EXPERIMENTAL STUDY ON WORKABILITY OF LIGHT WEIGHT CONCRETE WITH VARYING PERCENTAGE OF SUPER PLASTICIZERS AND ITS PERFORMANCE WITH THE STRENGTH PRAMATERS

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ABSTRACT: lightweight concrete can be defined as a type a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities and lessened the dead weight ,it has low density compared to the conventional concrete . Over the past six decades, EPS has become accepted world-wide as the safe, highly effective, economical form of building insulation. Building costs, rising energy costs and a greater awareness of global warming and energy conservation are important aspects of home building.With the increase in demand for construction materials, there is a strong need to utilize alternative materials for sustainable development. Super Plasticizers are a relatively new category of plasticizer and also the improved version of plasticizer. They are different from normal Plasticizers chemically. The use of Super Plasticizer in concrete is an important in advancement of concrete technology. Use of Super Plasticizer permits reduction of water to the extent up to 30% without reducing workability in contrast to the possible reduction up to 15% earlier by using Plasticizer. The use of Super Plasticizer is done for the production of flowing, self-levelling, self-compacting and also for the production of High Strength and High Performance Concrete. To increase the strength of concrete, some special cements are use. Cement and Super Plasticizer and also various primary tests like specific gravity etc. have also been executed to achieve high strength concrete. In this project three Super Plasticizers were used and compatibility studies were done with OPC 53 Cement and their strength parameters while using with M30 grade
Keywords: OPC 53 Cement, Super Plasticizer

I. INTRODUCTION

Now a days the use of admixtures in structural activity is on the rise. The admixture being the costly component of concrete, finding out the optimum dosage of the Super Plasticizer can reduce the cost of construction. However, the production of concrete is not eco-friendly. In this scenario, the use of readily available Super Plasticizer with optimum dosage can reduce the water content without any change in the strength of the concrete. Reduction in the water content can be greatly achieved with the usage of Super Plasticizer in the concrete.30% of water can be reduced by using Super Plasticizer.

Concrete

An artificial stone result obtained from hardening of a mixture made with Cement, aggregates, and water with or without an admixture is known as concrete. When these materials are combined together to form a concrete which is workable, it can be casted into beams, slabs etc. After mixing, the material faces a chemical combination and has a result that mixture sets and hardens reaching greater strength with age. Concrete have high compressive strength and poor in tensile strength. It also induces shrinkage stresses.

Workability

It is a property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, transported, placed, consolidated, compacted etc. The factors effecting lubrication effect on concrete to decrease internal friction to help easy compaction are,

- Higher in the water content per cubic meter of concrete, there will be higher fluidity in concrete which leads to increase in workability
- Higher in the aggregate-cement, leaner is concrete i.e. less quantity of paste is available to provide lubrication, for unit surface area of aggregate and due to this the workability decreases.
- Taking the surface texture and surface area into consideration workability changes, it is more for rough when compared with smooth texture.

Segregation

A good concrete contains all the ingredients like Cement, aggregates and water are properly distributed to give a homogeneous mix. Segregation is defined as "the separation of constituent materials of concrete". Segregation is of three types, one is coarse aggregate coming out or settling down from the rest, secondly the paste getting separated from coarse aggregate and water separating out from rest of the material as it is of lowest specific gravity.

II. LITERATURE REVIEW

C. Jayasree et al (2011): According to this paper, the interaction between cement and Super Plasticizer in concrete is a blend of both physical and chemical mechanisms are interdependent. Any other investigations are not available to understand the physio-chemical nature for this interaction. A wide range of cements and Super Plasticizers are used with varying transportation duration and climatic condition will give the fundamental study that explains the mechanisms of interactions and helps to identify the incompatibility situations. In order to understand the interactions, both application scale as well as the molecular scale study is done where some insight can be obtained into physio-chemical interactions between cement particles and water reducer molecules

C. Jayasree et al (2012): In this paper, the rheology of cement paste due to the effect of Super Plasticizer along with optimizing dosage of Super Plasticizer is studied. The flow behaviour of cement paste is evaluated by conducting a simple tests like Marsh cone test, Mini slump and viscometer tests. Furthermore, tests on concrete were done to correlate the flow behaviour of cement paste and the results were compared. And it is concluded that, In order to make a study on the flow behaviour through Penetration test, the Super Plasticizer paste at 60 min after mixing shows the loss in fluidity for all the Super Plasticizer and its corresponding dosage.

Janardhana Maganti et al (2012): Experiment was done on taking PPC, and from the results it is observed that even though the coarse aggregate, fine aggregate, water, chemical admixture (Super Plasticizer) and method of mixing of concrete are kept constant with the change in the different brands of PPCs there is change in compatibility between cement and Super Plasticizer. Hence it is important to know the compatibility between cement and Super Plasticizer. Temperature should be maintained to conduct the compatibility tests. Every Super Plasticizer should undergo compatibility studies to know the flow properties of cement with concerned Super Plasticizer. To obtained greater slump retention, SNF based Super Plasticizer should be used. But there will be less fluidity for SNF when compared to PCE based Super Plasticizer. More amount of SNF based Super Plasticizer is required to get more amount of fluidity, whereas less amount of PCE based Super Plasticizer should be used. But when cost of Super Plasticizers are compared, SNF based Super Plasticizer is less than PCE based Super Plasticizer

Flow test:

This test is conducted to know the flow behaviour of the cement paste made with some dosage of the Super Plasticizer. This dosage is determined from the datasheet provided by the manufacturer of the corresponding Super Plasticizer. According to the dosage suggested by the manufacturers, the range has been increased up to two points and tests have been conducted. The w/c ratio is kept constant throughout the experiment. For the present study the w/c that was considered is 0.35 and 0.4. This should be conducted at controlled condition i.e. 27±20C.Different trails have been done with changing the dosage of the Super Plasticizer to obtain the Optimum Dosage of the Super Plasticizer. Firstly this test is conducted without using Super Plasticizer to compare the flow behaviour of that cement with using Super Plasticizer and to know the w/c ratio.

Test procdure:

100 grams of cement is taken in a container.70% of water is added to cement and blended it thoroughly without having any lumps and then remaining 30% of water with Super Plasticizer is added to the cement paste and mixed it. This Slurry is made to flow freely on a glass plate by leaving it for some time. The diameter of the flown paste is measured in two directions and average that value is considered as the actual diameter of the paste which have been flowed freely. After completion of one trial, another trial have to be done with increasing the dosage of Super Plasticizer of 0.1% and the flow diameter is noted.

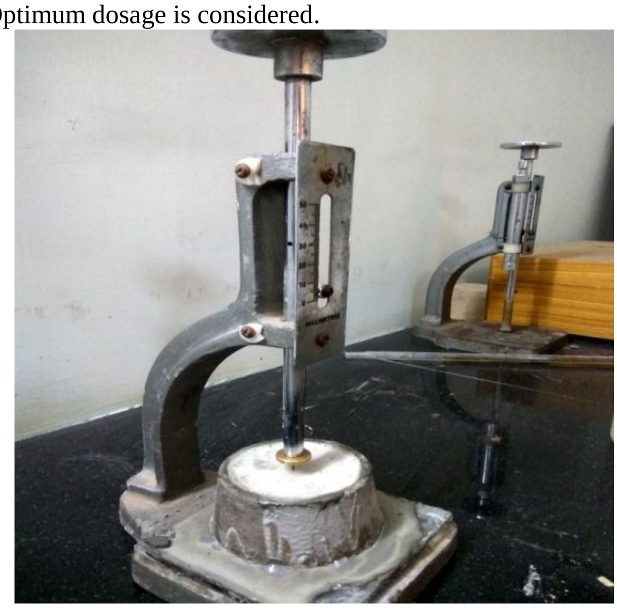
These diameters are noted and a graph is plotted between Dosage and flow of the cement paste. Dosage is taken on X-axis and flow of the paste is taken on Y-axis. The variation in the curve is observed for various dosages of Super Plasticizer with different w/c ratio. From graph, optimum dosage is obtained. The dosage at which there is no further significant change in the curve i.e. no change in the flow is called as Optimum dosage.

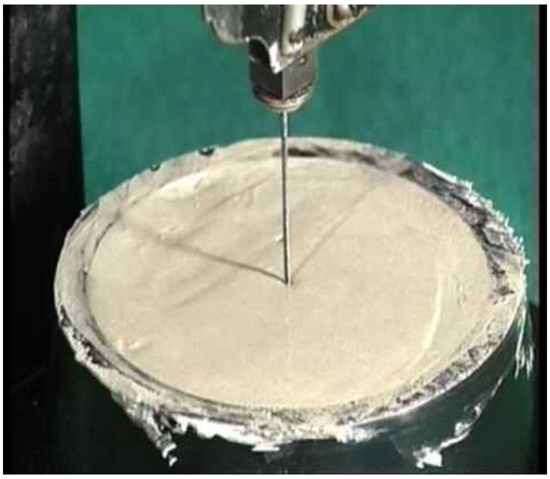
Penetration test:

OPC 53cement is subjected for penetration using different types of Super Plasticizer and with different w/c ratios. The depth of penetration is observed for every half an hour interval with different types of Super Plasticizers. This test results helps to know the setting time with respective to that Super Plasticizer.

Test Procedure:

400 grams of cement is taken and checked thoroughly so that the cement must not contain any lumps. The w/c ratio that is considered is 0.35. Add 70% of required water to the cement powder and stir it thoroughly. Now add the dosage of the Super Plasticizer with remaining 30% of water. The dosage that is going to consider for this test is 5 dosage values (before and after of the optimum value). This solution is added to the cement paste and blending is done. Introduce this cement paste into Vicat Apparatus. The introduction of cement paste must be done within 5 minutes after the addition of water. Vicat needle is let to penetrate into the cement paste for every half an hour interval of time i.e. for 30mins, 60mins, 90mins and 120mins. This procedure is continued with increasing the dosage of Super Plasticizer. The test is conducted with variation in w/c ratio (0.4 w/c). The results were observed for two different w/c ratios and Optimum dosage is considered.





Mini Slump test:
This test is conducted to know the flow behaviour of the cement paste. A cone of 57mm height, 19mm top diameter and 38mm bottom diameter is taken to conduct this experiment. The flow diameter of the cement paste is measured when Super Plasticizer is added to the cement. At the dosage less than the optimum dosage, there will be no flow in the cement paste and at optimum dosage, required flow is observed. Even after increasing the dosage after the optimum value there is no further increase in the flow of the cement paste.

Test Procedure:
Take 200 grams of OPC-53Cement. Add 70% water to cement and mix it thoroughly. Now add 30% of water and Super Plasticizer to that cement paste. Pour this cement paste into the cone and lift the cone and measure the diameter of the flow of cement paste after lifting the cone. This is the flow diameter of cement paste. This procedure is conducted with increasing the dosage of the Super Plasticizer upto 5 intervals. The above test is conducted at 0.35 w/c ratio. The same test is conducted by taking 0.4 w/c ratio. And the results are compared to know that whether there is any variation in optimum dosage value with increase in w/c ratio.

Sieveanalysis
Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.
The apparatus used are –
i) A set of IS Sieves of sizes – 80mm, 63mm, 50mm, 40mm,31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm and 75µm.
ii) Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample.

Compressive strength test:
Test Procedure:
The measuring and testing of test specimens were undertaken as soon as possible after being removed from the curing tank. All specimens were tested in a wet condition and excess water removed from the surface. The dimensions of the test specimens were measured and recorded. The plates were cleaned when necessary to ensure no obstruction from small particles or grit. Any loose particles were removed from the uncapped bearing surfaces of the specimens. It was ensured there was no trace of lubricant on the bearing surfaces. The 150 x 150 mm plate was placed on top and bottom of the beam directly opposite each other. The specimens were centered on the bottom platen of the testing machine. The upper platen was lowered until uniform pressure was provided on the specimen. A force was applied at the required rate shown by the rotating disc on the testing machine.
The maximum force applied to the cylinder was recorded and the compressive strength(C) calculated:

$$\text{Compressivestrength} = \frac{P}{A}$$

Where, P = maximum load (in kg) applied to the specimen,
A = cross-sectional area of the cube on which load is applied

Flexural strength test:
Test procedure:
Test specimens shall be prepared by moldings concrete to a beam section, curing and storing in accordance with standard procedure. The section of the beam shall be square of 100 mm or 150 mm. The overall length of the specimen shall be 4d to 5d. The ratio of d to the maximum particle size of aggregate shall be not less than three. Circular rollers manufactured out of steel having across section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be3dand the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For molded specimens, the mold filling direction shall be normal to the direction of loading. The load shall be applied slowly without shock at such a rate as to increase the stress at a rate of .06 + .04 N/mm^2 per second.
The Flexural Strength (F_b) is given by,

$$F_b = \frac{P \times L}{b \times d^2}$$

Where, F_b = Flexural strength (N/mm^2),
P = maximum load in kg applied to the specimen,
l = length in cm of the span on which the specimen was supported,
b = Measured width in cm of the specimen,
d = Measured depth in cm of the specimen at the point of failure.

Indirect tensile strength test:
Test Procedure:
The diameters of the specimen in the plane in which it is being tested as well as the lengths where the bearing strips are in contact were determined. The bearing strips between the testing jig and the test specimen were aligned. The testing jig was centered in the compression machine and the top platen was lowered. A small force was applied to ensure correct seating was achieved. The force was at the required rate without shock (shown on the inner disc of the machine). The maximum force applied to the concrete before failure was recorded. The fracture type and appearance of concrete were also recorded.
The Indirect tensile strength (T) of the specimen was calculated using the following equation,

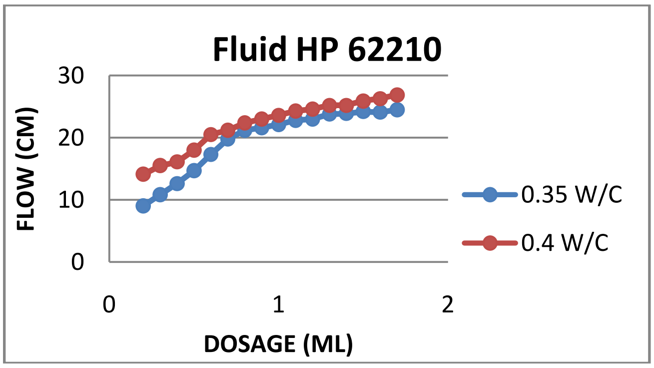
$$Tensile\ strength = \frac{2P}{\pi l d}$$

Where, T= Tensile strength (N/mm^2),
P= maximum applied load indicated by the testing machine (N),
l= length (mm) and
d= diameter (mm)

III. TEST RESULTS

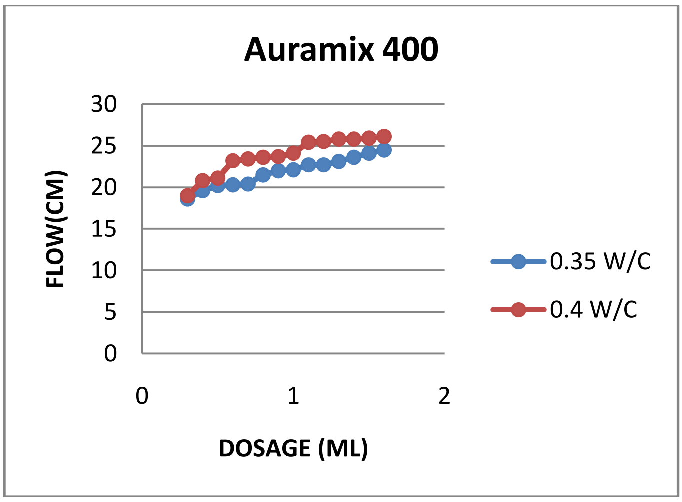
Flow test results for CHRYSO Fluid HP 62210 Super Plasticizer with 0.35 and 0.4 w/c ratio

Dosage of Super Plasticizer (ML)	Flow at 0.35 W/C(cm)	Flow at 0.40 W/C(cm)
0.2	9	14.1
0.3	10.8	15.5
0.4	12.6	16.1
0.5	14.7	18.0
0.6	17.3	20.5
0.7	19.8	21.2
0.8	21.2	22.4
0.9	21.6	23.0
1.0	22.1	23.6
1.1	22.8	24.3
1.2	23.0	24.6
1.3	23.8	25.2
1.4	23.9	25.2
1.5	24.2	25.9
1.6	24.1	26.3
1.7	24.5	26.9



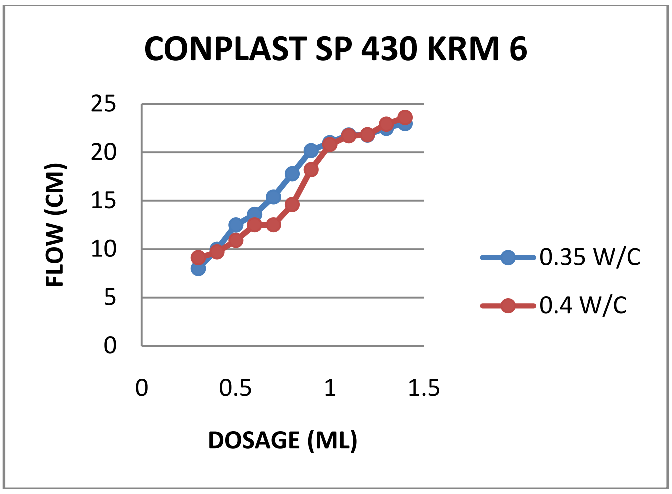
Flow test results for FOSROC Auramix 400 Super Plasticizer with 0.35 and 0.4 w/c ratio

Dosage of Super Plasticizer (ML))	Flow at 0.35 W/C(cm)	Flow at 0.40 W/C(cm)
0.3	18.6	19.0
0.4	19.6	20.8
0.5	20.2	21.1
0.6	20.3	23.5
0.7	20.4	23.4
0.8	21.5	23.3
0.9	22.0	23.7
1.0	22.1	24.1
1.1	22.7	25.4
1.2	22.7	25.5
1.3	23.1	25.8
1.4	23.6	25.9
1.5	24.1	25.9
1.6	24.5	26.1



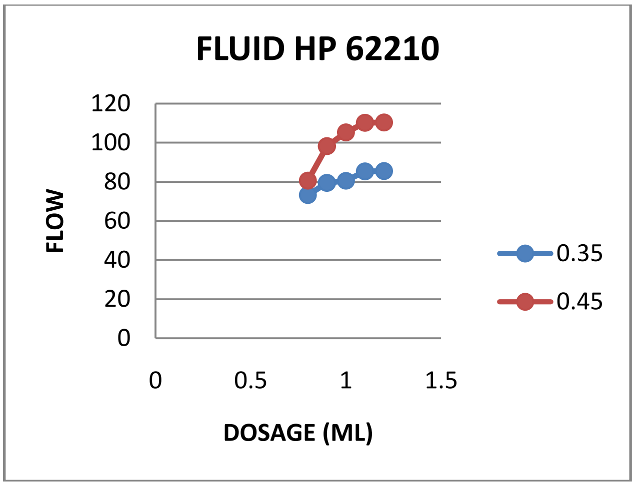
Flow test results for FOSROC CONPLAST SP 430KRM 6 Super Plasticizer with 0.35 and 0.4 w/c ratio

Dosage of Super Plasticizer (ml)	Flow at 0.35 W/C(cm)	Flow at 0.40 W/C(cm)
0.3	08.0	09.1
0.4	10.0	09.7
0.5	12.5	10.9
0.6	13.6	12.5
0.7	15.4	12.5
0.8	17.8	14.6
0.9	20.2	18.2
1.0	21.0	20.8
1.1	21.8	21.7
1.2	21.8	21.8
1.3	22.5	22.9
1.4	23	23.6



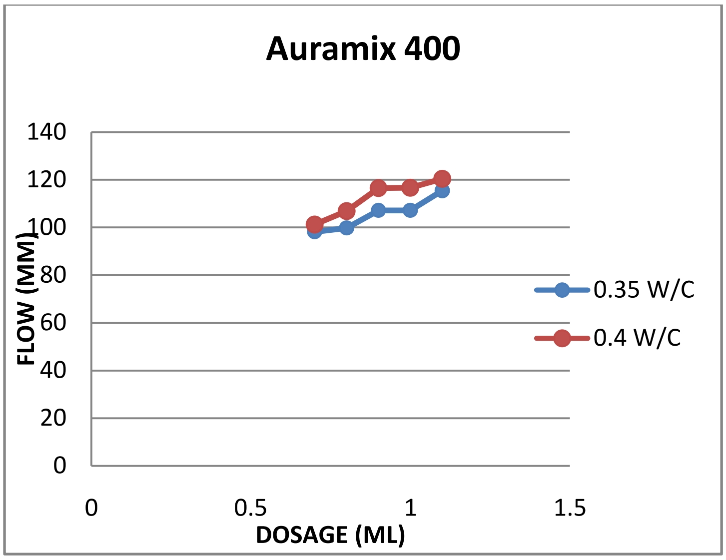
Mini Slump results for CHRYSO Fluid HP 62210 Super Plasticizer with 0.35 and 0.4 w/c ratio

Dosage (ml)	FLOW(mm) at 0.35 w/c	FLOW(mm) at 0.40 w/c
0.8	73.2	80.6
0.9	79.5	98.2
1.0	80.5	105.2
1.1	85.4	110.2
1.2	85.5	110.3



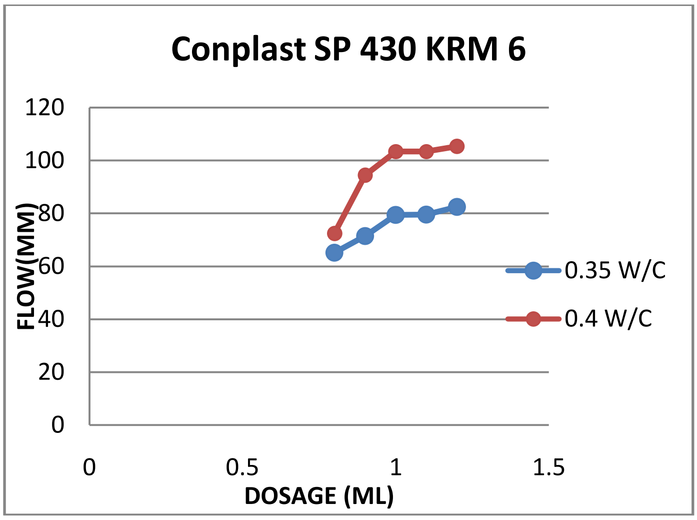
Mini Slump results of for FOSROC Auramix 400 Super Plasticizer with 0.35 and 0.4 w/c ratio

Dosage (ML)	FLOW(mm) at 0.35 w/c	FLOW(mm) at 0.40 w/c
0.7	98.2	101.2
0.8	99.8	106.8
0.9	107.2	116.5
1.0	107.2	116.6
1.1	115.5	120.4



Mini Slump results of for FOSROC Conplast SP 430 KRM 6 Super Plasticizer with 0.35 and 0.4 w/c ratio

Dosage (ML)	FLOW(mm) at 0.35 w/c	FLOW(mm) at 0.40 w/c
0.8	65.2	72.4
0.9	71.5	94.5
1.0	79.5	103.4
1.1	79.6	103.4
1.2	82.5	105.4



Penetration results for CHRYSO Fluid HP 62210 Super Plasticizer at 0.35 w/c ratio

Dosage (ML)	30mins	60mins	90mins	120mins
0.8	1mm	4mm	8mm	11mm
0.9	2mm	6mm	10mm	12mm
1.0	3mm	4mm	10mm	12mm
1.1	4mm	6mm	15mm	20mm
1.2	6mm	8mm	19mm	22mm

Penetration results for CHRYSO Fluid HP 62210 Super Plasticizer at 0.40 w/c ratio

Dosage (ML)	30mins	60mins	90mins	120mins
0.8	1mm	2mm	7mm	9mm
0.9	2mm	6mm	12mm	13mm
1.0	2mm	5mm	10mm	15mm
1.1	3mm	6mm	15mm	21mm
1.2	4mm	6mm	20mm	24mm

Penetration results for FOSROC Auramix 400 Super Plasticizer at 0.35 w/c ratio

Dosage (%)	30mins	60mins	90mins	120mins
0.7	--	1mm	2mm	3mm
0.8	1mm	3mm	4mm	6mm
0.9	1mm	4mm	5mm	9mm
1.0	2mm	4mm	6mm	11mm
1.1	2mm	6mm	9mm	13mm

Penetration results for FOSROC Auramix 400 Super Plasticizer at 0.40 w/c ratio

Dosage (%)	30mins	60mins	90mins	120mins
0.7	--	1mm	2mm	4mm
0.8	1mm	3mm	3mm	5mm
0.9	3mm	5mm	8mm	13mm
1.0	5mm	7mm	12mm	16mm
1.1	2mm	5mm	10mm	19mm

Penetration results for FOSROC Conplast SP 430 KRM 6 Super Plasticizer at 0.35 w/c ratio

Dosage (%)	30mins	60mins	90mins	120mins
0.7	1mm	3mm	15mm	21mm
0.8	2mm	6mm	18mm	25mm
0.9	12mm	15mm	18mm	25mm
1.0	10mm	13mm	18mm	25mm
1.1	12mm	14mm	20mm	27mm

Penetration results for FOSROC Conplast SP 430 KRM 6 Super Plasticizer at 0.40 w/c ratio

Dosage (%)	30mins	60mins	90mins	120mins
0.7	--	1mm	10mm	15mm
0.8	5mm	9mm	15mm	22mm
0.9	5mm	10mm	14mm	25mm
1.0	6mm	12mm	19mm	27mm
1.1	8mm	14mm	20mm	25mm

Sieve Analysis Fine aggregate

In the present investigations fine aggregate is natural sand obtained from local marked is used.

Sl.No:	Property	Result
1	Specific gravity	2.53
2	Fineness modulus	2.94
3	Bulk Density (loose state)	1.61 Gram/cc
4	Bulk Density	1.68 Gram/cc

Sieve Analysis for fine aggregates
Weight of Fine Aggregate sample taken = 1000Grams

sno	Is sieve	Weight retained(gm)	% wt retained (gm)	Cumulative % of wt retained	Percentage passing (by weight)
1	10mm	0	0	0	100
2	4.75 mm	13	1.30	1.30	98.70
3	2.36 mm	24	2.40	3.70	96.30
4	1.18 mm	140	14.00	17.50	82.50
5	600 µ	560	55.60	80.30	19.70
6	300 µ	220	22.0	96.30	3.70
7	150 µ	29	2.9	100	0
8	Less than 7 µ	14	0	0	0
total		1000		2.94	

Fineness modulus of F.A = Total cumulative % retained\100 = 294.00/100 = 2.94

Coarse aggregate

The coarse Aggregate used in this experimental investigation is crushed granite of 12.5 mm maximum size, which was obtained from the local crushing plant.

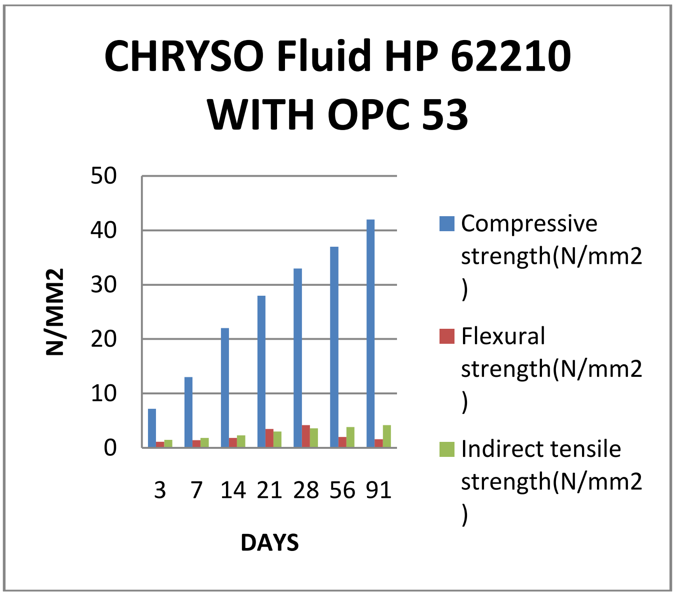
Sl.No:	Property	Result
1	Specific gravity	2.60
2	Fineness modulus	5.90
3	Bulk Density (loose state)	1.40Gram/cc
4	Bulk Density	1.31 Gram/cc

Weight of coarse Aggregate sample taken = 5000Grams

sno	Is sieve	Weight retained(gm)	% wt retained (gm)	Cumulative % of wt retained	%passing(by weight)
1	20mm	0	0	0	100
2	10mm	530	10.6	10.6	89.4
3	4.75 mm	4230	84.6	95.2	4.8
4	2.36 mm	240	4.8	100	0
5	1.18 mm	0	0	100	0
6	600µ	0	0	100	0
7	300µ	0	0	100	0
8	150µ	0	0	100	0
total		5000		605.8	

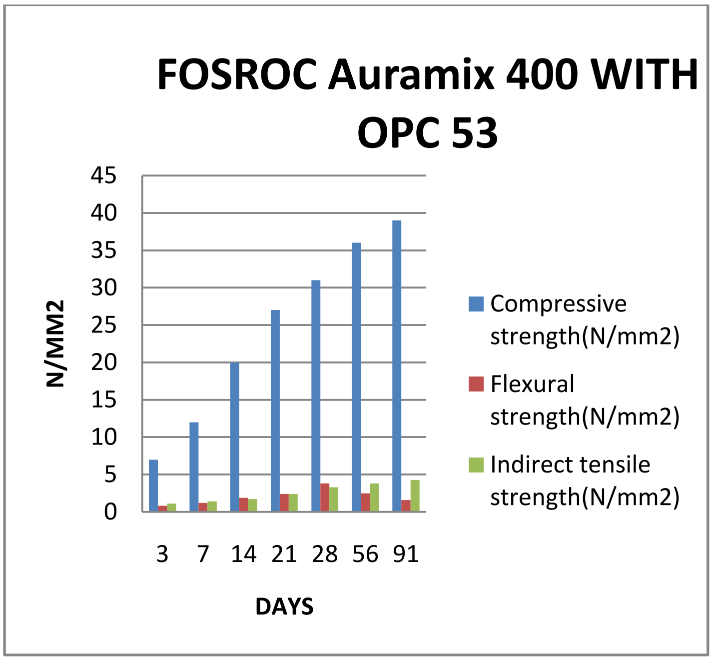
CHRYSO FLUID HP 62210
strength results for OPC-53 with the addition of CHRYSO Fluid HP 62210 super plasticizer using with M30 grade

Curing period(Days)	Compressive strength(N/mm2)	Flexural strength(N/mm2)	Indirect tensile strength(N/mm2)
3	7.2	1.1	1.5
7	13	1.4	1.8
14	22	1.8	2.3
21	28	3.5	3.0
28	33	4.2	3.6
56	37	2.0	3.8
91	42	1.6	4.2



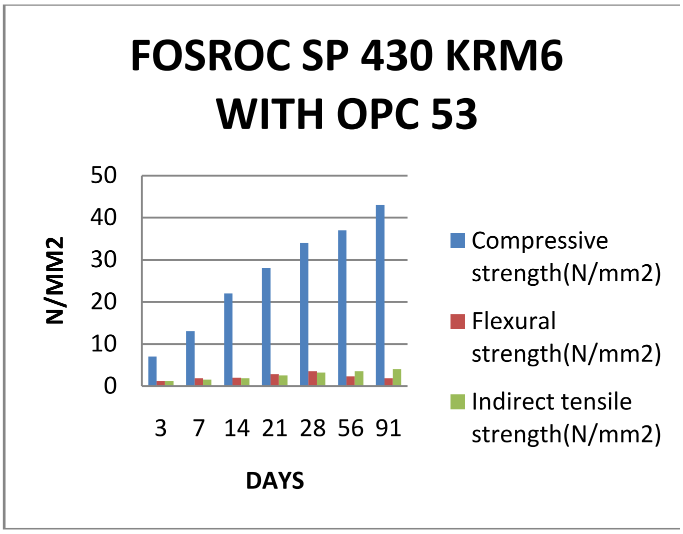
FOSROC AURAMIX 400
strength results for OPC-53 with the addition of FOSROC Auramix 400 super plasticizer using with M30 grade

Curing period(Days)	Compressive strength(N/mm2)	Flexural strength(N/mm2)	Indirect tensile strength(N/mm2)
3	7	0.81	1.1
7	12	1.2	1.4
14	20	1.9	1.7
21	27	2.4	2.4
28	31	3.8	3.3
56	36	2.5	3.8
91	39	1.6	4.3



FOSROC SP 430 KRM6
strength results for OPC-53 with the addition of FOSROC SP 430 KRM6 super plasticizer using with M30 grade

Curing period(Days)	Compressive strength(N/mm2)	Flexural strength(N/mm2)	Indirect tensile strength(N/mm2)
3	7	1.2	1.2
7	13	1.8	1.5
14	22	2.0	1.8
21	28	2.8	2.5
28	34	3.5	3.2
56	37	2.3	3.5
91	43	1.8	4



IV. CONCLUSIONS

1) The optimum dosage of the PCE based Super Plasticizer is 0.9% with respect to weight of the cement.
Whereas the optimum dosage of SNF based Super Plasticizer is 1.0% with respect to weight of cement.
2) A graph is plotted between Dosage and diameter of flow for both Flow test and Mini Slump test and it is observed that after reaching the optimum dosage, even with the increase in the dosage of Super Plasticizer there is no significant change in the flow behaviour of the Super Plasticizer.
3) For Penetration test, at optimum dosage there is maximum penetration. Due to the over dosage of the Super Plasticizer there is delay in setting time for PCE 1 Super Plasticizer.
4) PCE based Super Plasticizers flows more when compared to SNF based Super Plasticizer when added to OPC 53 cement.
5) Due to the usage of Super Plasticizer, water can be reduced upto 30% than the original requirement of water.
6) The over dosage leads to retardation in setting, segregation, and uneconomical usage of Super Plasticizer.
7)The low in dosage of Super Plasticizer leads to loss of fluidity.

REFERENCES

[1] Jayasree C and RavindraGettu (2012), “Choice of Compatibility Cement-Super Plasticizer Combinations”, The Indian concrete journal, January-March, 2012.
[2] Jayasree C, Manu Santhanam and RavindraGettu (2011) “Cement Super Plasticizers Compatibilities-Issues and Challenges”, The Indian concrete journal, July 2011, pp-48-60.
[3] Anshuman Dograand Richa Bhardwaj(2014) “Study of the Admixture-cement Compatibility for the Economic Production”, International Journal of Civil Engineering research, 2014. Vol. 5, No. 1,pp. 43-48
[4] Agarwal S.K, Irshad Masood and Malhotra (2000) “Compatibility of Super Plasticizers with different cements”, Construction and Building Materials (2000), Volume-14, Issue -5, pp 253-259.
[5] Jayasree C and RavindraGettu (2008) “Experimental study of the Flow behaviour of Super Plasticized cement paste”, Materials and Structures, January 2008.
[6] S.M.Maheshwarappa, Madhuvan S, Chetan Kumar K.M., J.K.Dattatreya(2014) “Effect of Super Plasticizers Compatibility on the workability, Early age strength and Stiffening characteristics of OPC, PPC and PSC pastes and mortar”, International Journal of Research in Engineering and Technology (IJRET) Volume 3, Issue 03, May 2014.
[7] Nanak J Pamnani, Palakkumar D. Patel, Dr. A.K. Verma, JayeshkumarPitroda (2013) “Comparison and Optimization of Dosage of Different Super-Plasticizers forSelf-Compacted Concrete Using

