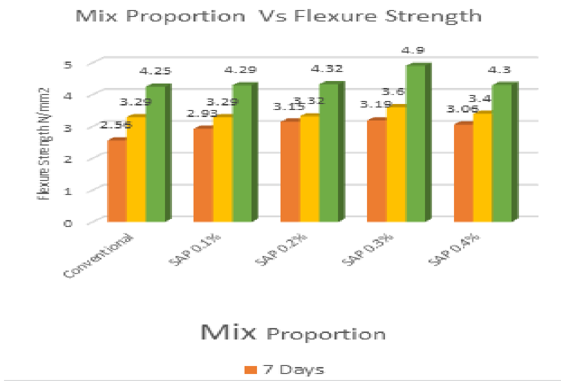

Fig 6.3 Average Flexural strength of SAP polymer concrete

VI. CONCLUSIONS AND RECOMMENDATIONS

1. The optimum dosage of SAP for addition for maximum strengths was found to be 0.3% for M30 grade of concrete.
2. Addition of SAP leads to a significant increase of Compressive, tensile and flexure strengths.
3. The self-cured concrete using SAP was more economical than conventional cured concrete.
4. Self-curing concrete is reducing the improper curing problems.

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