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Effect of Binary Blending of Mineral Admixture on Rheological Properties of Self Compacting Concrete

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Abstract - *The Experimental investigations are carried out for determining the binary blending of mineral admixture on Rheological Properties of Self-compacting concrete (SCC).For this purpose several mix designs of SCC for the proportion of C.A:F.A (45:55) was carried out. For the different proportion of the fly ash: silica fume,calculate the yield stress and plastic viscosity. The SCC was prepared as per the said mix proportion of CA: FA and test were carried out on LCPC box and V funnel to find Rheological property of SCC.*

***Key Words*: SCC, Silica Fume LCPC Box, V funnel, fly ash, and superplasticizer.**

1. INTRODUCTION

Rheology is the science of the deformation and flow of matter, and is concerned with the relationships between stress, strain, rate of strain, and time. The term rheology deals with the materials whose flow properties are more complicated than those of simple fluids (liquids and gases)

The rheological principles and techniques applied to concrete include the deformation of hardened concrete, handling and placing of freshly mixed concrete, and behaviour of it's constitute parts namely, cement slurries and paste. However, in this chapter only rheological properties of fresh concrete are considered.

1.1Rheometry

Rheology is the study of the flow of complex flow liquids in complex flow geometries. Examples might range from the pulsating flow of blood in the human body to the steady and transient flow of polymer melts in polymer processing equipment. With all this "complexity" in mind, Rheometry is the measurement of flow of these complex fluids in simple in order to understand flow behaviour of complex flows. This rheological description can be obtained by applying/measuring either velocities or forces to/in the liquid in such simple geometries which can then converted into fundamental forms of stresses, strains and strain rates.

1.3 Rheometers:

The scientific instruments in which rheometric measurements are performed are called rheometers. They incorporate the necessary simple flow geometries described above, in which the liquid or suspension being measured is subjected to forces or movements, and from which the resulting force or movement is measured. They are usually in electro-mechanical in nature.

1.4 Rheological Properties:

Rheology, defined as the science of deformation and flow, has been an area of serious concrete research since the 1970's. The rheological properties of fresh concrete are rather complex and can be time dependent due to cement hydration. In this approach, fresh concrete could be considered as coarse aggregates suspended in a liquid mortar phase, or sand particles in liquid paste. Thus, the evaluation of the paste and mortar would yield useful information in the optimization of mix proportions of SCC. The proposed flow properties of concrete are to be represented by the Bingham model. The two characteristic Bingham parameters are the yield stress and the plastic viscosity as shown in Figure 4.1.

The simplest flow equation of concrete can be written as,

$$\tau = \tau_0 + \mu \gamma$$

Where τ_0 is the yield value indicating the cohesion of thematerial, μ is constant having dimension of the viscosity and termed as plastic viscosity, τ and γ shear stress and shear strain of material. This mathematical relationship is called as Bingham model.

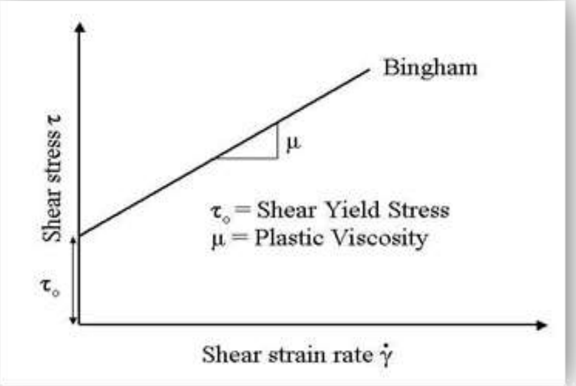

Fig.-1 Bingham Rheology Model

According to this Bingham model (Fig.4.1), fresh concrete must overcome a limiting stress (yield stress) before it can flow. Once the concrete starts to flow, shear stress increases linearly with increases in strain rate as defined by plastic viscosity. Thus, one target rheological property of SCC is to reduce the yield stress to as low as possible so that it behaves like a Newtonian fluid with zero yield stress. The other target property is 'adequate' viscosity to hold all the constituents evenly. The use of Bingham parameters is helpful in describing the behaviour of fresh concrete and in understanding the influence of various mix constituents it is obvious that appropriate Bingham rheological values depend on the materials and equipment's used. Thus, to get reliable values of rheological parameters for SCC, it is important to specify the type of equipment, testing procedure and the nature of constituent materials used for the mix.

2. MATERIAL SPECIFICATION

Following are the materials used for the experimental work.

2.1 Cement

The cement used in this experimental work is 53 grades Ordinary Portland Cement. All properties ofcement are tested by referring IS 12269 - 1987 Specification for 53 Grade Ordinary Portland cement. The specific gravity of the cement is 3.15. The initial and final setting times were found as 108 minutes and 222 minutes respectively. Standard consistency and strength of cement was 32% and 53.7 N/mm^2.

2.2 Water

Potable water used for the experimentation.

2.3 Fine aggregate

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.80 and fineness modulus of 3.895 are used as fine aggregate. The water absorption is of 4.08%.

2.4 Coarse Aggregate

Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 20mm having the specific gravity value of 2.90 and fineness modulus of 7.136 are used as coarse aggregate. The water absorption is of 2.26%.

2.5 Fly ash

Fly ash is a by- product obtained during the combustion of coal in thermal power plants, Typical physical properties: - Colour: grey, Specific gravity: 2.1.The advantage of Fly ash when used with Portland cement ensures higher durability of concrete avoids thermal cracking and improves workability. Slag has a pozzolanic reaction which allows the increase of concrete strength.

2.6 Silica Fume

Silica Fume is finely divided mineral admixture, available in both incompact and compacted forms. It is also referred to as micro silica and condensed silica fume. Very fine nano crystalline silica produced in electric arc furnaces as by product of the production of elemental silicon or alloys containing silicon. The source of silica fume is taken from Walter enterprises Mumbai.

2.7 Super plasticizer

The super plasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observe that with the use of large quantities of finer material, the concrete is much stiff and requires more water for required workability. Hence in the present investigation samples of superplasticizer are used for better results. Also to check the compatibility of superplasticizer with concrete Master Glenium sky 8276 is used.

The BASF's Master Glenium sky 8276 superplasticizer having specific gravity of 1.12 is used.

3. LCPC BOX TEST

- About 12 liter of concrete is needed to perform the test, sampled normally.
- Set the V-funnel on firm ground.
- Moisten the inside surfaces of the LCPC box and funnel.
- Keep the trap door open to allow any surplus water to drain. Close the trap door and place a bucket underneath
- The experimental device used is LCPC Box with a 0.90m length, a 0.20m width and a 0.16m height.
- A volume of 12 liters of material is emptied in a V-Funnel, then in a horizontal channel One minute after stopping the flow, the pictures are taken through one of the sidewalls of the channel (See Figure 2 and fig 3).
- Measure the time for v funnel to empty.
- Measure the h1 and h2 height and Lmax length. By the following Benaicha M.[2], N. Roussel[5] and Zerbino R.[6] formula we are calculating the yield stress and viscosity.

$$\tau_0 = \frac{\rho g L_o}{2L_{max}}\left[h_1 - h_2 + \frac{L_o}{2}\ln\left(\frac{L_o+2h_2}{L_o+2h_1}\right)\right]$$

Sample Calculation

$$\tau_0 = \frac{2533.67\times 9.81\times 0.2}{2\times 0.8}\left[(0.075-0.02) + \frac{0.2}{2}\ln\left(\frac{0.2+2\times 0.02}{0.2+2\times 0.075}\right)\right]$$

τ_0 =53.32 Pa.

$$\mu = \frac{\left(\frac{Tv}{3.04}\right)}{0.013}$$

Sample Calculation

$\mu = \frac{\left(\frac{8.5}{3.04}\right)}{0.013}$

μ=79.09 Pas.

Where

L_0= Width of LCPC Box

ρ = Density of concrete

g = Acceleration due to gravity

Lmax= Maximum length of flow

h_1= Initial height

h_2= Final height

$\tau_{0=}$ Yield Stress

T_v =V funnel time

μ= Plastic viscosity

Fig.-2 LCPC box

Fig.-3 Measurement of LCPC

4.RESULT

Table No. 1 Lcpc Box H1 & H2 for M40 Grade Concrete With 20 % Mineral Admixture

Mix ID	H1 (MM)	H2 (MM)	Lmax (MM)
FS1	75	20	805
FS2	65	30	815
FS3	75	30	808
F1	75	20	812
S1	72	25	804

Table No.2 LCPC Box H1 & H2 for M40 Grade Concrete With 30 % Mineral Admixture

Mix ID	H1 (MM)	H2 (MM)	Lmax (MM)
FS4	75	30	890
FS5	75	35	900
FS6	75	35	895
F2	65	28	893
S2	75	31	898

Table No.3 LCPC Box H1 & H2 for M50 Grade Concrete With 20 % Mineral Admixture

Mix ID	H1 (MM)	H2 (MM)	Lmax (MM)
FS7	75	20	820
FS8	75	30	815
FS9	68	30	808
F3	73	23	805
S3	78	25	810

Table No. 4 Lcpc Box H1 & H2 for M50 Grade Concrete With 30 % Mineral Admixture

Mix ID	H1 (MM)	H2 (MM)	Lmax (MM)
FS10	75	30	896
FS11	65	20	890
FS12	68	23	900
F4	75	33	895
S4	75	38	898

Table No. 5 V Funnel Observation

MIX ID	TIME
FS1	8.5 sec
FS2	8.8 sec
FS3	8.6sec
F1	7.9sec
S1	7.5 sec
FS4	7 sec
FS5	7.5 sec
FS6	5 sec
F2	6 sec
S2	6.8 sec
FS7	8.5 sec
FS8	8.8 sec
FS9	8.6sec
F3	7.9sec
S3	7.5 sec
FS4	6.8 sec
FS5	6 sec
FS6	5 sec
F2	6.2 sec
S2	6.5 sec

Table No. 6 Yield Stress And Plastic Viscosity For different Mix

MIX ID	Yield Stress Pa(τ_0)	Plastic Viscosity Pas (μ)
FS1	53.32	79.09
FS2	33.92	81.76
FS3	46.91	80.00
F1	52.78	73.46
S1	50.59	69.46
FS4	42.22	64.15
FS5	28.11	69.46
FS6	39.97	38.27
F2	31.97	52.30
S2	41.13	61.92
FS7	52.63	79.09
FS8	46.80	81.76
FS9	38.48	80.00
F3	49.79	73.46
S3	54.52	69.46
FS4	42.20	49.69
FS5	36.50	52.30
FS6	38.11	38.27
F2	40.33	54.82
S2	36.37	58.45
FS1	53.32	79.09
FS2	33.92 Pa	81.76 Pas

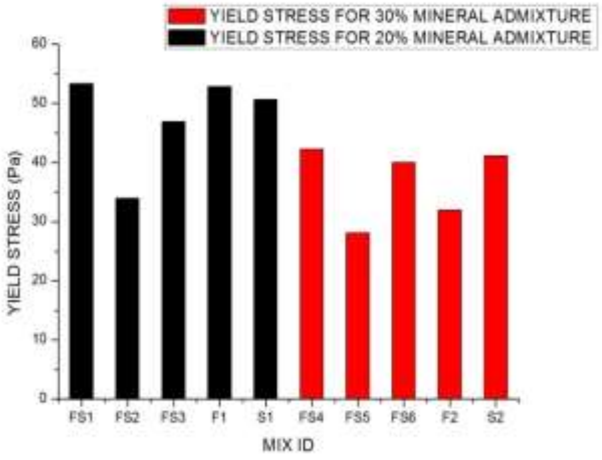

Fig.-4 Yield Stress for M40 Grade of SCC

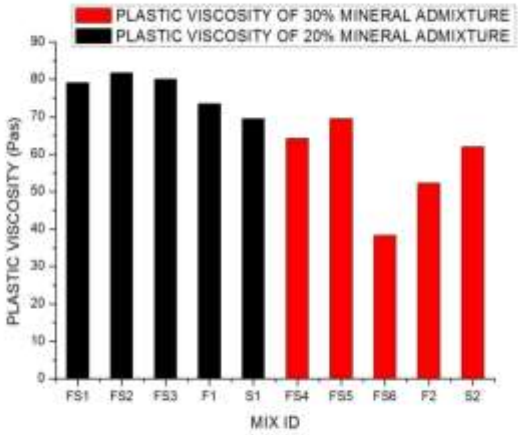

Fig.-5 Plastic Viscosity for M40 Grade of SCC

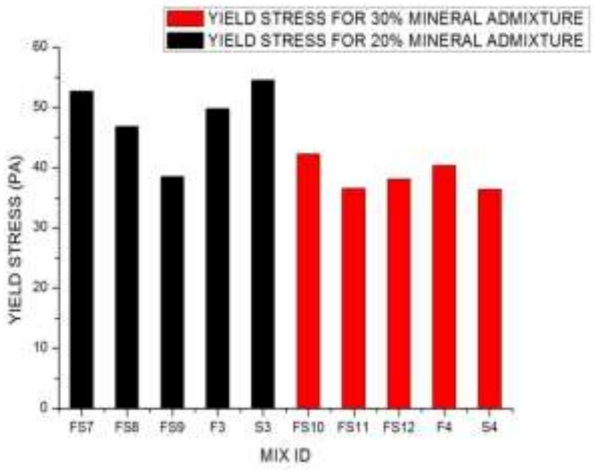

Fig.-6 Yield stress for M50 Grade of SCC

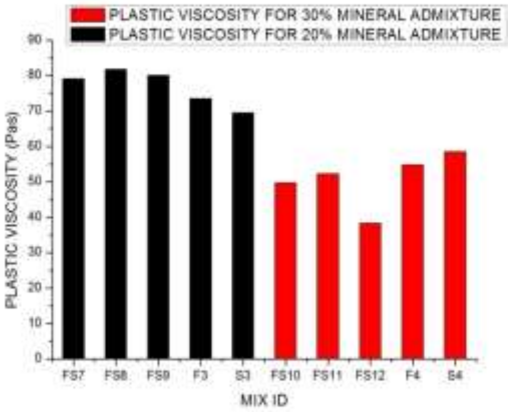

Fig.-7 Plastic Viscosity for M50 Grade of SCC

4. VALIDATION OF RESULTS

Validation of results by from earlier research literature Banfill P.F.G.[1]

Table No. 7 Validation of Rheological Properties

Sr. No.	Method	Unit	Typical Range of Values		Property	Obtained Results
1	LCPC Box test	Pascal	50	200	Yield Stress	42.50 Pa, 36.50 Pa
2	V-Funnel test	Pascal-Sec	20	100	Plastic Viscosity	49.69 Pas, 52.30 Pas

5. CONCLUSION

The LCPC box and V funnel test to find yield stress and Plastic Viscosity is cheap and simple technique than Rheometers. The yield stress and plastic viscosity decreases as the powder content increases.

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