# Strength and Durability Study on Fly-ash Concrete Blended with Superabsorbent Polymer

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**Abstract -** *Superabsorbent polymer, also known as Sodium polyacrylate, plays an important role in concrete because it can absorb and hold incredibly large quantities of liquid compared to its own mass. The use of (SAP) superabsorbent polymer to achieve internal curing and crack sealing was investigated in this research. This polymer absorbs liquid using osmotic pressure and is engineered specifically for water absorption and retention. The addition of SAP to concrete alters its properties, such as void packing, shrinkage resistance, and workability. Internal curing will improve cement hydration and, as a result, it will reach "Higher Lateral Strength." To improve lateral strength, flyash is substituted with (PPC) Portland pozzolana cement in a constant proportion of 2%. SAP is applied to plain concrete in various proportions of 0.2 percent, 0.3 percent, and 0.4 percent of weight of cement, with 2% of flyash replacing cement. The primary aim of this research is to compare the effects of fresh and hardened M30 concrete mix with SAP to traditional concrete. It has been established that the most innovative, effective, and safe superabsorbing polymers available on the market today.*

***Key Words***: **Internal Curing, Superabsorbent polymer, Flyash, Concrete, Sealing of the cracks.**

## 1. INTRODUCTION

Cross-linked polymers known as superabsorbent polymers (SAP) absorb, swell, and hold a considerable volume of liquid without dissolving. In the 1960s, SAPs were first used in personal care items such as nappies. In 2005, global SAP production capacity was estimated to be around 1.48 million tons. SAP is used in concrete technology to increase strength and workability, as well as to avoid shrinkage cracking and leakage through cracks and to cure the concrete internally.

Because of this Water Entraining Properly, Super Absorbent Polymer is most advantageous in the field of agriculture in the early stages. Later researchers pioneered the use of SAP as an additive in concrete. The SAP was used to prevent water from passing through cracks and voids. SAP is mixed into a dry concrete mixture. When water is applied to the mix, SAP absorbs it and retains it, resulting in a 250-fold increase in volume. The retained water is transformed into a gel that fills the voids left by hydration and the freeze-thaw effect. Increased heat of hydration allows water from concrete to evaporate, resulting in the formation of voids. Shrinkage cracks are caused by the expansion and contraction of concrete, which produces a large number of voids. To achieve the highest strength and longevity, concrete structures must be properly cured. Because of the lack of water and the difficulty of curing at such a high altitude, perfect curing cannot be accomplished manually. As concrete needs water that is not readily accessible. Self-curing is the solution to this problem. The addition of SAP to concrete results in internal or self-curing. In desert areas (e.g., Rajasthan), where water is scarce, the advantage of self-curing is more effective. Self-curing concrete is one of the unique concretes for dealing with inadequate curing caused by human error. Water scarcity in arid regions, inaccessibility of buildings in difficult terrains, and areas where the existence of fluorides in the water can negatively affect the properties of concrete Concrete structures must be properly cured in order to satisfy efficiency and reliability criteria. This is accomplished in traditional curing by applying external curing after combining, putting, and finishing. Internal curing is a method for supplying additional moisture to concrete in order to improve cement hydration and minimize self-desiccation. As a result, the most efficient approach for eliminating autogeneous shrinkage is to use a superabsorbent polymer.

## 2. 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 highstrength 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 highstrength 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.

## OBJECTIVES

- Analyse adoption of alternative materials as an aspect of sustainable concrete mix design.
- Study effect of internal curing as a complement to traditional curing in conventional concrete.
- Casting of specimens with aggregate replacement and inclusion of SAP (Super Absorbent Polymer) with varying proportion as an internal curing agent and testing them for Compressive Strength.

● Study the effect of reduced shrinkage on properties of internally cured concrete over conventionally cured concrete through test for strength.

## 3. MATERIALS AND METHODOLOGY

The materials used in the preparation of Concrete are:
1. Cement
2. Fine aggregate i.e., Natural Sand
3. Coarse aggregate
4. Water
5. Fly-ash
6. SAP

To produce good quality of concrete we need good quality ingredients which satisfy the Standards. Hence tests on different ingredients mentioned above are conducted as per IS standards which are presented below. Properties are represented in the form of Tables for every material used in the production of Concrete.

**Cement**

Portland Pozzolana Cement of 43 grade of AMBUJA brand confirming to I.S is used in the present work. The cement is tested for its various properties as per IS: 4031 – 1988 and found to be confirming to the requirements as per IS: 1489-1999 Part-1. In order to avoid the possible variation in the properties of cement from various batches all the specimens are prepared from the same batch of cement. The results of tests concluded on cement are as follows.

Cement - Portland Pozzolana Cement
Brand Name - Birla gold cement
Specific Gravity - 3.1

**Fine Aggregate – Natural Sand:**

Sand which is passed on 4.75mm sieve & retained on 150µ sieve are used

**Physical Properties of Natural Sand**

| S.NO | PROPERTY | VALUE | REQUIREMENTS AS PER IS 383 |
|---|---|---|---|
| 1 | Fine Aggregate | Sand | As per Indian Standards |
| 2 | Specific Gravity | 2.65 | 2.6-2.8 |
| 3 | Water Absorption | 0.25% | Should not be > 1% for construction |
| 4 | Density | 1450 gm/cc | Within the Code Provisions |
| 5 | Fineness Modulus | 2.74 | 2.6-2.9 |

**Table -1: Properties of natural sand**

**Coarse Aggregate:**

The Coarse aggregate is free from clay matter, silt and organic impurities etc. the coarse aggregate is also tested for specific gravity and it is 2.82, fineness modulus of coarse aggregate is 4.07. Aggregate of normal size 20 mm downgraded 60% passed on 20.0 mm sieve and remaining 40% is taken from the sieve 10.0 mm (passing) and 4.75 mm (retained) is mostly used in the experimental works, which is acceptable according to IS: 383– 1970

**Properties of Coarse Aggregate**

| S .no | Property | Value | Requirements as Per IS 383 |
|---|---|---|---|
| 1 | Coarse Aggregate | Machine crushed granite | Within the Code Provisions |
| 2 | Specific Gravity | 2.75 | 2.6 to2.8 |
| 3 | Water Absorption | 0.33% | Should not be >1% |
| 4 | Fineness Modulus | 7.78 | 6.5-8.5 |
| 5 | Shape Tests a)Elongatio | | as per IS 2386part 1, the flakiness |

**Table -2: Properties of coarse aggregates**

**Water:**

About 38% of cement At Normal Room Temperature = 550ml.

**Fly Ash:** Fly ash also called flue ash, or pulverized fuel ash, is a result of coal combustion that is comprised of fine particles of burned fuel. Ash that falls to the bottom of the boiler is called bottom ash. Fly ash, generally, collected by electrostatic precipitators or any other type of particle filtration machine before these flue gases reach the chimney. The constituents of the ash can vary depending upon the source and composition of the coal which is being burnt, but in general, fly ash entails silicon dioxide (SiO2) (amorphous and crystalline), aluminum oxide and calcium oxide.

| CHARACTERISTICS | VALUES |
|---|---|
| Specific gravity | 2.07 |
| Fineness | 290 $m^2$/kg |
| Bulk density | 1100-1200 kg/$m^3$ |
| Colour | Light grey |

**Table-3: Index properties**

## SAP

Sodium polyacrylate, also known as water lock, is a sodium salt of polyacrylic acid with the chemical formula [-CH2-CH(COONa)-] n The SAPs are cross – linked polymer which is made from the polymerization of acrylic acid blended with sodium hydroxide in the presence of poly-acrylic acid. Superabsorbent polymer can absorb and retain extremely large amounts of a liquid relative to their own mass. The total absorbency and swelling capacity are controlled by the type and degree of cross-linkers. Low-density cross-linked SAP has a higher absorbent capacity and swells to a larger degree and vice.

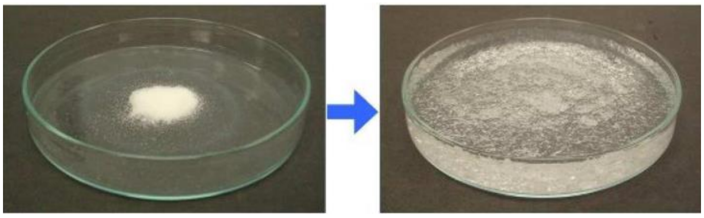


**Fig-1: Sodium polyacrylate**

**CONCRETE MIX DESIGN**

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The main objective is to stipulate the minimum strength and durability. It also reveals the relation between aggregate and past the other condition being equal, for workable mixes the strength of concrete varies as an inverse function of the water/cement ratio. Since the quantity of water depend upon the amount of paste, it is important that as little paste as possible should be used and hence the importance of grading.

**Grade of concrete M30 per m3**

Cement = 456 Kg/m3
Water = 186 Kg/m3
Fine aggregate = 707 Kg/m3
Coarse aggregate = 1122 Kg/m3
Fly-ash = 9.3 Kg/m3
SAP (0.2%) = 9.12 Kg/m3
SAP (0.3%) = 13.68 Kg/m3
SAP (0.4%) = 18.24 Kg/m3
Water cement ratio = 0.4

### 4. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

**4.1. Workability**

The mixed fresh concrete workability was measured immediately after mixing of the concrete according to IS: 1199-1959 and blended cement concrete specimens. Slump test was assessed to determine the consistency of concrete mixture. The main function of slump is to indirectly utilize or testing of the correct amount of admixture added in the medium paste.

| S.NO | Degree of Workability | % of SAP | Slump value |
|---|---|---|---|
| 1 | Slump value ( 50 - 100 ) medium | 0.2 | 132 |
| 2 | | 0.3 | 74 |
| 3 | | 0.4 | 45 |

**Table-4: Slump cone values**

**4.2 Compressive Strength**

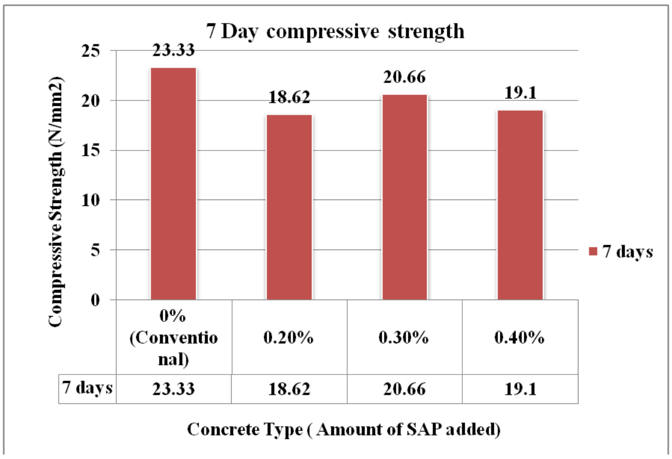
The specimens are cast by using required size moulds. The concrete is compacted by the trowel rod. The concrete is placed by the three layers for proper compaction. After casting, specimens are left for 24 hours for setting and then it is demoulded. Identification marks are made on face of the specimen and it is allowed for curing.

33 cubes are prepared with different percentage of SAP as additives of concrete. The size of cube is 150 x 150 x 150 mm

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

| S.No | Cube Description | Trial | Compressive strength (7 days) $N/mm^2$ | Compressive Strength (28 days) $N/mm^2$ |
|---|---|---|---|---|
| 1 | Conventional Concrete | T1 | 23.80 | 37.80 |
| | | T2 | 24.20 | 38.50 |
| | | T3 | 22.00 | 39.20 |
| | | **Avg** | **23.3** | **38.5** |
| 2 | 0.2% of SAP | T1 | 18.22 | 29.22 |
| | | T2 | 20.00 | 27.76 |
| | | T3 | 17.63 | 31.11 |
| | | **Avg** | **18.62** | **29.36** |
| 3 | 0.3% of SAP | T1 | 21.33 | 32.00 |
| | | T2 | 20.44 | 30.20 |
| | | T3 | 21.78 | 31.11 |
| | | **Avg** | **21.18** | **31.11** |
| 4 | 0.4% of SAP | T1 | 19.54 | 21.00 |
| | | T2 | 18.86 | 20.67 |
| | | T3 | 17.79 | 22.76 |
| | | **Avg** | **18.73** | **21.47** |

**Table -5: Compressive Strength values**



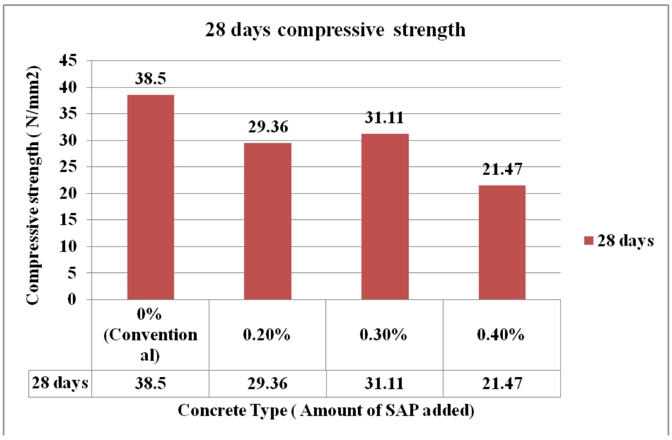




**Fig-2: Compressive Strength charts**

## DURABILITY TEST

Durability is the most important criteria for the design of Reinforced concrete structure. It is requirement of long term performance of concrete structure. Generally, concrete is affected by chemicals and environment effects. The cube after 28 days curing is immersed in 5% of HCl of the total volume of water to evaluate the decrement of strength to normal condition. Initial weight of cube was measured to compare the weight loss after HCl immersion.

| Specimen type | Initial weight (Kg) | Weight After Acid Immersion (Kg) |
|---|---|---|
| 0.2% SAP | 9.23 | 8.82 |
| 0.3% SAP | 8.44 | 8.23 |
| 0.4% SAP | 8.46 | 7.96 |

**Table-6: Durability**

## 5. SUMMARY AND CONCLUSIONS

The influence of addition of SAP and replacement of PPC by fly-ash on the workability, compressive strength, shrinkage, durability of concrete has been studied through slump test, compressive strength and acid immersion test. With the incorporation of SAP, the slump of concrete is influenced by SAP volume and different entrained ways of internal curing water. The pre-absorbed SAP decreases the slump of mixture.

Appropriate Slump value was achieved with addition of 0.3% SAP. i.e Slump value ( 50 - 100)medium.

The 0.3% SAP concrete gives much greater strength than the 0.2% SAP and 0.4% SAP. According to 7 days strength the 0.3% SAP concrete gives lower strength than conventional concrete, but in 28 days strength the 0.3% SAP concrete is increased due to the water lock property of concrete.

We achieved weight of concrete after acid immersion is lesser than the original weight, it seems to gives better durability.

At SAP gets swelling in the concrete, which leads to arrest the shrinkage cracks by crack sealing mechanism.

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