EXPERIMENTAL STUDY ON SFRSCC BY USING MARBLE POWDER AND FLY ASH AS PARTIAL RELACEMENT

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Abstract : The current experiment was carried out to investigate concrete mixes with replacement of cement by marble powder and fly ash with inclusion of steel fibres. Cement was replaced by 30% of Fly ash with inclusion of 0%, 0.5%, 1% & 1.5% steel fibres. It was also replaced by 30% of marble powder with inclusion of 0%, 0.5%, 1% & 1.5% steel fibres. Concrete cubes of size 150mmX150mmX150mm, prisms of size 100mmX100mmX500mm & cylinders of diameter-150mm & height-300mm were tested for compressive strength, flexural strength & split tensile strength in accordance with ASTM test methods at 7 and 28 days respectively. Maximum compression strength results were secured with mix proportion of 30% of Fly Ash and 1.0% of Steel Fibres when compared with substitution of Marble Powder in concrete. Maximum Split tensile strength results were secured with mix proportion of 30% of Fly Ash and 1.0% of Steel Fibres when compared with substitution of Marble Powder in concrete. Maximum Flexural strength results were secured with mix proportion of 30% of Fly Ash and 1.0% of Steel Fibres when compared with substitution of Marble Powder in concrete.

Index Terms **– Self Compacting Concrete, Steel Fibres, Marble Powder & Fly Ash.**

I. INTRODUCTION

Self-Compacting Concrete (SCC) has capacity to spread individually into the covering without the assistance of any outer vibration. It gets placed by using its own weight without segregation & bleeding. The significance of SCC is that it preserves total concrete's durability and characteristics. It also meets its expected performance demand. SCC can be utilized in places of heavy reinforced sections. It can likewise be put where there is no way to vibrators for compaction. SCC was first created in Japan in the year 1986 by Okamura. It was used for settling the durability problems in concrete. It was also used as there was reduction of number of skilled labours in Japan's construction industry.

II. MATERIALS

1. *Cement*:
   OPC of specification 53 grade conforming to IS 12269-1987, from a single batch was utilized all through the span of the project work. The initial and final setting times were found as 38.5 minutes and 319 minutes respectively.

2. *Fine Aggregate:*
   Sand which passed through 4.75 mm sieve & locally available was used. It belongs to zone II of IS 383-1970. The specific gravity of 2.66 was used as fine aggregate. The bulk density of sand is 1595 kg/m^3 & the water absorption of 1.0%.

3. *Coarse Aggregate:*
   Crushed stones of size more than 12mm & less than 20mm complying to IS 383-1970, were used. The specific gravity of 2.70 was used as coarse aggregate. The bulk density of coarse aggregate is 1687 kg/m^3 & the water absorption of 0.880%.

4. *Steel Fibres:*
   Crimped Steel fibers were used throughout this project. The parameters of steel fibres are listed below.

Table No. 1: Properties of Steel Fibre

Sr. No.	Parameter	Value
1	Length	30 mm
2	Diameter	0.6 mm
3	Aspect Ratio	50
4	Density	7840 Kg/m^3
5	Specific Gravity	7.9

5. *Fly Ash:*
Fly ash acquired from thermal power plant situated at Raichur Thermal Power Plant was used in this project. Fly ash has spcific gravity of 1.9.

Table No. 2: Physical Properties of Fly Ash

Sr. No.	Formula	% Content
1	SiO_2	59.00
2	Al_2O_3	22.50
3	Fe_2O_3	3.70
4	CaO	6.90
5	SO_3	1.00
6	MgO	1.40
7	K_2O	0.90
8	LOI	4.60

6. *Marble Powder:*
Locally available Marble powder was used in this project. The properties of marble powder are listed below.

Table No. 3: Physical Properties of Marble Powder

Sr. No.	Parameter	Description
1	Colour	White
2	Form	Powder
3	Odour	Odourless
4	Moisture Content %	1.59
5	Specific Gravity	2.67

Table No. 4: Chemical Properties of Marble Powder

Sl. No.	Oxide	Percentage Content
1	SiO_2	28.35
2	Al_2O_3	0.42
3	Fe_20_3	9.70
4	CaO	40.45
5	MgO	16.25
6	Density (g/cm^3)	2.80

7. *Chemical Admixture (Super Plastisizer):*
To improve the workability of the concrete mixture, a high scope of water lessening agent i.e. Fosroc Conplast SP430 is used. The property of the chemical admixture is shown in table below:

Table No. 5: Properties of Chemical Admixture

Sr. No.	Parameter	Description
1	Appearance	Brown liquid
2	Specific gravity	1.2
3	Chloride Content	Nil to BS 5075
4	Air entrainment	less than 2%
5	Alkali content	Typically less than 72 g. Na_2O equivalent /liter of admixture

III. MIX PROPORTION:

The mix proportion obtained for Self compacting concrete & Conventional concrete for M40 grade is tabulated below:

Table No. 6: Shows the Mix Proportions for SSC M40 grade of concrete

Water to cement Ratio	Cement	Sand	Coarse Aggregate	Super plasticizer
0.35	1.0	1.52	1.36	0.015

Table No. 7: Shows the Mix Proportions for Conventional M40 grade of concrete

Water to cement Ratio	Cement	Sand	Coarse Aggregate
0.44	1.0	1.50	2.71

IV. PREPARATION AND CASTING OF SPECIMENS:

Concrete mixture is prepared as per the mix design resulted from the calculations. First a dry mix is prepared by adding all the ingredients in dry state until uniformity is achieved. Then as per the values obtained from mix design, required quantity of water is poured in the dry mix and mixing is properly done till homogeneous mixture is obtained.

For testing of concrete mixture, three types of specimens namely cubes, cylinders & prisms were casted. Cubes were casted in moulds of size 150mm×150mm×150mm. Cylinders were casted in moulds of size having diameter-150mm & height-300mm. Prisms were casted in moulds of size having length-100mm×100mm×500mm. In order to prevent sticking of concrete inside the mould, oil is put on the inner sides of the mould in layers before pouring fresh concrete.

After casting the moulds, they were kept to set aside for 24 hours. After 24 hours samples were taken out from the moulds. They were cured for 7 days & 28 days to complete its curing process. The compression test, split tensile strength test & flexural strength test were done on cubes, cylinders & prisms respectively.

V. RESULTS AND DISCUSSION:

1. Tests for Fresh Concrete

To know the workability of the self-compacting concrete, slump flow time & diameter tests were done and to know the deformability and consistency of fresh concrete J-Ring, L-Box ratio & V-funnel tests are carried out.

Table No. 8: Shows the Slump Flow, L-Box ratio & V-funnel Test results

Sr. No.	Percentage of Marble Powder / Fly Ash	Percentage of Steel Fibre	Slump 650-850 mm	T_{50cm} Slump 2-5 s	V-Funnel 6-12 s	L-Box Ratio 0.8-1.0
M1	0	0	720	3.2	7.2	0.93
M2	30 MP	0	695	3.5	7.6	0.87
M3	30 MP	0.50	670	4.0	8.5	0.85
M4	30 MP	1.0	660	4.5	8.9	0.81
M5	30 MP	1.50	650	4.9	9.5	0.92
M6	30 FA	0	690	3.6	7.7	0.94
M7	30 FA	0.50	675	3.9	8.6	0.90
M8	30 FA	1.0	660	4.6	9.1	0.85
M9	30 FA	1.50	650	5.0	9.7	0.82

2. Tess for Hardened Concrete

2.1 Compression Strength Test

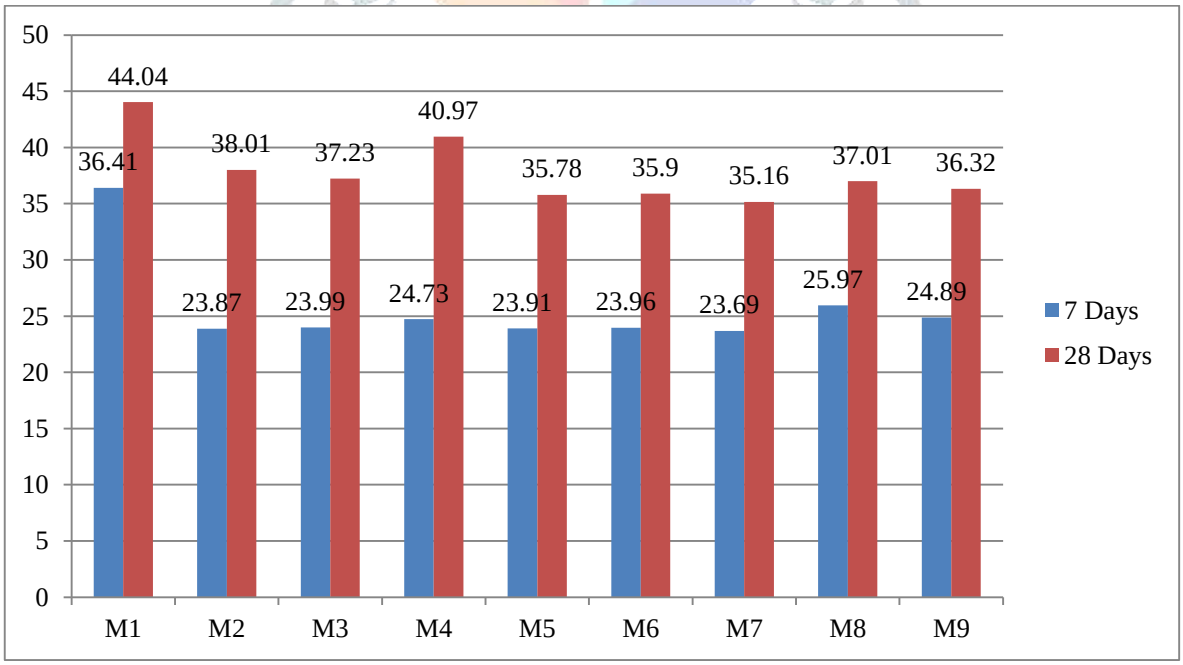
For compression strength test, cubes of dimension 150 x 150 x 150 mm were casted. Later they were and cured for 7 & 28 days. After completion of curing, they were experimented on compression testing machine as per IS 516-1959. Universal

testing machine (UTM) was used to carry out this test. Load at which the cube sample fails is noted. The compression strength is found by dividing load by area of the cube sample. 36 cubes were casted for this test.

Compression strength = (Load/Area) N/mm^2

Table No. 9: Shows the Compression Test Results @ 7 Days and 28 Days

Mix designation	Percentage of Marble Powder / Fly Ash	Percentage of Steel Fibre	Compressive Strength @ 7 days	Compressive Strength @ 28 days	Average Compressive Strength @ 7 days	Average Compressive Strength @ 28 days
M1	0	0	37.46	44.70	36.41	44.04
			35.35	43.37		
M2	30 MP	0	23.24	38.42	23.87	38.01
			24.50	37.60		
M3	30 MP	0.50	23.60	37.70	23.99	37.23
			24.37	36.75		
M4	30 MP	1.0	25.40	40.35	24.73	40.97
			24.05	41.59		
M5	30 MP	1.5	24.24	36.10	23.91	35.78
			23.57	35.45		
M6	30 FA	0	23.78	35.66	23.96	35.90
			24.13	36.13		
M7	30 FA	0.50	24.10	35.64	23.69	35.16
			23.28	34.67		
M8	30 FA	1.0	25.67	36.82	25.97	37.01
			26.27	37.19		
M9	30 FA	1.5	25.15	36.15	24.89	36.32
			24.63	36.48		



Graph No. 1: Shows the Compression Test Results @ 7 Days and 28 Days

The Maximum compressive strength of 25.97N/mm2 &37.01N/mm² was obtained with M8 mix proportion of 30% of Fly Ash and 1% of Steel Fibres at 7 & 28 days curing respectively.

Figure no- 1: Shows the Failure Behavior for Cube

2.2 The Split Tensile Strength Test

For split tensile strength test, cylinders of dimension 150 x 300 mm were casted. Later they were cured for 7 & 28 days. After curing they were tested on digital compression testing machine as per IS 516-1959. Universal testing machine (UTM) was used to carry out this test. Load at which the cylinder sample fails is noted. The split tensile strength is calculated by dividing load by area of the cube sample. 36 cylinders were casted for this test.

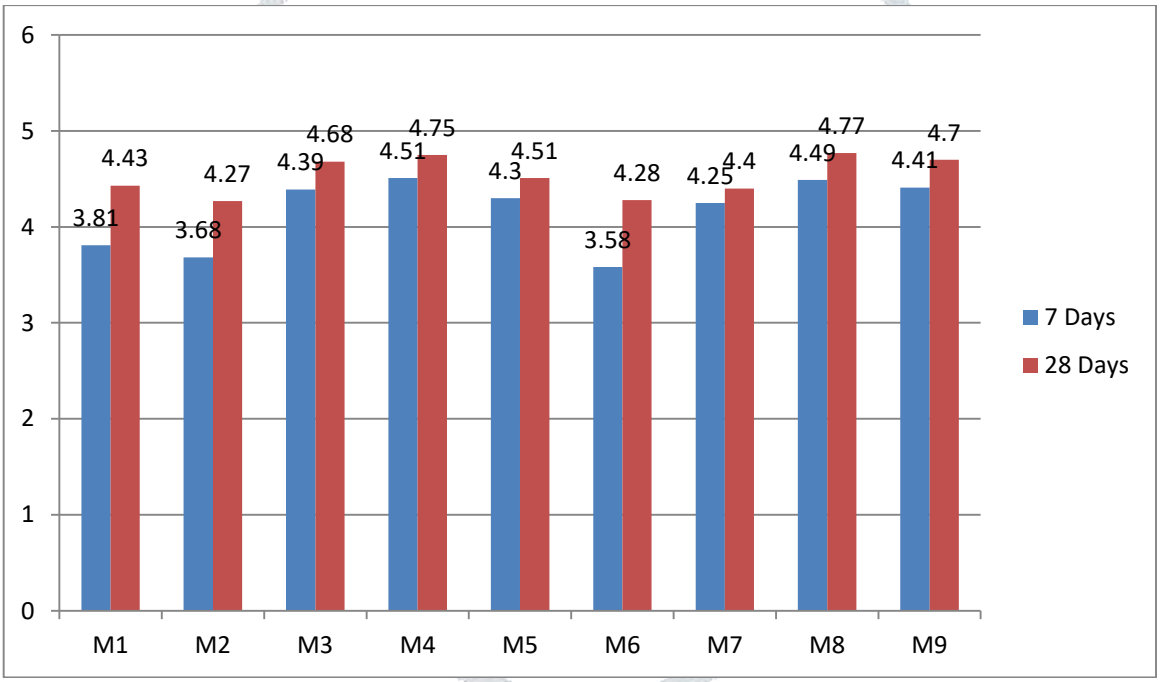
Split tensile strength = (2 x Load) / (π x height x dia) N/mm^2

Table No. 10: Shows the Split Tensile Strength Test Results @ 7 Days and 28 Days

Mix designation	Percentage of Marble Powder / Fly Ash	Percentage of Steel Fibre	Split tensile Strength @ 7 days	Split tensile Strength @ 28 days	Average Split tensile Strength @ 7 days	Average Split tensile Strength @ 28 days
M1	0	0	3.86	4.5	3.81	4.43
			3.75	4.35		
M2	30 MP	0	3.7	4.26	3.68	4.27
			3.65	4.28		
M3	30 MP	0.50	4.34	4.66	4.39	4.68
			4.44	4.69		
M4	30 MP	1.0	4.52	4.79	4.51	4.75
			4.49	4.71		
M5	30 MP	1.5	4.31	4.57	4.30	4.51
			4.29	4.45		
M6	30 FA	0	3.6	4.33	3.58	4.28
			3.55	4.23		
M7	30 FA	0.50	4.24	4.45	4.25	4.40
			4.26	4.34		
M8	30 FA	1.0	4.58	4.88	4.49	4.77
			4.39	4.65		
M9	30 FA	1.5	4.5	4.77	4.41	4.70
			4.32	4.63		

The Maximum Split Tensile strength of 4.49N/mm2 &4.77N/mm² was obtained with M8 mix proportion of 30% of Fly Ash and 1% of Steel Fibres at 7 & 28 days curing respectively.

Figure no- 2: Shows the Failure Pattern of Cylinder



Graph no-2: Shows the Split Tensile Strength Test @ 7days & 28 days in N/mm²

2.3 The Flexural Strength Test

For flexural strength test, prisms of dimension 100 x 100 x 500 mm were casted. Later they cured for 7 & 28 days. They were tested under 2-point loading. 36 prisms were casted for this test.

Flexural strength = (load x length) / (width x depth^2) N/mm^2

Table No. 11: Shows the Flexural Strength Test Results @ 7 Days and 28 Days

Mix designation	Percentage of Marble Powder / Fly Ash	Percentage of Steel Fibre	Flexural Strength @ 7 days	Flexural Strength @ 28 days	Average Flexural Strength @ 7 days	Average Flexural Strength @ 28 days
M1	0	0	7.38	8.05	7.52	8.15
			7.65	8.25		
M2	30 MP	0	6.73	7.88	6.84	7.79
			6.95	7.69		
M3	30 MP	0.50	8.85	9.47	8.83	9.46
			8.8	9.45		
M4	30 MP	1.0	8.98	9.76	8.96	9.75
			8.94	9.73		
M5	30 MP	1.5	8.92	9.63	8.91	9.63
			8.9	9.62		
M6	30 FA	0	8.74	9.55	8.72	9.52
			8.7	9.49		
M7	30 FA	0.50	8.88	9.69	8.85	9.65
			8.82	9.6		
M8	30 FA	1.0	8.98	9.83	8.97	9.79
			8.96	9.75		
M9	30 FA	1.5	8.91	9.78	8.87	9.74
			8.83	9.7		

The Maximum Flexural strength of 8.97N/mm2 &9.79N/mm² was obtained with M8 mix proportion of 30% of Fly Ash and 1% of Steel Fibres at 7 & 28 days curing respectively.

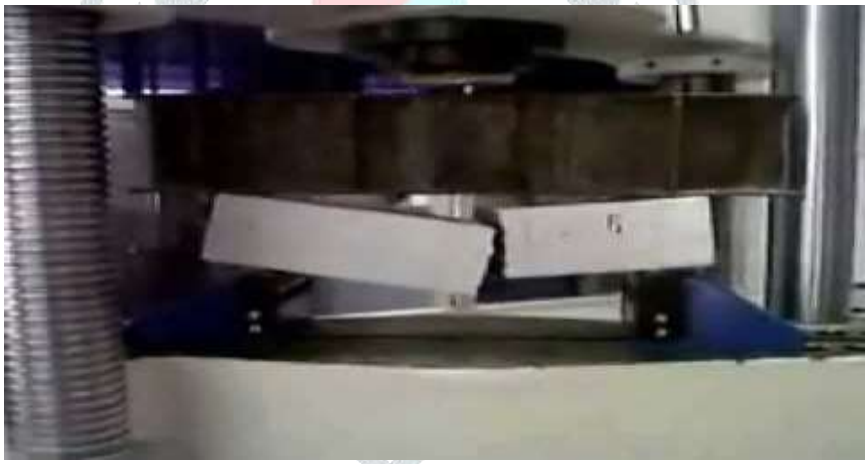
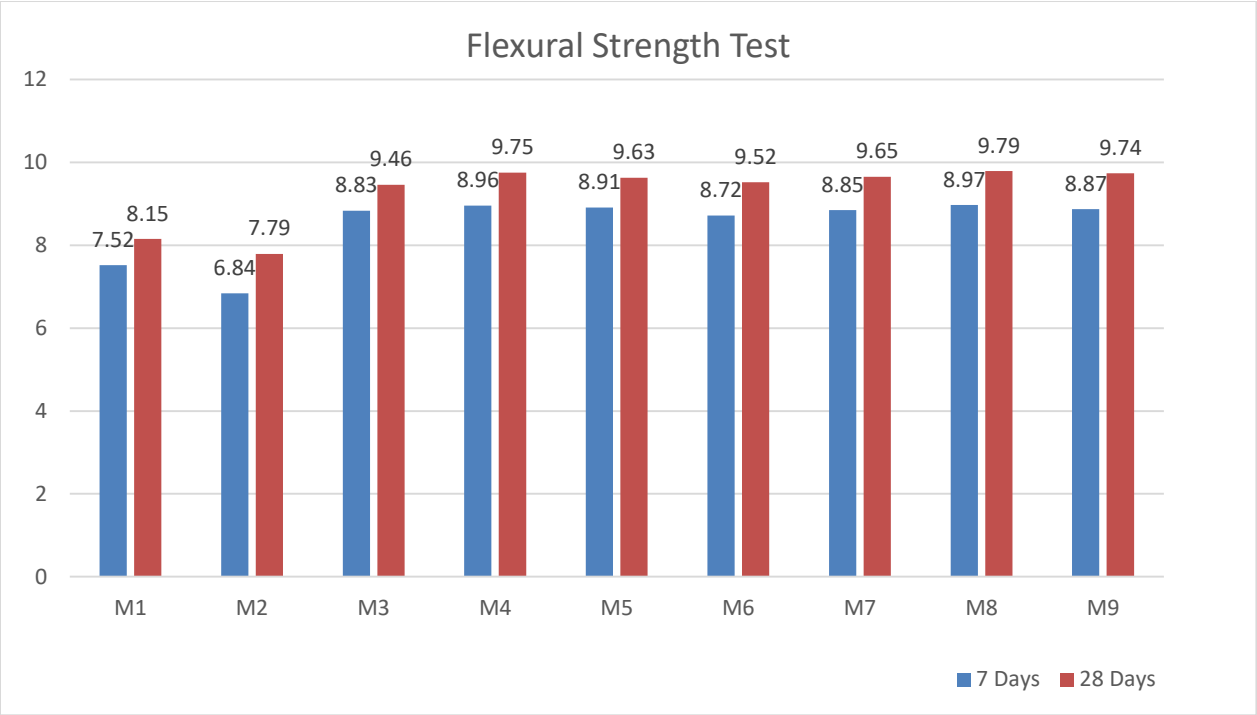


Figure no- 3: Shows the Failure Pattern of Prism



Graph no-3: Shows the Flexural Strength Test @ 7days & 28 days in N/mm²

VI. CONCLSION

1. From the experimental investigation with Fly Ash replaced by 30%and Steel Fibres 0%, 0.5%, 1% & 1.5% by cement, & Marble Powder replaced by 30%and Steel Fibres 0%, 0.5%, 1% & 1.5% by cement, Fly Ash replaced by 30% of cement& 1% of Steel Fibres were found to be optimum.

2. Maximum compression strength results were secured with mix proportion of 30% of Fly Ash and 1.0% of Steel Fibres when compared with substitution of Marble Powder in concrete.

3. Maximum Split tensile strength results were secured with mix proportion of 30% of Fly Ash and 1.0% of Steel Fibres when compared with substitution of Marble Powder in concrete.

4. Maximum Flexural strength results were secured with mix proportion of 30% of Fly Ash and 1.0% of Steel Fibres when compared with substitution of Marble Powder in concrete.

VII. FUTURE SCOPE OF STUDY

1. As M40 grade of concrete is used in this investigation, higher grades of concrete can be investigated by conducting different tests.
2. Different varieties of fibers may be included to concrete to obtain higher strength of concrete
3. In this investigation work OPC is used. Therefore, PCC shall be utilized in concrete.
4. SSC may be prepared by using GGBS and Alccofine as cement replacement in concrete.
5. Natural sand may be replaced by artificial sand in this study and investigated by conducting tests on concrete.

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