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Application of Xanthan Gum as a Viscosity Modifying Admixture along with Super Plasticizer for Self-Compacting Concrete (SCC)

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***Abstract*— Self-Compacting Concrete (SCC) is known for its high resistance to segregation, excellent deformability and use without applying vibration in congested reinforced concrete structures characterized by difficult casting conditions. The use of viscosity modifying admixtures (VMA) has proved to be very effective in stabilizing the rheological properties and consistency of Self-Compacting concrete (SCC). Using new generation chemical admixture makes it possible to produce self-compacting Concrete. In this study, the possibility of producing self-compacting concrete using a polysaccharide type VMA (Xanthan Gum) along with super plasticizer were used varying dosages. A more detailed study was carried out on the SCC fresh and hardened properties such as slump flow, flow time, compressive strength, split tensile strength and flexural strength of different mixes with various dosages of Xanthan Gum along with super plasticizer. The performance of various SCC mixtures with VMA and super plasticizer was compared with normal concrete mix and found that harden properties were better than normal concrete mix.**

***Index Terms*— Self-Compacting Concrete, SCC, Super Plasticizer (SP), Viscosity Modifying Admixture (VMA), Stability, Rheology.**

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 behavior 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, polysaccharides Xanthan Gum as VMA was tested in the production of SCCs along with super plasticizer. The fresh concrete properties (slump flow, flow time) and hardened concrete properties (compressive strength, split tensile strength and flexural strength) of mixtures were evaluated and compared with normal concrete mix.

II. EXPERIMENTAL PROGRAM

A. Materials

1. Cement

Ordinary Portland Cement 53 Grade (Binani) 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

2. 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.

3. Admixture

A Sulphonated Naphthalene (SAMPLAST300)-based super plasticizer and polysaccharide based-VMA (Xanthan Gum) were used in concrete. The properties of admixtures are presented in Table 2.

Table 2. Properties of admixtures

	Xanthan Gum	Super Plasticizer

Chemical Composition	polysaccharide based	Sulphonated Naphthalene
Particle Size (μm)	200	-
Specific Gravity	-	1.20
Viscosity	1350 cPs	80 cPs
pH	7.3	6

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/m^3. For each binder content, the W/C ratio, superplasticizer and VMA contents were determined by trial mixtures. The mix design is given in Table 3.

Table 3. Mix design for M25 Grade

Grade	M25
Cement	394.32 kg
Water	197.16 kg
Fine Aggregate	682.83 kg
Kapachi	750.40 kg
Grit	422.10 kg
Density(kg/m^3)	2446.81
w/c ratio	0.5

C. Testing Procedure

For preparing SCCs, a pan 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 mixtures.

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 mixtures.

For Flexural strength tests were conducted on 100x100x500 mm cubic specimens, after standard curing. Three specimens were prepared and tested for each mixtures.

D. Concrete Mix Proportions

Concrete mix proportions are given in Table 4.

Table 4. Concrete Mix Proportion

W/C ratio	Xanthan Gum %	Super Plasticizer %
0.5	0.0 0.2 0.4 0.6 0.8 1.0 1.2	0.5
0.5	0.0 0.2 0.4 0.6 0.8 1.0 1.2	1.0

III. TEST RESULTS AND DISCUSSION

A. Fresh Concrete Properties

A detailed study conducted on Xanthan Gum included concrete (Mixing proportions are given in Table 3) for the binder content of 400 kg/m^3 and the fresh concrete testing results are exhibited in Table 5 with respect to w/c ratio of 0.50 and 0.5%, 1.0% SP.

The addition of Xanthan Gum, slump-flow decreased, flow time increased and L-box value also decreased. But after addition of Xanthan Gum percentage more than 0.6% then slum flow value more decreased.

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 5. Fresh Concrete Properties

XG	SP	T50 time	Slump Flow	L-Box
0.0 %	0.5 %	2.34 sec	741 mm	0.90
	1.0 %	2.18 sec	754 mm	0.92
0.2 %	0.5 %	2.59 sec	733 mm	0.87
	1.0 %	2.37 sec	744 mm	0.88
0.4 %	0.5 %	2.83 sec	715 mm	0.84
	1.0 %	2.65 sec	726 mm	0.86
0.6 %	0.5 %	2.99 sec	685 mm	0.81
	1.0 %	2.78 sec	697 mm	0.83
0.8 %	0.5 %	3.29 sec	649 mm	0.77
	1.0 %	3.13 sec	664 mm	0.78
1.0 %	0.5 %	3.51 sec	623 mm	0.72
	1.0 %	3.36 sec	638 mm	0.75
1.2 %	0.5 %	3.69 sec	605 mm	0.70
	1.0 %	3.47 sec	616 mm	0.71

Table 6. Compressive Strength at 7 and 28 Days

XG	SP	7 Days	28 Days
0.0 %	0.0 %	23.04	33.83
	0.5 %	23.34	34.14
	1.0 %	23.85	34.65
0.2 %	0.5 %	24.44	36.87
	1.0 %	25.01	37.53
0.4 %	0.5 %	24.23	37.87
	1.0 %	25.13	38.45
0.6 %	0.5 %	24.00	40.78

	1.0 %	25.78	41.22
0.8 %	0.5 %	23.53	37.77
	1.0 %	24.31	38.61
1.0 %	0.5 %	22.54	34.44
	1.0 %	23.15	35.87
1.2 %	0.5 %	20.39	31.03
	1.0 %	21.04	31.96

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

The 7 Days and 28 Days flexural strengths of SCCs are given in Table 8 and graphs of flexural strength are shown.

Table 7. Split Tensile strength at 7 Days and 28 Days

XG	SP	7 Days	28 Days
0.0 %	0.0 %	2.46	3.58
	0.5 %	2.43	3.64
	1.0 %	2.41	3.68
0.2 %	0.5 %	2.59	3.76
	1.0 %	2.66	3.84
0.4 %	0.5 %	2.57	3.86
	1.0 %	2.68	3.93
0.6 %	0.5 %	2.54	4.00
	1.0 %	2.73	4.09
0.8 %	0.5 %	2.47	3.89
	1.0 %	2.58	3.95
1.0 %	0.5 %	2.36	3.64
	1.0 %	2.44	3.81
1.2 %	0.5 %	2.14	3.26
	1.0 %	2.19	3.34

Table 8. Flexural Strength at 7 Days and 28 Days

XG	SP	7 Days	28 Days
0.0 %	0.0 %	3.37	4.46
	0.5 %	3.41	4.52
	1.0 %	3.43	4.55
0.2 %	0.5 %	3.42	4.57
	1.0 %	3.47	4.62
0.4 %	0.5 %	3.45	4.65
	1.0 %	3.56	4.74
0.6 %	0.5 %	3.53	4.79
	1.0 %	3.59	4.87
0.8 %	0.5 %	3.48	4.63
	1.0 %	3.53	4.71
1.0 %	0.5 %	3.41	4.51
	1.0 %	3.46	4.57
1.2 %	0.5 %	3.34	4.40
	1.0 %	3.37	4.43

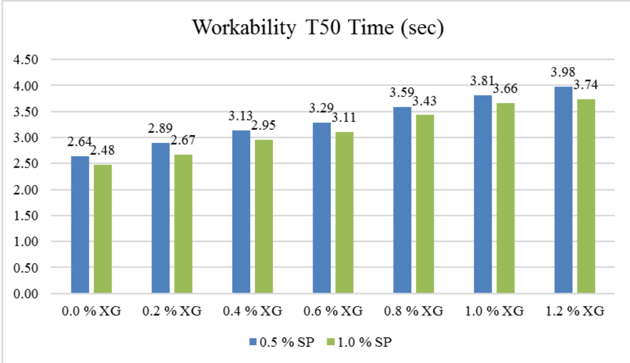

Fig. 1. Workability T50 Time (sec)

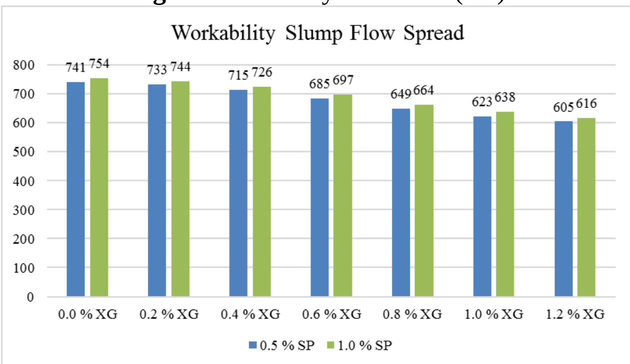

Fig. 2. Workability Slump Flow (mm)

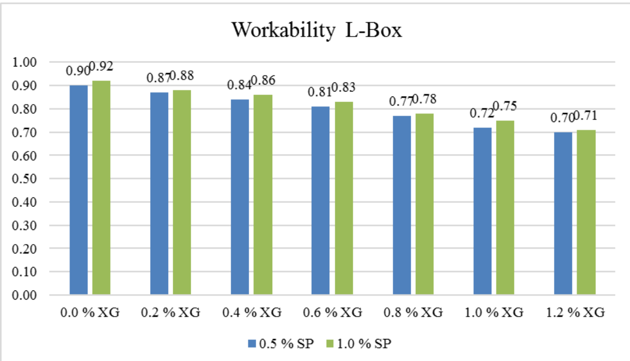

Fig. 3. Workability L-Box (H2/H1)

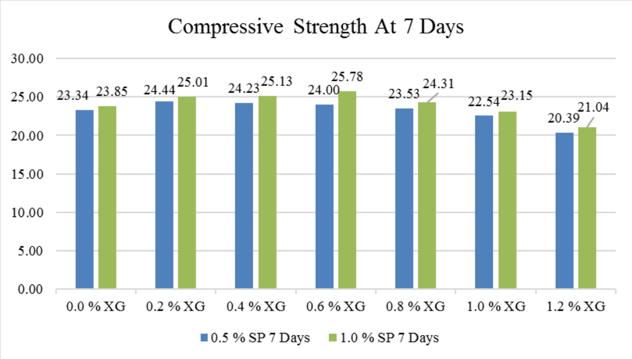

Fig. 4. Compressive Strength at 7 Days

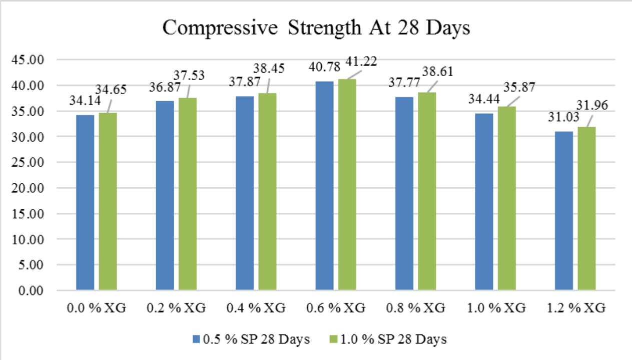

Fig. 5. Compressive Strength at 28 Days

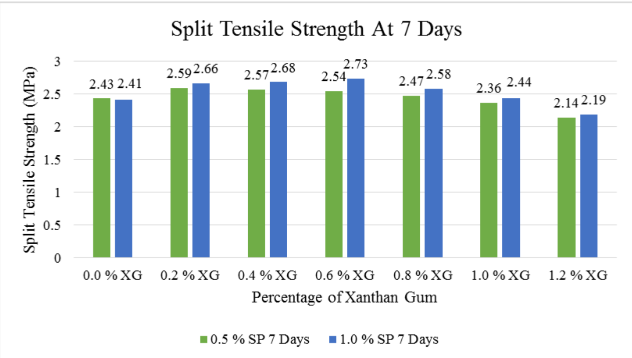

Fig. 6. Split Tensile Strength at 7 Days

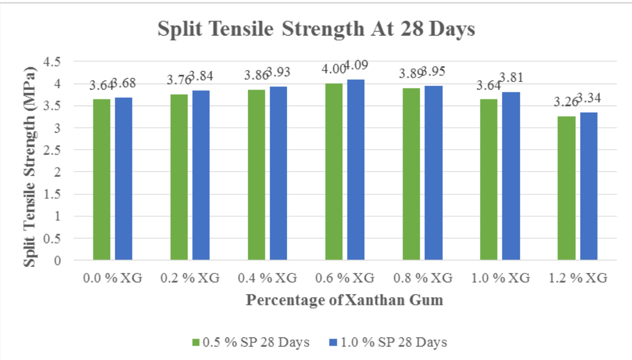

Fig. 7. Split Tensile Strength at 28 Days

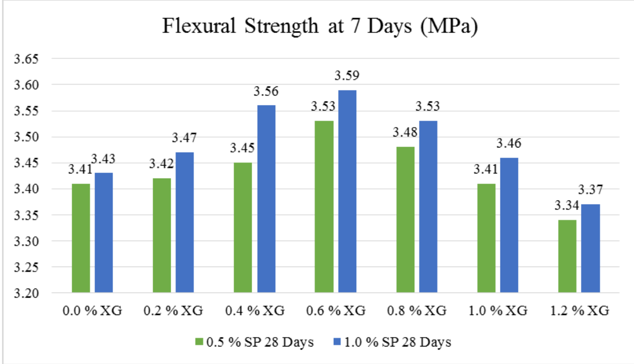

Fig. 8. Flexural Strength at 7 Days

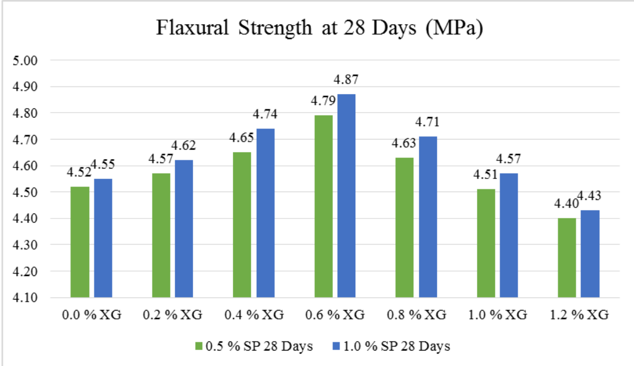

Fig. 9. Flexural Strength at 28 Days

IV. CONCLUSIONS

1) To increase flowability Super plasticizers are required with Xanthan Gum.
2) Workability results shows that T50 time is increasing with increasing dosage of Xanthan Gum along with Superplasticizer.
3) Workability results shows that Slump flow is decreasing with increasing dosage of Xanthan Gum.
4) Xanthan Gum 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 Xanthan Gum along with super plasticizer. After adding more than 0.6% of Xanthan Gum along with superplasticizer compressive strength and split tensile strength is decreasing.
6) At 7 Days and 28 Days (0.6% Xanthan Gum and 0.5% SP) and (0.6% Xanthan Gum and 1.0% SP) gives higher compressive strength, split tensile strength and flexural strength.

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