Effect Of Silica Fume And Marble Powder On Self-Compacting Concrete In Presence Of Different Viscosity Modifying Admixture

Tapan Gandhi[1], Abbas Jamani[2]
[1, 2] Dept of Structural Engineering
[1]Student of L.J. Institute of Engineering and Technology
[2]Assistant Professor, L.J. Institute of Engineering and Technology

Abstract*- The Objective of this Experimental work is to examine the effect of substitution of cement with silica fume and marble powder on the rheological, mechanical properties and durability of self-compacting concrete(SCC) with different viscosity modifying admixture(VMA). M30 grade of concrete was used in this study. OPC (ordinary Portland cement) was replaced by 5% silica fume and 10% marble powder which kept constant in all combinations. Cellulose ether and Starch ether is used as VMA at variant percentage (0.15 % – 0.8 %) in this study. The workability of fresh SCC was measured by Slump flow, L-box and V-funnel Tests. Compressive, flexural and split tensile strength test was carried out for the hardened properties. Acid attack and Sulphate attack was carried out for durability tests of SCC. The results shown that 0.6% of cellulose ether and 0.45 % of starch ether gives better result as compared to other combinations of VMA.*

Keywords- Marble Powder, Silica Fume Cellulose Ether, Starch Ether, Self-Compacting Concrete, Viscosity Modifying Agents, superplasticizer.

I. INTRODUCTION

Self-compacting concrete (SCC) is a highly viscous concrete that can spread into place under its own weight and accomplish good link in the absence of vibration without revealing defects due to segregation and bleeding. Self-compacting concrete is a creation of technological improvements in the area of underwater concrete technology where the mix is proportioned to assure high fluidity as well as high resistance to water reduction and segregation. SCC was established in Japan in the late 1980s, and recently, this concrete has expanded wide use in many nations for different applications and structural formations.

Several changed approaches have been used to develop SCC. One technique to achieve self-compacting property is to increase suggestively the amount of fine materials (e.g., silica fume & marble powder) without changing the water content related with common concrete. One alternative method consists of incorporating a viscosity modifying admixture (VMA) to improve stability. The use of VMA along with suitable concentration of superplasticizer (SP) can ensure proper deformability and suitable workability, foremost to a good resistance to segregation. Mix containing VMA shows shear-thinning behaviour where viscosity decreases with the increase in shear proportion. Such concrete is typically thixotropic where the viscosity build-up is encouraged due to the association and predicament of polymer chains of the VMA at a lower shear rate that can more inhibit flow and increase viscosity. The thixotropic property increases the stability of the concrete and decreases the risk of segregation after moulding.

In this study, starch ether and cellulose ether as VMA was tested in the creation of SCCs along with superplasticizer. The fresh concrete properties (slump flow, V-funnel and L-box test) and hardened concrete properties (compressive strength, split tensile strength and flexural strength) of mixtures were estimated and compared with ordinary concrete mix.

II. EXPERIMENTAL WORK

A. Materials

Cement

Ordinary Portland Cement of 53 Grade manufactured by siddhi cement company was used in concrete mixes corresponding to IS-8112. The specific gravity of cement is 3.15.

Sand

Natural river sand is used as fine aggregate. As per IS: 2386 (Part III)-1963 , the bulk specific gravity in oven dry condition and water absorption of the sand are 2.6 and 1% respectively.

Aggregate

Crushed stones of maximum size 20 mm are used as coarse aggregate. As per IS: 2386 (Part III)-1963 [6], the bulk specific gravity in oven dry condition and water absorption of the coarse aggregate are 2.66 and 0.3% respectively.

Silica fume

silica produced in electric arc furnaces as a by-product of the production of elemental silicon or silica-alloys. Silica-fume obtained from "Guru Corporation, Ahmedabad Chemical properties of Silica-fume are given in the Table 1.

Marble powder

In that project the collection of marble powder from kisan gadh, rajasthan. The specific gravity of Marble powder is 2.54. Chemical properties of marble powder are given in the Table 1.

Table 1. Chemical properties of Marble powder and Silica fume

Chemical properties		
	Marble Powder	Silica Fume
SIO2(%)	3.8	88
AL2O3(%)	0.56	--
FE2O3(%)	1.1	--
CAO(%)	68.72	1.0
SO3(%)	--	2.0
MGO(%)	1.6	--
Physical properties		
Loss on ignition	34.3	4.0
Specific Gravity	2.54	2.2

Admixture

A polycarboxylate ether (cornflow pc2) based super plasticizer and Starch ether and Cellulose ether as VMA were used in concrete. The properties of admixtures are presented in tables 2 & 3.

Table 2. Typical properties of Cellulose Ether

Appearance	Off white
Viscosity (mPa s, 2% sol 25 *C)	850
Humidity	<6.0%
Ash Content	<5.0%
pH value	5.5-7.0

Table 3. Typical properties of Starch Ether

Appearance	White powder
Density	Approx 500kg/m3
Dry Content	Approx 95%
Ash Content	<5.0%
pH value	6 in sol.
Viscosity (mPa s)	950

B. Mix Design

A standard mix M30 grade was calculated as per Indian Standard (IS 10262-2009). The concretes were prepared at cementitious materials (Cement+MP+SF) dosages of 405 kg/m3. For each binder content, the W/C ratio and superplasticizer kept constant with different percentage of VMA contents were determined by trial mixtures. The mix design is given in Table 4.

Table 4. mix design for M30 grade of concrete

Grade	M30
Mix Ratio	**1:2.04:2.14**
Water (Kg)	182.657
Cement (Kg)	344.743
Silica fume (SF) (Kg)	20.279
Marble powder(MP) (Kg)	40.558
Sand (Kg)	827.631
Aggregate (<10 mm) (Kg)	505.2
Aggregate (>12.5 mm) (Kg)	365.9
W/C ratio	0.45

C. Testing Procedure

For preparing SCCs, a batch mixer was used. First coarse aggregates, fine aggregates, cement, marble powder, silica fume were mixed with ½ of the mixing water for 2 min. After addition of VMA and superplasticizer, mixing continued up to total 10 min. Slump flow, V-Funnel, L-box tests were performed on the SCC in fresh state to determine flow properties.

For Compressive strength, tests were conducted on 150x150x150 mm cube moulds, after 28 days of proper curing. 3 Cubes were casted and tested for each combination.

For split tensile strength, tests were conducted on cylindrical moulds with a diameter of 150 mm and a height of 300 mm, after 28 days of proper curing. 3 specimens were casted and tested for each combination.

For Flexural strength, tests were conducted on 150x150x700 mm beam moulds, after 28 days of proper curing. 3 specimens were casted and tested for each combination.

D. Concrete mix proportions

Table 5. Concrete Mix proportions.

VMA	W/C Ratio	Proportions %	Super plasticizer %
Cellulose Ether	0.45	0.00	1
		0.20	
		0.40	
		0.60	
		0.80	
Starch Ether	0.45	0.00	1.2
		0.15	
		0.30	
		0.45	
		0.60	

III. TEST RESULTS AND DISCUSSION

A. Fresh Concrete Properties

A detailed study directed on various VMAs included concrete (Mixing proportions are given in Table 5) for the binder content of 400 kg/m^3 and the fresh concrete testing results are exhibited in table 6 & 7 with respect to w/c ratio of 0.45.

Table 6. Fresh properties of SCC Mix with Cellulose Ether

Material	Proportion %	Flow Test(mm)	V-Funnel Test	L-Box Test
Cellulose Ether	0.00	740	7	0.87
	0.20	714	6	0.82
	0.40	622	8	1
	0.60	676	6	0.84
	0.80	569	7	1

Table 7. Fresh properties of SCC Mix with Starch Ether

Material	Proportion %	Flow Test(mm)	V-Funnel Test	L-Box Test
Starch Ether	0.00	760	7	0.87
	0.15	673	6	0.84
	0.30	630	11	0.83
	0.45	624	8	1
	0.60	540	9	1

B. Hardened Concrete Properties

The 7 Days and 28 Days compressive strengths of SCCs are given in Table 8, 9, 10 and graphs of compressive strength are shown.

Table 8. compressive strengths of SCC.

VMA	Proportions %	Compressive strength at 7 days (N/mm^2)	Compressive strength at 28 days (N/mm^2)
Normal		26.07	38.59
Cellulose Ether	0.00	25.02	38.103
	0.20	23.68	46.5
	0.40	25.21	42.37
	0.60	26.09	43.97
	0.80	19.33	38.01
Starch Ether	0.00	25.73	37.74
	0.15	24.65	38.16
	0.30	24.96	40.02
	0.45	26.48	41
	0.60	23.67	38.01

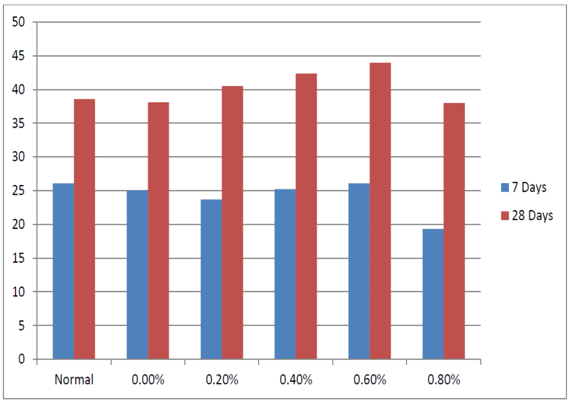

Fig 1 compressive strengths of Cellulose Ether.

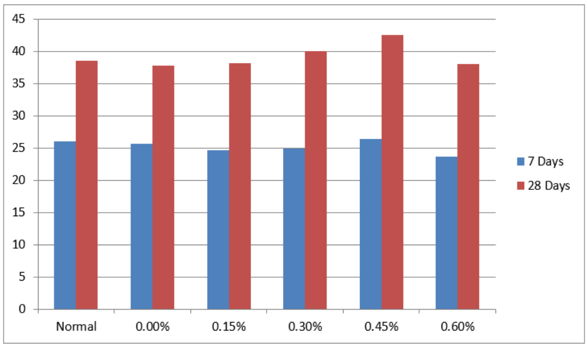

Fig 2 compressive strengths of Starch Ether.

Table 9. Flexure strength of SCC

VMA	**Proportions %**	**Flexure strength at 28 days (N/mm2)**
Normal		3.8
Cellulose Ether	0.00	3.93
	0.20	4.13
	0.40	4.89
	0.60	5.56
	0.80	4.27
Starch Ether	0.00	4.01
	0.15	4.24
	0.30	4.65
	0.45	4.8
	0.60	4.15

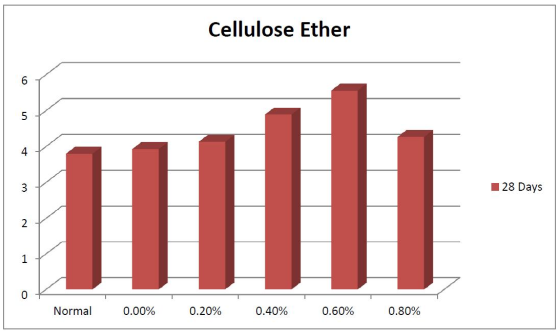

Fig 3 Flexure strength of Cellulose Ether

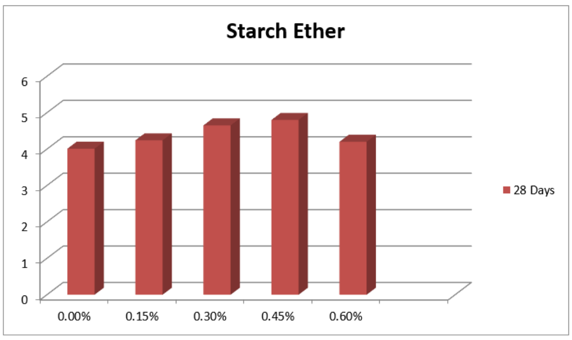

Fig 4 Flexure strength of Starch Ether.

Table 10. Split Tensile strength of SCC.

VMA	**Proportions %**	**Split Tensile strength at 28 days (N/mm^2)**
Normal		3.25
Cellulose Ether	0.00	3.18
	0.20	3.35
	0.40	3.58
	0.60	3.71
	0.80	3.44
Starch Ether	0.00	3.3
	0.15	3.41
	0.30	3.69
	0.45	4.26
	0.60	3.42

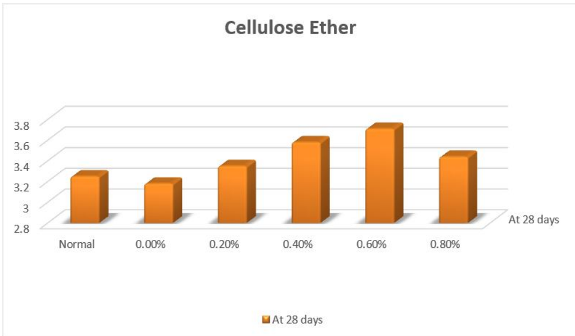

Fig 5 Split Tensile strength of Cellulose Ether

Fig 6 Split Tensile strength of Starch Ether

C. Durability

The 28 days durability test results were given in graphs and tables as shown in figure.

In sulphate resistance test, cubes are immersed in 5% sodium sulphate solution and bulk diffusion should be checked.

In acid resistance test, cubes of different combinations were compared with normal cube by bulk diffusion, visually inspection and compressive strength.

Table 11. Bulk diffusion and Compressive strength in Sulphate at 28 days

Material	Proportion %	Wt. of cubes after 28 days of water curing (Kg)	Wt. of cubes after 28 days of sulphate curing (Kg)	Compressive strength after 28 days in sulphate
Normal		8.12	8.28	34.01
Cellulose Ether	0.00	7.94	8.13	32.98
	0.20	7.74	7.93	34.27
	0.40	7.72	7.95	35.11
	0.60	7.87	8.06	36.87
	0.80	8.07	8.34	31.98
Starch Ether	0.00	8.03	8.193	32.56
	0.15	7.83	7.90	33.19
	0.30	7.73	7.821	34.13
	0.45	8.10	8.296	35.37
	0.60	8.26	8.423	33.1

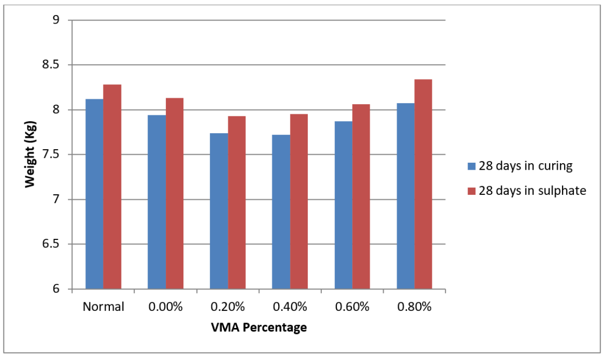

Fig 7 Average bulk diffusion in sulphate resistance test of Cellulose Ether

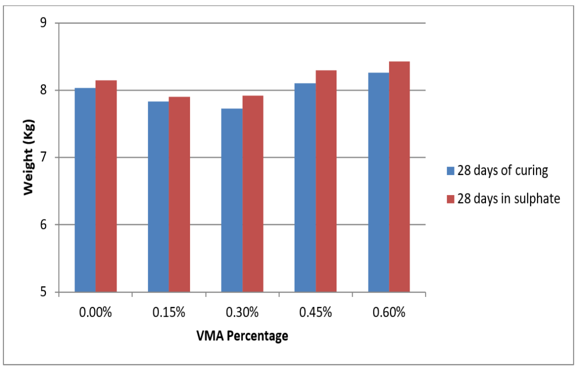

Fig 8 Average bulk diffusion in sulphate resistance test of Starch Ether

Table 12. Bulk diffusion and Compressive strength in Acid at 30 days

Material	Proportion %	Wt. of cubes after 28 days of water curing (Kg)	Wt. of cubes after 28 days of acid curing (Kg)	Compressive strength after 28 days in acid
Normal		8.67	7.51	26.09
Cellulose Ether	0.00	8.04	7.45	26.4
	0.20	7.87	7.21	29.7
	0.40	7.73	7.3	29.89
	0.60	7.98	7.62	37.67
	0.80	7.65	7.19	26.42
Starch Ether	0.00	8.26	7.85	27.1
	0.15	7.82	7.44	26.86
	0.30	7.44	7.024	27.72
	0.45	7.96	7.41	27.9
	0.60	7.56	7.14	26.21

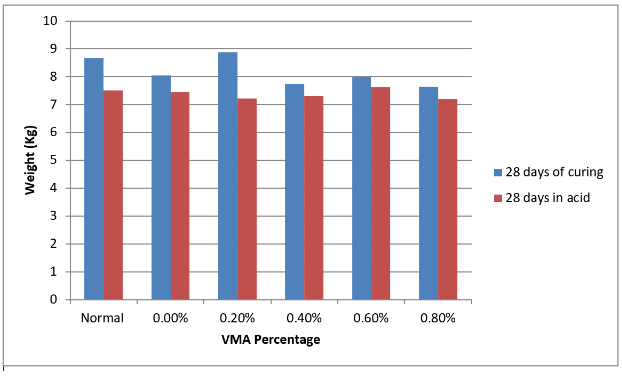

Fig 9 Average bulk diffusion in acid resistance test of Cellulose Ether

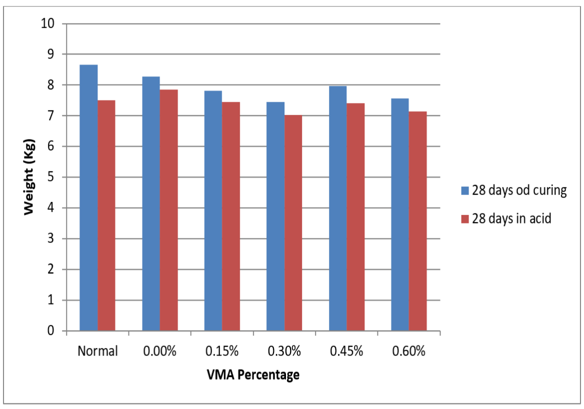

Fig 10 Average bulk diffusion in acid resistance test of Starch Ether

IV. CONCLUSION

1) Superplasticizer are required to increase flowability along with Viscosity modifying admixture.
2) Using of marble powder as binder material in SCC it enhances its physical, mechanical properties along with silica fume.
3) Adding marble powder more than 10% reduces the strength at 28 days.
4) With increasing the dosage of VMA, workability results show that flow value were decreases.
5) In Cellulose Ether, compressive strength, split tensile strength and flexure strength should be increased at 0.6 % of content along with 1% of superplasticizer. Use of more than 0.6% content decreases the strength.
6) In Starch Ether, compressive strength, split tensile strength and flexure strength should be increased at 0.45 % of content along with 1.2% of superplasticizer. Use of more than 0.45% content decreases the strength.
7) In Acid Resistance test bulk reduction is observed in both the VMA and in normal concrete. While in Sulphate resistance test bulk expansion is observed in both the VMA.

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