# EXPERIMENTAL STUDY ON THE EFFECT OF SAP ON CONCRETE

**P. Indhra[1], Dr. I. Padmanaban[2]**

*[1] Student, Department of Civil Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India*
*[2]Head of the Department, Department of Civil Engineering, Sri Krishna College of Technology, Coimbatore, Tamilnadu, India*

---------------------------------------------------------------------***---------------------------------------------------------------------

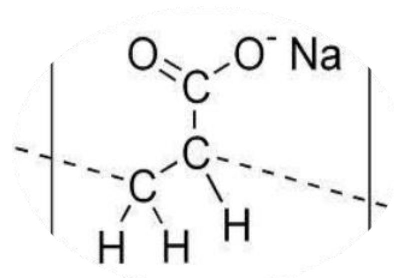
**Abstract** – *The effect of super absorbent polymer (SAP) on concrete is the subject of an experimental research in this thesis. The addition of SAP to concrete has a variety of advantageous effects on the concrete's varied qualities. Both the interior and exterior of the concrete have been cured. The strength of the concrete is significantly impacted by this form of curing. This is also made possible by SAP's crack-healing mechanism, which is useful when cracks form inside of concrete as a result of the hydration process. By employing various mineral admixtures in the percentages of 30% fly ash, 10% GGBS, and 10% silica fume, 50% of the cement content is partially replaced. SAP, or SODIUM POLYACRYLATE, is used in amounts of 0.1%, 0.3%, and 0.5%. Concrete's workability and placement are improved as a result of SAP's impact on it. However, if too much SAP is added to the mixture, it could cause more voids to form in the mass of the concrete, which would then have a detrimental impact on the hardened concrete. This study's main objective is to test various hardened SAP-induced concrete strengths and compare them to conventional concrete. Then, using ANSYS software, the beam finite element approach can be obtained.*

***Key Words***: **Super Absorbent Polymer (SAP), Internal curing, crack healing mechanism, Sodium polyacrylate, Detrimental impact 0.1%, 0.3% & 0.5% finite element method – ANSYS**

## 1. INTRODUCTION

Concrete repair solutions are becoming more and more significant in contemporary technology as a result of the significant amount of infrastructure that is prematurely degrading. The use of SAP (SUPER ABSORBENT POLYMER) to enhance the microstructure and durability-related characteristics of mortars of average strength prepared using supplemental cementitious ingredients is not widely known, yet. Crack repair, self-healing, internal curing, strength characteristics, shrinkage reducing, and self sealing are all included in this SAP.

SUPER ABSORBENT POLYMER:




CHEMICAL FORMULA OF SUPER ABSORBENT POLYMER

SAP: SODIUM POLYACRYLATE is a sodium salt of polyacrylic acid, also known as water lock. The SAPs are cross-linked polymers created by polymerizing sodium hydroxide and polyacrylic acid in the presence of acrylic acid. A SAP can become up to 99.99% fluid and absorb 450–500 times its weight (40–60 times its own specific volume), yet when placed in a 0.9% saline solution, the absorption may only be 40–50 times its weight. Later researchers start using SAP as an addition in the production of concrete. The SAP was used to stop water from passing through spaces and fissures. It basically falls into two categories. They are cross-linked, ionic polymers. Preferably with cross linked polymer as sodium polyacrylate.

## 2. OBJECTIVE

a. To give an alternate method of preventing corrosionin reinforced steel;

b. To give an alternate method of preventing corrosionin reinforced steel;

c. To reduce the cost of maintenance; To increase thedurability and strength of the material.

## 3. SCOPE

a. To determine the impact of sap on the shrinkage and creep of concrete, experimental research will becarried out.

b. Researching techniques to fill in the gaps left by the sap's release of water

c. To test the bond strength in addition to sap with cement, experiments will be conducted.

## 4. LITERATURE REVIEW

The research on various applications and techniques for assessing SAP concrete prepared with various chemical and mineral admixtures is covered in this paper. The work done by many researchers on SAP-influenced concrete is thoroughly reviewed in this chapter.

Fazhon wang (2009), The water entrained by SAP in this study is nearly depleted after 7 days, creating many pores in the paste structure. But it causes AS, internal relative humidity, and strength. When applying a high dosage of SAP or entrained air, the compressive strength decreases. The compressive strength of SAP concrete reaches 24.7 N/mm2 after three days and 51 N/mm2 after 28 days. Flexural strength of SAP concrete at 3 days was 5.6 N/mm2 and at 28 days was 9.6 N/mm2.

O.Mejlhede Jensen (2013), According to this study, SAP is used in concrete that can hold 5000 times its weight in water. The dry weight of the water absorbs between 100 and 400 g/g. The results produced two opposing unfavourable consequences. The concrete's compressive strength has slightly diminished. Another is empty production. Better strength qualities are achieved by employing a cement ratio that is less than 0.45. participates in the creation of frost, the reduction of shrinkage, and the change of freeze-thaw rheology. The option of actively regulating the entrained air in the hardened concrete is provided by the use of SAP. Finalizing the outcome as tripled yield stress and a 25% increase in plastic viscosity for concrete with an initial water-to-cement ratio of 0.4 and it seals the crack formed on the surface inn high performance concrete.

Gemma Rodriguiz de Sensale (2014) employed two methodologies in this paper. In terms of auto shrinkage deformation and compressive strength, the effects of adding more LWA and SAP are explored, and their best uses are also described. To attain improved durability and strength properties, the optimal SAP use is 0.3% and LWA is used inplace of fine aggregate.

kenneth seeria (2015), Review of internally cured concrete is provided in this publication. It participates in the production of high strength concrete by adding SAP as an additive and substituting the main aggregate with LWA.Next, it was addressed how to employ SRA and cut back on external curing.

Ravindra D. Wark Hade (2016), SAP in concrete is being tested in this investigation. The mechanical properties of concrete are the primary focus of this study's SAP. Sap doses range from 0.1% to 0.7%, with a water cement ratio of roughly 0.45. The outcomes were controlled rheological characteristics and decreased autogenous shrinkages.

## 5. MATERIALS USED

### 5.1 ORDINARY PORTLAND CEMENT

The definition of cement is a bonding substance with cohesive and adhesive qualities that enables it to bind various building elements and create a compacted assembly. One of the most popular varieties of Portland cement is ordinary or normal Portland cement. A fine, grey powder is cement. To form concrete, it is combined with water and ingredients like sand, gravel, and crushed stone. As the concrete dries, a paste made of cement and water holds the other components together. Argillaceous and calcareous are the two fundamental components of regular cement. Clay predominates in argillaceous materials while calcium carbonate does so in calcareous materials. A maximum of 15% of the total mass of active blended ingredients should be added to cement. Kiln ash 17 and inactive blended ingredients, which should make up no more than 5% and 10% of the cement mass, respectively, are permitted to take their place.

FIG 1. Cement

### 5.2 FINE AGGREGATE

For the creation of concrete, manufactured sand is used instead of river sand. It is made by smashing brittle granite stone. Sand that has been crushed has a cubical shape with grounded edges and has been rinsed and graded for use in building. M-Sand has a particle size of less than 4.75mm. It is less expensive to carry manufactured sand from a distance than river sand since it may be made by crushing strong granite boulders. It is necessary to utilise M-Sand because natural sand is becoming more and more expensive and scarcer. Sand that has been manufactured has the ability to replace natural sand and aids in maintaining both the ecological and economic balance.

FIG 2. Fine Aggregate

### 5.3 COARSE AGGREGATE

The shape of coarse aggregates might be angular, rounded, or irregular. The course aggregate grading restrictions for both single size aggregate and graded aggregate are listed in IS 383 - 1970 - table 2, Clause 4.1 and 4.2. To produce cohesive and solid concrete, the grading of coarse aggregate is crucial. Smaller course aggregate particles, such as sand, fill the spaces left by the bigger course aggregate particles. This reduces the amount of mortar (a cement-sand-water mixture) needed to fill the remaining spaces. The chance of segregation is reduced by properly grading coarse aggregate, especially for higher workability. The compatibility of concrete is also enhanced by proper grading of coarse particles.

FIG 3. Coarse Aggregate

### 5.4 WATER

In general, water that is suitable for drinking can be used to make concrete. It is also typically acceptable to use water from lakes and streams that have marine life. There is no need for sample when water is acquired from the aforementioned sources. Unless tests show that the water is satisfactory, it should not be used in concrete when it is suspected that it may contain sewage, mine water, or waste from industrial facilities or canneries. Since tap water is occasionally used for casting and low water levels may cause quality changes, water from such sources should be avoided. For mixing and curing the concrete samples, ordinary drinkable water is employed.

FIG 4. Water

### 5.5 FLY ASH

Flyash produced by burning sub-bituminous coals is known as ASTM Class C fly ash or high-calcium fly ash because it often contains more than 20% CaO. On the other side, fly ash from bituminous and anthracite coals is referred to as ASTM Class F fly ash or low-calcium fly ash. It has less than 10% CaO and is mostly made of an aluminosilicate glass. Depending on the chemical and mineral components, fly ash can take on a dark grey hue.

FIG 5. Fly Ash

### 5.6 GGBS

GGBS, or "Ground Granulated Blast Furnace Slag," is a by-product of the iron-making blast furnaces and is a cementitious material used mostly in concrete. It can alternatively be referred to as GGBS or lag cement, even though it is typically referred to as GGBS in the UK. This slag is occasionally tapped off as a molten liquid, and in order to employ it in the production of GGBS, it must be quickly quenched in a lot of water. Quenching produces granules that resemble coarse sand and optimises the cement's tensile qualities. The dried and powdered granulated slag is next processed.

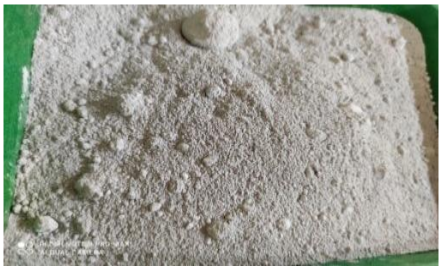


FIG 6. GGBS

### 5.1 SILICA FUME

Silica fume is a by-product of making ferrosilicon alloys or silicon metal. Concrete is among silica fume's most advantageous applications. It is an extremely reactive pozzolan due to its chemistry and physics. There are wet and dry varieties of silica fume for usage in concrete. Following the good concreting methods recommended by the American Concrete Institute, silica fume concrete should be delivered, placed, completed, and cured.

FIG 7. Silica Fume

### 5.8 SUPER ABSORBENT POLYMER

The SAPs are cross-linked polymers created by polymerizing sodium hydroxide and polyacrylic acid in the presence of acrylic acid. SAP: SODIUM POLYACRYLATE is a sodium salt of polyacrylic acid, sometimes referred to as water lock. Two different types of polymers exist. They are cross-linked polymers of the ionic type. The kind and strength of cross- linkers determine the total absorbency and swelling capacity. Cross-linked SAP with a low density has a greater capacity for absorption and expands more, and vice versa. A SAP may absorb 450–500 times its weight (between 40 and 60 times its own specific volume), and it can develop into up to 99.99% fluid, but when placed in a 0.9% saline solution, the absorption lowers to perhaps 40– 50 times its weight.

The use of SAP as an additive in concrete construction islater pioneered by researchers.

FIG 8. Super absorbent polymer

### 5.9 SUPER PLASTICIZER

Super plasticizers, often referred to as high range water reducers, are chemical admixtures utilised when well-dispersed particle suspension is required. These polymers are employed as dispersants to prevent particle segregation (gravel, coarse and fine sands) and to enhance the flow properties of suspensions, such as in concrete applications. Their inclusion to mortar or concrete permits the development of self- consolidating concrete and high performance concrete by reducing the water to cement ratio while maintaining the mixture's workability. When the water to cement ratio falls, concrete gains strength. Conplast SP430 is based on Sulphonated Napthalene Polymers and is supplied as a brown liquid that dissolves rapidly in water. Conplast SP430 has been specifically designed to produce high-quality concrete with decreased permeability while yet offering considerable water reductions of up to 25%. Site trials with the concrete mix are the greatest way to identify the ideal dosage since they allow for the measurement of the effects of workability, strength growth, or cement reduction. Conplast SP 430 site testing should always be contrasted with mixes without any admixtures. Conplast SP430 should be added in the specified amount together with the measuring water. For optimal results, prewette the mixture with 80% of the required amount of water before adding Conplast SP430 super plasticizer in the final step.

FIG 9. Super plasticizer

## 6. RESULTS AND DISCUSSION

### 6.1 FRESH CONCRETE PROPERTIES

SAP Concrete with varying amounts of super absorbent polymer and various mineral admixtures, such as fly ash, GGBS, and silica fume. Super absorbent polymer percentages of 0.1%, 0.3%, and 0.5% were investigated for Slump flow and compaction factor. The table below includes the results of the fresh properties of all SAP concrete with various percentages.

| S.NO | % OF SAP | SLUMP VALUE | COMPACTION FACTOR |
|---|---|---|---|
| 1. | 0.1% | 120 mm | 0.88 |
| 2. | 0.3% | 100 mm | 0.86 |
| 3. | 0.5% | 90mm | 0.84 |

Table 1 - Fresh concrete test calculation for M30

### 6.2 HARDENED CONCRETE PROPERTIES

The results of compressive strength and split tensile strength tests were presented in the table below with SAP percentages of 0.1%, 0.3%, and 0.5% with fixed percentages of cement, fly ash, GGBS, and silica fume.

| S.NO | SAP % | CUBES N/ $mm^2$ | |
|---|---|---|---|
| | | 7 DAYS | 28 DAYS |
| 1. | 0.1% | 18.56 | 31.72 |
| 2. | 0.3% | 22.29 | 34.3 |
| 3. | 0.5% | 20.42 | 32.25 |

Table 2 -Test results for compressive strength

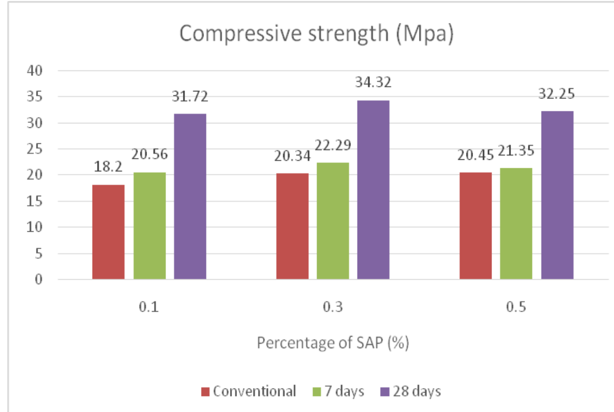



FIG 10. Bar chart showing compressive strength

The maximum values for compressive strength test are obtained for the mix cement 50%, Fly Ash 30%, GGBS 10% & Silica Fume 10% with SAP percentage of 0.3% gives an increase of 11% strength value at 28 days when compared tonormal mix.

### 6.3 SPLIT TENSILE STRENGTH TEST

Concrete cylinder specimens with a 150 mm diameter and a

300 mm height were cast in order to determine the material's split tensile strength. The ideal values discovered by the compression test were used to cast the cylinders. Cylinders were tested when they were 7 and 28 days old. The following table shows the impact of several SAP dosages, such as 0.1%, 0.3%, and 0.5%, on the split tensile strength of M30 Grade Concrete Mix (cement 50%, fly ash 30%, GGBS 10%, and silica fume 10%) at the age of 7, 28 days.

| S.NO | SAP % | SPLIT TENSILE STRENGTH | | | |
|---|---|---|---|---|---|
| | | 7 DAYS | | 28 DAYS | |
| | | Load KN | Strength N/$mm^2$ | Load KN | Strength N/$mm^2$ |
| | | 130 | 1.83 | 230 | 2.68 |
| 1. | 0.1% | 110 | 1.5 | 160 | 2.26 |
| 2. | 0.3% | 150 | 2.30 | 250 | 3.54 |
| 3. | 0.5% | 135 | 1.91 | 220 | 3.12 |

Table 3 - Test Results for Split Tensile Strength

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

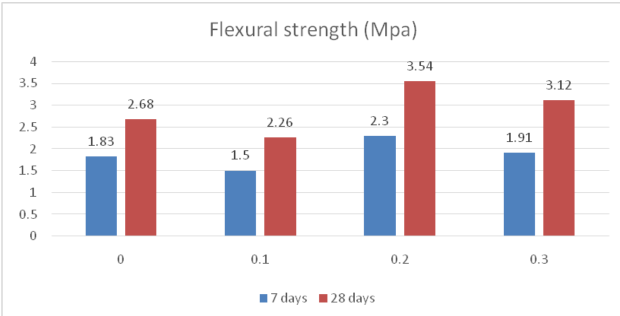



FIG 11.Bar chart showing Split tensile strength test

The maximum values for split tensile test are obtained for the mix cement 50%, Fly Ash 30%, GGBS 10% & Silica Fume 10% with SAP percentage of 0.3% gives an increase of 9% strength value at 28 days when compared to normal mix.

### 6.4 FINITE ELEMENT ANALYSIS

Utilizing the ANSYS workbench, the beam's analytical model was built, and the features of load deflection were examined. Engineers frequently choose ANSYS Workbench as their platform of choice. In essence, we set up the materials using simulation and design model, respectively.

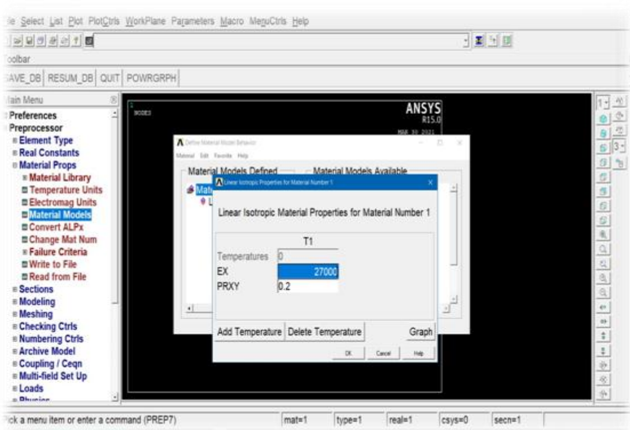


FIG 12. Linear Isotropic Material Properties

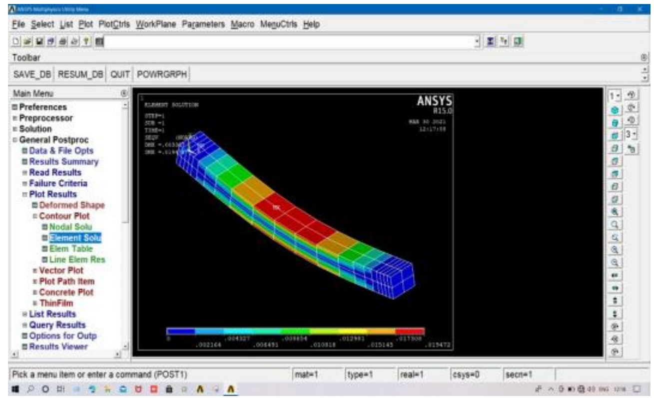


FIG 13. Element Solution

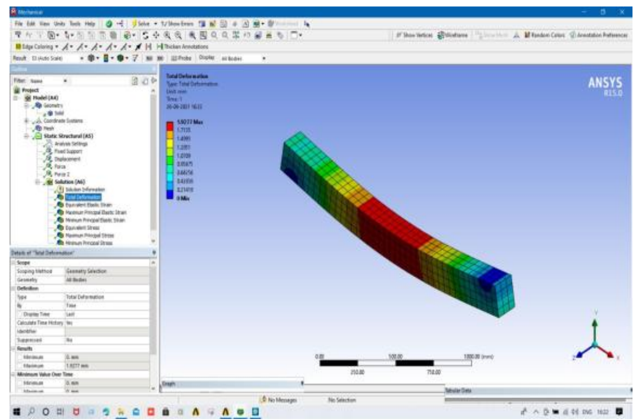


FIG 14. Total Deformation

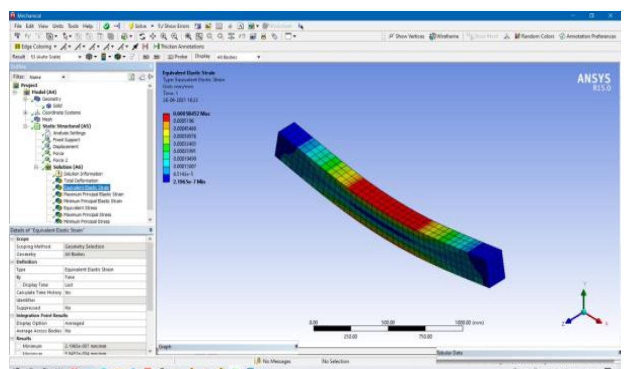


FIG 15. Equivalent Elastic Strain