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Investigation on Micro Silica and Fly Ash as a Partial Replacement Material in Self Compacting Concrete

KEYWORDS: self compacting concrete, Micro Silica, Fly Ash, Super-plasticizer

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ABSTRACT *Self-Compacting Concrete is an innovative concrete that does notrequire vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement.*

This paper presents an experimental investigation on strength aspects like compressive, flexural and split tensile strength of self-compacting concrete containing different mineral admixtures and workability tests for different mineral admixtures (slump, L-box, U-box, V-Funnel, J-ring and T50) are carried out. The methodology adopted is that mineral admixtures are replaced by 5 %, 10%, 15%, 20%, 25%, 30% and 35% for Portland cement and performance is measured and compared. The influence of mineral admixtures on the workability, compressive strength, splitting tensile strength and flexural strength of self-compacting concrete was investigated. The mix proportion is obtained as per the guidelines given by European Federation of producers and contractors of special products for.

The following inferences were made; optimum dosage of super plasticizer enhanced the flow property of the concrete. As a result, overall improvements in the flow and filling ability of the self-compacting concrete were observed. It is observed that when mineral admixtures used in self-compacting concrete, can reduce the amount of super- plasticizer necessary to achieve a given fluidity.

INTRODUCTION

Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. Numerous types of concrete have been developed to enhance the different properties of concrete. Self Compacting Concrete is an innovative concrete that does not require any vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. Self-Compacting Concrete is a complex system that is usually proportioned with one or more additions and one or more chemical admixtures. A key factor for a successful formulation is a clear understanding of the role of the various constituents in the mix and their effects on the fresh and hardened properties. Successful self-compacting concrete must have high fluidity (for flow under self-weight), high segregation resistance (to maintain uniformity during flow) and sufficient passing ability so that it can flow through and around reinforcement without blocking or segregating. Superplasticizers added to concrete provide a better workability. One of the disadvantages of selfcompacting concrete is its cost, associated with the use of chemical admixtures and use of high volumes of Portland cement. One alternative to reduce the cost of self-compacting concrete is the use of additions. Due to the better engineering and performance properties, additions such as silica fume, fly Ash, are normally included in the production of high-strength and high-performance concrete. The incorporation of mineral admixtures also eliminates the need for viscosity-enhancing chemical admixtures.. One of the most important differences between self-compacting concrete and conventional concrete is the incorporation of mineral admixture. Since cement is one of the most expensive components of concrete, reducing the cement content is one of the economical solutions. Besides these economical benefits, the use of by-products or waste materials reduces environmental pollution.

OBJECTIVES

1. For Design mixes for self compacting concrete mixed with fly Ash and Micro silica seperatly in various Percentages and to study its fresh and hardened state concrete properties.
2. For design mixes of self compacting concrete mixed with fly ash incorporating silica fume for optimal dosage of replacement material and to study its fresh and hardened state concrete properties.
3. To compare the compressive strength at the ages of 7and 28 days, split tensile strength and flexural behaviour of self compacting concrete at 28 days for M30 and M40 grades of concrete mixes.

MATERIAL PROPERTIES

CEMENT

Ordinary Portland cement of 53 grade was used and tested for physical and chemical properties and found to be conforming to various specifications as per IS: 12269-1987.

Table 1 Physical Properties of Cement

Sl No	Tests on cement	Observations
1	Specific gravity	3.10
2	Normal consistency	32 %
3	Initial setting time	37 min
4	Compression strength 7 Days 28 days	 29 N/mm2 55.5 N/mm2

Fine Aggregate

The aggregate which is passing through 4.75 mm sieve is known as fine aggregate. Locally available river sand which is free from organic impurities is used sand passing through 4.75mm sieve and retained on 150 micron IS sieve is used in this investigation. The physical properties of fine aggregate like specific gravity, bulk density, grada-

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tion and fineness modulus is tested in accordance with IS: 2386-1975.

Table 2 Properties of fine Aggregate

Properties	Observations
Fineness Modulus	2.72
Specific Gravity	2.70
Bulk Density (Kg/m^3)	1710

COARSE AGGREGATE

The crushed coarse aggregate of 20 mm maximum size rounded obtained from the local crushing plant; (Bidadi, Karnataka) 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 : 2386-1975.

Table 3 Properties of Coarse Aggregate

Properties	Observations
Fineness Modulus	5.97
Specific Gravity	2.75
Bulk Density (Kg/m3)	1530

FLY ASH

Fly ash is obtained from Brick Klin in bidadi Ramanagram, Karnataka. The physical and chemical properties of fly ash are given in the table, respectively and conform to IS: 3812-2003.

Table 4 Physical Properties of Fly Ash

Physical Properties	Test Results
Colour	Grey
Specific Gravity	2.17

MICRO SILICA OR SILICA FUME

Micro silica is a highly efficient pozzolanic material and as considerable potential for use in concrete. Micro silica is obtained from Sri Sai Durga Agences, Bangalore, produced by Nuchems pvt ltd Bangalore

ADMIXTURE: CONPLAST SP 430

Conplast SP 430 is an admixture of a new generation made from the Forsoc Company. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. Conplast SP 430 is free of chloride & low alkali. It is compatible with all types of cements.

TYPICAL PROPERTIES

Aspect: Dark brown liquid
Relative Density: 1.08 ± 0.01 at 25°C
pH: >6
Chloride ion content: < 0.2%

MIX PROPORTIONS

Table 5 Mixture Proportions for Fly Ash Self-Compacting Concrete (Kg/m3) For M35 Grade concrete

Materials	Conventional	Fly Ash						
		M35 F.A 1	M35 F.A 2	M35 F.A 3	M35 F.A 4	M35 F.A 5	M35 F.A 6	M35 F.A 7
Percentage	-	5%	10%	15%	20%	25%	30%	35%
Cement	520.80	494.76	468.72	442.68	416.64	390.6	364.56	338.52
Flyash	-	26.04	52.08	78.12	104.16	130.20	156.24	182.28
Micro silica	-	-	-	-	-	-	-	-
W/C Ratio	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
F.A	920.8	920.8	920.8	920.8	920.8	920.8	920.8	920.8
C.A	753.4	753.4	753.4	753.4	753.4	753.4	753.4	753.4
Super plasticizer	3.124	2.96	2.81	2.66	2.50	2.34	2.19	2.03

Table 6 Mix Proportions for Micro Silica Self-Compacting Concrete (Kg/m3) For M35 Grade concrete

Materials	Conventional	Micro Silica						
		M35 M.C 1	M35 M.C 2	M35 M.C 3	M35 M.C 4	M35 M.C 5	M35 M.C 6	M35 M.C 7
Percentage	-	5%	10%	15%	20%	25%	30%	35%
Cement	520.80	494.76	468.72	442.68	416.64	390.6	364.56	338.52
Flyash	-	-	-	-	-	-	-	-
Micro silica	-	26.04	52.08	78.12	104.16	130.20	156.24	182.28
W/C Ratio	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
F.A	920.8	920.8	920.8	920.8	920.8	920.8	920.8	920.8
C.A	753.4	753.4	753.4	753.4	753.4	753.4	753.4	753.4
Super plasticizer	3.124	2.96	2.81	2.66	2.50	2.34	2.19	2.03

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Table 7 Mixture Proportions for Fly Ash Self-Compacting Concrete (Kg/m3) For M40 Grade concrete

Materials	Conventional	Fly Ash						
		M40 F.A 1	M40 F.A 2	M40 F.A 3	M40 F.A 4	M40 F.A 5	M40 F.A 6	M40 F.A 7
Percentage	-	5%	10%	15%	20%	25%	30%	35%
Cement	595.20	565.44	535.68	505.92	476.16	446.40	416.64	386.88
Flyash	-	29.76	59.52	89.28	119.04	148.80	178.56	208.32
Micro silica	-	-	-	-	-	-	-	-
W/C Ratio	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
F.A	884.87	884.87	884.87	884.87	884.87	884.87	884.87	884.87
C.A	723.94	723.94	723.94	723.94	723.94	723.94	723.94	723.94
Super plasticizer	3.57	3.39	3.21	3.04	2.86	2.68	2.50	2.32

Table 4: Mixture Proportions for Micro Silica Self-Compacting Concrete (Kg/m3) For M40 Grade concrete

Materials	Conventional	Micro Silica						
		M40 M.C 1	M40 M.C 2	M40 M.C 3	M40 M.C 4	M40 M.C 5	M40 M.C 6	M40 M.C 7
Percentage	-	5%	10%	15%	20%	25%	30%	35%
Cement	595.20	565.44	535.68	505.92	476.16	446.40	416.64	386.88
Flyash	-	-	-	-	-	-	-	-
Micro silica	-	29.76	59.52	89.28	119.04	148.80	178.56	208.32
W/C Ratio	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
F.A	884.87	884.87	884.87	884.87	884.87	884.87	884.87	884.87
C.A	723.94	723.94	723.94	723.94	723.94	723.94	723.94	723.94
Super plasticizer	3.57	3.39	3.21	3.04	2.86	2.68	2.50	2.32

Table 5: Mixture Proportions for Incorporation of admixtures at 20 % Replacement in Self-Compacting Concrete (Kg/m3) For M35 Grade concrete

Materials	Conventional	Micro Silica		
		M40 .I.C 1	M40 I.C 2	M40 I.C 3
Percentage Replacement	-	20%	20%	20%
Cement	520.80	416.64	416.64	416.64
Fly ash	-	78.12	52.08	26.04
Micro silica	-	26.04	52.08	78.12
W/C Ratio	0.40	0.40	0.40	0.40
F.A	920.8	920.8	920.8	920.8
C.A	753.4	753.4	753.4	753.4
Super plasticizer	3.124	2.96	2.81	2.66

Table 6: Mixture Proportions for Incorporation of admixtures at 20 % Replacement in Self-Compacting Concrete (Kg/m3) For M40 Grade concrete

Materials	Conventional	Micro Silica		
		M40 .I.C 1	M40 I.C 2	M40 I.C 3
Percentage Replacement	-	20%	20%	20%
Cement	595.20	565.44	535.68	505.92
Flyash	-	89.28	59.52	29.76
Micro silica	-	29.76	59.52	89.28
W/C Ratio	0.35	0.35	0.35	0.35
F.A	884.87	884.87	884.87	884.87
C.A	723.94	723.94	723.94	723.94
Super plasticizer	3.57	3.39	3.21	3.04

EXPERIMENTAL RESULTS AND ANALYSIS

Fresh State Properties

The fresh state properties like slump flow, V-funnel test, L-box test U-box test and J-ring test has been carried out to determine the flowability and passability. And the test results has been tabulated in the table below

Table 7: Workability Test Results

Sl. No	Mixture No	W/C Ratio	Slump (mm)	T 50_{cm} Slump Flow (sec)	V-Funnel (sec)	L- Box (h2/h1)	U-Box (h2-h1)	J-Ring (mm)
1	M35 F.A 1	0.40	660	3	7	0.815	19	8
2	M35 F.A 2	0.40	668	4	7	0.826	22	8
3	M35 F.A3	0.40	675	3	6	0.913	26	8
4	M35 F.A 4	0.40	672	4	8	0.984	23	10
5	M35 F.A 5	0.40	650	3	10	1.112	21	11
6	M35 F.A 6	0.40	665	3	11	0.885	27	12
7	M35 F.A 7	0.40	670	3	10	0.876	24	11
8	M35 M.C 1	0.40	680	3	9	0.911	17	7
9	M35 M.C 2	0.40	685	2	8	0.815	16	6

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10	M35 M.C 3	0.40	672	4	12	0.895	18	8
11	M35 M.C 4	0.40	668	4	9	0.882	19	11
12	M35 M.C 5	0.40	670	3	7	0.956	15	10
13	M35 M.C 6	0.40	685	4	10	1.124	14	9
14	M35 M.C 7	0.40	680	5	11	1.118	19	9
15	M40 F.A 1	0.35	690	5	8	0.925	23	5
16	M40 F.A 2	0.35	700	6	8	0.963	20	6
17	M40 F.A 3	0.35	715	5	8	0.973	19	4
18	M40 F.A 4	0.35	705	4	7	0.956	21	7
19	M40 F.A 5	0.35	695	3	6	0.974	24	8
20	M40 F.A 6	0.35	710	3	9	0.871	26	8
21	M40 F.A 7	0.35	705	4	8	0.879	28	9
22	M40 M.C 1	0.35	690	4	8.8	1.01	14	10
23	M40 M.C 2	0.35	685	5	8.5	1.012	15	11
24	M40 M.C 3	0.35	690	4	9.8	0.989	18	9
25	M40 M.C 4	0.35	688	6	10.6	0.976	19	8

Sl. No	Mixture No	W/C Ratio	Slump (mm)	T 50_{Cm} Slump Flow (sec)	V-Funnel (sec)	L- Box (h2/h1)	U-Box (h2-h1)	J-Ring (mm)
26	M40 M.C 5	0.35	675	3	8.7	0.918	17	8
27	M40 M.C 6	0.35	700	4	11.4	0.936	16	11
28	M40 M.C 7	0.35	715	4	11.5	0.952	12	10
29	M35 I.C 1	0.40	702	4	10.6	0.885	23	13
30	M35 I.C 2	0.40	705	5	10.1	0.869	18	10
31	M35 I.C 3	0.40	695	5	10.	0.843	27	9
32	M40 I.C 1	0.35	685	5	9.5	0.851	25	12
33	M40 I.C2	0.35	700	4	11.2	0.987	21	8
34	M40 I.C 3	0.35	705	4	10	0.964	22	10

SPECIMEN DETAILS

The specimens casted are

a) Cubes of 150mm×150mm×150mm size (for Compression Test)
b) Cylinder of 150mm dia×300mm length (for Split Tensile Test)
c) Prism of 150mm×150mm×700mm size (for Flexural strength Test

Table 8: Strength results for M35 grade of concrete for Micro Silica as partial replacement material

Specimen	Compressive Strength in N/mm2		Split Tensile Strength (N/mm2)	Flexural strength (N/mm2)
	7 Days	28 Days		
M35 00% S.F	23.85	38.81	3.17	3.18
M35 05% S.F	25.04	40.59	3.41	4.42
M35 10% S.F	28.44	41.48	3.70	4.84
M35 15% S.F	29.48	44.30	4.09	4.91
M35 20% S.F	32.15	45.63	4.71	5.12
M35 25% S.F	26.07	42.81	4.13	4.29
M35 30% S.F	24.44	40.44	3.80	4.15
M35 35% S.F	24.15	37.63	3.60	3.66

Table 9: Strength results for M35 grade of concrete for Fly Ash as partial replacement material

Specimen	Compressive Strength in N/mm2		Split Tensile Strength (N/mm2)	Flexural strength (N/mm2)
	7 Days	28 Days		
M35 00% F.A	23.85	38.81	3.17	3.18
M35 05% F.A	24.30	39.11	3.03	3.25
M35 10% F.A	25.33	39.41	3.32	3.46
M35 15% F.A	27.56	41.93	3.85	4.01
M35 20% F.A	28.15	43.26	4.52	4.36
M35 25% F.A	24.89	40.89	3.89	3.87
M35 30% F.A	23.26	38.22	3.75	3.53
M35 35% F.A	20.15	34.81	3.32	3.18

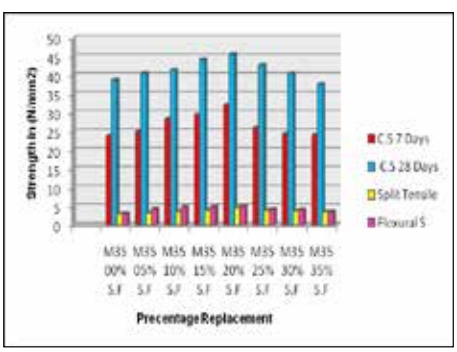

Fig 1: Graphical Representation Strength results for M35 grade of concrete for Micro Silica as partial replacement material

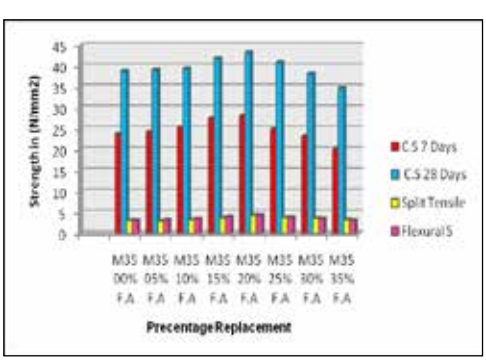

Fig 2: Graphical Representation Strength results for M35 grade of concrete for Fly Ash as partial replacement material

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Table 10: Strength results for M40 grade of concrete for Micro Silica as partial replacement material

Specimen	Compressive Strength in N/mm2		Split Tensile Strength (N/mm2)	Flexural strength (N/mm2)
	7 Days	28 Days		
M40 0% S.F	29.63	40.15	3.22	4.36
M40 05% S.F	33.48	42.96	3.56	4.77
M40 10% S.F	34.22	44.15	3.75	5.05
M40 15% S.F	35.41	45.78	4.23	5.39
M40 20% S.F	36.15	48.30	4.81	6.08
M40 25% S.F	34.07	46.37	3.99	5.60
M40 30% S.F	33.19	42.81	3.70	5.05
M40 35% S.F	30.96	41.19	3.46	4.42

Table 11: Strength results for M40 grade of concrete for Fly Ash as partial replacement material

Specimen	Compressive Strength in N/mm2		Split Tensile Strength (N/mm2)	Flexural strength (N/mm2)
	7 Days	28 Days		
M40 0% F.A	29.63	40.15	3.22	4.36
M40 05% F.A	30.67	40.59	3.12	4.49
M40 10% F.A	31.26	41.33	3.32	4.70
M40 15% F.A	32.44	42.96	3.65	4.98
M40 20% F.A	34.67	43.56	3.94	5.53
M40 25% F.A	28.89	40.74	3.27	4.56
M40 30% F.A	27.70	37.78	3.08	4.08
M40 35% F.A	26.81	35.41	2.69	3.25

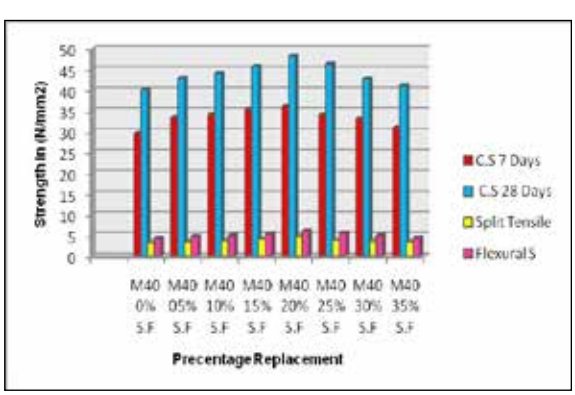

Fig 3: Graphical Representation Strength results for M40 grade of concrete for Micro Silica as partial replacement material

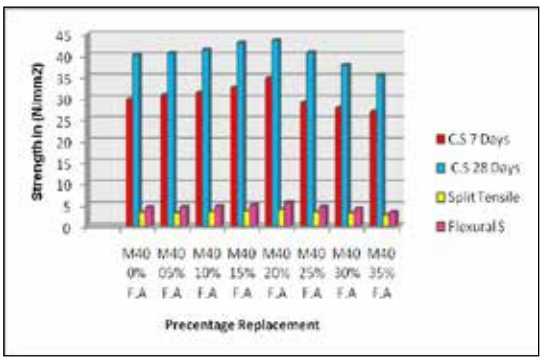

Fig 4: Graphical Representation Strength results for M40 grade of concrete for Fly Ash as partial replacement material

Table 12: Strength results for Incorporating of Micro Silica and Fly Ash in M35 grade of concrete

Specimen	Compressive Strength in N/mm2		Split Tensile Strength (N/mm2)	Flexural strength (N/mm2)
	7 Days	28 Days		
M35 I.C	25.04	40.59	3.46	5.39
M35 I.C	33.48	45.78	4.33	6.29
M35 I.C	22.07	37.63	3.75	5.74

Table 13: Strength results for Incorporating of Micro Silica and Fly Ash in M40 grade of concrete

Specimen	Compressive Strength in N/mm2		Split Tensile Strength (N/mm2)	Flexural strength (N/mm2)
	7 Days	28 Days		
M40 I.C	30.81	41.19	4.13	5.88
M40 I.C	38.52	47.70	4.76	6.91
M40 I.C	31.11	39.70	4.23	5.88

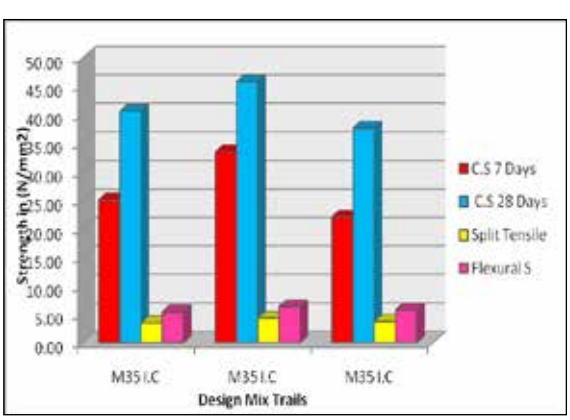

Fig 5: Graphical Representation Strength results for Incorporating of Micro Silica and Fly Ash in M35 grade of concrete

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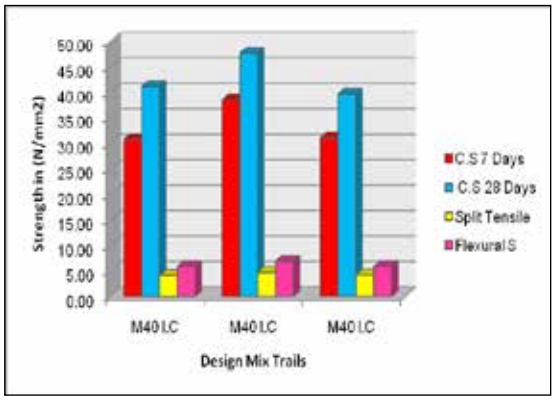

Fig 6: Graphical Representation Strength results for Incorporating of Micro Silica and Fly Ash in M40 grade of concrete

CONCLUSION

The present study has shown that the mineral admixture added to SCC has a considerable increase in compressive, flexural and split tensile strength.

1. SCC with partial replacement material of cement have a slump in the range of 650-800mm and a flow time ranging from 8-10sec and the slump flow decreases with increase in Fly ash for both M35 and M40 grades of concrete.
2. The Specimen with 5%, 10%, 15% . 20% of Micro Silica and Fly Ash shows an increase of compressive strength by 4.58%, 6.57 %, 13.21%, 15.38% for Micro Silica and 0.76%, 1.52%, 7.89%, 10.60% for Fly Ash Respectively for M35 Grade of Concrete.
3. The Specimen with 5%, 10%, 15% . 20% of Micro Silica and Fly Ash shows an increase of compressive strength by 7.01%, 9.31%, 12.75%, 17.80% for Micro Silica and 1.11%, 2.92%, 6.81%, 7.93% for Fly Ash Respectively for M40 Grade of Concrete.
4. The Specimen with replacement material at 20% incorporating 10% of Micro Silica and 10% of Fly Ash shows an increase of compressive strength by 17.15% for M35 and 18.35% for M40 Grade of Concrete with respect to that of conventional concrete respectively.
5. The SCC developed split tensile strengths ranging from 3.17 N/mm2 to 4.76 N/mm2 for Micro Silica and 3.17 N/mm2 to 4.40 N/mm2 for Fly Ash in M35 Grade of Concrete.
6. The SCC developed split tensile strengths ranging from 3.24 N/mm2 to 4.69 N/mm2 for Micro Silica and 3.24 N/mm2 to 4.46 N/mm2 for Fly Ash in M40 Grade of Concrete.
7. SCC with Mineral Admixtures as partial replacement of cement material at 20% replacement gives higher Flexural Strength.
8. SCC with incorporating mineral admixture (i.e. Fly Ash and Micro Silica) of 50% each in 20% of replacement gives higher results in Compressive strength, Split tensile strength, and Flexural Strength.
9. It Proves Economical by Incorporating 2 or more mineral admixture in SCC.

SCC with mineral admixtures mixes show higher compressive, split tensile and flexural strength rather than normal compacting concrete. Use of fly ash increased the workability characteristics of SCC mixtures.

SCOPE FOR FURTHER WORKS

1. Further studies can be done using different mineral admixtures like GGBS, rice husk ash, cement kiln dust etc. as cement replacement material.
2. Studies can be done by incorporating different mineral admixtures with varying the percentage as cement replacement material.
3. Studies can be done by incorporating different mineral admixtures and Different types of fibres.
4. Studies can be done with fibres of different aspect ratio.

REFERENCE

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