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Comparative study on the effect of Packing Factor on Workability and Mechanical Properties of High Strength Self Compacting Concrete (M70) with different mineral admixtures

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Abstract-Experimental investigation was carried out to know the effect of Packing Factor on the workability and mechanical properties of high strength self-compacting concrete with two sets of mineral admixtures. One set (MIX1) consists of Ground Granulated Blast Furnace Slag (GGBS) and Micro Silica as mineral admixtures. Second set (MIX2) consists of Fly ash and Micro Silica as mineral admixtures. The work focused on concrete mixes having Packing Factors of 1.10, 1.11, 1.12, 1.13 and 1.14. Packing Factor (PF) of aggregate is defined as the ratio of mass of aggregate of tightly packed state in SCC to that of loosely packed state. The SCC mixes are designed with different proportions of GGBS, Fly Ash, with different binder ratios for different Packing Factors by using NAN-SU design method. The study shows that workability is more for mix with Fly Ash as mineral admixture when compare to mix with GGBS for same PF. Compressive strength of mix with GGBS as mineral admixture is more when compare to mix with Fly Ash as mineral admixture.

Keywords-Self-Compacting Concrete, Packing Factor (PF), Workability, GGBS, Fly Ash, Micro silica, Super plasticizer and VMA.

I. INTRODUCTION

Self-compacting concrete having advanced viscosity and workability properties can easily fill the moulds without the necessity of using vibrators. High volume of mineral powder is a necessity for a proper self-compacting concrete design [1]. For this purpose, mineral admixtures such as limestone powder, Fly Ash, micro silica, Rice husk ash and Blast furnace slag can be used [2,3]. In this study, the effect of Packing Factor on fresh and hardened properties of high strength self - compacting concrete has been investigated. It is apparent that workability depends on a number of interacting factors such as water content, aggregate type and grading, fine aggregate to coarse aggregate ratio, packing factor, kind and dosage of super plasticizers, and the fineness of cement. The main factors on self-compacting concrete are the water and super plasticizer contents of the mix since by simply adding them the inter particle lubrication is increase. In this research mix design used is based on NAN-SU method [4].

II. MATERIAL AND MIX PROPORTION

This part of the paper presents the specifications of the mixes used for obtaining the workability, compressive strength, split tensile strength and flexural strength of self-compacting concrete.

Ordinary Portland cement (OPC 53 grade), GGBS, Fly ash and Micro silica were used as cementitious materials. Natural river sand and crushed gravel with a nominal maximum size of 10 mm were used as the aggregate [5]. Chemical admixtures used were GLENIUM B233 (a new generation based on modified poly carboxylic ether) as super plasticizer [6] and Glenium Stream-2 as VMA [7]. In this research W/C ratio and FA/CA ratios used are 0.25 and 52/48 for different Packing Factors based upon trials. The percentage of Micro Silica and VMA added are 7% and 0.3% for all mixes based upon trials. Mix proportions are shown in Tables 1(a) and 1(b).

III. RESULTS AND DISCUSSIONS

The workability tests performed in this research were as per EFNARC [8,9] guidelines. They are Slump flow, L-box, U-box and V-funnel. The results of workability tests on high strength self-compacting concrete are shown in Table 2. It is observed that Slump Flow decreases as the Packing Factor (PF) increases for both the mixes. For mix with GGBS as mineral admixture slump flow decreases by 4.41% whereas for mix with Fly Ash as mineral admixture slum flow decreases by 4.34%. It is observed that T500 and V- funnel times increases as the PF increases for both the mixes. For mix with GGBS as mineral admixture T500 and V-funnel values increases by73.68% and 68.54% respectively. Whereas for mix with Fly Ash as mineral admixture T500 and V-funnel times increase by 67.59% and 59.90% respectively. Results of Slump flow, T500 and V-funnel tests indicate that filling ability decreases as the PF increases for both the mixes.

It is observed that the values of V-funnel at T5 minutes test increases as the PF increases for both the mixes. For mix with GGBS as mineral admixture T5 time increases by 28.24%, where as for mix with Fly Ash as mineral admixture T5 time increases by 26.44%. It indicates that segregation resistance decreases as the PF increases.

It is observed that the filling height of U-box test increases as the PF increases for both the mixes. For mix with GGBS as mineral admixture filling height increases by 140.00%, where as for mix with Fly Ash as mineral admixture filling height increases by 300.00%. It is observed that the blocking ratio of L-box test increases as the PF increases for both the mixes. For mix with GGBS as mineral admixture blocking ratio increases by 3.6%, where as for mix with Fly Ash as mineral admixture blocking ratio increases by 5.15%. It indicates that passing ability decreases as the PF increases.

Overall it is observed that as the Packing Factor increases, the workability decreases. This is due to the decrease in water binder ratio and increase in aggregate binder ratio. Mix with Fly Ash as mineral admixture is more workable than mix with GGBS as mineral admixture. This is due to the spherical form of Fly Ash particles.

The results of compressive strength, split tensile strength and flexural strength are shown in Table 3. For mix with GGBS as mineral admixture compressive, split tensile and flexural strengths decrease by 3.46%, 16.08% and 18.58% respectively. Whereas for mix with Fly Ash as mineral admixture compressive, split tensile and flexural strengths decrease by 4.14%, 13.82% and 18.71% respectively. It is observed that as the Packing Factor increases, the strengths decreases. This is due to the increase in aggregate binder ratio. Strength of mix with GGBS as mineral admixture is higher than mix with Fly Ash as mineral admixture. This is due to the fineness and hydraulic properties of GGBS.

Table 1 (a): Mix proportions of concrete for different packing factors-MIX1

Mix Components	Concrete Mixes				
	M1 P.F=1.10	M2 P.F=1.11	M3 P.F=1.12	M4 P.F=1.13	M5 P.F=1.14
	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)

Cement	574	574	574	574	574
GGBS	54.20	45.47	36.73	28.00	19.27
Micro Silica	40.18	40.18	40.18	40.18	40.18
F.Aggregate	829.40	836.94	844.48	852.20	859.56
C.Aggregate	790.94	798.13	805.32	812.52	819.71
Water/Binder	151.85	149.34	146.83	144.32	141.81
Super Plasticizers	11.31	11.15	10.99	10.84	10.68
VMA	1.722	1.722	1.722	1.722	1.722

Table 1 (b): Mix proportions of concrete for different packing factors-MIX2

Mix Components	Concrete Mixes				
	M1 P.F=1.10	M2 P.F=1.11	M3 P.F=1.12	M4 P.F=1.13	M5 P.F=1.14
	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)	Qty.(kg/m^3)
Cement	574	574	574	574	574
Fly Ash	40.73	34.16	27.60	21.04	14.48
Micro Silica	40.18	40.18	40.18	40.18	40.18
Fine aggregate	829.40	836.94	844.48	852.20	859.56
Coarse aggregate	790.94	798.13	805.32	812.52	819.71
Water	152.05	149.52	146.97	144.42	141.88
Super Plasticizers	11.07	10.95	10.83	10.71	10.59
VMA	1.722	1.722	1.722	1.722	1.722

Table 2: Workability of the concrete mixes-MIX1 and MIX2

Workability Tests	Concrete Mixes									
	M1 PF=1.10		M2 PF=1.11		M3 PF=1.12		M4 PF=1.13		M5 PF=1.14	
	MIX 1	MIX 2	MIX 1	MIX 2	MIX 1	MIX 2	MIX 1	MIX 2	MIX 1	MIX 2
Slump flow (mm)	680x 680	690x 690	668x 668	680x 680	662x 662	675x 675	658x 658	670x 670	650x 650	660x 660
T 500(sec)	2.66	2.87	3.77	3.41	4.16	3.82	4.23	4.03	4.62	4.81
V-funnel(sec)	6.93	6.51	8.86	7.46	10.4	8.1	10.99	9.67	11.78	10.41
V-funnel T_5 min (sec)	11.65	8.12	12.17	12.03	13.53	12.96	14.02	13.73	14.94	14.11
L-box(h2/h1)	0.97	0.98	0.96	0.975	0.95	0.969	0.93	0.95	0.92	0.94
U-box (mm)	5	2	6	4	8	6	10	7	12	8

Table 3: Development of compressive strength, split tensile strength and flexural strength at 28 days for MIX1 and MIX2

Concrete Mix	Compressive strength (N/mm^2)		Split tensile strength (N/mm^2)		Flexural strength (N/mm^2)	
	MIX 1	MIX 2	MIX 1	MIX 2	MIX 1	MIX 2
M1 PF=1.10	84.03	83.71	4.54	4.14	6.89	6.84
M2 PF=1.11	83.91	83.26	4.37	4.10	6.72	6.69
M3 PF=1.12	82.62	81.62	4.15	4.04	6.18	6.20
M4 PF=1.13	82.13	81.03	4.07	3.95	5.71	5.77
M5 PF=1.14	81.12	80.24	3.81	3.84	5.56	5.61

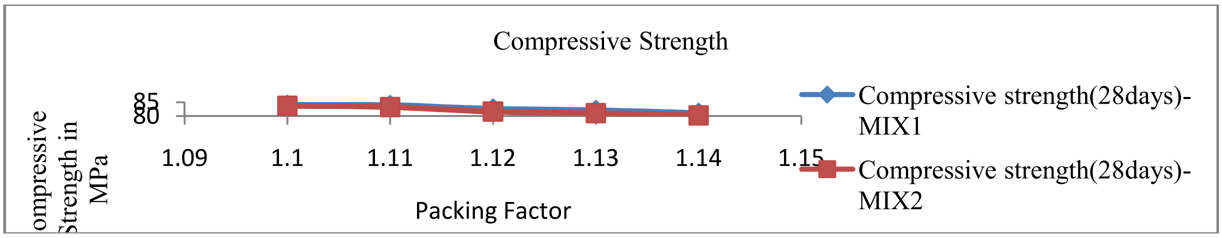

Figure 1: Packing Factor Vs Compressive strength

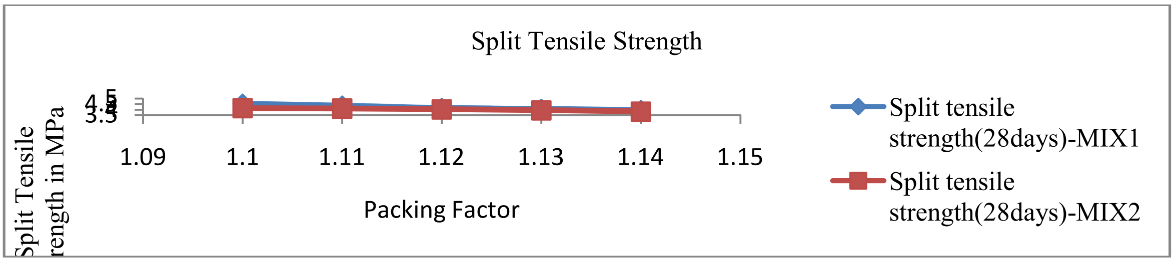

Figure 2: Packing Factor Vs Split tensile strength

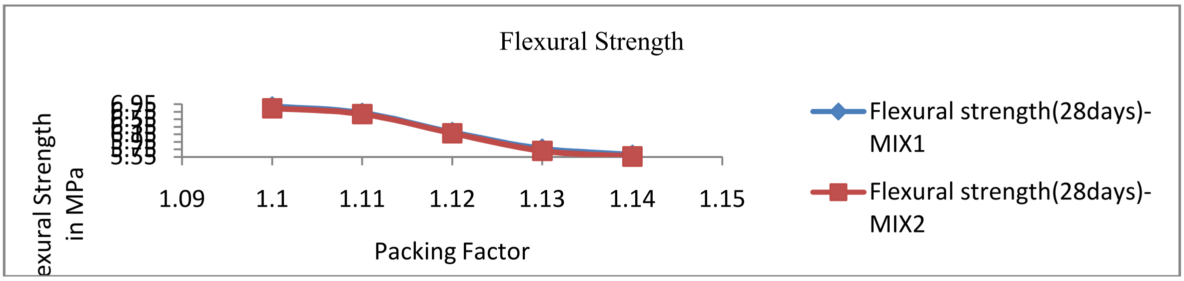

Figure 3: Packing Factor Vs Flexural strength

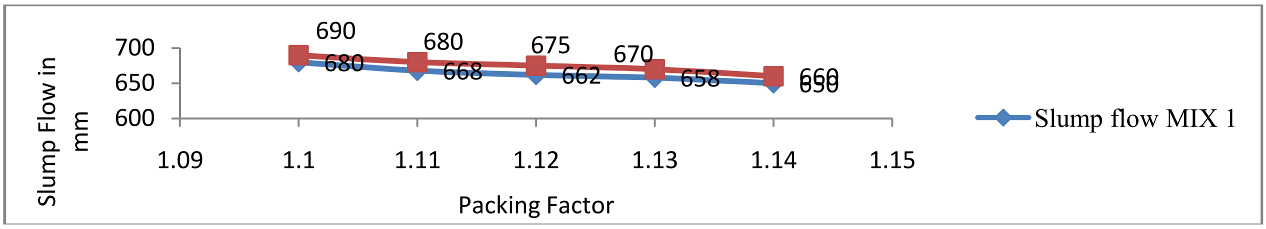

Figure 4: Packing Factor Vs slump flow

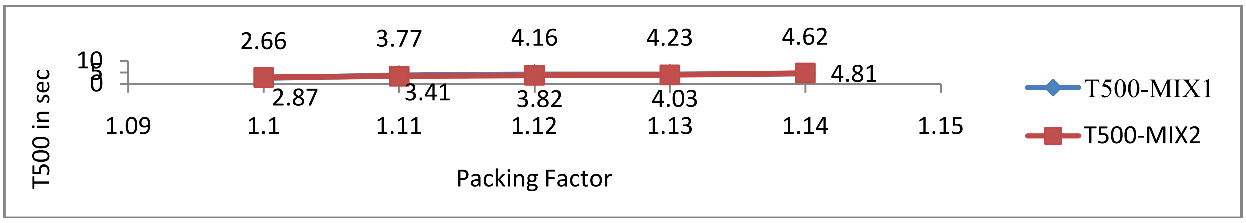

Figure 5: Packing Factor Vs T500

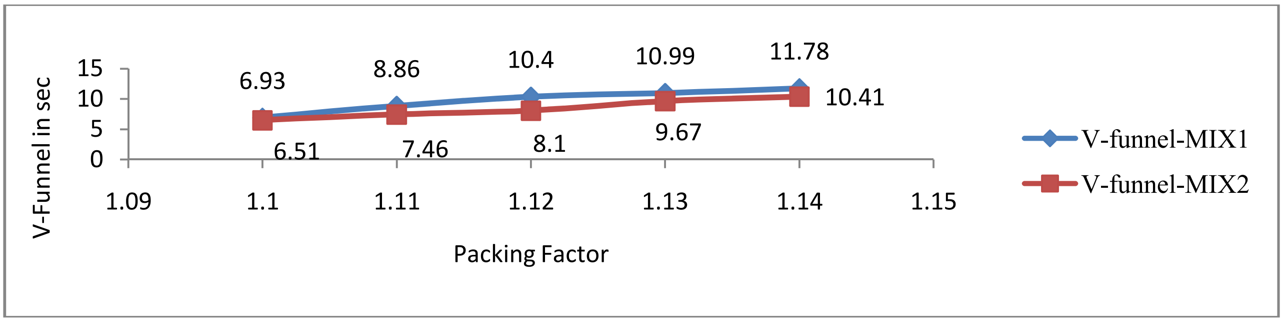

Figure 6: Pacing Factor Vs V-funnel

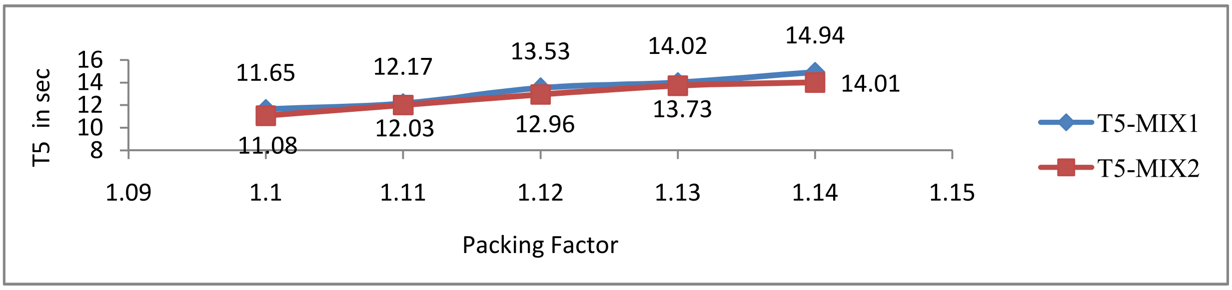

Figure 7: Packing Factor Vs T5

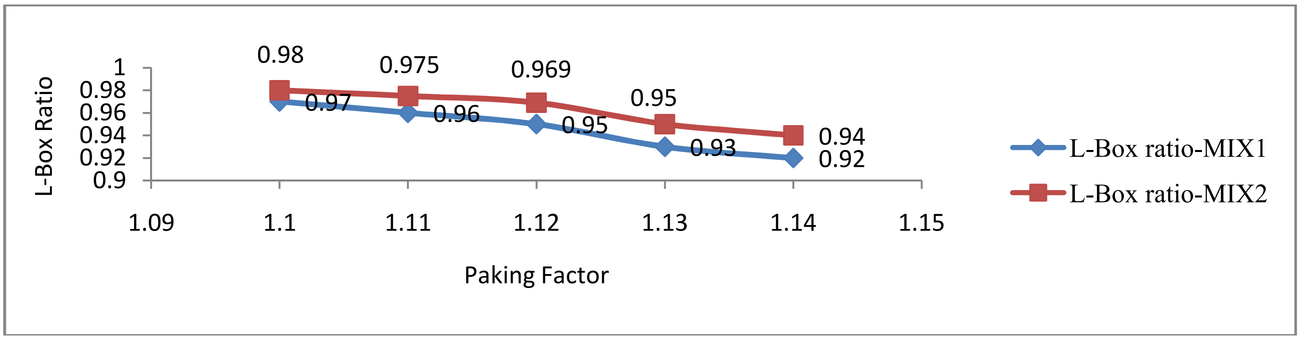

Figure 8: Packing Factor Vs L-Box Ratio

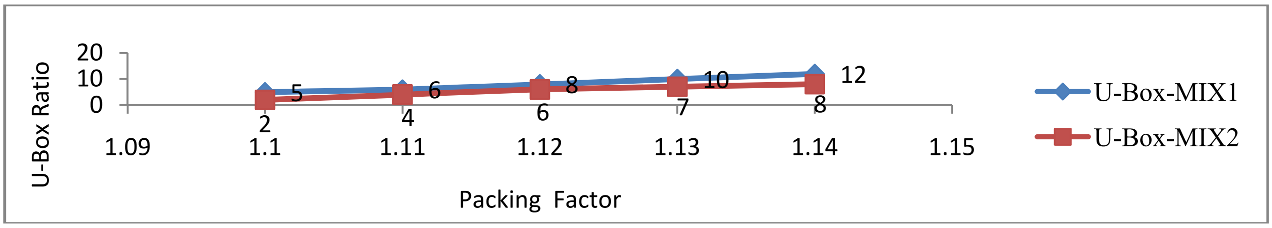

Figure 9: Packing Factor Vs U-Box

IV. CONCLUSIONS

The following conclusions are drawn from the study on the effect of Packing Factor on workability and
mechanical properties of high strength self compacting concrete with GGBS, Fly Ash and Micro Silica as mineral admixtures and they are applicable for the range of parameters and materials used in this study.

1. Required minimum workability and target strengths are achieved for a Packing Factor of 1.14 for M70 grade high strength self compacting concrete for both the mixes i.e one mix with GGBS as mineral admixture and another mix with Fly Ash as mineral admixture. This is due to high aggregate binder ratio.
2. Maximum strengths are achieved for a Packing Factor of 1.10 with optimum workability for M70 grade high strength self compacting concrete for both the mixes. This is due to low aggregate binder ratio.
3. Mix with Fly Ash as mineral admixture is found to be more workable than mix with GGBS as mineral admixture. This is due to the spherical form of the fly ash particles.
4. Compressive, split tensile and flexural Strengths of mix with GGBS as mineral admixture is observed to be more than mix with Fly Ash as mineral admixture. This is due to fineness and hydraulic properties of GGBS.
5. The present studies recommend to use a Packing Factor of 1.12 based on the results of flow properties and strength properties.

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