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RHEOLOGICAL CHARACTERISTICS OF SELF COMPACTING CONCRETE CONTAINING FLYASH

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ABSTRACT

Self compacting Concrete (SCC) is a high performance concrete, that can flow under its own weight to completely fill the form work. This concrete has an ability to compact without any mechanical vibration.SCC is suitable for placing in difficult conditions and also in congested reinforcement. It is becoming a popular choice in concrete industries, due to ease of placement in situations with heavily congested reinforcement and where compaction becomes diffficult . This paper envisages the variation of fresh state, , properties of self compacting concrete containing fly ash in different percentages 0%,10%,20%,30% by weight of cement as partial replacement of cement. The workability characteristics like filling ability, passing ability have been assessed using slump flow and T_{50} time, V Funnel time, L-Box blocking ratio, as per EFNARC Guidelines.

Keywords : Self compacting concrete, slum flow test, V−funnel fly ash

INTRODUCTION

Self-Compacting Concrete (SCC)[(1)] originally developed in Japan , is a new category of concrete characterized by its ability to spread and self consolidate in the form work. The vibration or compaction of concrete is eliminated using self compacting concrete. The self compacting concrete is suitable for the situation, where vibration is difficult and reinforcement is highly congested.

Self compacting concrete is highly flowable that can spread through and around dense reinforcement under its own weight. This concrete adequately fills the voids without segregation, bleeding and without need of significant vibration. SCC has proved to be beneficial due to faster construction, reduction in man power, better surface finish, easy placing, improved durability, suitable for thinner concrete section, etc. Due to the above advantages ,the SCC has been described as the most revolutionary development in the concrete construction.

This technology is based on increasing the amount of fine materials like fly ash , GGBS, Silica fume, stone powder etc. without changing the water content compared to conventional concrete.

The SCC mixes are designed and tested to meet the demands of project .The mix designed should have the ability to flow without vibration through heavily congested reinforcemet under its own weight and ability to retain homogeneity without segregation. The concrete mix can be treated as self compacting, if it has filling ability, passing ability and segregation resistance. The flow properties of concrete at the green stage are significantly governed by paste content, aggregate volume and admixes dosages .The flow properties of the cement are characterized in fresh state by different methods like slump flow, V-funnel, J-ring etc based on European

Federation of National Trade Association Representing producers and applicators of Specialist- Building Products (EFNARC)[(2)] specifications and guidelines.

The objective of this study to understand the fresh state properties of SCC containing fly ash in various proportions as partial replacement of cement and small quantity of super plasticizer. An experimental program has been developed to investigate the behavior of self compacting concrete containing fly ash .The fresh state properties have been assessed using the methods as per EFNARC specification. The workability characteristics like filling ability, passing ability have been assessed using the following tests.

- The slump flow and T_{50} time
- V-funnel time
- L-Box blocking ratio

MATERIALS USED

Cement

Birla gold cement (Grade 43) was conforming to IS 8112-1989 used. Its physical properties are as given in Table 1.

Fly ash

Class F Fly ash obtained from"Thermal Powers Plant BirSinghPur (Pali) India" The physical and chemical properties of fly ash are given in the Table 2 and Table 3, respectively

Table -1. Physical Properties of Cement

Physical property	Results obtained	IS: 8112-1989 specifications
Fineness (retained on 90-µm sieve)	9.0	10mm
Normal Consistency	30%	-
Vicat initial setting time (minutes)	90min	30second min
Vicat final setting time (minutes)	300min	600second max
Compressive strength 3-days (MPa)	22Mpa	22.0 Mpa min
Compressive strength 7-days (MPa)	35Mpa	33.0Mpa min
Compressive strength 28days(MPa)	45 Mpa	43.0 Mpa min
Specific gravity	3.14	

Table- 2. Physical Properties of Fly Ash

Sr. No.	Physical Properties	Test Results
1.	Colour	Grey (Blackish)
2.	Specific Gravity	2.21

Table-3 Chemical composition of fly ash

S.NO.	Characteristic	Percentage by weight
1.	Silica, SiO_2	53.14
2.	Alumina Al_2O_3	25.88
3.	Fe_2O_3	3.14
4.	TiO_2	1.51
5.	CaO	0.34
6.	Mgo	1.13
7.	NaO_2	1.19
8.	K_2O	1.22
9.	SO_3	0.53
10.	P_2O_5	1.65

ADMIXTURES

The superplasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observant that with the use of large quantities of finer material (fine aggregate + cement + fly ash) the concrete is much stiff and requires more water for required workability hence, in the present investigation Polycarboxylic ether based super plasticizer FAIRFLO RMC is used as water reducing admixture.

Aggregates

Locally available fine and coarse aggregates are used in this study and conformed to Indian standard specifications IS 383-1970.

Fine aggregate

In the present investigation natural fine aggregate from local market is used. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS :2386 are given in table 4

Table-4 Physical properties of Fine aggregates

Property	Results
Fineness modulus	2.71
Specific gravity	2.60
Bulk density (Kg/m3) Loose state Compact state	1.60 1.70

COARSE AGGREGATE

The crushed coarse aggregate obtained from the local crushing plant is used in the present study. The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS ; 2386 are given is table 5.

Table-5 Physical properties of Coarse aggregate

Property	Result
Fineness modulus	6.14
Specific gravity	2.62
Bulk density (Kg/m^3) Loose state Compact state	1475 1690

MIX DESIGN WITH DATA

The proposed study is being carried out to develop self compacting concrete using fly ash and Cement in varying combinations for use in the Indian conditions. Following guidelines of EFNARC for rheological properties of concrete in fresh state and using Japanese method of mix design as reference, Initial mix design was carried to form S0 at coarse aggregate content of 30% by volume of concrete and fine aggregate content of 50% by volume of mortar in concrete and cement (480kg/cubic meter), keeping the water/binder (W/B) ratio constant 0.40 (by weight). The dosage of super plasticizer was estimated to be 2.7 % of powder content (Cement, Fly ash). Slump flow test, V- Funnel, L box test satisfies the limits laid by EFNARC. Now 0% 10%, 20%, 30% weight of cement is replaced by equal weight i.e. 0%, 10%, 20%, 30% weight of fly ash respectively and S0, S10, S20, S30, S´0, S´10, S´20, S´30 self compacting concrete is prepared which satisfy rheological properties. Dosages of super plasticizer were decided as per requirement of slump flow.

S stands for Self Compact Concrete having water binder ratio as 0.40.

S´ stands for concrete having water binder ratio as 0.45.

Suffix after S or S´ indicates % Fly ash used in the mix as partial replacement of cement.

The mix proportion is shown in table-6

Table -6 Mix Proportions

S.No	Mix	Cement Kg/m^3	Fly ash Kg/m^3	Fine Aggregate Kg/m^3	Coarse. Aggregate Kg/m^3	Water Kg/m^3	S.P. Kg/m^3	W/B ratio
1	S0	480	0	890	810	192	13.30	0.40
2	S10	432	48	890	810	192	9.90	0.40
3	S20	384	96	890	810	192	9.68	0.40
4	S30	336	144	890	810	192	9.40	0.40
5	S´0	450	0	890	810	202	9.25	0.45
6	S´10	405	45	890	810	202	8.20	0.45
7	S´20	360	90	890	810	202	6.40	0.45
8	S´30	315	135	890	810	202	4.80	0.45

TEST METHODS

Self- Compacting Concrete is characterized by filling ability, passing ability and resistance to segregation. Different methods have been developed to characterize the properties of SCC.

The fresh state properties of SCC have been assessed as per EFNARC Guidelines.

Tabl 7 shows the recommended values for different tests as per EFNARC Guidelines

Table - 7 Recommended Limits for Different Properties

Sr. No.	Property	Range
1.	Slump Flow Diameter	650-800 mm
2.	T_{50cm}	2-5 sec
3.	V-funnel	6-12 sec
4.	L-Box H2/H1	≥ 0.8

The slump flow test

The slump flow test is used to assesse the horizontal free flow of SCCwithout obstacles.The test also indicates resistance to segregation .The apparatus for the slump flow test is used as per specification (fig.1). on lifting the slump cone filled with concrete the average diameter of the spread of concrete is measured (fig.2). The time required for the concrete to make a diameter of 50cm is also measured, This is also $T5_0$ time.

Figure 1: Slump Cone test

Figure 2: Slump Flow

V Funnel Test - The flow ability of the fresh concrete can be tested with the V-funnel test, the funnel is filled with about 12 liters of concrete and time taken for it to flow through the apparatus is measured sorter. The time better will be the flow ability.

The arrangement is shown in fig.3

L Box – L Box test is used to assess the passing ability of SCC to flow through tight opening including spacing between reinforcing bars and other obstruction(fig-4). The Vertical section of the L Box is filled with concrete and then they get is lifted the blocking ratio is determined (The ratio of height of concrete at the end of the horizontal section, H_2 height of concrete at begging of the h_1 horizontal Section)

Figure 3: V-Funnel test apparatus used

Figure 4: L-Box test apparatus used

RESULTS AND DISCUSSION

The results of the SCC mixes prepared are summarized in Table-6. The rheological characteristics results are given in table- 8.

In the present analysis the cement is replaced by Fly ash up to 30% (10%, 20% & 30%) by weight of cement and quantities of the fine aggregates and coarse aggregates are kept constant i.e. 890 kg/m^3 and 810 kg/m^3 respectively. The fine aggregate is kept approximately 37% by weight of concrete. The coarse aggregate is kept approximately 34% of weight of concrete.

The water powder ratio is kept 0.40 and 0.45 by weight. For this, the total powder content is taken as 480 kg/m^3 and 450 kg/m^3 respectively. The mixes thus prepared to follow the EFNARC guidelines. The mix proportions are shown in Figure-5.

As the quantity of Flyash increase from 0 to 30% , the quantity of super plasticizer reduces significantly from 13.30 kg/m^3 to 9.40 kg/m^3, 2.77% to 1.96% of weight of powder (for W/B ratio 0.4) and 9.25 kg/m^3 to 4.8 kg/m3 for i.e. 2.05% to 1.06% of weight of powder (for W/B ratio of 0.45) as shown in Figure-6.

The variation of rheological characteristics are summarized as below-

Slump flow characteristics: - the slump flow increases from 650 to 680 mm (for W/B ratio 0.4) and 687 to 695 mm (for W/B ratio 0.45) these results are within the prescribed limits EFNARC guidelines. The slump flow results are shown in figure. This indicates that with the increase in flyash content, The flow ability of the SCC improves. It can be seen from figure 7.

T50 time: - The T50 time reduces from 5 sec. to 3 sec (for W/B-.40) and 4.1 sec. to 3.0 sec. (for W/B=0.45). The T50 time is also an indication of flow ability .A lower time indicates greater flow ability. This means that the flow ability improves with the increase in fly ash content as shown in figure 8.

V-funnel time: The V-funnel time limits are 8-12 sec as per EFNARC guidelines. The V-funnel time reduces from 12 sec to 8 sec and 9 sec to 8.1 sec for W/B ratio 0.40 and 0.45 respectably. This test is measure of ease in flow of concrete-; shorten time indicates greater flow ability. The variation of test results is shown in figure 9.

L-Box Results: The blocking ratio (H_2/H_1) reduces from 0.87 to 0.75(for W/B= 0.40) and 0.79 to 0.75 (for W/B ratio= 0.45).

The L-Box test- blocking ratio indicates that all the mixes have good passing ability and there is not much variation with the increase in Fly ash content, Figure-10.

Table 8- Work ability results

Sr. No.	Mix	Slump Flow (mm)	T50 cm (sec)	V-funnel (sec)	L-Box Blocking ratio (H_2/H_1)
1	S0	650	5.0	12	0.88
2	S10	665	4.0	9.0	0.85
3	S20	685	3.6	8.4	0.82
4	S30	680	3.0	8.1	0.80
5	S´0	687	4.1	9.0	0.80
6	S´10	689	3.5	8.6	0.79
7	S´20	690	3.0	8.0	0.78
8	S´30	695	3.0	8.0	0.78

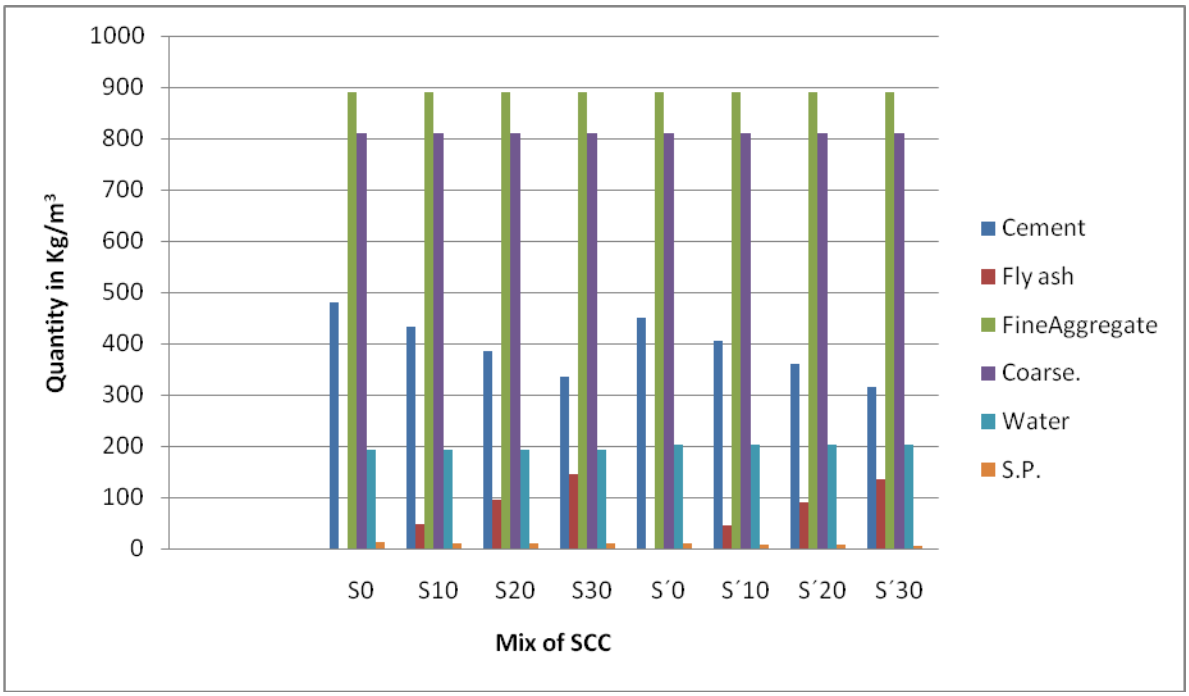

Figure – 5: Mixes of SCC showing quantity of ingredients

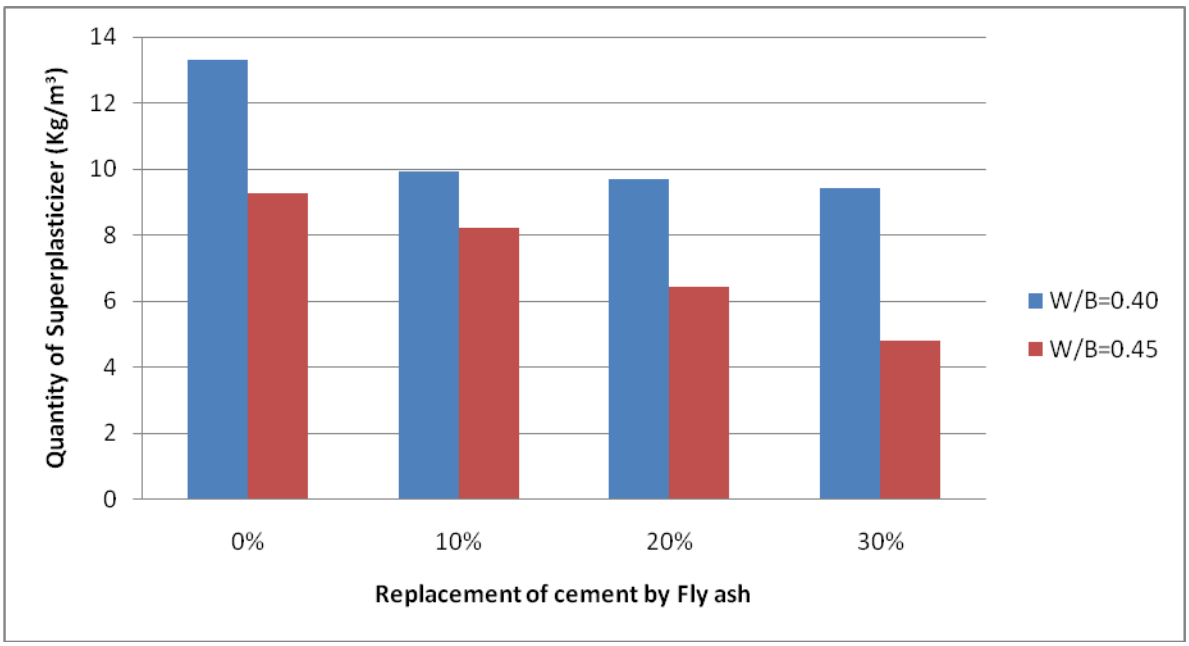

Figure – 6: Variation in quantity of super plasticizer with replacement of cement by Flyash

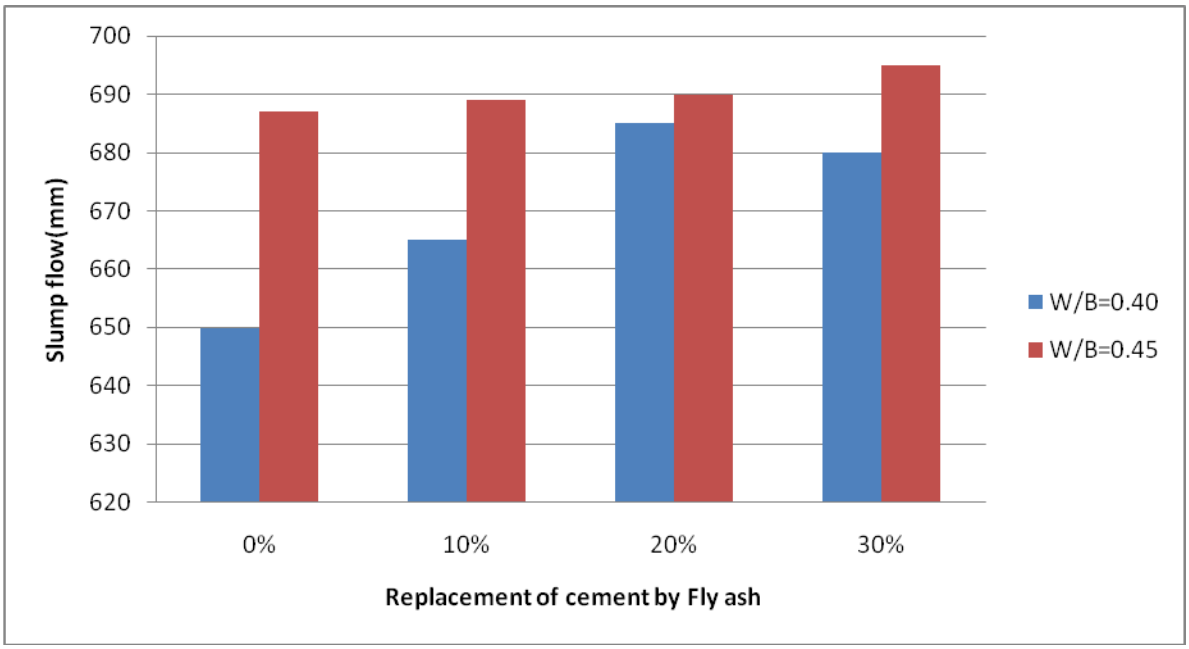

Figure – 7: Slump flow results

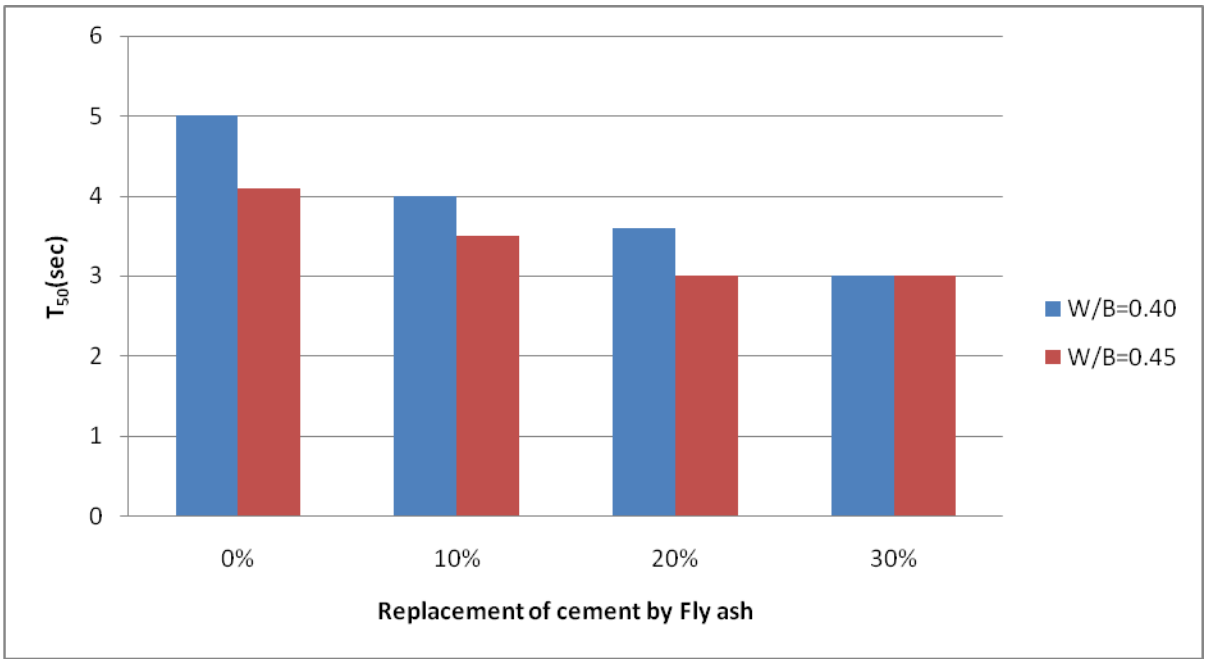

Figure – 8: T_{50} Results

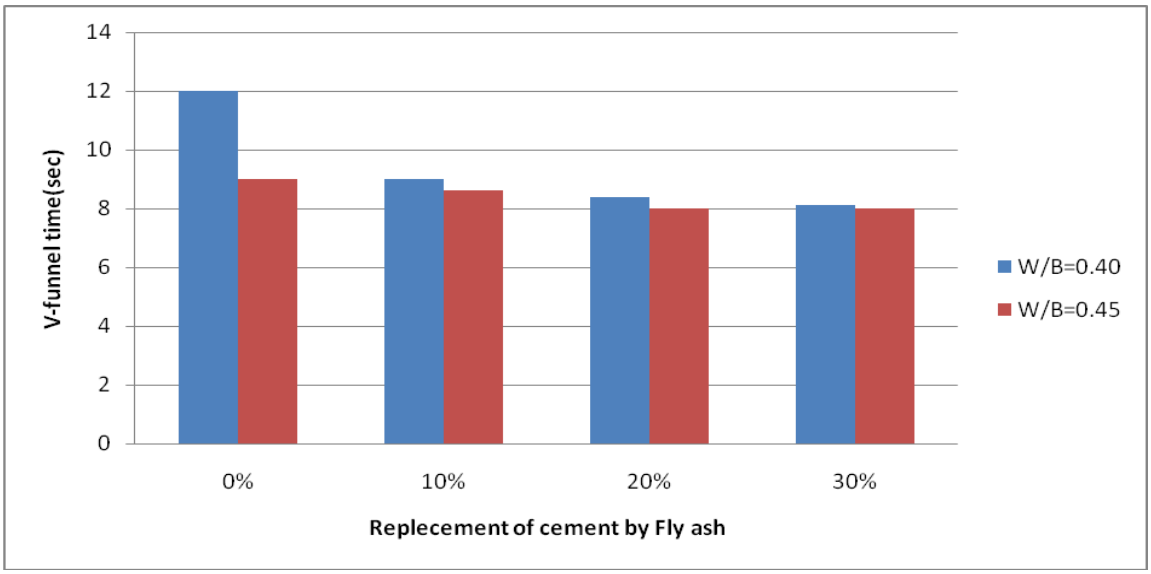

Figure – 9: V-funnel test results

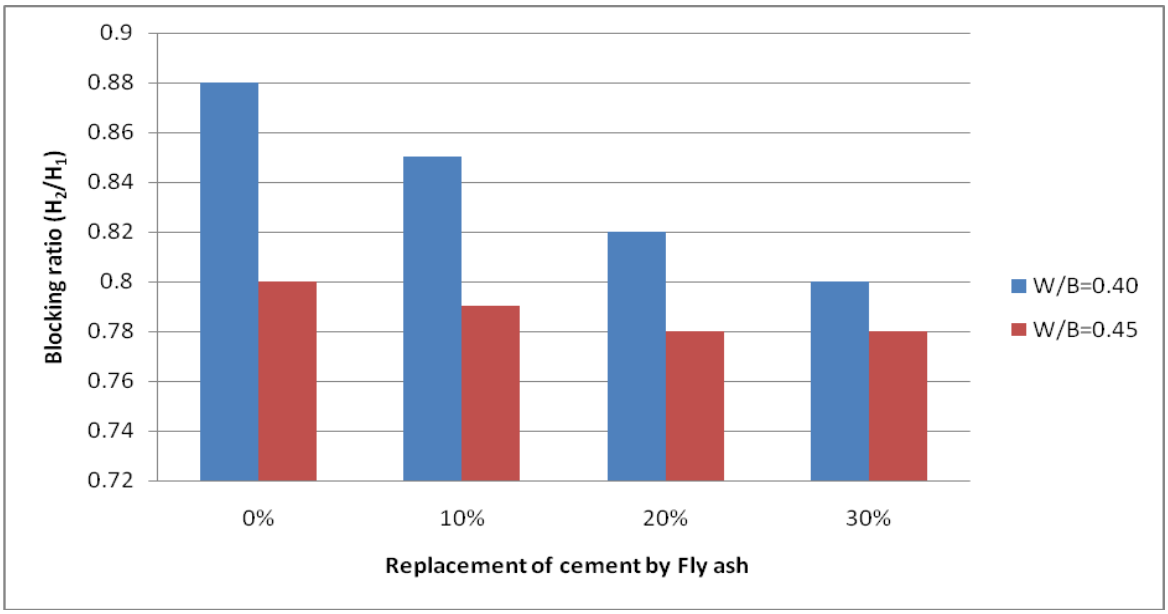

Figure – 10: L-Box Blocking ratio Results

CONCLUSIONS

On the basis of Test prrformed on self compacting concrete concrete developed using Flyash produced from thermal power plant Birsinghpur Pali of Madhya Pradesh, the rheological characteristics have been assessed. The test were performed on no. of specimens for two types of mixes having water binder ratio as 0.40 and 0.45. The cement replacement was, 10% 20% & 30% by weight of Flyash quantities. The fresh state properties were assessed as per EFNARC guidelines such as slump flow test, L-Box test, V-funnel test.Based on the above investigations the following conclusions have been drawn: -

1.With the increase in Fly ash content the flow ability of concrete improves (The slump flow increases from 650 mm to 680 mm for W/B= 0.40, and 687 mm to 695 mm for W/B=0.45). It can also be concluded that more the water binder ratio better will be the flow ability. The results of T_{50} time also indicates that greater

flow ability has been achieved as the Fly ash content in SCC is increased, because T_{50} time has been reduced significantly with the increase in Fly ash content.

2. The reduction in V-funnel time from 12 sec to 8 sec (for W/B= 0.40) and from 9 sec to 8.1 sec (for W/B= 0.45) also indicates that addition of Fly ash resulted a greater flow ability.

3. The blocking ratio results found from L-Box test indicates that all the mixes has good passing ability. Although the variation in blocking ratio with the increase in Fly ash content, is not significant.

4. The addition of Fly ash resulted in a decreases of super plasticizer content for same or better workability.

The results of this study show that it is possible to produce a good performing SCC using locally available Fly ash.The rheological characteristics are within the limits as specified in EFNARC Guidelines.

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