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Experimental Study of Sodium Polyacrylate on Fiber Reinforced Self Curing Concrete

Nirdesh Vaidya[1], Pukhraj Sahu[2]
[1]*M.Tech Scholar (Structural Engineering), Govt. Engineering College, Jagdalpur, C.G., India*
[2]*Assistant Professor, Department of Civil Engineering, Govt. Engineering College, Jagdalpur, C.G., India*

Abstract: In order to get the necessary properties of concrete, the early stages of the curing process need maintaining a sufficient moisture content and temperature. But effective curing of concrete is not always possible in many situations. An attempt has been made to produce internally cured concrete using sodium polyacrylate, as super absorbent polymer. An experiment was conducted using M25 grade concrete with sodium polyacrylate at 0.1%, 0.3%, and 0.5% by weight of cement, respectively. Sodium polyacrylate was chosen because of its ability to absorb and gradually release water. Concrete is commonly used in construction due to its compressive strength, however it has considerable weaknesses in tensile strength. To address these concerns, an attempt has been made to improve the tensile strength of concrete by incorporating fibers. This experiment aims to evaluate the impact of super absorbent polymers (SAPs) on the mechanical properties of coconut and polypropylene fiber-reinforced concrete. The mechanical properties of different concrete mix with varying amounts of SAPs, polypropylene fibers, and coconut fibers were evaluated. Concrete cubes and cylinders were cast and tested for seven days and twenty-eight days, respectively According to the experiment results, when SAP was used in concrete with different amounts of coconut and polypropylene fibers, the compressive and tensile strength of the concrete increased.

Keywords: Super absorbent polymer (SAP), Sodium Polyacrylate, Self curing concrete, Coconut Fiber, Polypropylene Fiber, Fiber-reinforced concrete.

I. INTRODUCTION

Concrete is a brittle substance with low tensile and high compressive strength. Fibers are being added into concrete to help it overcome these drawbacks. One of the main reasons for utilizing fibers in concrete is to improve its tensile and flexural strength. Fiber-reinforced concrete is a composite material made of concrete that has discrete, evenly spaced, or discontinuous fibers added to it. Concrete is simply strong in compression but weak in tension.

As concrete dries and cures, it experiences volumetric changes that may cause shrinkage and the development of cracks. Fibers serve to regulate and minimize these cracks by providing additional support that restricts the expansion and contraction of the concrete. This is particularly helpful in reducing plastic shrinkage cracks that arise when the concrete is still in its plastic condition and drying shrinkage cracks that arise as the concrete hardens. Another important advantage of fiber-reinforced concrete is its greater toughness and impact resistance. Concrete that contains natural fibers, such coconut fibers, has better mechanical qualities and supports environmental sustainability. Natural fibers are a more sustainable option than synthetic ones because they are biodegradable, renewable, and frequently available locally. The tensile strength of concrete is strongly increased by adding fibers, whether they come from manmade materials or natural sources like coconut husk. These fibers, as reinforcement, disperse stress uniformly and prevent cracks from forming.

In this experiment, we produced fiber-reinforced concrete using coconut and polypropylene fibers to reduce the formation of micro-cracks that may occur during the curing process. It is essential to maintain proper moisture and temperature throughout the early curing phases in order to obtain the necessary characteristics. For optimal strength development, concrete must be maintained wet during the curing process. There are several ways to maintain moisture on the surface of the concrete, including pounding, spraying, and sealing the surface with a barrier made of curing compound to stop moisture loss. But in many cases, effective cure isn't always possible. Therefore, employing chemicals that self-cure will be the best option. Self-curing chemicals help to lower evaporation, which enhances concrete's water retention.

This experiment used sodium polyacrylate, a super absorbent polymer (SAP) known for its ability to absorb and hold large amounts of water. Sodium polyacrylate and other cross-linked polymers are used to make SAPs, which are commonly utilized in hygiene, agriculture, and packaging products. SAPs improve internal curing in concrete by absorbing excess water while mixing and releasing it gradually.

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This reduces autogenous shrinkage. SAPs also improve hydration by gradually releasing water, so cement particles are thoroughly hydrated. The concrete's strengthened by this ongoing hydration. SAPs also decrease the chance of concrete cracking. By incorporating SAPs into concrete, performance problems can be addressed, and environmental sustainability in buildings can be improved.

II. AIM OF EXPERIMENT

1) To find the optimal dose of superabsorbent polymer (SAP) utilized in self-curing concrete.
2) To find the optimal dose of coconut and polypropylene fibers in fiber-reinforced self-curing concrete.
3) To determine the compressive strength and split tensile strength of controlled concrete, self-cured concrete, and fiber-reinforced self-cured concrete.

III. MATERIALS

The basic components of a concrete mix were cement, coarse and fine aggregates, water, chemical additives and mineral admixtures. Several types of reinforcing fibers could be utilized in construction -related concrete. In this experiment, 10% of the cement was replaced with flyash, and the concrete was reinforced with different quantities of polypropylene and coconut fibers. Sodium polyacrylate was utilized as a self curing agent.

1) *Cement:* OPC43 grade cement was utilized throughout the experimental program, conforming to IS: 8112 – 1989 specifications. Multiple tests were done on the cement, which indicates a specific gravity of 3.12, fineness of 8.56%, and a consistency of 31%.
2) *Flyash:* Fly ash is a byproduct of coal-fired power plants that interacts with lime to produce cementitious compounds. In this experiment, class C fly ash was employed. Flyash had a 2.40 specific gravity, according to test.
3) *Sand:* River sand, which is readily available in the area, was utilized as fine aggregate in the experimental program. Its specific gravity was 2.76 and its fineness modulus was 2.63. According to IS-383-1970, river sand falls under zone II.
4) *Coarse Aggregate:* The aggregate particles retained on a 4.75 mm IS sieve are referred to as coarse aggregate. Up to a maximum size of 20 mm, locally available coarse aggregate was used in the experimental program. Specific gravity of the coarse aggregate was measured to be 2.82, and its fineness modulus was found to be 4.07, confirming to IS 393-1970.
5) *Water:* The water used to create concrete shouldn't contain oil, alkalis, acids, or any other harmful impurities. In the lab, drinking water was used to produce concrete and allow it to cure.
6) *Sodium Polyacrylate:* The super absorbent polymer used in this experiment was sodium polyacrylate. Super absorbent polymers (SAP) are a subclass of polymeric materials. SAPs, as employed in this experiment, are non-corrosive, non-toxic materials that can absorb water several times their own weight. which had bulk density of 0.85 and density of 1.08.

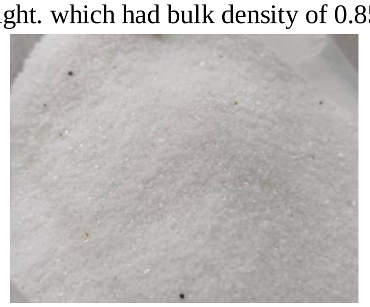

Figure 1- Sodium Polyacrylate

7) *Polypropylenefiber :* The synthetic fibers known as polypropylene are made from polymerized propylene, which has high tensile strength, elasticity, low moisture absorption, and chemical resistance. In this experiment, polypropylene fiber in different amounts, such as 0.5%, 1% and 1.5% by weight of cement was used to produce fiber-reinforced concrete.

Figure 2- Polypropylene Fiber

8) *Coconut Fiber:* Coir, also known as coconut fiber, is a natural fiber that is obtained from the coconut husk and is used to make a variety of products, including floor mats, doormats, mattresses, and brushes. In this experiment, fiber-reinforced concrete was made using coconut fiber. The coconut fiber in different amounts, such as 0.5%, 1% and 1.5% by weight of cement was used to produce fiber-reinforced concrete. Compared to synthetic fibers, these natural fibers are more environmentally friendly because they are readily available, renewable, and biodegradable.

Figure 3- Coconut Fiber

IV. METHODOLOGY

The design mix of M25-grade concrete was designed according to IS 10262:2019. 10% cement was substituted with flyash for all mixtures. A total of ten mixes, designated M1 through M10, were created. M1 is controlled concrete, M2 to M4 is self-cured concrete, and M5 to M10 is a mix that includes both SAP and fiber to produce fiber-reinforced self-cured concrete. Self-curing concrete mixes contain varying amounts of SAP, such as 0.1%, 0.3%, and 0.5% by weight of cement, compared with controlled concrete mixes (M1) that contain 0% SAP. To determine the optimum amount of SAP, self-cured concrete mixtures was compared with controlled concrete that has 0% SAP. Fibre r/f self-cured concrete is made by adding the maximum percentages of sap and fibers, such as coconut fiber (CF) and polypropylene fiber (PPF), to the mixture at 0.5%, 1%, and 1.5% by weight of cement material, respectively. Both controlled and self-cured concrete mixes were evaluated for compressive strength and split tensile strength.

Table 1- Concrete mix proportion

S. No.	Materials	Quantity in kg/m^3
1.	Cement	415.8
2.	Fly-ash	46.2
3.	Fine aggregate	606.71
4.	Coarse aggregate	1091.93
5.	water	202.74

A. *Mixing and Casting*

Weigh batching was used to measure the amount of cement, sand, fly-ash, and coarse aggregate. In this experiment, concrete was mixed by hand and compaction was done using tamping rod. The mixing operation begins with dry mixing of cement, fly-ash, sand, and aggregates by hand . SAPs were then added to the mix. The dry mix was gradually added with polypropylene and coconut fibers to ensure even dispersion. Following that, the water was added. After that, the mixture was mixed one more time for three to four minutes to produce a uniform concrete mix.

Figure 4- Fiber-Reinforced Self Cured Concrete Mix Using Coconut Fiber

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B. Casting and Curing

Standard 150x150x150 mm3 cube moulds were utilized for testing compressive strength, while cylindrical moulds with a 300 mm height and 150 mm diameter were used for tests of split tensile strength. The concrete was poured into moulds in three-layers, with each layer compacted with a tamping rod to eliminate air bubbles and ensure proper compaction. After casting, the specimens were demoulded after 24 hours and then cured in water for durations of 7 and 28 days. This curing phase is vital for the hydration of cement and the development of the concrete's strength. The self-curing samples were kept inside the room at room temperature to cure. The controlled concrete was placed in a water tank for curing.

Figure 5- Concrete Cube Specimens

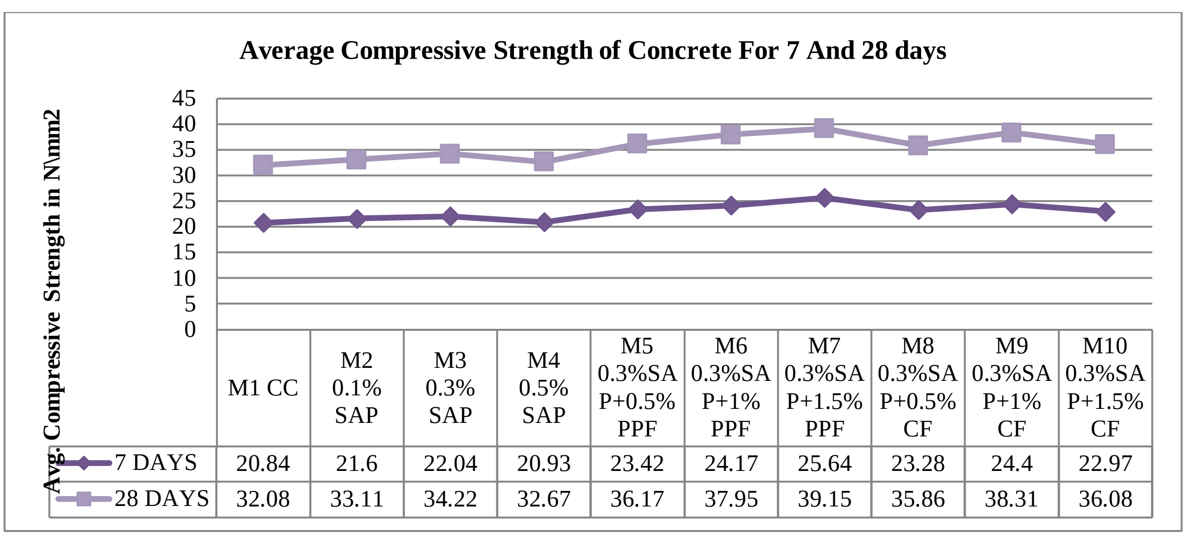
V. RESULTS

A. Compressive Strength Test

Test cubes of 150 x 150 x 150 mm were made from freshly poured concrete for this experiment. The specimens were tested using a 1000KN load-carrying compression testing machine, and the load was applied until failure was reached. In this experiment, materials were subjected to compression testing for 7 and 28 days. For the compressive test, numerous concrete compositions were investigated. Using graphs, the chart shows the variation in average compressive strength between 7 days and 28 days. Three cubes were tested for all mixes, and the average value is reported. The following formula was used to get the compressive strength:

Compressive strength $= \frac{failure\ load\ (P)\ in\ KN}{cross\ sectional\ area\ in\ mm^2}$

Figure 6- Compressive Strength Test of Concrete Cube



	M1 CC	M2 0.1% SAP	M3 0.3% SAP	M4 0.5% SAP	M5 0.3%SAP+0.5% PPF	M6 0.3%SAP+1% PPF	M7 0.3%SAP+1.5% PPF	M8 0.3%SAP+0.5% CF	M9 0.3%SAP+1% CF	M10 0.3%SAP+1.5% CF
7 DAYS	20.84	21.6	22.04	20.93	23.42	24.17	25.64	23.28	24.4	22.97
28 DAYS	32.08	33.11	34.22	32.67	36.17	37.95	39.15	35.86	38.31	36.08

CHART 1 – The Average Compressive Strength of All Concrete Mix For 7 And 28 Days

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B. Tensile Strength Test

Tensile strength refers to a concrete's ability to withstand tensile stress. The split-tensile strength method was used to determine the tensile strength of concrete. A cylindrical specimen of 150 mm in diameter and 300 mm in height was utilized for the test. The specimen is positioned horizontally and put into the compression testing machine. The test was conducted for 7 and 28 days. The average split tensile strength variations at 7 and 28 days was graphically shown in the figure. Three cylinders were tested for all of the mixes, and the average value was calculated. In order to determine split tensile strength, the following formula was used:

$$F_{\text{split}} = \frac{2P}{\pi DL}$$

Where, P = failure load in KN

D = diameter of cylindrical mould, L= length of cylindrical mould

Figure 7-Concrete Cylindrical specimens

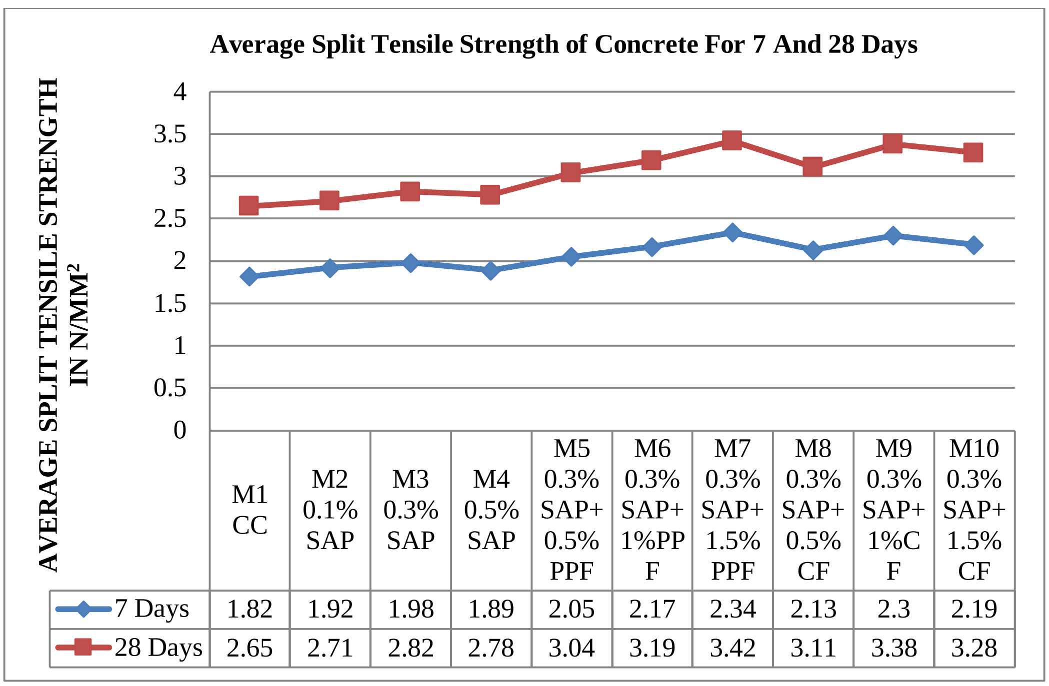

Chart 2 – The Average Split Tensile Strength of All Concrete Mix For 7 And 28 Days

VI. CONCLUSIONS

1) Self-curing concrete with 0.3% SAP had a higher water retention rate than self-curing concrete with 0.1% and 0.5% SAP, respectively.
2) It has been found that the optimum SAP dose produces better outcomes than SAP excessive amounts. Concrete may become weakened by excessive sap consumption.
3) It has been found that sodium polyacrylate is a more beneficial material for producing strong, internally cured concrete. Due to its ability to cure without drying out, self-cured concrete helps conserve water. A good material to utilize in areas with water limitations and curing-related issues is self-curing concrete.

4) For M25 grade concrete, the optimal SAP dosage has been found to be 0.3% in order to optimize the concrete's strength. With the addition of SAP, the compressive and split tensile strengths increased significantly.
5) The addition of polypropylene and coconut fibers improves the compressive strength and split tensile strength of fiber reinforced self curing concrete. In this experiment, the optimum dosage was found to be 1% for coconut fiber and 1.5% for polypropylene fiber.
6) Concrete reinforced with polypropylene fibers showed better results compared to concrete reinforced with coconut fibers. Additionally, the use of coconut fibers was found to minimize the weight of the fiber-reinforced concrete.

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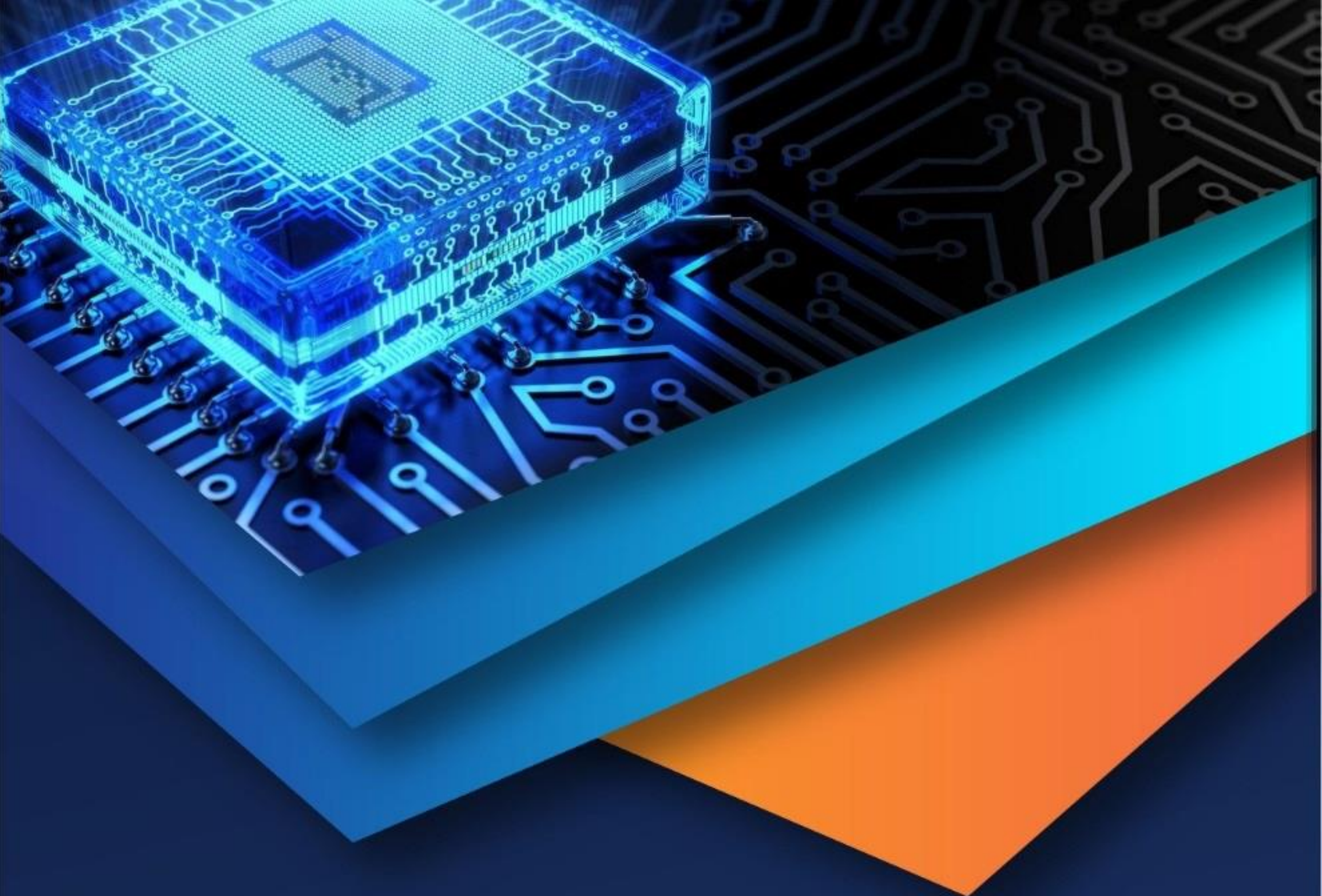

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