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STUDY OF STRENGTH AND DURABILITY OF SUPER ABSORBENT POLYMER INTRODUCED CONCRETE

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Abstract - *The present study involves the use of SAP for crack sealing and self curing. The addition of SAP alters the various properties of concrete like increased workability, increased fire resistance and shrinkage resistance, etc. The self curing helps in better hydration of cement which leads to achieve higher later strength. When fly ash is used as a cement replacement, increased later compressive strength, increased resistance to alkali-silica reaction (ASR), less heat generation during hydration, increased pore refinement, decreased permeability, decreased water demand, increased workability and decreased cost. In the present study, SAP of 0.1%, 0.3% and 0.5% are added to fly ash (30%) replaced cement containing concrete mix. The main focus of this study is to compare results of hardened concrete of M30 concrete mix with SAP to conventional concrete by studying compressive strength and durability.*

Key Words: **Concrete, Fly ash, Super Absorbent Polymer, Crack Sealing, Internal Curing**

1. INTRODUCTION

Super Absorbent Polymer is most advantageous in the field of agriculture, medical, waste management, etc. Due to this water entraining property later, researchers initiate the use of SAP as additive in concrete construction. The SAP used to block the water flow through cracks and voids[1]. 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 versa.

SAP is added to dry mix of concrete. When water is added to mix SAP absorbs water and retains it thereby increase in volume by 250 times. The retained water is converted into the form of gel which fills the voids created due to hydration and freeze-thaw effect. The water from concrete evaporated by increased heat of hydration which leads to formation of voids. Expansion and contraction of concrete creates large number of voids which leads to Shrinkage cracks[2].

Proper curing of concrete structure is necessary to meet best strength and durability requirements. Perfect curing cannot be done manually because of less availability of water and difficulty of height of curing at site. When water is needed for concrete is not readily available. The solution of this problem is self curing. Internal or self curing is achieved by adding of SAP to concrete. In the present study SAP of 0.1%, 0.3% and 0.5% is added to 30% flyash replaced concrete and comparative results were predicted for compressive strength, durability and SEM analysis.

2. EXPERIMENT

2.1. Materials Used: Material used in the present study as follows were cement(OPC), fly ash, fine aggregate (river sand passing through 4.75mm), coarse aggregate (well graded), SAP, and Water.

2.1.1 Cement: Ordinary Portland Cement of super grade confirming to IS 12269:2013.

2.1.2 Fly ash: Class C fly ash is designated in ASTM C 618 and originates from sub bituminous and lignite coals.

2.1.3 Fine Aggregate: Locally available river sand confirming to Grading zone II of IS 383 –1970.

2.1.4 Coarse Aggregate: Locally available quarry stone in good strength conforming to IS 383-1970.

2.1.5 Water: Portable water free from acidity and alkalinity.

2.1.6 SAP: Sodium Poly acrylate is a synthetic polymer used in cosmetics and personal care products in part because of its ability to absorb as much as 500 times its mass in water (Fig. 1). It is seen as a white powder when dry, but turns into a gel-like substance when wet, and is primarily used as a thickening agent.

Sodium polyacrylate procured from CHEMZEST, also known as water lock, is a sodium salt of polyacrylic acid with the chemical formula $[-CH_2-CH(COONa)-]_n$. The SAPs are crosslinked polymer which is made from the polymerization of acrylic acid blended with sodium hydroxide in the presence of poly-acrylic acid. The technical specification of SAP is categorized in Table 1.

Fig-1 : **Swelling characteristics of SAP used**
(Before and after Swell)

2.2 Tests on concrete Materials

The Characteristics properties of the materials[3] used to prepare concrete are presented in Table 2.

Table – 1: The technical specification of SAP used

Particulars		Specification
Appearance		White Fine Granular
Free Absorbency (g/g)	Distilled water	350 – 500
	0.9% NaCl	≥50
Centrifugal Retention Capacity (CRC), g/g		≥30
Absorbency Under Load (AUL) (0.3 PSI), g/g		≥28
Absorbency Under Load (AUL) (0.7 PSI), g/g		≥20
Absorption Speed (by Vortex Method)		≤70
pH Value		6.0 – 7.0
% of moisture		≤5

Table-2: Characteristic properties of concrete materials

S.No	Concrete Material	Property	Value
1	Cement	Consistency	36 %
		Fineness	90µ
		Setting Time	35min(Initial)
2	Fine Aggregate	Sieve Analysis	4.75mm passed
		Specific Gravity	2.79
3	Aggregate	Water Absorption	1 %
		Crushing strength	44 %
		Impact Value	42.2 %
4	Fly Ash	Fineness	45µ
		Consistency	28 %
		Setting Time	30 mins(Initial)
5	SAP	Water Absorption	140ml by 1g SAP
6	Cement+ flyash + SAP	Consistency	40 %
		Setting time	40mins(Initial)

2.3 Fresh concrete tests

Slump cone test[1] was conducted to determine the workability of fresh concrete and is depicted in the Table 3.

Table 3: Slump cone test analysis of fresh concrete prepared

S. No	% of SAP	Slump Value (mm)
1	0	0
2	0.1	132
3	0.3	75
4	0.5	54

2.4 Design Mix

The mix proportions for concrete material were arrived to satisfy all requirements in both fresh and hardened stage[2]. The design mix adopted for the present studies were IS 10262- 2009. The proportion of M30 concrete is used to attain strength of 30Mpa. The OPC 53 of 305.2 kg/m^3 is batched with 30% (130 kg/m^3) replacement of flyash. SAP of 0.1%, 0.3% and 0.5% added to concrete mix as an additive. The Fine aggregate and coarse aggregate are added corresponding to the mix proportion of 1 : 1.55 : 2.57 derived from design mix. The mix is prepared with constant W/C ratio of 0.4 to achieve good workability. Excess amount of water added than design mix which depends on amount of SAP added.

2.5 Cube casting

Standard sizes of 150mm x 150mm x 150mm as per ASTM standards concrete cubes were casted by using M30 grade of concrete[6]. OPC cement was replaced with 30% of fly ash and SAP of various proportions of 0.1%, 0.3% and 0.5% as additive. Materials were measured accurately with considering wastage of 2% using weigh balance. SAP added to mix at dry stage, and then water is added gradually. Materials were mixed thoroughly and proper compaction

should be done to achieve greater lateral properties of strength and durability. After 24 hours specimen is removed from mould and subjected to curing for 7, 14 and 28 days. Compression test was calibrated for 7, 14 and 28 days by using Compression testing machine capacity of 1000KN and results were recorded.

3. RESULTS AND DISCUSSION

3.1 Test for curing

Appropriate Slump value was achieved with addition of 0.3% SAP. So the curing test is conducted on 7 day curing with 0.3% of SAP. Six numbers of cubes were casted with 0.3% of SAP. In the six cubes, three of them were used for internal (Self) curing and other three were used for External Curing. After 7 days compression test was conducted to predict the type of curing which gives high strength. The Strength comparison of self curing with external curing is tabulated in table 4.

Table-4 : Compressive strength of cube with SAP (External Vs Internal curing) – after 7day

S.No	Curing Method	Trial 1	Trial 2	Trial 3
1	External Curing (0.3%SAP)	18.9	19.5	18
2	Internal Curing (0.3 % SAP)	20	20.44	21.13

3.2 Compressive Strength test

3.2.1 Destructive Test using Compression Testing Machine

Compressive strength was conducted on cubes of 7 days and 14 days internal curing for conventional, 0.1%, 0.3% and 0.5% of SAP .The Compressive strength variation of SAP introduced concrete given in Table 5.

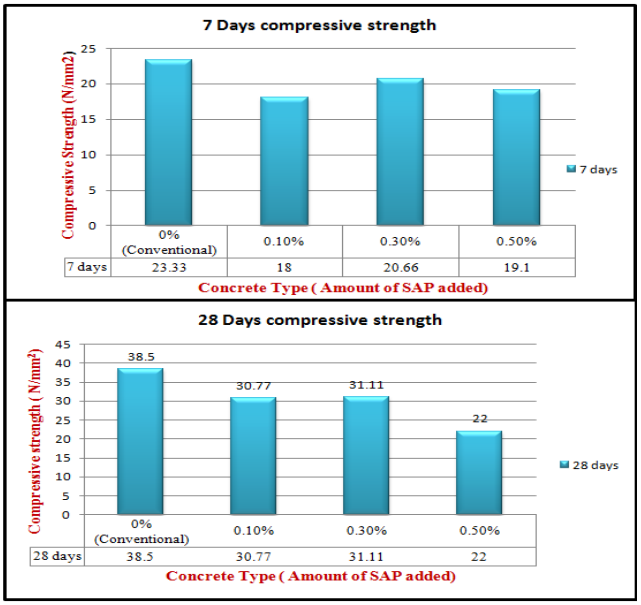

Fig. 2 : Compressive Strength results

Table 5 - Compressive strength variation of SAP introduced concrete

S.No	Cube Description	Trial	Compressive Strength (7 days)	Average Strength (7 days)	Compressive strength (28 days)	Average Strength (28 days)
1	Conventional concrete	I	23.80	23.33	37.80	38.5
2		II	24.20		38.50	
3		III	22.00		39.20	
4	0.1 % SAP	I	18.67	18.00	30.22	30.77
5		II	20.00		28.89	
6		III	16.00		31.11	
7	0.3 % SAP	I	20.00	20.66	32.00	31.11
8		II	20.44		30.20	
9		III	21.13		31.11	
10	0.5 % SAP	I	20.44	19.10	20.00	22.00
11		II	18.66		22.67	
12		III	18.22		23.56	

3.2.2 Non Destructive Test

3.2.2.1 Rebound Hammer Test

Rebound hammer test (Schmidt hammer test) is done to find out the compressive strength of concrete as per IS: 13311 (Part 2) – 1992. A Schmidt hammer measures the surface hardness and penetration resistance offered by a section of concrete.

The extent of the rebound to surface (a factor of the surface hardness) is measured on a graduated scale. The rebound is designated as a rebound number or rebound index. Higher rebound numbers indicate the concrete possesses greater compressive strength.

Table - 6 : Rebound hammer test results

S.No.	Trial	Rebound Number	Mean
1	I	24	31.55
2	II	34	
3	III	32	
4	IV	26	
5	V	40	
6	VI	28	
7	VII	30	
8	VIII	32	
9	IX	38	

3.2.2.2 Ultrasonic Pulse Velocity Test

An ultrasonic pulse velocity test is an in-situ, non destructive test to check the quality of concrete. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure.

Table - 7 : UPV test results

Time Travel (µs)	Pulse Velocity (Km/S)	Mean Pulse Velocity (Km/ S)	Concrete Quality
23.80	6.3	6.60	Very Good
26.70	5.62		
18.90	7.94		

3.3 Durability test

Durability is the most important criteria for the design of Reinforced concrete structure[7]. 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.

Table - 8 : Durability test results

Specimen Type	Initial Weight	Acid Weight
0.1 % SAP	8.9	8.52
0.3% SAP	8.44	8.23
0.5 % SAP	8.42	7.86

4. DISCUSSION AND RESULT

The cube specimens (conventional, 0.1 % SAP, 0.3 % SAP and 0.5 % SAP introduced cube) were tested. Totally 33 numbers of cubes were casted. Three numbers of cubes for each proportion of SAP for destructive compression test, 3 conventional cubes for curing test, Non destructive test conducted for one cube for each ratio of SAP.

Concrete with proportion of 0.3% SAP gives greater strength and durability than other proportion of SAP. 7 day strength of 0.3 % SAP gives lower strength than conventional, but in 28 days the strength of 0.3 % SAP increases due to water lock property of concrete.

5. CONCLUSION

Super Absorbent Polymer used as a concrete additive to achieve greater later age properties. Here SAP used as Self curing agent which reduces the formation of shrinkage and cracks of concrete[8]. Based on experimental investigation following conclusions were made.

(a) Optimum usage of SAP is 0.3%, gives higher compressive strength than other proportions of SAP.

(b) Self curing of concrete provides resistance to shrinkage cracks, which increases durability.

(c) Self curing reduces the amount of water required to the process of curing. Saving of water as much as possible.

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