A STUDY ON CONCRETE USING SAP AS AN INTERNAL CURING AGENT FOR WATER CEMENT RATIOS HIGHER THAN 0.4

G.Anamika[1], N.Mohamed Nizar[2]
[1]PG Student, Structural Engineering, Chendhuran college of Engineering and Technology, Pilivalam, Pudukkottai.
Email: anamisevi@gmail.com

[2]Assistant Professor, Department of Civil Engineering, Chendhuran college of Engineering and Technology,
Pilivalam, Pudukkottai..
Email: nizar21189@gmail.com

ABSTRACT

Proper curing of concrete is necessary so that the concrete ensures intended performance and durability requirements. Internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing Water. Conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e., curing is taken to happen 'from the outside to inside'. Proper curing of concrete structures is important to ensure that they meet their intended performance and durability requirements. Therefore an effective in situ curing is necessary to maximize the degree of hydration and to minimize the cracking problems due to drying shrinkage. Concrete is accompanied with evaporation, loss of internal relative humidity, early age cracking and eventually loss of strength. This project is to add super absorbent polymer to concrete at various proportions. In this study, the effect of internal reservoirs as agent for internal curing (Various volume fraction and various aspect ratios) on the short term and long term engineering properties of concrete will be investigated.

KEYWORDS: Super Absorbent Polymer, Density, Water absorption, Compressive strength, Split tensile strength , Flexural Strength.

I. INTRODUCTION

In this project "Internal Curing" is achieved by adding "Super Absorbent Polymer" as an internal curing agent. The main objective of the project is to analyze the strength variation between the concrete casted under normal external curing, concrete casted by SAP alone.

Cubes, cylinders and beams are casted in order to achieve the compressive strength, split tensile strength and flexural strength of the specimens.

Gaston Espinoza-Hijazin and Mauricio Lopez., (2011) investigated that the **Extending internal curing to concrete mixtures with W/C higher than 0.42**. This paper presents the effect of IC as a complement to traditional curing in relatively high W/C concretes (W/C above 0.42) under drying conditions. The results of t-student test showed that internal curing: Significantly increased cement degree of hydration with 99.9%of confidence level. Significantly increased compressive strength with 98.8% of confidence level. Significantly decreased chloride ion permeability of concretewith99.0% of confidence level.

C. Selvamonyet al., (2010) presented the **investigations on self-compacted self-curing concrete using limestone powder and clinkers**. This paper presents the effect of replacing the cement, coarse aggregate and fine aggregate by limestone powder (LP) with silica fume, quarry dust and clinkers. Fresh properties, flexural and compressive strengths and water absorption properties of Concrete were determined. Silica fume was observed to improve the mechanical properties of SCC.

M.S.Ravikumar et al., (2008) on **behaviour of self compacted self curing kiln ash concrete with various admixtures**. The main objective of the study was producing and evaluating SCC made with high-volumes of klin ash. They were experimented ten SCC mixtures and one control concrete. They were determined fresh properties, flexural and compressive strengths of self compacted concrete. The use of silica fume in concrete significantly increased the dosage of super plasticizer (SP). Finally they suggest that certain quarry dust (QD), silica fume(SF) and kiln ash (KA) combinations can improve the workability of SSCs, more than QD, SF and KA alone.

This present project is carried out as per the following method. The properties of mineral admixtures are studied by carrying out strength and workability test. Then the concrete cubes, cylinders are added with SAP in concrete with various mix ratios and the specimens are subjected to loading separately up to the failure. The load carrying capacity, deflection and crack pattern of the concrete cubes, cylinders and beams are studied.

II. EXPERIMENTAL PROGRAM

2.1.MATERIALS USED

2.1.1.CEMENT

In the present investigation OPC 53 Grade PENNA brand cement confirming to IS: 12269-(1987) was used and its properties are tabulated in Table 1.

Sl.No	Physical properties of cement	Results
1	Specific gravity	3.15
2	Standard consistency (%)	27%
3	Initial setting time (min)	30
4	Final setting time (min)	690

Table 1 Properties of cement

2.1.2. FINE AGGREGATE

The fine aggregate used in this experimental investigation was natural river sand confirming to zone II as per IS: 383-1987. The properties of fine aggregate are shown in Table 2.

2.1.3. COARSE AGGREGATE

Crushed aggregates particles passing through 20mm and retained on 10mm I.S sieve was used as natural aggregates which met the grading requirements. The properties of coarse aggregate are shown in Table 2.

Properties of aggregates	Fine aggregates	Natural coarse aggregate
Specific gravity	2.67	2.74
Fineness modulus	2.8	7.4
Water absorption	0.815%	0.195%
Impact value	_	16.73%
Grading of sand	Zone II	_

Table 2: Properties of Aggregates

2.1.4.SUPER ABSORBENT POLYMER

Effect of super-absorbent polymer (SAP) as agent for internal curing on free autogenous shrinkage and compressive strength of concrete with low w/c ratios is investigated. Water entrainment by means of SAP leads to the controlled formation of water-filled macro pore inclusions in the fresh concrete, which prevent self-desiccation shrinkage of the hardening concrete.

Physical and chemical properties of SAP

Boiling point = >350F

Vapour pressure = <10mm Hg

Solubility in water = swells

Appearance and Odor = White odorless solid

Specific gravity = 0.65-0.85

Flash point = non flammable

2.1.5 MIX PROPORTIONING

Concrete mix design for M_{30} grade in this experiment was designed as per the guidelines specified in I.S. 10262-1982. The Table 4 shows mix proportion of concrete.

Water	186 lit /m^3	0.4	186 lit /m^3	0.45
Cement	465 kg/m^3	1	413.3 kg/m^3	1
Fine Aggregate	590.46 kg/m^3	1.27	605.45 kg/m^3	1.5
Coarse Aggregate	1113.39 kg/m^3	2.40	1141.66 kg/m^3	2.8

Table 3: Mix proportioning

III. EXPERIMENTAL METHODOLGY

The specimen of standard cube of 150mm x 150mm x 150mm and cylinders of 300mm x150mm and beam of 500x100 10mm were used to determine the compressive strength, split tensile strength and flexural strength of concrete. Three cubes, three cylinders, three flexural beams were cast for each concrete mixture with 30 and 40 percentage of SAP. Totally 90 specimens were casted , Among that 30 number of cubes, 30 number of cylinders and 30 number of flexural beams. The water cement ratio adopted was 0.40 and o.45 through all the mix proportions. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 and 28 days and Compression Testing Machine (CTM) with capacity of 2000KN were used to test its compressive strength and split tensile strength ,flexural strength test is carried by three point loading system. The beams were mounted over two pedestals and the concentrated loads were applied by means of 40T Universal Testing machine (UTM).

IV . RESULTS AND DISCUSSIONS

4.1COMPRESSIVE STRENGTH

In cement-based materials, the compressive strength is a considered as the most important mechanical properties. Substitution of SAP in concrete affected the compressive strength development process over time depending on their characteristics. Compressive strength value of all mixtures is listed in the below Table 4.

W/C	Curing condition	% OF SAP	Compressive strength	
			7 days	28 days
0.4	NIC	-	30.02	42.41
0.4	NIC	-	28.78	41.12
0.4	NIC	-	29.09	41.57
0.4	IC	30	28.21	40.30
0.4	IC	30	27.48	39.26
0.4	IC	30	28.11	40.16
0.4	IC	40	31.40	44.86
0.4	IC	40	31.97	45.67
0.4	IC	40	32.79	46.84
0.45	NIC	-	27.58	39.40
0.45	NIC	-	26.99	38.56

0.45	NIC	-	27.37	39.10
0.45	IC	30	25.28	36.12
0.45	IC	30	24.88	35.54
0.45	IC	30	24.50	35.01
0.45	IC	40	29.83	42.62
0.45	IC	40	29.48	42.12
0.45	IC	40	29.30	41.86
0.5	NIC	-	26.28	37.55
0.5	NIC	-	25.98	37.12
0.5	NIC	-	26.16	37.38
0.5	IC	30	22.83	32.61
0.5	IC	30	23.42	33.46
0.5	IC	30	21.79	31.14
0.5	IC	40	26.50	37.86
0.5	IC	40	26.68	38.12
0.5	IC	40	26.99	38.56

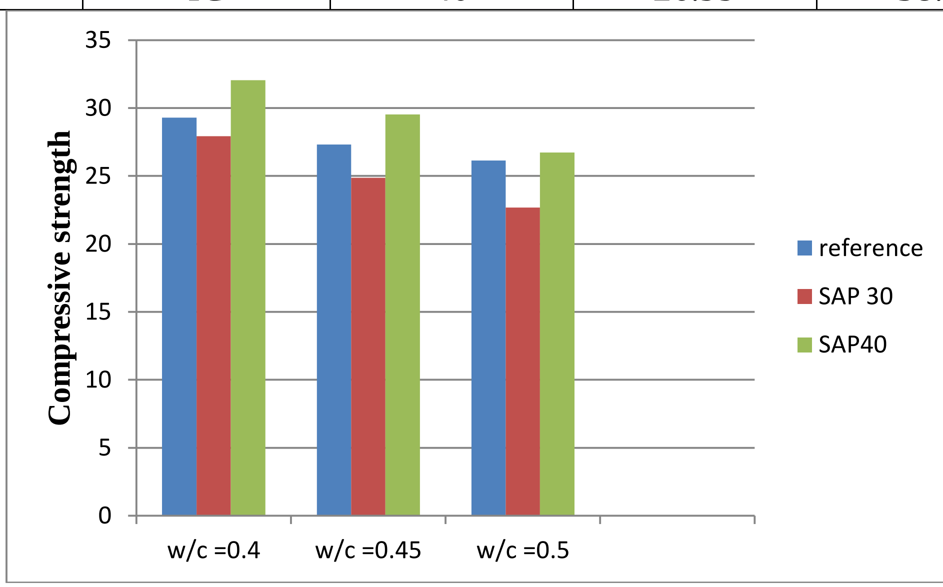

Figure 1 : 7 Days Compressive Strength

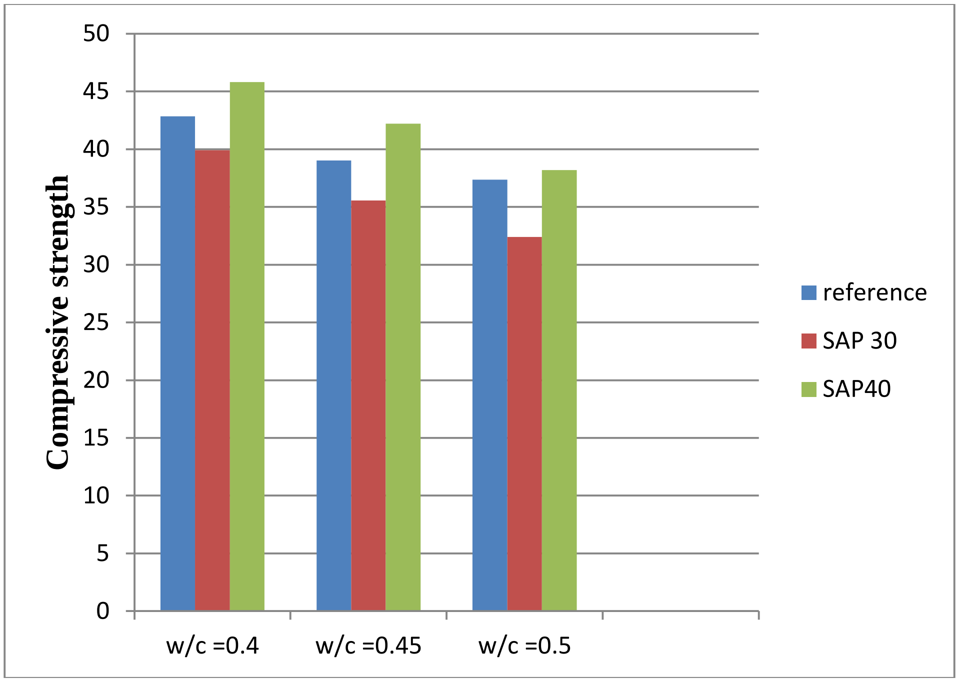

Figure 2 : 28 Days Compressive Strength

Figure clearly shows that the compressive strength of SAP 40 is significantly higher than the reference mixture and SAP30. From the Figure it was observed that the inclusion of SAP improve the compressive strength of the concrete.

4.2 SPLIT TENSILE STRENGTH

Although the Compressive strength is the most important property of the hardened concrete, the tensile strength is critical properties for concrete subjected to tensile force which is induced by autogenous shrinkage. Split tensile strength value of all mixtures is listed in Table.

Table 5 : Split Tensile Strength

W/C	Curing condition	% OF SAP	Split tensile strength	
			7 days	28 days
0.4	NIC	-	2.59	3.7
0.4	NIC	-	2.55	3.65
0.4	NIC	-	2.52	3.6

0.4	IC	30	2.63	3.76
0.4	IC	30	2.55	3.64
0.4	IC	30	2.51	3.58
0.4	IC	40	2.87	4.11
0.4	IC	40	2.79	3.98
0.4	IC	40	2.72	3.88
0.45	NIC	-	2.10	3.01
0.45	NIC	-	2.06	2.95
0.45	NIC	-	1.96	2.80
0.45	IC	30	2.13	3.04
0.45	IC	30	1.99	2.84
0.45	IC	30	2.04	2.91
0.45	IC	40	2.39	3.42
0.45	IC	40	2.36	3.38
0.45	IC	40	2.42	3.46
0.5	NIC	-	1.82	2.60
0.5	NIC	-	1.71	2.44
0.5	NIC	-	1.41	2.01
0.5	IC	30	1.58	2.26
0.5	IC	30	1.62	2.31
0.5	IC	30	1.42	2.02
0.5	IC	40	2.03	2.91
0.5	IC	40	1.98	2.83
0.5	IC	40	2.12	3.01

IC : Internal Curing applied
NIC : No Internal Curing applied

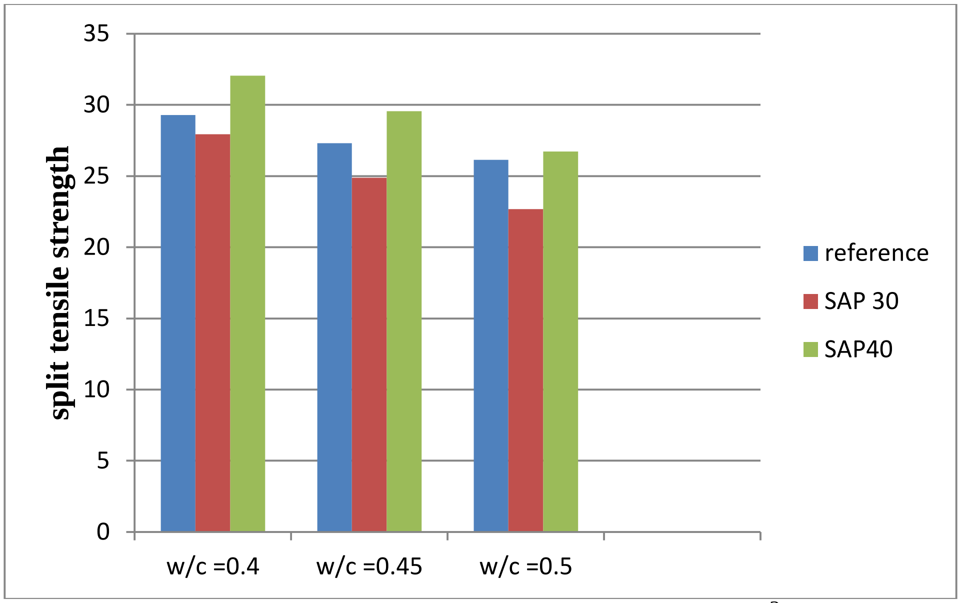

Figure 3 :7 Days Split Tensile Strength (N/Mm^2)

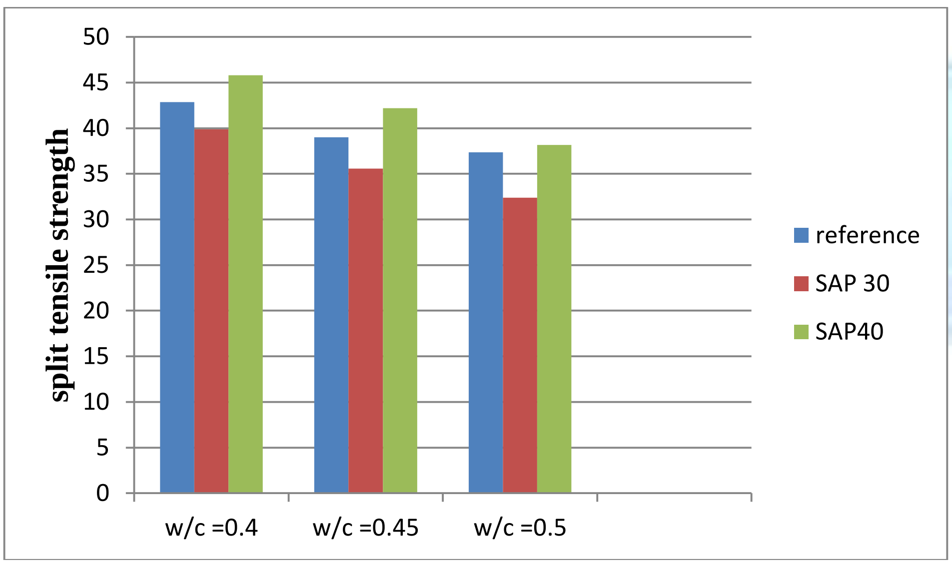

Figure 4: 28 Days Split Tensile Strength

Figure clearly shows that the split tensile strength of SAP 40 is increased compared with other two mixtures. There is a small difference between SAP 30 and the reference mix. It concludes that, Internal curing is not enough for SAP 30

4.3.FLEXURAL STRENGTH

Flexural strength test is carried out on Flexural beams (length 150 mm, breadth 300 mm, depth 300mm) also stored immediately after mixing in a climate room. Three point loading system was adopted for the tests. Flexural strength value of all mixtures is listed in the below Table

Table 6 : Flexural Strength

W/C	Curing condition	% OF SAP	Flexural strength	
			7 days	28 days
0.4	NIC	-	4.46	6.38
0.4	NIC	-	4.27	6.10
0.4	NIC	-	4.82	6.87
0.4	IC	30	4.52	6.55
0.4	IC	30	4.38	6.45
0.4	IC	30	4.22	6.35
0.4	IC	40	4.82	6.89
0.4	IC	40	4.86	6.94
0.4	IC	40	4.72	6.78
0.45	NIC	-	3.58	5.12
0.45	NIC	-	3.85	5.50
0.45	NIC	-	3.75	5.36
0.45	IC	30	3.78	5.40
0.45	IC	30	3.75	5.36
0.45	IC	30	3.70	5.26
0.45	IC	40	4.08	5.83
0.45	IC	40	3.79	5.42
0.45	IC	40	3.98	5.68
0.5	NIC	-	3.51	5.01
0.5	NIC	-	3.58	5.12
0.5	NIC	-	3.47	4.96
0.5	IC	30	3.64	5.20
0.5	IC	30	3.57	5.10
0.5	IC	30	3.50	5.01
0.5	IC	40	3.72	5.32
0.5	IC	40	3.93	5.62
0.5	IC	40	3.79	5.42

IC : Internal Curing applied
NIC : No Internal Curing applied

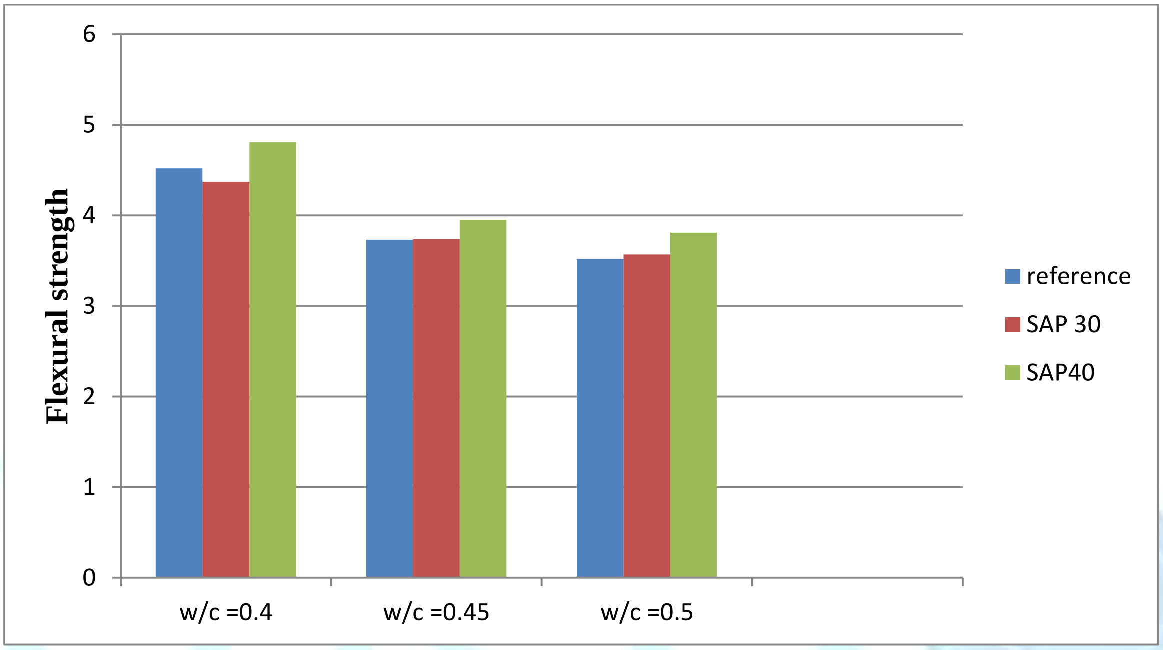

Figure5 : Flexural Strength (7 Days)

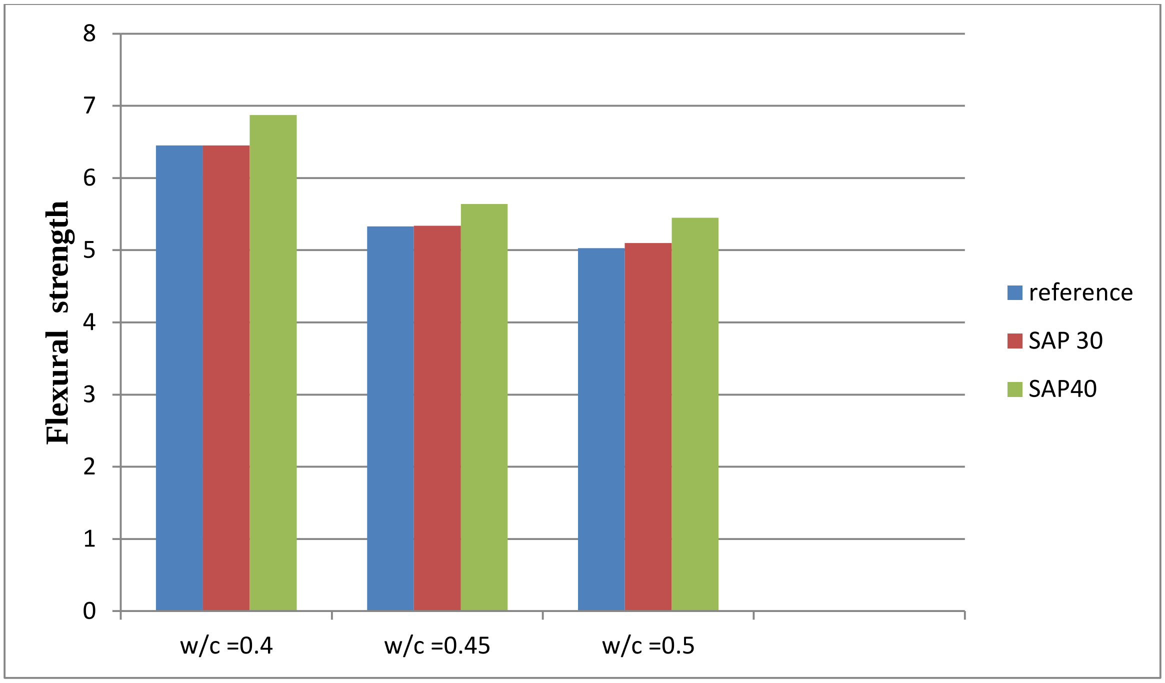

Figure6: Flexural Strength (28 Days**)**

Figure clearly shows that the flexural strength of SAP 40 is increased compared with other two mixtures. There is a small difference between SAP 30 and the reference mix. It concludes that, Internal curing is not enough for SAP 30. For water cement ratio 0.4 it is more strength compared to other water cement ratios 0.45 and 0.5.

v . CONCLUSIONS

This study demonstrated the effective approach for mitigating the autogeneous shrinkage by means of SAP as an internal curing agent. Based on the test results following conclusions were drawn. Addition of SAP leads to a significant increase of mechanical strength. The effectiveness of internal curing by means of SAP applied to a high-performance concrete is the highest if 45 kg/ m^3 water is added by means of 1 kg/m^3 SAP. SAP 30 and SAP 40 enhanced their compressive strength when compared to the normal specimen. Substitution of SAP much not increase the tensile and flexural strength in early ages, and the strength values are significantly high in later age i.e. 28 days.Super absorbent polymer 40 increases the flexural strength at 28 days compared to controlled specimen and SAP 30 beam specimens

REFERENECS

1] V.H. Villarreal, D.A. Crocker, Better pavements through internal hydration, Concrete International (February 2007) 32–36.

[2] D. Cusson, T. Hoogeveen, An experimental approach for the analysis of early-age behaviour of high-performance concrete structures under restrained shrinkage, Cement and Concrete Research 37 (2) (February 2007) 200–209.

[3] K. Kovler, Testing system for determining the mechanical behaviour of early-age concrete under restrained & free uniaxial shrinkage, Materials & Structures 27 (1994) 324–330.

[4] O. Bjontegaard, T. Kanstad, E.J. Sellevold, T.A. Hammer, Stress inducing deformations and mechanical properties of high-performance concrete at very-early-ages, 5th Int. Symposium on Utilization of High-Strength/High- Performance Concrete, Norway, Sandefjord, June 1999, pp. 1027–1040.

[5] P.F. Hansen, E.J. Pedersen, Maturity computer for controlled curing and hardening of concrete, Nordisk Betong 41 (19) (1977) 21–25.

[6] J. Zhang, D. Cusson, L. Mitchell, T. Hoogeveen, J. Margeson, The maturity approach for predicting different properties of high-performance concrete, 7th International Symposium on Utilization of High-Strength/ High-Performance Concrete, Washington, USA, ACI SP 228-11, 1, June 20–24, 2005, pp. 135–154.

[7] D. Bentz, P. Halleck, A. Grader, J. Roberts, Four-dimensional X-ray microtomography study of water movement during internal curing, Slide Presentation made at the International RILEM conference on Volume Changes of Hardening Concrete: Testing and Mitigation, August 20–23, 2006, Denmark, Lyngby.

[8] D. Cusson, T. Hoogeveen, New test method for determining coefficient of thermal expansion at early age in high-performance concrete, 12th International Conference on Chemistry of Cement, Montreal, Canada, July 2007, 12 pp.

[9] A. Bentur, Early age cracking tests, in early age cracking in cementitious systems, report of RILEM committee TC 181-EAS, in: A. Bentur (Ed.), RILEM Publications Sarl, France, Bagneux, 2002, pp. 241–255.

[20] S. Zhutovsky, K. Kovler, A. Bentur, Influence of cement paste matrix properties on the autogenous curing of high-performance concrete, Cement and Concrete Composites 26 (2004).

[10] D.P. Bentz, Internal curing of high-performance blended cement mortars, ACI Materials Journal 104 (4) (July–August 2007) 408–414.