The Effect of Superplasticizers on Concrete– A Review

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Abstract- *Superplasticizers are chemicals which enhance the workability of concrete without any extra water content. They allow a higher strength concrete with lower water content. This review mainly focus on the relation between dosage of Superplasticizers and their effect on the mechanical properties of concrete. Also the fresh properties of concrete such as slump, setting time, water absorption, porosity and permeability are reviewed as they are greatly influenced by Superplasticizers. At times, Superplasticizers are actually used to enhance the fresh properties of concrete rather than strength point of view.*

Keywords- Superplasticizer, concrete, workability, porosity, permeability

I. INTRODUCTION

Concrete, the second most used entity of the world is getting better day by day due to it's large and wide applications. Strength is always an important criteria for researches on concrete. Admixtures play a vital role in making concrete apt for it's various purpose specific applications by enhancing it's different properties. Superplasticizers are one of the most important classes of chemical admixtures used today. They are mainly used for three reasons - (i) to produce highly workable concrete for easy placement. (ii) to produce concrete with a low water content for higher strength and durability or (iii) to produce concrete with low cementitious and water contents for better economy[1]. Superplasticizer is a type of water reducer; however the difference between SP and water reducer is that SP will significantly reduce the water required for mixing. Mechanism of SP is through giving the cement particle highly negative charge so that they repel each other due to same electrostatic charge. [2] Superplasticizers are grouped under four major types namely- sulphonated naphthalene formaldehyde condensed (SNF), sulphonated Melamine formaldehyde condensed (SMF), modified lignosulfonates(MLS) and other types such as polyarchylates, polysterene sulfonates, polymers etc[3]

Effectiveness of a given dosage of SP depends on water/cement ratio. Effectiveness increases as w/c ratio decreases. Compatibility with actual cement is one of the most important parameters that is needed to be considered and it's not recommended that the cement and superplasticizer conform the standard separately. [4]. In fresh state, utilisation of SP will normally reduce the tendency to bleeding due to reduction in water/cement ratio or water content in concrete. However if w/c ratio is maintained, there is a tendency that SP will prolong the time of set of concrete as more water is available to lubricate the mix.In case of hardened concrete, the use of SP will increase the compressive strength by enhancing the effectiveness of compaction to produce a denser concrete [5]. The SP affects properties of fresh and hardened concrete by reduction in interfaciall tension, multilayered adsorption of organic molecules, reducing its evaporation and wastage, release of water trapped amongst the cement particles, retarding effect of cement hydration and change in the morphology of hydrated cement [6]. An optimal dosage will produce a concrete with good workability maintained throughout the required amount of time but without any major effect on setting time or initial mechanical properties[7]. The increase in slump due to SP depends on the type of cement, ambient temperature, dosage and type of high range water reducer [8]. In most cases, a high dosage of HRWR would lead to increase in initial setting time which may help in hot weather concrete[9]. Different types of superplasticizers are seen to have different effects on properties and performance of concrete. Acrylic polymer performs significantly better than sulphonated naphthalene based superplasticizer as it provides higher slump values, lower slump loss and higher water reduction. It was also found to have higher compressive strength and durability performance[10]. It's more beneficial if superplasticizer is added to lower grade flyash than to higher grade mix and continuous curing is essential for strength development of flyash concrete since they provide lower early strength than plain concrete [11]. The current review is concerned with the crucial role Superplasticizers have on fresh and hardened properties of concrete.

Compressive strength and slump values for various superplasticizers in different dosages

Sr. No	Type of super plasticizer	Characteristic strength/ Mix proportion	w/c ratio	%of superplasticizer added	Slump value (mm)						Reference
1.						1 day	3 days	7 days	14 days	28 days	
	Visco ASTM	1:1:2	0.4	0	25			29.75	32.30	40.10	
	C494 type A		0.4	0.8	75			30.50	36.00	41.55	
	And F of		0.35	0	15			25.17	36.21	41.50	
	Carboxylic ether		0.35	0.8	50			28.38	37.55	43.60	
			0.3	0	10			25.80	34.55	42.20	
			0.3	0.8	45			27.70	36.80	44.50	
		1:1.5:2.5	0.4	0	35			20.30	28.30	35.90	
			0.4	0.8	95			20.90	30.40	37.30	
			0.35	0	30			22.40	31.20	38.00	
			0.35	0.8	85			25.10	32.80	40.20	
			0.3	0	5			22.50	32.00	35.50	
			0.3	0.8	50			24.50	33.90	37.00	
		1:1.5:3	0.4	0	15			25.60	29.90	36.90	
			0.4	0.8	65			30.69	32.60	39.70	
			0.35	0	50			21.40	23.25	36.25	
			0.35	0.8	95			23.80	31.85	38.65	
			0.3	0	25			21.00	31.25	34.25	
			0.3	0.8	65			23.15	32.15	35.15	
											[12]
2	Gleniu m ASTM		0.4	0	25			29.75	32.30	40.10	
	C494 type A	1:1:2	0.4	0.8	200			30.79	38.86	43.59	
	And F of		0.35	0	15			25.17	36.21	41.50	
	polycarboxylates		0.35	0.8	175			29.30	37.60	45.17	

			0.3	0	10			25.80	34.55	42.20	
			0.3	0.8	125			30.10	38.70	47.20	
		1:1.5:2.5	0.4	0	35			20.30	28.30	35.90	
			0.4	0.8	150			21.70	36.70	39.55	
			0.35	0	30			22.40	31.20	38.00	
			0.35	0.8	110			26.00	36.24	43.00	
			0.3	0	5			22.50	32.00	35.50	
			0.3	0.8	80			24.90	34.90	43.60	
		1:1.5:3	0.4	0	15			25.60	29.90	36.90	
			0.4	0.8	80			32.50	36.80	43.20	
			0.35	0	50			21.40	23.25	36.25	
			0.35	0.8	250			25.20	32.00	41.00	
			0.3	0	25			21.00	31.25	34.25	
			0.3	0.8	90			24.15	33.02	41.25	
3	Libom ent- FF			0				33	39	39	
	ASTM C 494	M30		0.6				28	31	35	
	Type F			1.2				35	37	41	[13]
				1.8				40	44	44	
				2.5				27	32	29	
4	Gleniu m C380										
		M30	0.56	0	125	15.97	27	36.31		42.22	
				0.4	140	16.75	31.16	36.57		42.77	
				0.6	155	20.05	34.18	42.92		44.61	
				0.8	165	20.41	34.38	41.17		46.79	[14]
				1.0	180	19.78	33.98	40.60		44.21	
				1.2	190	20.00	32.84	40.70		42.46	

Effect of Superplasticizers on slump(workability) :

The superplasticizer help to retain concrete in liquid stayed for longer time. This reduces the slump loss during transportation of concrete to the site[13]. The steric hinderance is far more effective than electrostatic repulsion mechanism to grant this prolonged fluidity[15]. Also from the table above we can observe that slump value increases with increase in percentage of Superplasticizers added. This is true only till an optimum dosage of SP beyond which the cohesiveness of concrete is lost.

Effect on compressive strength:

Increase in strength is pronounced at more ages of concrete, hence initially the increase is only little [12]. Continuous strength gain is observed by high early compressive strength (at 7 days) since the reaction between cement particles and water is active. With time the rate becomes lower as compared to early age. [13]. The increase in compressive strength is mainly due to the additional water provided by SP for concrete mixing. This accelerates the hydration resulting in better strength. Hence increase in

dosage will show increase in strength for all ages. But when it goes beyond the optimum limit, compressive strength starts decreasing. This decrease is the outcome of bleeding and segregation that effects the uniformity of concrete.

Effect on water absorption, porosity and permeability:

From the experimental results obtained in available literatures, it is found that for water absorption from 3 to 28 days, the optimum dosage is 800ml/100 kg of cement [14]. This dosage of SP shows the least amount of water absorbed by concrete. Till this limit, higher is the value of SP dosage, lesser will be the water absorption. Any dosage above or below the optimum would exhibit higher water absorption values. Porosity reduces with time as the pore structure and size decreases. This is because the pores get filled with the Hydration product – calcium silicate hydrate. [14]. Similar to the case of water absorption, any value above or below the optimum would show greater porosity. Till this limit, the porosity will be inversely proportional to dosage of SP. The reason behind increase in porosity after the optimum is the onset of bleeding and segregation at very high dosage of SP. Permeability too follows the rules applicable to water absorption and porosity. The lowest permeability is found for 0.8% of Superplasticizer added to concrete.

II. CONCLUSION

Superplasticizers have number of benefits such as increasing the workability of concrete, enhancing the setting time, reducing water absorption, permeability, porosity etc leading to a denser and durable concrete. It also imparts better mechanical properties which can be seen through higher compressive, tensile as well as flexural strength. The key factor for harnessing these multiple advantages is finding the optimum percentage which not only increases the required properties but also cause no adverse effects on other properties. As any dosage below or above the optimum would result in reduction of required characters of superplasticised concrete. Better ways like use of silica fumes need to be found to counter the unwanted harmful effects of high dosage of superplasticizers.

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