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AN EXPERIMENTAL STUDY ON SELF COMPACTING OF CONCRETE

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ABSTRACT: Self-compacting concrete is a flowable concrete mixture with excellent strength and durability properties. It can be able to flow under its own weight and it is able to compact itself without any additional vibration or compaction effort. It completely fills formwork and makes it suitable for filling even in the presence of congested reinforcement. The mix design and testing methods are different compared with ordinary concrete. In this paper the self-compacting concrete mix design is done by IS 10262(2009) code book using EFNARC guide lines. However getting high strength self-compacting concrete is simple compared to medium and low strengths. In this an attempt has been made to study self-compacting concrete for different sizes of coarse aggregates that is 10mm, 12.5mm and 20mm by using Ordinary Portland cement, fine aggregate, coarse aggregate, water, fly ash as a mineral admixture and Master Glenium SKY 8630 as a combination of super plasticizer and viscosity modifying agent. Various trail mixes have been done to satisfy the workable properties of SCC. The fresh properties of self-compacting concrete such as slump flow test, slump flow T50cm test and L-Box test were conducted and checked against EFNARC guidelines. Further, compressive strength test at the age of 7 and 28 days, split tensile strength test and flexural strength test at the age of 28 days is determined for Self-compacting concrete.
Key words: - Self compacting concrete, strength, durability, EFNARC, mineral admixture

I. INTRODUCTION

1. SELF COMPACTING CONCRETE

Self-Compacting Concrete (SCC) is a special concrete of high performance which has excellent deformability in the fresh state and high resistance to segregation and can be placed and compacted under its self-weight without any vibration. In SCC durability was the main concept and the purpose was to develop a concrete mix that would eliminate the need for vibration to achieve compaction. Self-Compacting Concrete can achieve the above mentioned characteristics by its unique fresh properties viz;

- Filling ability
- Passing ability
- Resistance to segregation

Unlike the conventional concrete, self- compacting concrete doesn't require compacting using external force from mechanical equipment such as an immersion vibrator; instead SCC is designed in such as way that it gets compacted using its own weight and characteristics.

Once applied, the self-compacting property enables the concrete to fully reinforce around the steel structures and completely fill the space within the framework. The self-compacting of concrete is achieved without losing any kind of strength, stability, or change in properties. The need for Self compacting concrete was first started in Japan when they got a decline for availability of skilled labour in 1980’s. They need sufficient skilled labour for making of durability structures. Then they developed Self Compacting Concrete which compacts itself with its own weight without vibration. After the development of Self Compacting concrete in Japan many organizations have started the investigation work all over the world to know the properties of Self Compacting Concrete. The work was started by Prof.*Okamura* from Japan, which led to development of Self Compacting concrete in the year 1988. Ozawa et al from Tokyo University formed a committee to further investigate about Self Compacting concrete. The main of his study is to find out the workable properties for Self Compacting concrete. In 1988 prototype Self Compacting Concrete was completed satisfying various properties. After completion of this usable work it was named as “Self Compacting Concrete”. Later a society developed guide lines for the use of Self Compacting concrete which covers important topics such as material selection, workability of concrete etc.

II. LITERATURE REVIEWS

Reena K and Mallesh M did an investigation on the experimental studies on M20 self compacting concrete. In this study Nan Su mix design was followed by modifying the Nan Su coefficient to attain M20 grade self compacting concrete. In this current work an immense selection of Self compacting concrete has been grown using fly ash as a mineral admixture with replacement in Portland cement of 43 grade. Slump flow, V-funnel, L-Box, U-Box tests have been done and the fresh properties acquired are confirmed against EFNARC guidelines. Compressive strength test have also been done for the mixes at the age of 7 and 28 days of curing. It is seen that for Nan-Su coefficient, C=11f1c the M20 grade self compacting concrete mix is satisfied.

Self compacting concrete specimens have been casted for 7 days and 28 days compressive strength of cube size 15cm x15cmx15cm which has contents of Cement, Fine aggregate, Coarse aggregate, Fly Ash and super plasticizer taken in mix proportion of 1: 4.41: 3.24: 0.7: 0.905.

As Nan-Su‟s co-efficient increases, the water cement ratio and the cement content get increased. As the water cement ratio increases, the flow ability of the concrete also get increased. And also if Nan-Su‟s co-efficient increases, the quantity of filler material per m3 gets lower. As the filler material decreased, strength get increased. From this investigation it was concluded that Nan-Su‟s method of mix design is also applicable for lower grade of SCC.

N R Gaywala, D B Raijiwala did an investigation on Self compacting concrete – A concrete of next decade. In this current investigation the research on discrete hardened properties of Self Compacting Concrete utilizing the Ordinary Portland Cement and low-calcium fly ash as binder material. The hardened properties like compressive strength are investigated in experimental work and are compared with M25 grade of concrete. In this paper they didn't followed any mix design. The proportion was taken by trial and error approach. After 13 to 14 trials they decided the mix proportion and replacement of cement with fly ash is done in different percentages.
Mix-1: 85.0% cement and 15.0% fly ash
Mix-2: 75.0% cement and 25.0% fly ash
Mix-3: 65.0% cement and 35.0% fly ash
Mix-4: 55.0% cement and 45.0% fly ash
Mix-5: 45.0% cement and 55.0% fly ash
The maximum compressive strength, split tensile strength, Flexural strength and pull out strength for self-compacting concrete have been obtained by addition of 15% of fly ash in mix as compared to addition of 25%, 35%, 45% and 55% cement replacement by fly ash. SCC gives better durability results as compared to conventional concrete. M25 grade of concrete and Mix-3 (35% fly ash) compressive strength, tensile strength, flexural strength and pull out strength results are nearer so in construction of heavily congested reinforcement structures and high rise buildings, so this mix proportion can be adopted.

III. MATERIALS

Cement: Ordinary Portland cement of grade 53 is used in the present experimental work. The cement used is tested for Bulk density, specific gravity, Fineness, consistency, initial and final setting time and is confirmed to various specifications of IS 12269-1987. The powder (cement + mineral admixtures) content in Self Compacting Concrete is more when compared with conventional concrete.

TABLE-3.1Physical properties of 53 grade ordinary Portland cement

Test	units	requirement
Fineness	m^2/kg	225
Setting time - initial	min	30
Final	min	600
Soundness – le-chatelier method	mm	10

Fly ash:
The fly ash used in this SCC is from Vijayawada thermal power station. It is a waste product, generated by the combustion of coal. Fly ash also reduces pollution when compared with cement. Low heat of hydration is produced by adding mineral admixtures like fly ash. The amount of fly ash used in this experimental work is 10%, 20%, 30% replacement by weight of cement. Adding of fly ash by more than 40% reduces concrete permeability Adding of mineral admixtures like fly ash, GGBS etc, enhances deformability and also increases the cohesiveness of the paste and stability of Self Compacting Concrete. Also adding of fly ash enhances the workability properties. The reason fly ash added to Self Compacting Concrete is that it reduces the super plasticizer dosage, reduces the risk of blocking and improves the permeability of concrete.
Fine aggregate:
Fine aggregate content is more in SCC. The shape and size of aggregate plays an important role in self-compacting concrete. The specified size of fine aggregate used in EFNARC guide lines is 125microns but here we used 600 micron size. In this work zone 3 fine aggregate is used. IS 383:1970 code of practice is followed.
The sand used for the experimental programme was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust. Properties of the fine aggregate used in the experimental work are tabulated in Table. The aggregates were sieved through a set of sieves to obtain sieve analysis and the same is presented in Table. The fine aggregates belonged to grading zone III.

Table-3.2:Physical Properties of fine aggregates

Sr. No.	Characteristics	Value
1.	Specific gravity	2.46
2.	Bulk density	1.4 kg/m3
3.	Fineness modulus	2.56 m2/g
4.	Water absorption	0.85 %
5.	Grading Zone (Based on percentage passing 0.60 mm)	Zone III

Table-3.3: Sieve analysis of fine aggregates

Sr. No.	Sieve Size	Mass retained	Percentage Retained	Cumulative Percentage Retained	Percent Passing
1	4.75 mm	4.0 g	0.4	0.4	99.6
2	2.36 mm	75.0 g	7.50	7.90	92.1
3	1.18 mm	178.0 g	17.8	25.70	74.3
4	600^m	220.0 g	22.0	47.70	52.3
5	300^m	274.0 g	27.4	75.10	24.9
6	150^m	246.5 g	24.65	99.75	0.25
			£=256.55		

Total weight taken = 1000gm
Fineness Modulus of sand = 2.56

Coarse aggregate:
In this SCC small sized and limited coarse aggregates should be used .The sizes of coarse aggregate used in this mix were 10mm, 12.5mm and 20mm. More than 20mm size aggregates are restricted due to blockage while passing of aggregate. However investigations are being done for bigger size aggregates. IS 383:1970 code of practice is followed.
The material which is retained on IS sieve no. 4.75 is termed as a coarse aggregate. The crushed stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 10 mm was used in our work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 3831970. The results of various tests conducted on coarse aggregate are given in Table 3.5 and Table 3.6 shows the sieve analysis results.

Table-3.4: Physical Properties of C.A

Sr. No	Characteristics	Value
1	Type	Crushed
2	Specific Gravity	2.66
3	Total Water Absorption	0.56
4	Fineness Modulus	6.83

Table-3.5: Sieve Analysis of C.A.

Sr. No.	Sieve Size	Mass Retained in gm	Percentage Retained	Cumulative Percentage Retained	Percent Passing
1	20 mm	0	0	0	100
2	10 mm	2516	83.89	83.87	16.13
3	4.75 mm	474	15.8	99.67	0.33
4	PAN	10	0.33	£= 183.54	

Total weight taken = 3Kg
FM of Coarse aggregate = [183.54+500] / 100 = 6.83.
Water:
Water used was fresh, colorless, and tasteless. Portable water free from organic compound is used in this experiment.
Super plasticizer:
Chemical admixture used is Master Glenium SKY 8630 as a combination of super plasticizer and viscosity modifying agent. By adding super plasticizer self compactability and requirements for filling ability and passing ability can be achieved. It also have high influence on filling ability and segregation resistance. It reduces the total amount of water content required to produce self compacting concrete.
Why Master Glenium SKY 8630?
Master Glenium sky 8630 contains low alkali and it is free of chloride. It is a new generation based modified polycarboxylic ether. The unique formulation of this admixture allows the concrete mix to achieve both self compacting properties and concrete stability. It is not only a super plasticizer but also contains viscosity modifying agent. Improves adhesion to reinforcement and increases durability. It has disparate chemical structure when compared with other traditional super plasticizers.

Physical properties of Master Glenium Sky 8630

Colour	Light Brown liquid
Relative Density	1.08± 0.01 at 25°C
pH	>= 6at 25°C
Chloride ion content	< 0.2%
Specific Gravity	1.08

Typical range of Self Compacting Concrete by weight

Constituent	**Range of the constituent (kg/m³)**
Powder(Cement + mineral admixture)	380-600
Water	150-210
Coarse aggregate	750-1000
Fine aggregate	48% to 55% of the total aggregate weight

Material properties
Properties of Materials

Material	Bulk Density	Specific Gravity
Cement	1478.101	3.15
Fly Ash	1410.45	2.11
Coarse Aggregate(10mm)	1623.10	2.72
Coarse Aggregate(12.5mm)	1664.67	2.73
Fine Aggregate	1560.22	2.61

Design of concrete mix
As there is no specified mix design in this paper we followed IS 10262(2009) code book using EFNARC guide lines.
Assumed a constant w/c = 0.5 for all mixes.
Selection of water content:
From table 2 of IS 10262(2009), maximum water content for 10mm aggregate = 208 liters
For 300mm slump = 208 + (30/100) ×208 = 270 liters

Based on trails with super plasticizer, arrived water content
= 270×0.8
= 216 liters
Calculation of cement content:
Water-cement ratio = 0.5
Cement content = 216/0.50 = 432 kg/m3
Mix Calculations:
The mix calculations per unit volume of concrete shall be as follows:-
Volume of concrete = 1 m3

$$\text{Volume of Cement} = \frac{Mass\ of\ cement}{Specific\ gravity\ of\ cement} \times \frac{1}{1000}$$
$$= \frac{432}{3.15} \times \frac{1}{1000}$$
= 0.137 m3

$$\text{Volume of water} = \frac{Mass\ of\ water}{Specific\ gravity\ of\ water} \times \frac{1}{1000}$$
$$= \frac{216}{1} \times \frac{1}{1000}$$
= 0.216 m3

Volume of all aggregates = 1- (0.1327+ 0.216)
= 0.647 m3
Mass of Fine aggregate = 0.647×0.55×2.61×1000
= 928 kg
Mass of Coarse aggregate = 0.647×0.45×2.72×1000
= 792 kg
Mix proportions for trail number 1
Cement = 432 kg/m3
Water = 216 kg/m3
Fine aggregate = 928 kg/m3
Coarse aggregate = 792 kg/m3
Cement: F.A: C.A = 1 : 2.1: 1.8

Mix Proportions:

TABLE-3.6 Fine and Coarse Aggregate

Mix	Proportions	Water %	Fly ash %	Aggregate size(mm)
1	1:2.1:1.8	0.5	0	10
2	1:2.1:1.8	0.5	10	10
3	1:2.1:1.8	0.5	20	10
4	1:2.1:1.8	0.5	30	10
5	1:2.3:2.0	0.5	0	12.5
6	1:2.3:2.0	0.5	10	12.5
7	1:2.3:2.	0.5	20	12.5
8	1:2.3:2.0	0.5	30	12.5
09	1:2.7:2.3	0.5	0	20
10	1:2.7:2.3	0.5	10	20
11	1:2.7:2.3	0.5	20	20
12	1:2.7:2.3	0.5	30	20

TABLE -3.7

Mix	Cement Kg/m^3	Fly ash Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3	Water Kg/m^3
1	432	0	928	792	216
2	389	43	928	792	216
3	346	86	928	792	216
4	302	130	928	792	216
5	406	0	960	819	200
6	365	41	960	819	200
7	330	81	960	819	200
8	325	122	960	819	200
09	284	0	1012	863	186
10	326	36	1012	863	186
11	290	72	1012	863	186
12	253	109	1012	863	186

Weights per m3

4. Mixing of concrete
The mixer should first be kept clean and in wet condition. The coarse and fine aggregates are put into the mixer and mixed for 1 minute. Next the cement and fly ash were added together with water and mixed for other 2 minutes. Finally super plasticizer was added. The total mixing should not exceed 15minutes from the time coarse and fine aggregates added to the mixer.

Fig 1: MIXING CONCRETE

Workability tests
A self compacting concrete is said to have good workability when it has an ability to compact by its own weight, transported and placed in the site. It is the property Workability is a property of freshly mixed concrete. Improper Workability effects strength and durability and also appearance. Various test methods have been done to satisfy

fresh properties of SCC. In the present work Slump flow, T_{50}cm slump flow, L-box and Sieve segregation tests were conducted.

1. Slump flow test (filling ability)
2. T_{50cm} Slump Flow (viscosity)
3. L-box test (passing ability)

Fig 2 : Slump flow and T_{50cm} test

Fig 3 : L – Box Test

Fig 4:Casting of Specimens

Fig 5 : Curing of Specimens

IV. RESULTS

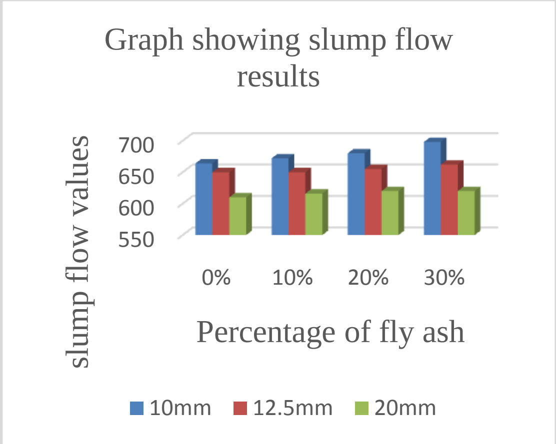
In this chapter, the parameters of fresh concrete like slump flow, slump flow T50cm, L-box and hardened concrete tests like compressive, split and flexural strengths are determined. The results are presented and graphs are drawn for various strengths and aggregate sizes.

WORKABILITY RESULTS

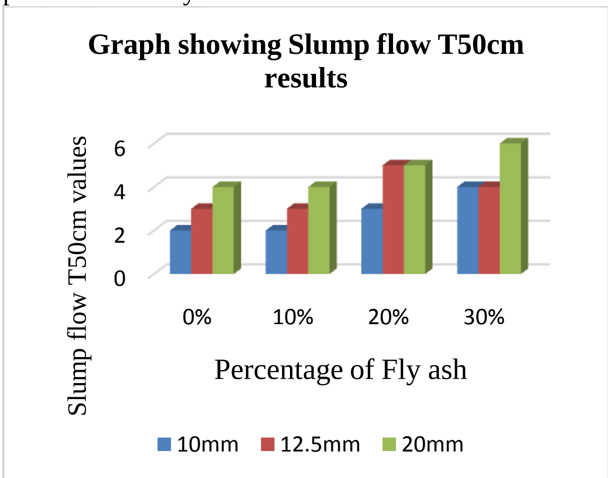
Workability tests like slump flow, Slump flow T50cm and L-box tests are conducted. Fly ash is added as a replacement for cement and different percentages of fly ash were tested. All the mixes satisfied the workability limits.

TABLE-4.1 Workability test results

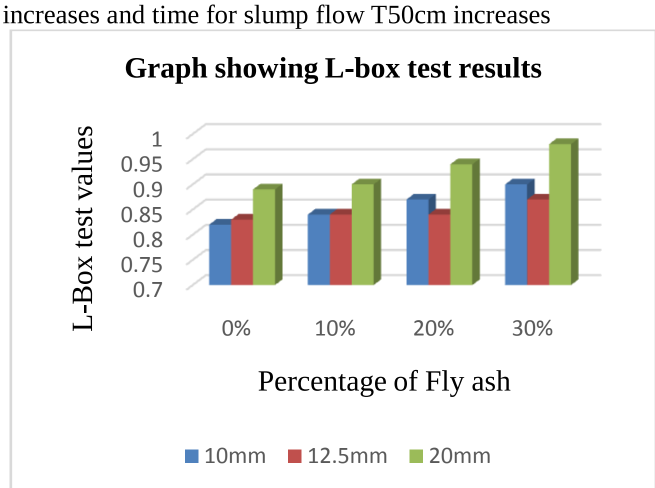
Mix	Aggregate size(mm)	Slump Flow(mm)	T50 cm(seconds)	L-Box
		600-800mm	2-6secs	0.8 - 1.0
1(0%)	10	664	2	0.82
2(10%)	10	672	2	0.84
3(20%)	10	680	3	0.87
4(30%)	10	698	4	0.9
5(0%)	12.5	650	3	0.83
6(10%)	12.5	650	3	0.84
7(20%)	12.5	655	5	0.84
8(30%)	12.5	662	4	0.87
09(0%)	20	610	4	0.89
10(10%)	20	616	4	0.90
11(20%)	20	620	5	0.94
12(30%)	20	620	6	0.98



From the graph it is shown that when fly ash percentage increases slump flow increases but when size of aggregate increases then slump flow decreases. Adding of fly ash improves workbality.



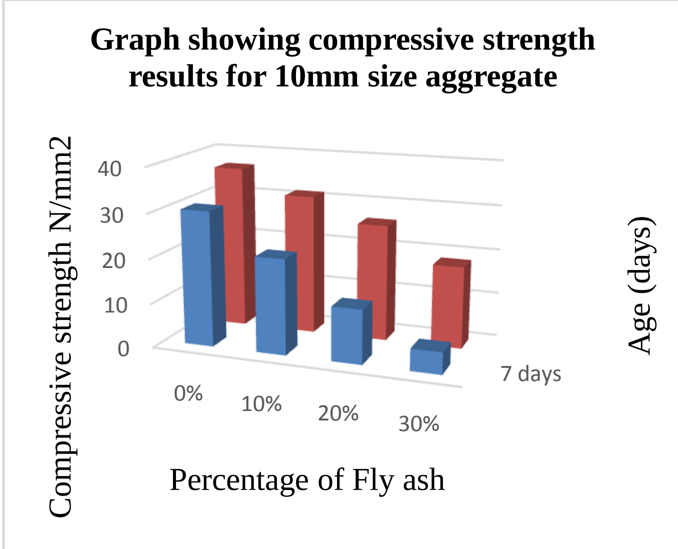
From the graph it is shown that by the increase in aggregate size, the time for slump flow T50cm decreases. But by increase in fly ash percentage the fineness of the mix increases and time for slump flow T50cm increases

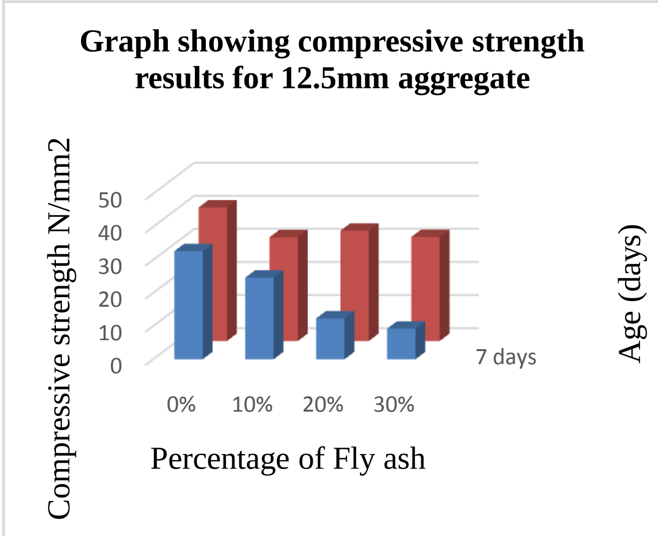


HARDENED CONCRETE

RESULTS: Compressive strength results

The cubes are tested are for 7 days and 28 days compressive strength. When fly ash replacement increases, the 7 days compressive strength decreases but later 28 days and after further days compressive strength increases gradually.





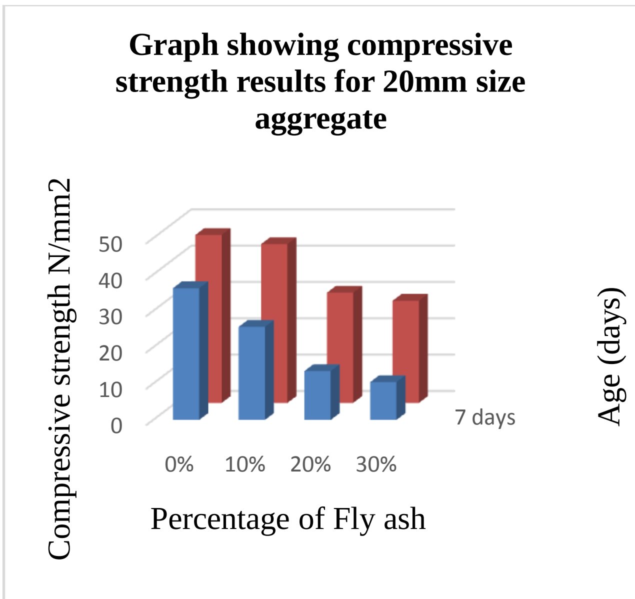


TABLE -4.2 Compressive Strength test results for 7 and 28 days

Mix no	Size of coarse aggregate	7days compressive strength (MPa)	28days compressive strength (MPa)	Grade of concrete
1	10	30.31	36.65	M30
2	10	21.33	31.33	M25
3	10	12.11	26.11	M20
4	10	4.86	18.37	M15
5	12.5	32.66	40.35	M30
6	12.5	24.66	33.32	M25
7	12.5	12.34	31.43	M25
8	12.5	9.24	25.74	M20
9	20	36.24	46.23	M40
10	20	25.60	43.71	M35
11	20	13.44	30.32	M25
12	20	10.40	28.12	M20

TABLE-4.3 Split Tensile strength test results for 28 days

Mix	Size of coarse aggregate(mm)	28 days Split Tensile strength (MPa)
1(0%)	10	3.10
2(10%)	10	2.34
3(20%)	10	2.04
4(30%)	10	1.58
5(0%)	12.5	3.25
6(10%)	12.5	2.57
7(20%)	12.5	2.37
8(30%)	12.5	1.98
9(0%)	20	3.6
10(10%)	20	3.45
11(20%)	20	2.2
12(30%)	20	2.03

TABLE-4.4 Flexural Strength test results for 28 days

Mix	Size of coarse aggregate(mm)	28 days Flexural strength
1(0%)	10	5.8
2(10%)	10	4.9
3(20%)	10	4.22
4(30%)	10	3.83
5(0%)	12.5	6.06
6(10%)	12.5	5.2
7(20%)	12.5	5.02
8(30%)	12.5	4.10
9(0%)	20	6.5
10(10%)	20	6.22
11(20%)	20	4.87
12(30%)	20	4.66

V. CONCLUSIONS

1.From the analysis it is concluded that partial replacement of ordinary Portland cement with fly ash does not affect the properties of fresh concrete to perform as Self Compacting Concrete.
2.Adding of Fly ash resulted in a decrease of super plasticizer content putting the workability as the same.
3.It is expected that durability properties of fly ash will be improved at later ages.
4.As there is no specific mix design for SCC, the mix design can be done in any method and required adjustments can be done as per EFNARC guide lines.
5.By this experiment it is known that mixing of 10mm and 12.5mm aggregate is more flowable than 20mm size aggregate.
6.By using different sizes of aggregate increases the strength of SCC.

SCOPE FOR FUTURE WORK:
This investigation can be extended to different concrete mixes with different chemical as well as mineral admixtures.

REFERENCES

[1] EFNARC (The European Federation of Specialist Construction Chemicals and Concrete Systems), The European Guidelines for Self-Compacting Concrete, May 2005.
[2] Paratibha aggarwal,Rafat siddique, Yogesh aggarwal, Surinder m gupta, Self-Compacting Concrete - Procedure for Mix Design
[3] VIPUL KUMAR, Study of Mix Design of Self Compacting Concrete, International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 05 | Aug-2015
[4] Mallesh M, Shwetha G C, Reena K, Madhukaran, Experimental Studies on M30 Grade Self Compacting Concrete, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 9, September 2015.
[5] Reena K , Mallesh M, EXPERIMENTAL STUDIES ON M20 SELF COMPACTING CONCRETE, International Journal of Advanced Technology in Engineering and Science Volume No.02, Issue No. 09, September 2014
[6] Mallesh.M , Sharanabasava, Reena.K , Madhukaran, Experimental Studies on M 25 Grade of Self Compacting Concrete, International Research Journal of Engineering and Technology (IRJET), Volume: 02 Issue: 06 | Sep -2015.
[7] Mallesh M., Praveen S, Reena K, H. Eramma, Experimental Studies on M35 Grade Self Compacting Concrete, International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 10, October 2015.
[8] S. M. Dumne, Effect of Super plasticizer on Fresh and Hardened Properties of Self-Compacting Concrete Containing Fly Ash, American Journal of Engineering Research (AJER),Volume-03, Issue-03, pp-205-211.

[9] N R Gaywala, D B Raijiwala, SELF COMPACTING CONCRETE: A CONCRETE OF NEXT DECADE, Journal of Engineering Research and Studies E-ISSN0976-7916.

[10] B.H.V. Pai, M. Nandy, A. Krishnamoorthy, P.K.Sarkar, Philip George, Comparative study of Self Compacting Concrete mixes containing Fly Ash and Rice Husk Ash,

