Effect of various viscosity modifying agents on Self Compacting Concrete

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Abstract-*In this study, an attempt has been made to study the effect of various viscosity modifying agents on self compacting concrete. The various viscosity modifying agents used in this study are micro silica, cellulose ether, starch ether. The fresh properties tests performed are flow test, V-funnel test, J-ring test and L-box test. Different mechanical tests like Compressive strength, flexural strength and split tensile strength of concrete containing cellulose ether, micro silica and starch as admixtures in various proportions along with superplasticizer compared with the normal concrete at the age of 7 days and 28 days.*

Keywords-Cellulose Ether, Micro silica, Starch Ether, Self Compacting Concrete, Viscosity Modifying Agents.

I. INTRODUCTION

Self-compacting concrete (SCC) is a highly flowable concrete that can spread into place under its own weight and achieve good consolidation in the absence of vibration without exhibiting defects due to segregation and bleeding. Self-compacting concrete is a product of technological advancements in the area of underwater concrete technology where the mix is proportioned to insure high fluidity as well as high resistance to water dilution and segregation. SCC was developed in Japan in the late 1980s, and recently, this concrete has gained wide use in many countries for different applications and structural configurations.

Several different approaches have been used to develop SCC. One method to achieve self-compacting property is to increase significantly the amount of fine materials (e.g., fly ash or limestone filler) without changing the water content compared with common concrete. One alternative approach consists of incorporating a viscosity modifying admixture (VMA) to enhance stability. The use of VMA along with adequate concentration of superplasticizer (SP) can ensure high deformability and adequate workability, leading to a good resistance to segregation. Mixture containing VMA exhibits shear-thinning behaviour where by apparent viscosity decreases with the increase in shear rate. Such concrete is typically thixotropic where the viscosity build up is promoted due to the association and entanglement of polymer chains of the VMA at a low shear rate that can further inhibit flow and increase viscosity. The thixotropic property increases the stability of the concrete and reduces the risk of segregation after casting.

In this study,micro silica, starch ether and cellulose ether as VMA was tested in the production of SCCs along with super plasticizer. The fresh concrete properties (slump flow, V-funnel, L-box test and J-ring test) and hardened concrete properties (compressive strength, split tensile strength andflexural strength) of mixtures were evaluated and compared with normal concrete mix.

II. EXPERIMENTAL PROGRAM

A. Materials

Cement

Ordinary Portland Cement 53 Grade (Ultratech) was used in production of concrete. The physical properties of cement are given in Table 1

Table 1. Physical Properties of Cement

Sr. No.	Physical Properties	Cement
1	Setting time in Min.	
	(a) Initial setting time (Minute)	43
	(b) Final setting time (Minute)	315
2	Soundness (By Le-chat Expansion in mm)	0.39
3	Compressive Strength in (MPa)	
	3 Days	29.53
	7 Days	40.78
	28 Days	57.34

Aggregate

The fine aggregate (specific gravity: 2.67) and course aggregate (specific gravity: 2.87 and 2.73) were used. The maximum size of aggregate was 20 mm.

Admixture

A Sulphonated Naphthalene (SAMPLAST300)-based super plasticizer and Micro silica, Starch ether and Cellulose ether as VMA were used in concrete. The properties of admixtures are presented in below tables.

Table 2. Chemical Properties of Micro Silica

Chemical Content	Proportion
SiO_2(%)	88
Cao(%)	1.0
SO_3(%)	2.0
Loss on ignition	4.0
NaO2 eq(%)	1.0
Density	2.24

Table 3. 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 4. 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. Design Mix

A normal mix M25 grade was designed as per Indian Standard method (IS 10262-2009). The concretes were prepared at cementitious material dosages of 400 kg/m3. For each binder content, the W/C ratio, superplasticizer and VMA contents were determined by trial mixtures. The mix design is given in Table 5

Table 5. Mix Design for M30 gradeSystem.

Grade	M30
Cement	405.58
Water	182.66
Fine Aggregate	827.60
Coarse Aggregate(>10mm)	365.820
Coarse Aggregate(<10mm)	505.180
w/c ratio	0.45

C. Testing Procedure

For preparing SCCs, a batch mixer was used. First coarse aggregates, fine aggregates, cement 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, flow time, L-box tests were performed on the SCC in fresh state to determine flow properties.

For Compressive strength tests were conducted on 150x150x150 mm cubic specimens, after standard curing. Three specimens were prepared and tested for each mixture.

For split tensile strength tests were conducted on cylinder specimens with a diameter of 150 mm and a height of 300 mm, after standard curing. Three specimens were prepared and tested for each mixture.

For Flexural strength tests were conducted on 150x150x700 mm beam specimens, after standard curing. Three specimens were prepared and tested for each mixture.

D. Concrete Mix Proportions

Concrete mix proportions are given in Table 6.

Table 6. Concrete Mix Proportion

VMA	w/c ratio	Proportions	Superplasticizer %
Micro Silica	0.5	0.0 %	1.0%
		0.5%	
		1.0%	
		1.5%	
		2.0%	
Cellulose Ether	0.5	0.0%	1.25%
		0.2%	
		0.4%	
		0.6%	
		0.8%	
Starch Ether	0.5	0.0%	1.5%
		0.15%	
		0.30%	
		0.45%	
		0.60%	

III. TEST RESULTS AND DISCUSSION

A. Fresh Concrete Properties

A detailed study conducted on various VMAs included concrete (Mixing proportions are given in Table 5) for the binder content of 400 kg/m3 and the fresh concrete testing results are exhibited in Table 7 with respect to w/c ratio of 0.45.

B. Hardened Concrete Properties

The 7 Days and 28 Days compressive strengths of SCCs are given in Table 6 and graphs of compressive strength are shown.

Table 6.1 Fresh properties of SCC Mix with Micro Silica asVMA

Sr. No	VMA %	Flow test(mm)	V-Funnel test(sec)	L-box(h2/h1)	J-ring (mm)
1	0	728	7.1	0.88	5
2	0.5	710	8.2	0.85	5
3	1.0	695	9.7	0.83	6
4	1.5	687	10.4	0.83	8
5	2.0	665	10.9	0.82	8

Table 8 Fresh properties of SCC Mix with Cellulose Ether as VMA

Sr. No	VMA %	Flow test(mm)	V-Funnel test(sec)	L-box(h2/h1)	J-ring
1	0	745	6.9	0.89	6
2	0.20	720	7.3	0.85	5
3	0.40	705	8.3	0.84	5
4	0.60	685	9.5	0.82	6
5	0.80	670	10.7	0.81	7

Table 9 Fresh properties of SCC Mix with Starch Ether as VMA

Sr. No	VMA %	Flow test(mm)	V-Funnel test(sec)	L-box(h2/h1)	J-ring
1	0	770	6.4	0.92	4
2	0.15	750	6.8	0.90	3
3	0.3	730	6.9	0.87	3
4	0.45	710	7.5	0.85	4
5	0.60	680	9.2	0.82	6

Table 10. Compressive strength of cube specimen at 7 and 28 days.

VMA	Proportions	Compressive strength at 7 days N/mm^2	Compressive strength at 28 days N/mm^2
Micro Silica	0.0 %	23.11	39.33
	0.5%	24.7	41.75
	1.0%	26.16	43.6
	1.5%	22.30	41.63
	2.0%	20.22	40.2
Cellulose Ether	0.0%	23.38	40.01
	0.2%	24.44	42.8
	0.4%	25.61	44.13
	0.6%	26.17	46.25
	0.8%	20.6	40.78
Starch Ether	0.0%	23.29	39.88
	0.15%	24.68	40.73
	0.30%	25.34	42.36
	0.45%	26.8	44.5
	0.60%	22.84	41.59
Normal	-	25.78	40.41

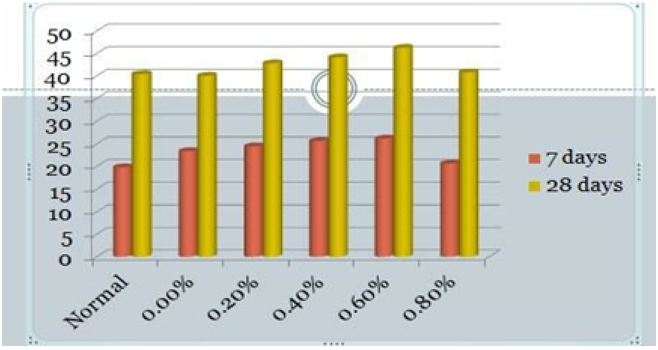

Fig 1. Compressive Strength at 7 and 28 days for Cellulose Ether

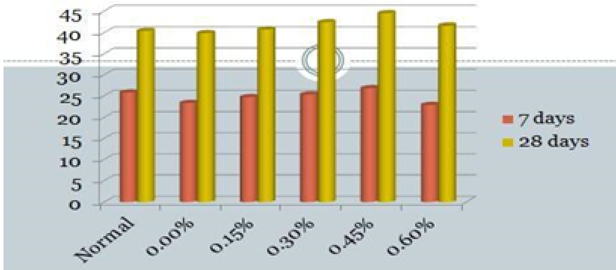

Fig 2. Compressive strength at 7 and 28 days for Starch Ether

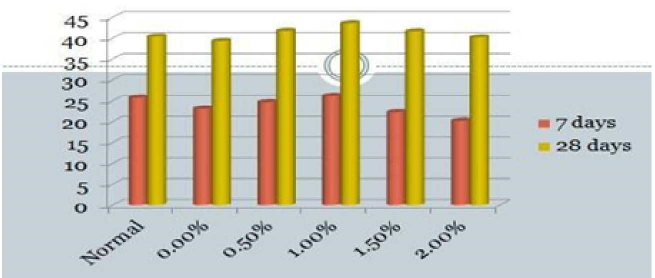

Fig 3. Compressive strength at 7 and 28 days for Micro Silica

Table 11 Split Tensile strength result at 28 days

VMA	Proportions	Split Tensile strength at 28 days N/mm^2
Micro Silica	0.0 %	3.63
	0.5%	4.01
	1.0%	4.27
	1.5%	3.53
	2.0%	3.65
Cellulose Ether	0.0%	3.201
	0.2%	3.41
	0.4%	3.75
	0.6%	3.89
	0.8%	3.29
Starch Ether	0.0%	3.40
	0.15%	3.46
	0.30%	3.81
	0.45%	4.75
	0.60%	3.33
Normal	-	3.23

Table 11 Flexure strength result at 28 days

VMA	Proportions	Flexure strength at 28 days N/mm^2
Micro Silica	0.0 %	4.71
	0.5%	4.8
	1.0%	5.45
	1.5%	4.79
	2.0%	4.22
Cellulose Ether	0.0%	3.80
	0.2%	4.92
	0.4%	5.30
	0.6%	6.01
	0.8%	4.69
Starch Ether	0.0%	3.79
	0.15%	4.68
	0.30%	5.08
	0.45%	5.79
	0.60%	4.78
Normal	-	3.83

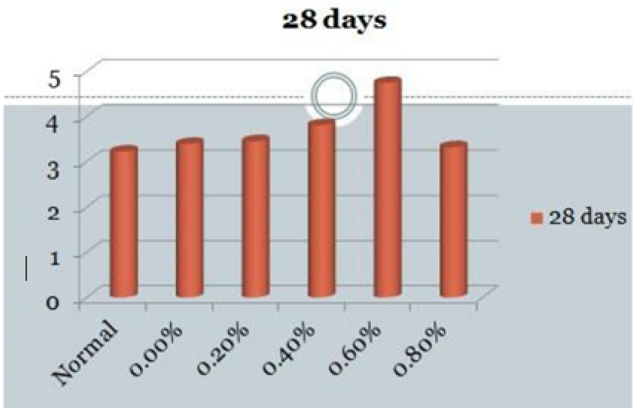

Fig 4. Split tensile strength of Cellulose Ether at 28 days

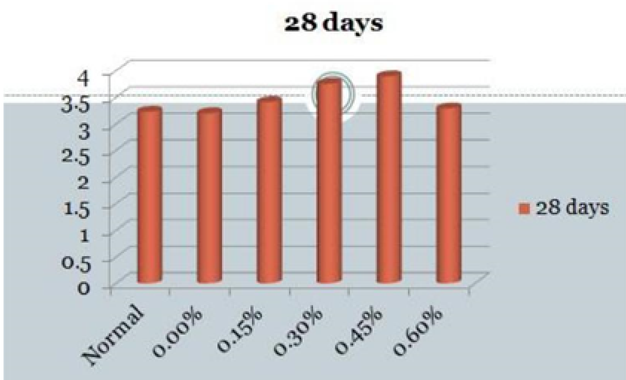

Fig 5. Split tensile strength of Starch Ether at 28 days

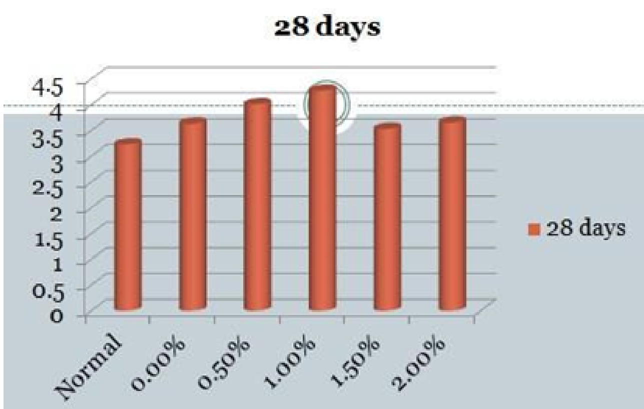

Fig 6. Split tensile of Micro Silica at 28 days

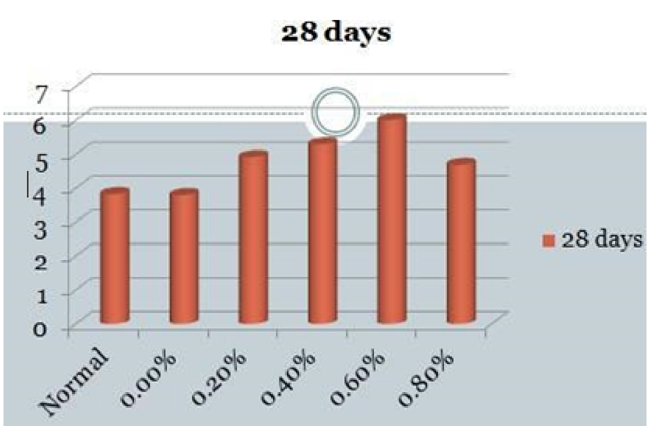

Fig 7.Flexural Strength of cellulose ether at 28 days

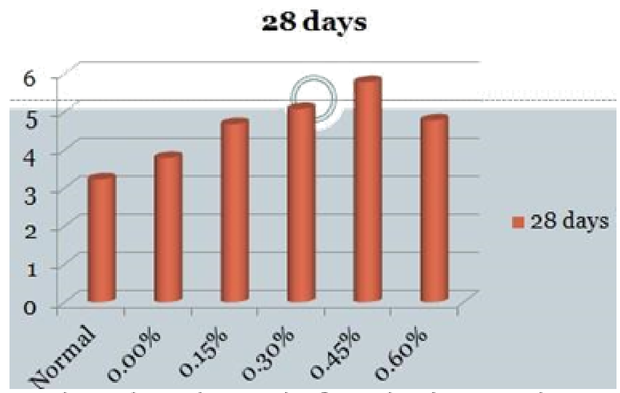

Fig 8. Flexural strength of Starch Ether at 28 days

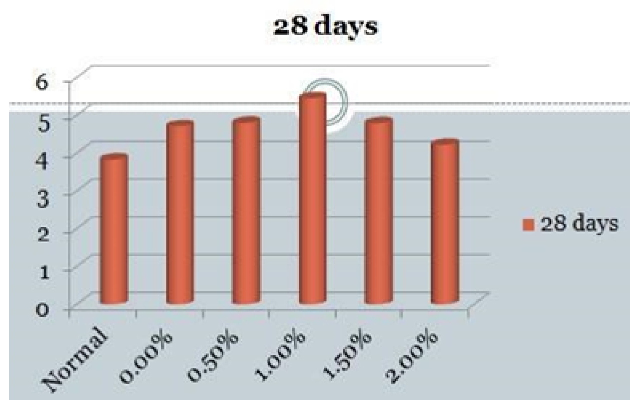

Fig 9. Flexural strength of Micro Silica at 28 days

IV. CONCLUSION

1) To increase flowability Super plasticizers are required with Viscosity Modifying agents.

2) Workability results shows that flow value is decreasing with increasing dosage of cellulose ether, Starch ether and Micro Silica along with Superplasticizer.

3) Workability results shows that V-funnel time is increasing with increasing dosage of cellulose ether, Starch ether and Micro Silica along with Superplasticizer.

4) Viscosity Modifying agents dosages increasing more than requirement then compressive strength, split tensile strength and flexural strength decreases.

5) At 7 and 28 Days Compressive strength, split tensile strength and flexural strength are increasing up to 0.6% of Cellulose Ether along with super plasticizer. After adding more than 0.6% of Cellulose Ether along with superplasticizer compressive strength and split tensile strength is decreasing.

6) At 7 and 28 Days Compressive strength, split tensile strength and flexural strength are increasing up to 0.45% of StarchEther along with super plasticizer. After adding more than 0.45% of Starch Ether along with superplasticizer compressive strength and split tensile strength is decreasing.

7) At 7 and 28 Days Compressive strength, split tensile strength and flexural strength are increasing up to 1.0% of Micro Silica along with super plasticizer. After adding more than 1.0% of Micro Silica along with superplasticizer compressive strength and split tensile strength is decreasing.

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