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EFFECT OF SUPER ABSORBANT POLYMER IN CONCRETE

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Abstract - *Concrete is the most widely consumed material in the world after water. The main ingredients of concrete are cement, sand, aggregate & water in specific proportion. Water is an essential ingredient in the mixing curing & hardening of concrete due to insufficient curing concrete may shrink, swell & possibly crack. But now the days we need to save the water and find some methods to reduce the use of water. As we know the water requirement for concrete mail for curing is very high. So reduce the use of water SAP are the efficiently use in concrete. SAP (Super Absorbent Polymer) is a polymeric material that has the ability to absorb a large amount of liquid from the surrounding & retain within their structure. Light weight aggregate was previously the only material used as an internal curing agent but there are some major problems regarding the strength & elastic modulus of concrete. The SAP is replacing the light weight aggregate & ensures very efficient internal water curing agent in concrete. By using SAP admixture in concrete it will prove to have many positive effect on the property of concrete in both stages fresh concrete & harden concrete by making M30 grade of concrete. The dosage of SAP varies from 0.15 to 0.60 % at an interval of 0.15 % is applying & casting cube of concrete containing SAP for compression test, cylinder of for conducting split tension test and Beam for conducting Flexural Strength on concrete and comparing its results with conventional concrete. Also NDT test of Ultrasonic Pulse Velocity is use to determine quality and impermeability of concrete for 28 days. An experimental result shows that the addition of SAP upto 0.30% together with the concrete improves the compressive, Flexural and Tensile Strength corresponding to the Normal Plain cement Concrete. But after for 0.45 and 0.60% of SAP reduces the Strength.*

Key Words: **1)** ***Super Absorbent polymer 2) Compressive strength, 3) flexural strength, 4) split tensile strength***

1. INTRODUCTION

In the last few decades great advance in concrete technology have arisen to a large extent out of the development and use of new chemical additive which although added to concrete in very small quantities can dramatically improve crucial properties of concrete in its fresh and harden state. One prominent example is the use super plasticizers. When super plasticizers are used with other appropriate ingredients they enable the development of new type of concrete like self-compacting concrete or ultra-high performance concrete. Water is an essential ingredient in the mixing, curing, and hardening of concrete. Its exchange with the surroundings causes hardened concrete to shrink, swell, and possibly crack. The moisture evaporates from the concrete surface due to this crack are form are known as shrinkage crack. The autogenously deformation of concrete is defined as the unrestrained, bulk deformation that occurs when concrete is kept sealed and at a constant temperature. When the autogenous deformation is a contraction, it may be referred to as autogenous shrinkage. Obviously, control of water is important to concrete.

By using SAP(Super Absorbent Polymer) as new component for the production of concrete materials makes available a number of new possibilities with respect to water control and ,as a result to the control over the rheological properties of fresh concrete, in addition water absorption and water release in either fresh or harder concrete. Well control and take release of water can be fostered by the specific design of SAP material to particular practical need. SAP absorbs water upto 5000 times to their own weight. SAPs belong to the group of so-called “smart materials” means the materials that, in a controlled way, significantly change their properties in response to an external stimulus. When SAPs are exposed to water, they swell, and when subsequently subjected to drying, they reversibly shrink. These key properties can actively be used in relation to concrete.

SAP can ensure very efficient internal water curing, Internal water curing has been used for decades to promote hydration of cement and to control the shrinkage of concrete during hardening. When SAP is added in the dry concrete then they absorb and store much more water than their own weight, within a short time. During the hydration process, the saturated SAPs supply the surrounding cement matrix with additional water. When dried out, the air filled pores of SAP (about 100 to 600 µm diameter) remain, acting similarly as pores generated by air-entraining agents. Besides a strong reduction of autogenous shrinkage and delayed drying shrinkage, the SAP addition can enhance the durability of concrete.

1.1 OBJECTIVES OF INVESTIGATION

Conventional concrete by using Super Absorbent Polymer in concrete by ranging from 0.15 to 0.60% with an increment of 0.15%. The main objective of this

investigation was to find out the effect of Super Absorbent Polymer on the concrete such as compressive strength, tensile strength and flexural strength. Also workability and Quality of concrete

. Following are the main objectives of the investigation:

1. To decide the percentage of SAP in concrete.
2. To check the mechanical properties like compression, flexure and tensile in harden stage.
3. To find workability of concrete by slump cone test (i.e. plastic stage).
4. To minimize & reduce the cracks from concrete.
5. To check the impermeability & Quality of concrete by Ultra sonic Pulse Velocity test

1.2 MIX MATERIALS

The material details are as follows:

A. Cement

For this research, locally available cement which is of the ordinary Portland cement type (53 grade) was used throughout the work. Specific gravity of cement was 3.15.

B. Fine Aggregate

Locally available fine aggregate used was 4.75 mm size confirming to zone II with specific gravity 2.84. The testing of sand was conducted as per IS: 383-1970.Water absorption and fineness modulus of fine aggregate was 1.023 % and 4.26 respectively.

C. Coarse Aggregate

Coarse aggregate used was 20 mm and less size with specific gravity 2.21. Testing of coarse aggregate was conducted as per IS: 383-1970. Water absorption and fineness modulus of coarse aggregate was 0.2% and 5.94 respectively.

D. Water

The water used was potable, colour less and odour less that is free from organic impurities of any type.

E. Super Plasticizer

Conplast SP 430 is used to improve workability of concrete.

F. SAP (Super Absorbant Polymer)

SAP used is in powder form of technical grade. They are Acrylamide/acrylic acid copolymers. Properties of Super Absorbant Polymer are tabulated as follows:

TABLE I
PHYSICAL PROPERTIES OF SUPER ABSORBANT POLYMER:

Sr. No.	Physical Properties	Value
1	FORM – dry	Powder
2	FORM – wet	Transparent gel
3	Particle size	0-2 mm
4	Water absorption with distilled water	800 g for 1 g
5	pH of absorbed water	Neutral
6	Density	1.08 (g/cm3)
7	Bulk density	0.85 (g/cm3)
8	Hydration/ Dehydration	Reversible
9	Decomposition in sun light	6 months

2. EXPERIMENTAL WORK AND TEST

A. Mix Design

Mix design carried out for M30 grade of concrete by IS 10262:2009, having mix proportion of 1:2.17:3.02 with water cement ratio of 0.40. The Super Absorbant Polymer can be used total volume of cement by 0.15 % to 0.60 % at an increment of 0.15% each. Chemical admixtures conplast SP430 is used in the work. And One set of 0.3% addition of sap is tested without curing.

B. Compressive, Flexural and Split Tensile Strength:

Concrete prepared with addition of different percentage SAP of total volume of cement by 0.15 % to 0.60 % at an increment of 0.15% each was cured under normal condition as per recommendations of IS and were tested at 3 days, 7 days and 28 days for determining the compressive, flexural and split tensile strength test and compared with the test results of conventional concrete.

C. NDT – Ultrasonic pulse velocity:

The ultrasonic pulse velocity test is conducted on all specimens which cured for 28 days as per IS recommendations. for determine quality and impermeability of concrete

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3. TEST RESULTS

A. *Compressive Strength:*

Three cubes of size 150 mm x150 mm x150 mm were casted to work out the 3rd, 7th and 28th day's compressive strength of all the proportions. The table III gives the results of test conducted on hardened concrete with 0 - 0.5 % Basalt Fiber for 3 days, 7days and 28 days.

TABLE II
EXPERIMENTAL TEST RESULTS FOR COMPRESSIVE STRENGTH

Sr. no	% SAP	Compressive Strength in MPA (3 Days)	Compressive Strength in MPA (7 Days)	Compressive Strength in MPA (28 Days)
1	0 %	12.08	27.48	39.09
2	0.15 %	14.76	28.26	41.95
3	0.3%	16.20	30.41	42.88
4	0.45 %	11.65	27.08	38.08
5	0.60 %	15.08	26.24	37.52
6	0.3% (WC)	10.45	26.46	37.84

It is clear from table II compressive strength obtained for concrete with 0.3 % SAP by total volume of cement shows a higher value by 25.43 % compared to conventional concrete for 3 days, 9.63 % compared to conventional concrete for 7 days and 8.83 % compared to conventional concrete for 28 Days. The 0.3% sap addition without curing concrete shows good result it could not achieve target mean strength but it is more than design strength for M30 grade of concrete.

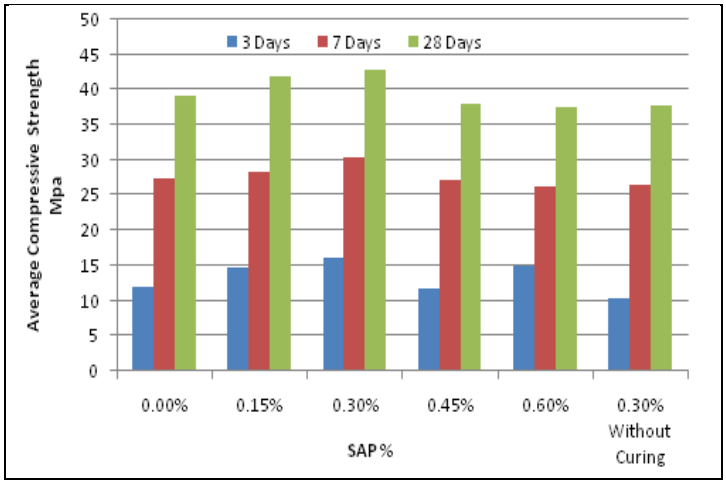

Fig. 1.Comparative compressive strength of concrete with % of SAP combine graph for 3 days, 7days and 28days in N/mm²

B. Flexural Strength

Three beam section of size 100 mm x 100 mm x 500 mm were casted and cured for 28 days. The flexural strength is determined by the

Formula:

$$fcr = P_f L / bd^2 \quad or \quad 3P_f a / bd^2$$

Where,

fcr = Flexural strength, MPa

P_f = Central load through two point loading system, N

L = Span of beam, mm

b = Width of beam, mm

d = Depth of beam, mm

a = distance between line of fracture to the nearest support, mm.

The table III gives the results of test conducted on hardened concrete with 0 - 0.60 % of SAP for 28 days.

TABLE III
EXPERIMENTAL TEST RESULTS FOR FLEXURAL STRENGTH

Sr No.	% of SAP	Flexural Strength in MPA (28 Days)
1	0 %	10.99
2	0.15%	11.31
3	0.30%	11.80
4	0.45%	11.35
5	0.60%	10.60
6	0.30% WC	8.70

It is clear from table III Flexural strength obtained for concrete with 0.3 % of SAP by total volume of cement shows a higher value by 6.86 % compared to conventional concrete for 28 days. The Flexural strength of the 0.3% addition sap without curing also shows good result.

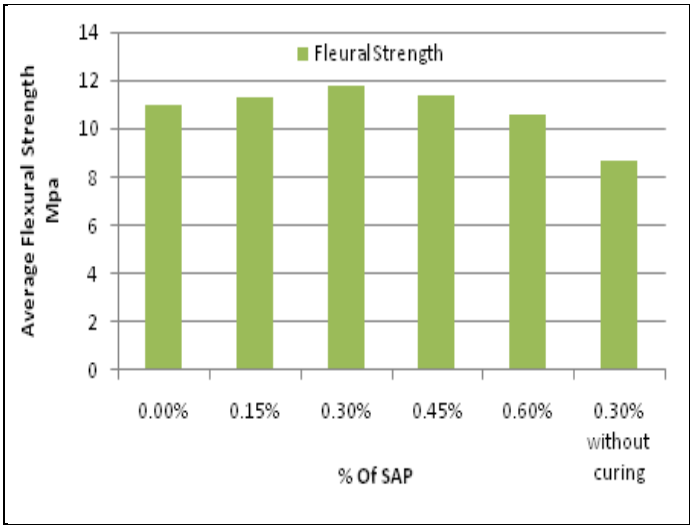

Fig.2. Comparative Flexural strength of concrete with SAP for 28 days.

B. Spilt Tensile Strength

Three cylindrical sections of diameter 150 mm and length 300 mm were casted and cured for 28 days. The split tensile strength of cylinder is calculate by the following formula:

$$fcys = 2P_{sp} / \pi D L$$

Where,

fcys = split Tensile strength, Mpa

P_{sp} = Load at failure, N

L = Length of cylinder, mm

D = Dia. Of cylinder, mm

The table IV gives the results of test conducted on hardened concrete with 0 - 0.60 % of SAP for 28 days.

TABLE IV
EXPERIMENTAL TEST RESULTS FOR SPLIT TENSILE STRENGTH

Sr. No	% of SAP	Split tensile Strength in MPA (28 Days)
1	0 %	2.88
2	0.15%	3.16
3	0.30%	3.70
4	0.45%	2.92
5	0.60%	3.02
6	0.30% WC	2.14

It is clear from table IV Split tensile strength obtained for concrete with 0.30 % of SAP by total volume of cement shows a higher value by 22.16 % compared to conventional concrete for 28 days.

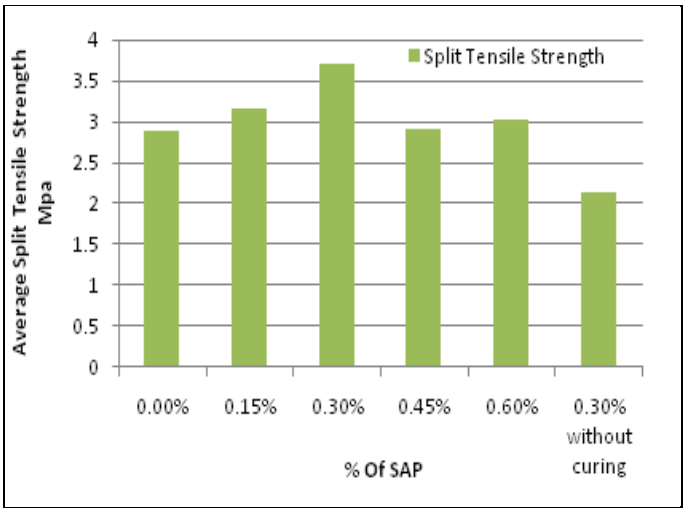

Fig. 3. Comparative Split Tensile strength of concrete with SAP for 28 days.

B. Workability Test

Slump Cone test was conducted for investigation of workability of fresh concrete. Following table shows the slump value for all proportions

TABLE V
SLUMP VALUE FOR ALL PROPORTIONS

Sr. No.	% of SAP	Slump Value
1	0 %	89
2	0.15 %	91
3	0.30 %	94
4	0.45 %	95
5	0.60 %	98
6	0.30 % WC	99

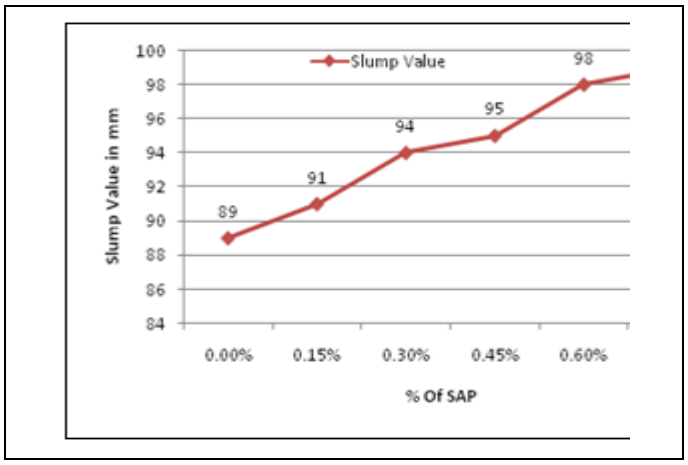

Fig. 4.Comparative Slump test of concrete with SAP for 28 days.

B. Ultrasonic Pulse Velocity test

UPV test was conducted on a cube for investigation of quality and impermeability of concrete with addition of SAP for 28 days. It gives the Pulse velocity from which we decided the quality of concrete i.e. excellent, good, medium and doubtful. Following table shows the range of pulse velocity and the quality of concrete for cube.

TABLE VI
RANGE OF PULSE VELOCITY AND QUALITY OF CONCRETE

Pulse Velocity (km/second)	Concrete Quality
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

The following table shows the readings of pulse velocity test of cube

TABLE VII
RESULT OF PULSE VELOCITY AND QUALITY

Sr. No.	% of SAP	Transducer Distance (cm)	Travel time (µs)	Pulse velocity (km/sec)	Quality of Concrete
1	0.0%	15	36.06	4.15	Good
2	0.15%	15	34.26	4.37	Good
3	0.30%	15	33.66	4.45	Good
4	0.45%	15	35.40	4.23	Good
5	0.60%	15	36.26	4.13	Good
6	0.30% WC	15	37.66	3.98	Good

It is clear from table no VII pulse velocity result of 0.30% of SAP is higher than other % of SAP. And quality of concrete for all cube is Good.

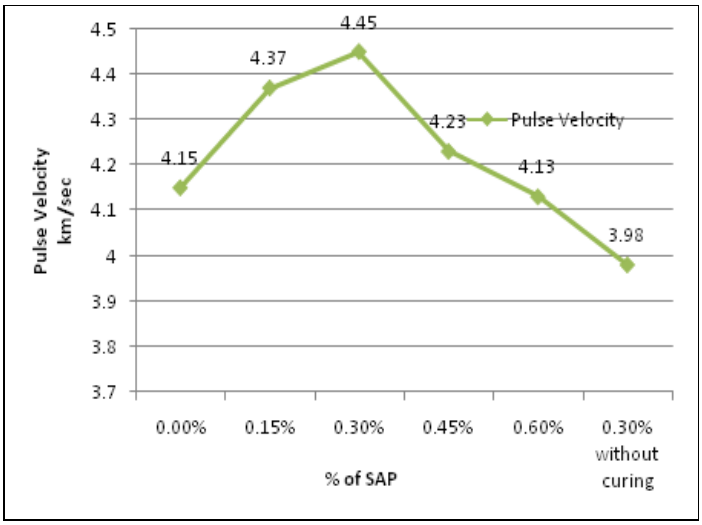

Fig. 5. Pulse velocity of concrete with SAP for 28 days

VI. RESULTS AND DISCUSSION

The influence of SAP on the Properties of concrete such as the compressive strength, Flexural strength, Split tensile strength and slump are studied. And also from UPV test impermeability and quality was calculated

An increase in the compressive strength is observed with the increase in the percentage of SAP from 0.15 % to 0.30%. With 0.30% of SAP the increase in strength approximately 3 days 25.43 %, 7 days 9.63 % and 28 days 8.83 %. The Flexural strength is observed with the increase in the percentage of SAP from 0.15 % to 0.30 %. With 0.30 % SAP the increase in strength approximately 28 days 6.86 %. The Split tensile strength test is observed with the increase in the percentage of SAP from 0.15 % to 0.30 %. With 0.30 % SAP the increase in strength approximately 28 days 22.16 %.

Slump test was carried out and the slump was found to be 94 mm with 0.3 % SAP. Considering the strength criteria, the addition of SAP by total volume of cement is feasible up to 0.3 %. Usage of SAP in concrete can prove to be economical.

UPV test was carried out and it was found that, all % of SAP had a good quality concrete with less permeability and less honeycomb structure.

4. CONCLUSIONS

Based on experimental observations, following conclusions can be established:

1) SAP concrete increases the compressive strength, flexural and tensile strength for 0.30% of SAP as compared with the conventional concrete.

2) As the Percentage of SAP in concrete increase's workability of concrete increases.

3) From strength point of view, Conventional concrete by using 0.30% SAP shows positive results.

4) It was found from the specimens, that the formation of cracks is more in the case of concrete without SAP than the SAP addition in concrete

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