EFFECT OF SELF CURING AGENT ON MECHANICAL PROPERTIES OF DIFFERENT GRADES OF CONCRETE

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ABSTRACT

Ensuring adequate moisture retention in concrete, especially within the initial 28 days post-pouring, is crucial for the progress of desirable concrete qualities. The curing process significantly influences the microstructure and pore configuration of concrete. Self-curing concrete, by minimizing water evaporation, has the potential to retain more water compared to regular concrete. Improper curing may result in a drop in concrete strength, with water-soluble polymers used as admixtures shown to impact concrete strength characteristics. Additionally, the curing process contributes to the enhancement of concrete durability and overall performance. Internal curing agents, such as superabsorbent polymers (SAP) possess the capacity to assimilate and retain a substantial quantity of water from the environment while maintaining their structural integrity. In this study, self-curing concrete grades M20, M30, and M40 are investigated, incorporating varying percentages of SAP (0.2, 0.4, 0.6, 0.8, and 1.0) in the mix. The prior of SAP in self-curing concrete does not compromise compressive strength. Furthermore, incorporating SAP in self-curing concrete does not lead to a reduction in split tensile strength. It is demonstrated that SAP can be employed in self-curing concrete up to 0.6% of the weight of cement without compromising the diverse strengths of the concrete.

Keywords: Self-curing concrete, superabsorbent polymers.

I. INTRODUCTION:

For concrete structures to be useful and last a long time, proper curing is necessary. In conventional building methods, mixing, putting, and finishing are completed before applying external curing. A potential technique called internal curing entails adding more moisture to the concrete so as to improve cement hydration and lessen self-desiccation. An internal curing agent is applied to concrete, serving as a supply of water to replace that which is lost to chemical shrinkage during cement hydration. Internal curing is now accomplished using two primary methods:

To avoid self-desiccation, the first technique uses saturated porous lightweight aggregate (LWA) as an internal water supply to make up for water lost during cement hydration. Superabsorbent polymers (SAP) that can absorb a significant quantity of water during concrete mixing are used in the second approach. By forming inclusions that retain free water, these polymers prevent self-desiccation when the cement hydrates. The internal curing agent's strong water absorption capacity and quick water desorption rates determine how successful it is. A phenomenon referred to as self-curing takes place when cement hydrates due to the presence of unincorporated internal water. It has been hypothesized that conventional curing prevents water from evaporating on the surface from the outside inward. Internal curing, which is alternatively referred to as self-curing results from saturated lightweight micro aggregates, superabsorbent polymers, or saturated wood fibres functioning as internal reservoirs. Several circumstances lead to the need for self-curing. Compared to ordinary Portland cement concrete; mixed cement systems may need more curing water from mineral admixtures. Early-age cracking may result from the decrease in capillary porosity if water is not easily accessible. Cement hydration requires internal curing, which requires extra internal water that is different from the mixing water. A little amount of fine aggregate or polymer is used to supply the extra water needed for internal curing. The use of self-curing admixtures becomes essential due to the significant water requirement for concrete work and the growing shortage of water resources.

1.1 Scope & Objective

The purpose of the study is to evaluate the effectiveness of adding super absorbent polymer to self-curing concrete at a weight percentage of 0% to 1.0% in the cement. The experiments outlined below aim to explore the performance of self-curing concrete across different concrete mix grades, namely M20, M30, and M40. The aspects under investigation embrace

Compressive strength,

Split tensile strength,

Stress-strain behaviour

II. EXPERIMENTAL INVESTIGATION

The purpose of the experiment was to determine how the presence of Super Absorbent Polymer (SAP) in Natural Aggregate influences the self-curing properties of concrete in a variety of grades, especially M20, M30, and M40. The researched material's main foci were its compressive strength and its stress-strain behavior.

For the purpose of the program, a total of 54 cubes, each measuring 150 mm in length, 150 mm in width, and 150 mm in height, as well as 54 cylinders, each measuring 150 mm in length and 300 mm in diameter, were cast and tested separately. For the normal curing concrete with a zero percent SAP content, six cubes and six cylinders were put aside; similarly, six cubes and six cylinders were set away for the self-curing concrete with a two percent SAP content, and so on. In self-curing concrete, the percentages of SAP from which it was utilized varied from 0.2 percent to 1 percent. All 54 cubes and 104 cylinders were subjected to a curing procedure that lasted for 28 days in order to evaluate their strength.

2.1 Materials Used:

Table 1: Materials Used for Mix Preparation

Constituents	NAME OF THE MATERIAL USED	
Cement	Ordinary Portland Cement 53grade	
Aggregates	Fine Aggregate	
	Coarse Aggregate	20mm
		10mm
Water	Portable Water	
Chemical Admixtures	Conplast Sp -430	
Chemical	Super Absorbent Polymer (Sap)	

Throughout the experiments, cement, fine aggregate, normal coarse aggregate, superabsorbent polymer, and water were employed. These materials had the following characteristics.

2.1.1 Cement:

The current investigation made use of OPC of grade 53, which was obtained from JAYPEE cement and was in accordance with Indian specifications IS: 12269-1987. Listed in table 2 are the results of some tests that were directed on the characteristics of cement.

Table 2: Physical Properties of Ordinary Portland Cement

S.NO	Characteristics	IS-specifications (IS:12269-1987)	Test results	Remarks
1	Standard consistency		32%	
2	Setting time in minutes i. Initial setting time ii.Final setting time	 >30 <600	 112 240	Satisfactory Satisfactory
3	Specific gravity	3.15	3.12	

2.1.3 Fine Aggregate:

Fine aggregate in the form of locally accessible sand has been employed, with the particle size distribution and attributes given in Table 3. It was necessary to eliminate any foreign compounds that were current in the sand before it could be used. The parameters of the fine aggregate, established by performed testing, are provided in Table 3

Table 3: Sieve Analysis of Fine Aggregate

S.no	IS sieve designation	Weight retained (g)	(%) retained	(%) passing	Cumulative (%) retained
1.	4.75mm	20	2	2	98
2.	2.36mm	50	5	7	93
3.	1.18mm	125	12.5	19.5	80.5
4.	600m (microns)	310	31	50.5	49.5
5.	300m (microns)	460	46	96.5	3.5
6.	150m (microns)	35	3.5	100	0
7.	Total	1000	-	-	$\sum F$=275

W.t of trial = 1000gm

Total (%) retained,

$\sum F = 275.00$

Fineness modulus of FA,

$\sum F/100 = 275.00/100$

F.M = 2.750

(This falls within the acceptable range of 2.0 to 3.5)

By examining column no. 5 (passage percentage) of table 3, it was determined that the sand belonged to zone-II of the IS:383-1970 classifications.

Table 4: Physical characteristics of FA

S.No	Characteristics	Test results
1.	Sp. gravity	2.560
2.	FM	2.150
3.	Zone of FA	II

2.1.4 Coarse Aggregate:

Locally accessible wrinkled stone aggregate of max size 20 mm has been utilized. The properties are declared in table 5 coarse aggregate has been sieved via IS: 150-micron sieve to eliminate dirt and other extraneous elements.

Table 5 Sieve Analysis of Coarse Aggregate (20mm)

Sieve no.	Wt retained In Kgs	% of wt retained	Cumulative % of wt retained	% Passing
80mm	0	0	0	100
40mm	0	0	0	100
20mm	2.995	59.9	59.9	59
10mm	1.99	39.8	99.7	0.3
4.75mm	0.015	0.3	100	0
2.36mm	0	0	100	0
1.18mm	0	0	100	0
600mm	0	0	100	0
300mm	0	0	100	0
150mm	0	0	100	0

Sample taken 5000 gms

FM of C.A = (cumulative % wt retained)/100 = 7.5960

Modulus of fineness should range from 6 to 8 for cost-effective mixes.

Table 6 Properties of Coarse Aggregate (20mm)

S.no	Features	Test results
1	specific gravity	2.61
2	Maximum size	20mm
3	Fineness modulus	6.80

Table 7 Possessions of CA (10mm)

S.No	Features	Test outcomes
1	Sp. gravity	2.61
2	Maximum size	10mm
3	Fineness modulus	4.90

Table 8 Sieve Analysis of CA (10mm).

Sieve no.	Wt retained in Kgs	%Of wt retained	Cumulative % of wt retained	% Passing
80mm	0	0	0	100
40mm	0	0	0	100
20mm	0.415	8.3	8.3	91.7
10mm	4.410	88.2	96.5	3.5
4.75mm	0.0175	3.5	100	0
2.36mm	0	0	100	0
1.18mm	0	0	100	0
600m	0	0	100	0
300m	0	0	100	0
150m	0	0	100	0

2.1.5 Water:

In accordance with IS: 456-2000 norms, the water used for concrete should satisfy portable quality specifications (pH: 6.8 to 8.0). For the creation of all concrete mixtures and hardening in this investigation, regular faucet water, assessed adequate for ingesting, has been utilized.

2.1.6 Super Plasticizers Conplast Sp 430

To increase the workability of concrete, a chemical component is added to lessen its frictional properties. The widely available superplasticizer Conplast SP 430, based on sulphonated naphthalene formaldehyde, is used to upsurge the concrete's capacity to be worked.

2.1.7 Super Absorbent Polymer

This large molecular weight polymer is cross-linked to some extent and includes strong hydrophilic groups like carboxyl and hydroxyl. High molecular materials and polymers, which can absorb and hold very large volumes of liquid compared to their own mass, are helpful to SAP users, as Table 4.6 illustrates. It has the capacity to absorb clean water up to 500 whiles its own weight, which it then releases under pressure.

TABLE 9: -Chemical Properties of Super Absorbent Polymer.

SAP	
Form	Crystalline powder
Residual Manometer	300PPM
PH Value	6.4
Density	0.610g/Cm3
Absorption rate	0.9% of Nacl .30˚C at 1 Min
Whiteness	75%
Liqiud Permeability	30ml/min

2.2 Casting:

2.2.1 Moulds:

The standard cast iron molds of dimensions (150x150x150mm) for cubes and (150diax300mm) for cylinders were used for casting specimens. Each mold was meticulously cleaned and lubricated before every use, and plastic sheets were placed underneath to facilitate mold casting.

2.3 Mixing, Compaction, And Curing

2.3.1 Mixing

Precise measurements of cement, sand, and coarse aggregate were taken before blending to achieve a uniform mixture. Appropriate to get a homogenous mix, water was added to help with appropriate mixing and every effort was taken to prevent lumps or balling from forming.

2.3.2 Compaction

Standard mechanical vibrator techniques, specifically a table vibrator, were employed for compacting the concrete. The table vibrator, with its appropriate inclination, effectively aligned the aggregates inside the example, requiring less vibration to transfer and solidify the mix into the molds. Compaction was performed on a platform-style vibrating table.

2.3.3 Curing

After two to three hours of casting, the specimens had identification markings inscribed on them. After being in the molds for a full day, the specimens were removed and left to cure in fresh water for a further 28 days. Cubes meant for self-curing were kept indoors at room temperature or under cover.

2.4 Testing Procedure

Cube and cylinder samples were inspected for compressive strengths, split tensile strengths, and stress-strain behavior at an early age of 28 days. The ensuing tests were directed:

- Compressive strength test
- Split Tensile Strength test
- Stress-strain behavior

Equipment used: CTM and Compress meter with 2 dial gauges.

III. CONCRETE MIX DESCRIPTIONS

Concrete cubes and cylinders were verified for compressive strength and stress-strain curves using standard cast iron molds that were 150 x 150 x 150 mm for the cubes and 300 mm for the cylinders. A total of sixty cubes and sixty cylinders were cast, six for apiece grade of mix at 28 days of age.

The models were separated into four groups: 0.2%, 0.4%, 0.6%, 0.8%, and 1.0% of SAP and ordinary concrete, respectively. These groups represented the volume percentages at which SAP substituted simple aggregate and cement. Created on the SAP composition as a percentage of cement mass, the classifications are as follows:

- PC: Plain Concrete
- 0.2%: Concrete thru 0.2% SAP
- 0.4%: Concrete thru 0.4% of SAP
- 0.6%: Concrete thru 0.6% SAP
- 0.8%: Concrete thru 0.8% SAP

- 1.0%: Concrete thru 1.0% SAP

Mix proportions were determined rendering to IS 10262-2009 for quantities required for 1 cubic meter of concrete for M20, M30, and M40 grade mixes.

Table 10 -Particulars of Mix Proportions

Grade of Concrete	**Cement in Kg/m3**	**Fine Aggregate in Kg/m3**	**CA in Kg/m3**	**Water in Ltr**
M20	342.00	585.00	1225.00	174.00
Ratio’s	1	1.71	3.58	W/c 0.51
M30	381.00	712.00	1282.00	164.0
Ratio’s	1	1.86	3.35	W/C 0.41
M40	410.00	725.00	1360.00	155.8
Ratio’s	1	1.81	3.45	W/C 0.38

Table 11: Particulars of Specimens to Be Casted

Type of Mix	**Compressive Strength (Cubes)**			**Split tensile Strength (Cylinders)**			**Stress - Strain Behaviour (Cylinders)**		
	M20	**M30**	**M40**	**M20**	**M30**	**M40**	**M20**	**M30**	**M40**
Plain	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
0.2%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
0.4%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
0.6%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
0.8%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1.0%	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total	18	18	18	18	18	18	18	18	18
	54 Cubes			54 Cylinders			54 Cylinders		
Total	54 CUBES			108 CYLINDERS					

Table 12: Particulars of Samples and Sizes.

Name of test	**Size of specimen**	**No. of mix**	**No. of specimens for each mix**	**Total no. of specimens**
Compressive strength test	150x150x150 mm cube	3	18	54
Split Tensile Strength	150x300mm cylinder	3	18	54
Stress strain behavior	150x300mm cylinder	3	18	54

IV. RESULTS & DISCUSSIONS:

4.1 Compressive Strength

A compression test conducted in accordance with IS: 516-1959 has been used to regulate the compressive strength of self-curing concrete. A detailed summary of the compressive strengths of ordinary concrete and concrete blends including Super Absorbent Polymer (SAP) in different percentages ranging from 0% to 1.0% is provided in Table 13, it presents the results for various SAP percentages used in self-curing concrete. Fig. 7 provides a graphic representation of the data, showing how different SAP addition percentages affect concrete of M20 grade. Research demonstrates that strength increases with a 0.6% rise in SAP and decreases between 0.6% and 1.0% SAP. Interestingly, adding SAP to concrete without having it externally cured strengthens it more than concrete that has been traditionally cured.

Table 13: Cube Compressive Strength of Concrete in Mpa At 28 Days Curing Period

S.no	Type of Concrete	For M_{20}	For M_{30}	For M_{40}
1	Plain	22.50	34.13	41.420
2	0.2%	23.330	34.73	45.180
3	0.4%	23.770	34.92	48.010
4	0.6%	24.120	35.15	50.780
5	0.8%	23.030	33.19	47.610
6	1.0%	22.710	33.69	42.300

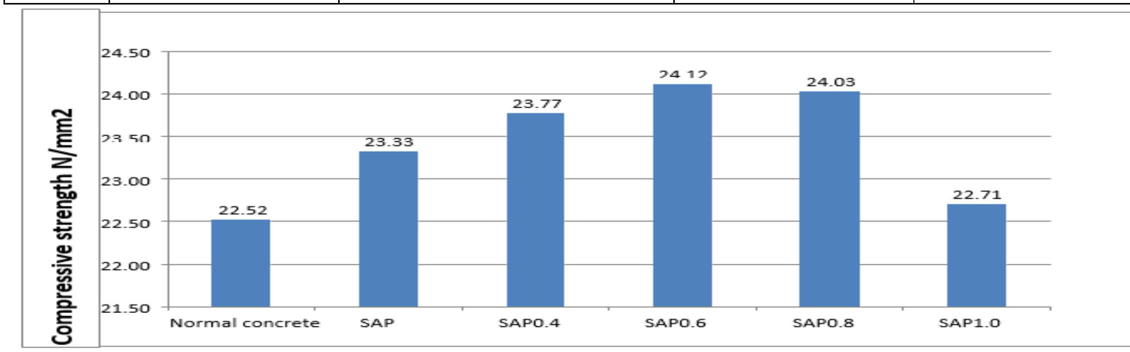

Figure 1: Graphical representation of test result for M20 grade concrete

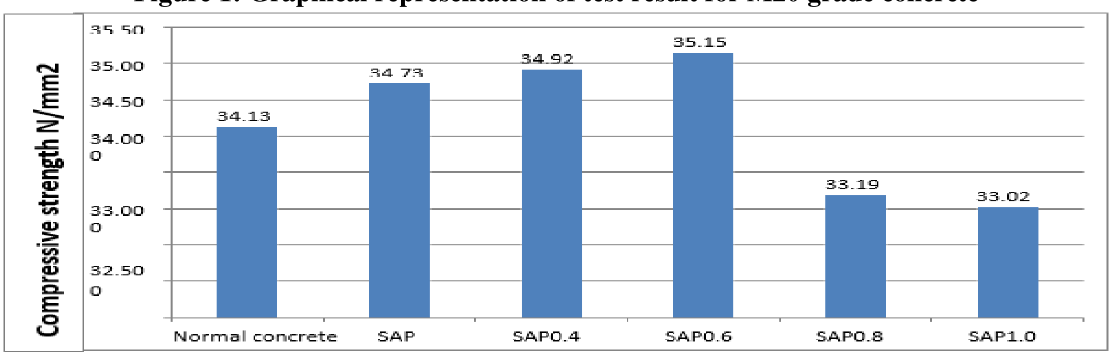

Figure 2: Graphical picture of test outcome for M30 grade concrete.

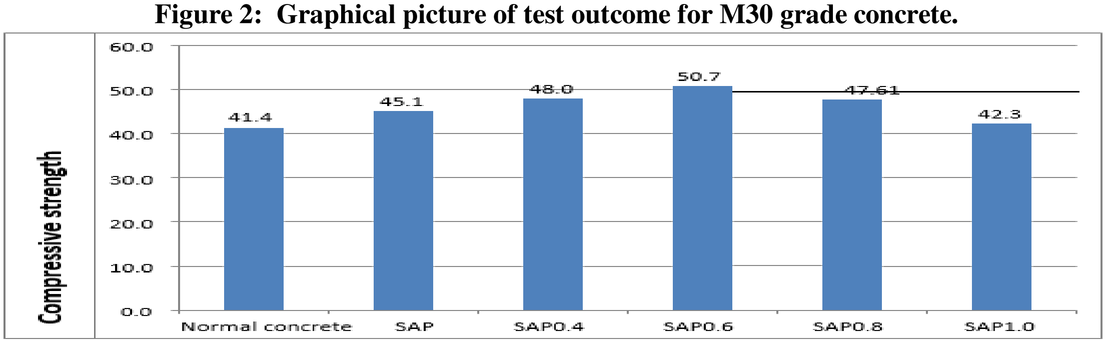

Figure 3: Graphical image of test outcome for M40 grade concrete

4.2 Split Tensile Strength:

Using a compression test, the SPT Strength of Self-Curing Concrete was evaluated in accordance with IS: 5816-1999 criteria. The SPT for ordinary concrete and blends including SAP are shown in Table 14, spanning from 0% to 1.0%, the SPT strength values for M20, M30, M40 grade self-curing concrete at different SAP addition percentages. The SPT values for M20 self-curing concrete with several SAP % are shown graphically in Figures. The SPT strength was improved by adding SAP in different proportions. Interestingly, as compared to other percentages, the concrete sample containing 0.60% SAP showed a little increase in strength.

Table 14: Split Strength of Concrete in Mpa At 28 Days Curing Period

S.no	Type of Concrete	For M_{20}	For M_{30}	For M_{40}
1	Plain	1.20	1.81	4.71
2	0.2%	1.23	2.10	4.93
3	0.4%	1.28	2.31	5.10
4	0.6%	1.35	2.71	5.18
5	0.8%	1.21	2.35	4.86
6	1.0%	1.12	2.24	4.39

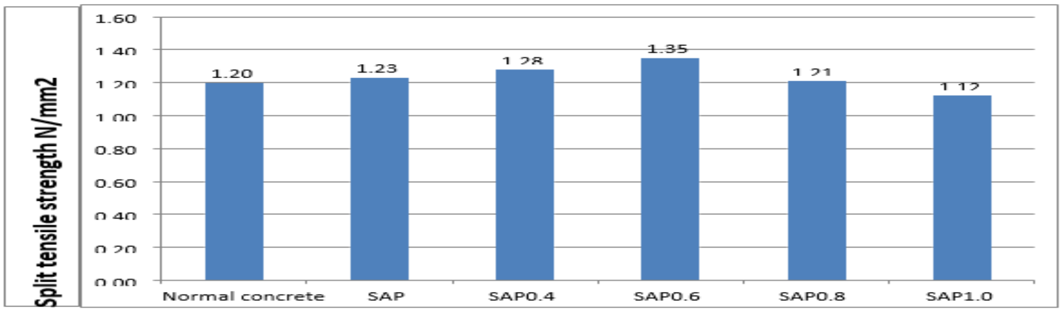

Figure 4: Graphical image of test outcome for M20 grade concrete

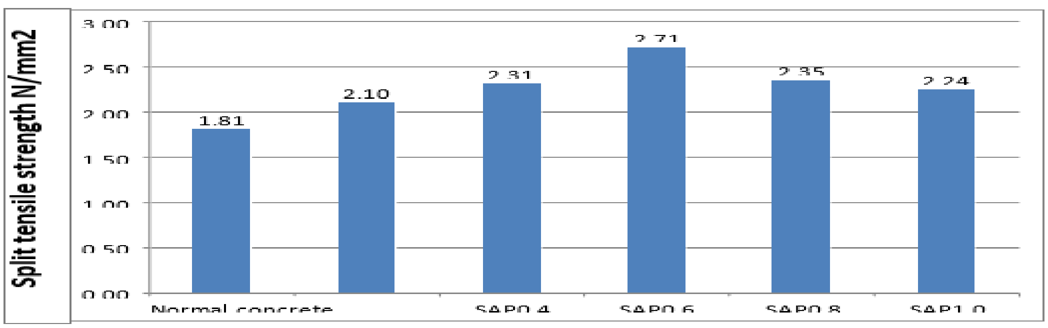

Figure 5: Graphical image of test outcome for M30 grade concrete

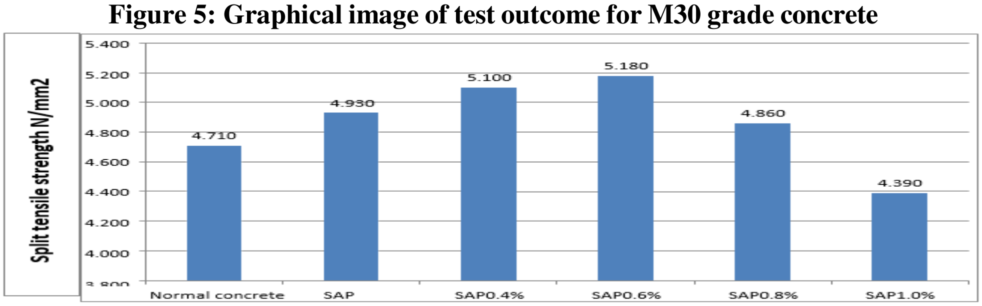

Figure 6: Graphical image of test outcome for M40 grade concrete

5.6 STRESS-STRAIN BEHAVIOR.

The stress-strain behavior of self-curing concrete for M20 grade, taking into account different percentages of SAP, is revealed in Table 15. Fig. 7 shows a graphic depiction of the stress-strain performance for M20 grade self-curing concrete at various SAP percentages. For M20 grade concrete, the strain consistent to the final stress (€p) increased beginning at 0.6% of SAP.

Table 15: -The outcomes of stress – strain behavior self-curing concrete for M20 grade concrete.

% of SAP	σu(MPa) Ulimate Stress	€p Strain conforming Ultimate stress	σb(MPa) Breaking Stress	€u Ultimate Strain	f_{ck} Characteristic strength
Plain	22	0.0018	17	0.0029	22.5
0.2%	21	0.0020	19	0.0031	23.33
0.4%	19	0.0021	17	0.0031	23.77
0.6%	17	0.0023	17	0.0032	24.12
0.8%	16	0.0024	16	0.0033	24.03
1.0%	18	0.0023	15	0.0031	22.7

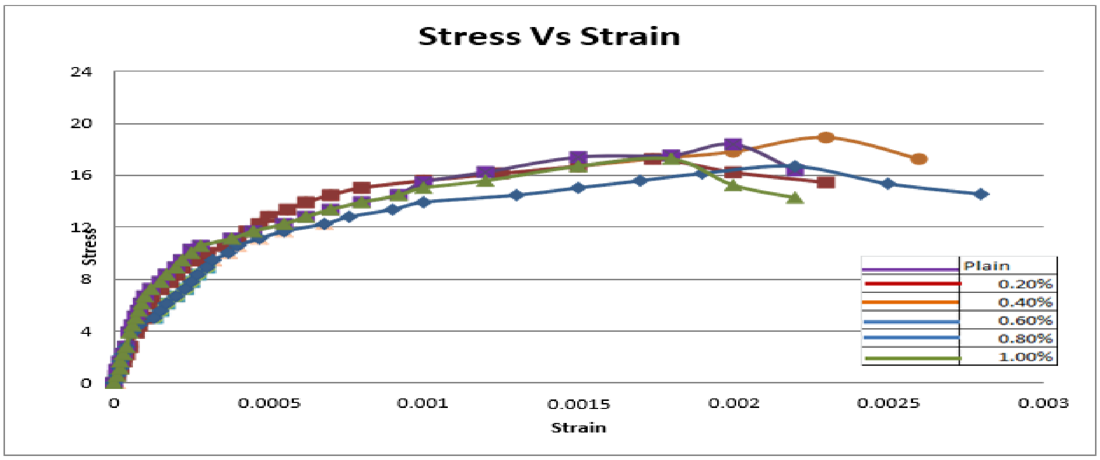

Figure 7: Graphical representation of Stress-strain behaviour for M20grade Concrete

Table 16: -The results of stress – strain behavior self-curing concrete for M30 Grade.

% of SAP	σu(MPa) Ultimate Stress	€p Strain corresponding Ultimate strain	σb(MPa) breaking stress	€u Ultimate Strain	F_{ck} Characteristic strength
Plain	33	0.0017	35	0.0029	34.13
0.2%	32	0.0019	33	0.0030	34.73
0.4%	34	0.0019	31	0.0030	34.92
0.6%	36	0.0020	32	0.0031	35.15
0.8%	37	0.0021	34	0.0032	33.19
1.0%	34	0.0023	31	0.0028	33.69

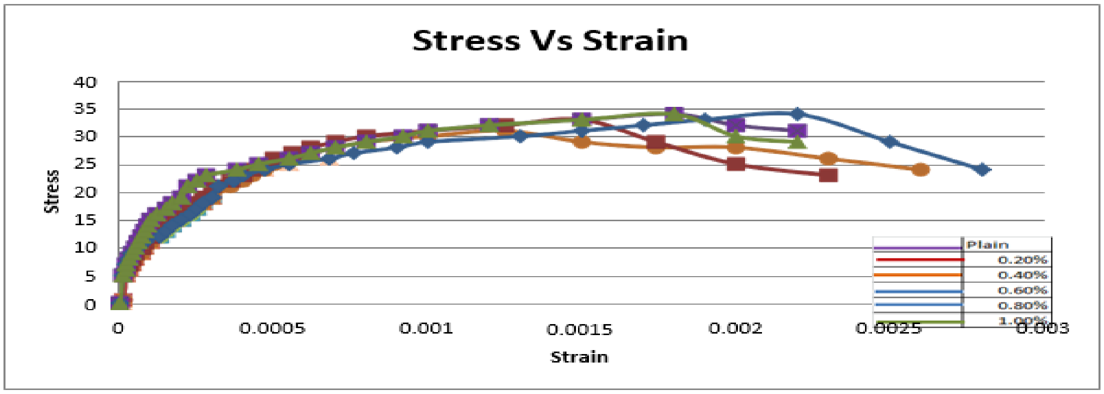

Figure 8: Graphical image of Stress-strain performance for M30grade Concrete

Table 17: -The results of stress – strain behavior of self-curing concrete for M40 grade.

%of SAP	σu(MPa) Ulimate Stress	€p Strain corresponding Ultimate strain	σb(MPa) breaking stress	€u Ultimate Strain	f_{ck} Characteristic strength
Plain	42	0.0018	39	0.0027	41.420
0.2%	40	0.0020	37	0.0029	45.180
0.4%	36	0.0022	33	0.0030	48.010
0.6%	32	0.0024	32	0.0031	50.780
0.8%	30	0.0025	30	0.0032	47.610
1.0%	31	0.0028	31	0.0035	42.300

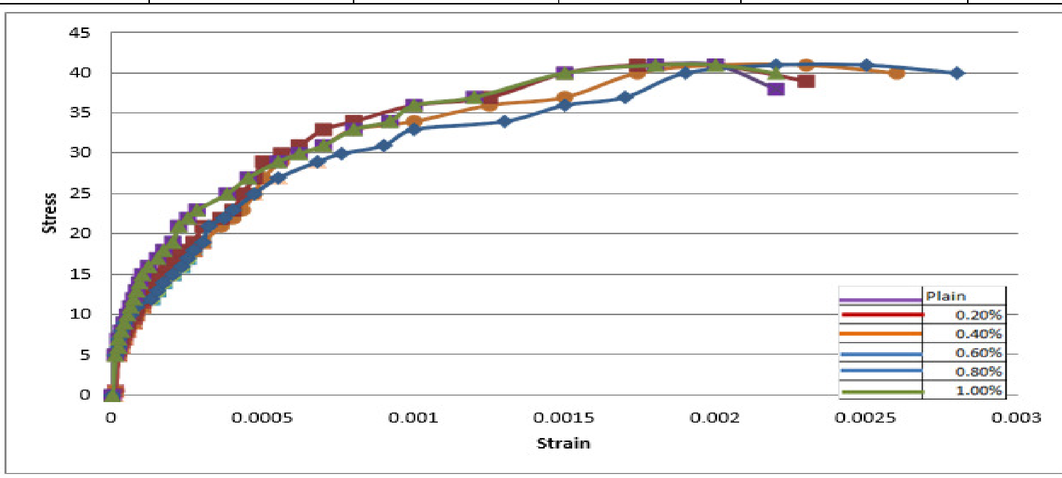

Figure 9: Graphical image of Stress-strain conducts for M40grade Concrete

Research has shown that when SAP increases, the final stress for different concrete grades is somewhat decreased. Furthermore, when the proportion of SAP in concrete rises, strain also increases.

V.CONCLUSION

1. For self-curing concrete, SAP is a great curing ingredient.
2. Adding SAP to self-curing concrete does not result in a reduction in compressive strength.
3. Using SAP in self-curing concrete does not reduce SPT strength.
4. SAP should be used up to 0.6% of the cement weight in self-curing concrete.

5. A significant decrease in the final stress is associated with an increase in SAP dosage for several grades of concrete.
6. Higher SAP doses cause a little increase in strain.
7. When self-curing concrete mixes are used instead of regular concrete, they retain more water.

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