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Mix Design of Self Compacting Concrete Using Fly Ash and Microsilica

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Abstract: ***Self compacting concrete is firstly developed in Japan in 1980; Self compacting concrete is a fluid mixture suitable for placing in structures with congested reinforcement without vibration. Self compacting concrete development must ensure a good balance between deformability and stability also, compatibility is affected by the characteristics of materials and the mix proportions, self compacting concrete is a concrete that exhibits high deformability while maintaining resistance to segregation. Self compacting concrete construction and placing becomes faster and easier it eliminates the need for vibration and reducing the noise pollution; which consumes both time and labor.***

Keywords: SSC, vibration, mix proportion, compacting, pollution

1. Introduction

Microsilica is a very fine pozzolanic material, as a byproduc t of the production of elemental silicon or ferro silicon.

Microsilica is an admixture used to enhance the properties of concrete. It is specifically used to produce self compacting concrete with high strength, more workability and other beneficial properties. Self-compacting concrete (SCC) is a flowing concrete mixture. The highly fluid nature of SCC makes it suitable for placing in difficult condition & in selections with congested reinforcement. Use of SCC can help in hearing related damages on the worksite that are induced by vibration of concrete, another advantages of SCC is that the time required to place large section in consider ability reduced. It is recently used at Mumbai for Bandra-Warli Sea Link Bridge.

2. Mix Design (For M20)

1) Concrete Specification

Strength: Characteristic Compressive Strength (Fck) = 20N/mm^2

Workability: = Medium

Workability (IS: 456 2000)

Placing Conditions	*Degree of Workability*	*Slump (mm)*
(1)	(2)	(3)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	*See* **7.1.1**
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; Floors; Hand placed pavements; Canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns; Slipform work; Pumped concrete	Medium	50-100 75-100
Trench fill; *In-situ* piling	High	100-150
Tremie concrete	Very high	*See* **7.1.2**

Durability: Exposure Condition = Mild

Table: Environmental Exposure Condition (IS: 456 2000)

Sl No.	Environment	Exposure Conditions
(1)	(2)	(3)
i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet
		Concrete exposed to condensation and rain
		Concrete continuously under water
		Concrete in contact or buried under non-aggressive soil/ground water
		Concrete surfaces sheltered from saturated salt air in coastal area
iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.
		Concrete completely immersed in sea water
		Concrete exposed to coastal environment
iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet
		Concrete in contact with or buried under aggressive sub-soil/ground water
v)	Extreme	Surface of members in tidal zone
		Members in direct contact with liquid/ solid aggressive chemicals

3. Materials Properties

a) Fine Aggregates
Zone =Zone 1

Table: Grading limit for fine aggregate (IS: 383-1970)

IS Sieve	*Equivalent BS Sieve*	*Zone-1*	*Zone-2*	*Zone-3*	*Zone-4*
10-mm	3/8-in	100	100	100	100
4.75-mm	3/16-in	90-100	90-100	90-100	95-100
2.36-mm	No. 7	60-95	75-100	85-100	95-100
1,18-mm	No. 14	30-70	55-90	75-100	90-100
600- micron	N0. 25	15-34	35-59	60-79	80-100
300-micron	No, 52	5-20	8-30	12-40	15-50
150-micron	No. 100	0-10	0-10	0-10	0-15

Specific Gravity =2.2
Dry Loose Bulk Density (DLBD) =1.39Kg/lit

b) Coarse Aggregates
Specific Gravity =2.58
Dry Loose Bulk Density (DLBD) =1.45Kg/lit
Maximum Aggregate Size = 30mm

c) Cement
Type of Cement (Fm) =OPC 53 Grade
Standard Deviation (s) =20.7Kg/cm3
Characteristic Strength of cement (Fc)=49.58N/mm2
(Fc = Fm – 1.65 s)
Cement Grade = Grade "D"
28 – Day Strength of Cement tested according to (IS : 4031-1968)

28 – Day Strength of Cement tested according to IS : 4031-1968			
A	31.9 – 36.8 N/mm^2	E	51.5 – 56.4 N/mm^2
B	36.8 – 41.7 N/mm^2	F	56.4 – 61.3 N/mm^2
C	41.7 – 46.6 N/mm^2	G*	61.3 – 66.2 N/mm^2
D	46.6 – 51.5 N/mm^2		

Maximum W/C ratio =0.55

Table Maximum water-cement ratio (IS:456 2000)

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 *and* 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m^3	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

1) Minimum Cement Content =285Kg/m^3
2) Slump – in mm =75mm.
3) Slump – Degree in workability =Medium
4) Target Strength
Standard Deviation's =5N/mm^2
Value of 't' =1.65

Table: Assumed Standard Deviation (IS: 456 2000)

Table 8 Assumed Standard Deviation

(Clause 9.2.4.2 and *Table* 11)

Grade of Concrete	Assumed Standard Deviation N/mm²
M 10, M 15	3.5
M 20, M 25	4.0
M 30, M 35, M 40, M 45, M 50	5.0

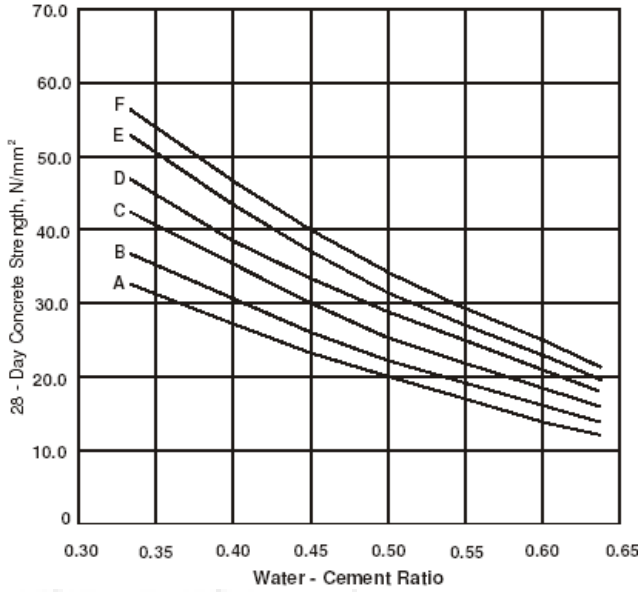
NOTE—The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate gradings and moisture content; and periodical checking of workability and strength. Where there is deviation from the above the values given in the above table shall be increased by 1N/mm².

Table: Value of "t" (IS: 10262-1982)

Acceptance proportion of low result	"t"
1 in 5	0,84
1 in 10	1.28
1 in 15	1.50
1 in 20	1,65
1 in 40	1,96
1 in 100	2.33

Target Mean Strength Fm =28.25 N/mm^2
(Fm = Fck + t x s

Relation between free water/cement ratio and concrete strength at 28 days for different Cement curves (IS: 10262-1982)



8. Water - Cement ratio [W/C] (from Graph) =0.48
9. Final W/C =0.48

C	FA	CA	Water
1	2.23	2.5	0.48

Mix Proportion

Table: mix proportion for 1 cubic meter of concrete.

Mixture	Cement (Kg/m^3)	SF (Kg/m^3)	FA (Kg/m^3)	Sand (Kg/m^3)	CA (Kg/m^3)	Water	SP (Kg/m^3)
CC	404			907	1010	194	
CC-1	364	40		907	1010	214	
SCC-A	282	40	80	907	1010	214	9.67
SCC-B	243	40	121	907	1010	214	9.67
SCC-C	202	40	162	907	1010	214	9.67

Where,
CC= Conventional Concrete
SCC-1= Self Compacting Concrete with 10% Microsilica.
SCC-A= Self Compacting Concrete wite 10% Microsilica, 20% Fly Ash, & 2.4% Superplasticizer.
SCC-B= Self Compacting Concrete wite 10% Microsilica, 30% Fly Ash, & 2.4% Superplasticizer
SCC-C= Self Compacting Concrete wite 10% Microsilica, 40% Fly Ash, & 2.4% Superplasticizer
SF= Silica Fume or Microsilica.
FA= Fly Ash.
CA= Coarse Aggregate.
SP= Superplasticizer.

4. Conclusion

On the basis of experimentation work carried out, the following conclusions are drawn:

1) As per the observed workability and high flow ability of SCC, it can be used in highly congested reinforcement structure as compare to conventional concrete.
2) 10% replacement of microsilica for cement makes a good strength of concrete..
3) Compressive strength of conventional concrete is obtained nearly equal to the compressive strength of Self Compacting Concrete using 10% Microsilica, 30% fly ash and 2.4% super plasticizer.
4) On a basis of total cost, including the labors charges, formwork and making good finished surfaces, SCC can be more advantageous.
5) Fly ash is very cheap, it can be used successfully in place of cement, it gives good results at very low content.
6) At this water/cement ratio, the Slump flow test, V-funnel test, L-Box test, U-Box test result were found to be satisfactory.

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