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Effect of Binary Blending of Mineral Admixture on Characteristics of Self Compacting Concrete

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Abstract: The Experimental investigations are carried out for determining the effect of binary blending of mineral admixture on characteristics of Self-compacting concrete (SCC).For this purpose several mix designs of SCC with fly ash and silica fume for the proportion of C.A:F.A (45:55) was carried out. The SCC was prepared as per the said mix proportion changes of Fly ash: Silica Fume and test were carried out on L box, J-ring test, V funnel and slump cone to find fresh property. The obtained results of fresh properties of SCC for proportions of CA: FA was compared with the standard values as per EFNARC guidelines.
Keywords: SCC, flowability, passing ability, FS (Fly ash: Silica Fume) and superplasticizer.

I. NTRODUCTION

The self-compacting concrete is concrete which can be compacted into every corner of formwork purely by means of own weight without compacting by any vibration equipment's. It is also known as self-leveling concrete, super workable, highly-flow able concrete, non-vibrating concrete or commonly abbreviated as self-compacting concrete (SCC). The concept of self-compacting concrete was proposed in 1986 by Prof. Hagime Okamura, but the prototype was first developed in 1988 in Japan by Prof. Ozawa at the University of Tokyo. The basic technique of placing fresh concrete has remained unchanged for many decades. Concrete transport equipment and compaction tools have become more sophisticated and reliable; concrete admixtures made it possible to better control some of the concrete properties; and concrete compaction could be done with less effort, but the basic concept of concrete compaction by using vibration energy has remained unchanged. One of the problems associated with manual compaction by vibration is the assurance of quality especially in complex structures, resulting from insufficient compaction during casting. Limitations of current concrete construction methodologies often impose considerable restrictions on the project architects and their structural designers. Another significant problem is related to the impact of conventional handling and placing techniques on the health and safety of concrete workers. The development of Self-Compacting Concrete (SCC), also referred to as ''Self-Consolidating Concrete'' and "High-Performance Concrete'', has recently been one of the most important developments in the building industry. It is a kind of concrete that can flow through and fill gaps of reinforcement and corners of moulds without any need for vibration and compaction during the pouring process. SCC requires high powder volumes at relatively low water/powder ratios with significant quantities of super plasticizers (sometimes supplemented by viscosity modifying agents). The powder generally consists of a combination of Portland cement with one more additions such as fly ash, GGBS, silica fume etc. therefore strength tends to be governed as much by the type and proportion of powder addition than by the water/powder ratio. Requirements for self-compacting concrete: The main characteristics of SCC are the properties in the fresh state. The mix design is focussed on the ability to flow under its own weight without vibration, the ability to flow thoroughly heavily congested reinforcement under its own weight, and the ability to retain homogeneity without segregation. The workability of SCC is higher than "very high" degree of workability mentioned in IS 456:2000.

II. METHODOLOGY ADOPTED

A. Review of literature related to Research.
B. To develop design mix analytically for M40 and M50 grade of concrete using I.S. 10262:2009 method.
C. To perform above mix design experimentally.
D. Experimentation.
E. To compare the experimental result as per EFNARC[10] guidelines.

III. MATERIAL SPECIFICATION

Following are the materials used for the experimental work.

A. Cement

The cement used in this experimental work is 53 grades Ordinary Portland Cement. All properties of cement are tested by referring IS 12269 - 1987 Specification for 53 Grade Ordinary Portland cement. The specific gravity of the cement is 3.15. The initial and final setting times were found as 108 minutes and 222 minutes respectively. Standard consistency and strength of cement was 32% and 53.7 N/mm2.

B. Water

Potable water used for the experimentation.

C. Fineaggregate

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.85 and fineness modulus of 3.87 are used as fine aggregate. The water absorption is of 1.60%.

D. CoarseAggregate

Crushed aggregate available from local sources has been used. The coarse aggregates with a maximum size of 20mm having the specific gravity value of 2.90 and fineness modulus of 7.136 are used as coarse aggregate. The water absorption is of 0.97%.

E. Flyash

Fly ash is a by- product obtained during the combustion of coal in thermal power plants, Typical physical properties: - Colour: grey, Specific gravity: 2.1.The advantage of Fly ash when used with Portland cement ensures higher durability of concrete avoids thermal cracking and improves workability. Slag has a pozzolanic reaction which allows the increase of concrete strength

F. Superplasticizer

The super plasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observe that with the use of large quantities of finer material, the concrete is much stiff and requires more water for required workability. Hence in the present investigation samples of superplasticizer are used for better results. Also to check the compatibility of superplasticizer with concrete Master Glenium sky 8276 is used.

The BASF’s Master Glenium sky 8276 superplasticizer having specific gravity of 1.12 is used.

IV. TEST OF SCC

A. L box Test

This test is based on a Japanese design for under water concrete. The test assesses the flow of the concrete and also the extent to which it is subjected to blocking by reinforcement.

B. V Funnel Test

The test was developed in Japan. The equipment consists of V-shaped funnel section. The described V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20mm.

C. Inverted Slump flow test

The slump flow test is used to assess the horizontal free flow of concrete in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on determining the slump. The diameter of the concretecircle is a measure for the filling ability of the concrete

D. J – Ring Test

The test is used to determine the passing ability of the concrete. The J Ring can be used in conjunction with the slump flow, the V-funnel. These combinations test the flowing ability and the passing ability of the concrete.

V. DESIGN OF CONCRETE BY IS CODE METHOD

Concrete mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

The mix design was carried out by using I.S. 10262:2009 method and specification provided by EFNARC[10] (2005). The concrete design mixes of M40 and M50 were carried out in concrete technology laboratory. Weigh batching was carried out for mixed design. For each mix, dry mixing of ingredients was done first, and then a weighed quantity of water was added to it. After adding water, wet mixing was carried out to get a homogeneous mix. The workability tests of concrete were carried out. The concrete cubes and cylinders were casted for compressive strength test. After curing for a specified period, the set of cubes, and cylinders were tested for strength test as per IS 516: 1959. The test results of M40 and M50 concrete mix design were tabulated in table 3.8 and 3.9.

A. For M40 Grade Concrete with Mineral Admixture 20% (For Fly ash : Silica Fume: 25:75)

Cement = 380 kg
Fly ash = 19kg
Silica Fume = 57kg
Total powder = 456kg
Water/Powder = 0.33
Free Water = W/P× Total powder
= 456×0.33
= 150.48kg
Addition of Super plasticizer reduce water content up to 20%
Actual Free water content = 150.48 - $\frac{20}{100} \times 150.48$
= 120.38
For 1 m^3 concrete
Cement = $\frac{380}{3.15} \times \frac{1}{1000}$
= 0.120 m^3
Fly ash = $\frac{19}{2.6} \times \frac{1}{1000}$
= 0.007 m^3
Silica Fume = $\frac{57}{2.2} \times \frac{1}{1000}$
=.025 m^3
Water = $\frac{120.38}{1} \times \frac{1}{1000}$
= 0.1203 m^3
Aggregate volume = 1-(0.120+0.007+0.025+.1203)
= 0.727m^3
Coarse aggregate = 0.45×0.727×2.9×1000
= 948.73 kg.
Fine aggregate = 0.55×0.727×2.8×1000
= 1119.58 kg
Water absorption calculation
For C.A. (2.26%)
= $\frac{2.26}{100} \times 948.73$
= 21.44kg
For fine aggregate (4.08%)
= $\frac{4.08}{100} \times 1119.58$

= 45.67 kg
Total Water = 120.38+21.44+45.67
= 187.50 kg
Corrected aggregate

C.A. = 948.73-21.44= 946.29 kg
F.A. = 1119.58 -45.67 = 1073.91kg
Quantities,
Cement = 380 kg
Fly ash = 19 kg
Silica Fume = 57kg
C.A = 946.29 kg
F.A. = 1073.91kg
Water = 187.50 kg
Sp. Dosage = 3.8 kg

B. For M50 Grade Concrete with Mineral Admixture 20% (For Fly ash : Silica Fume :25:75)

Cement = 400 kg
Fly ash = 20kg
Silica Fume = 60kg
Total powder = 480 kg
Water/Powder = 0.33
Free Water = W/P× Total powder
= 480×0.33
= 158kg
Addition of Super plasticizer reduce water content up to 20%
Actual free water content = 158.4 - $\frac{20}{100} \times \frac{158.4}{1}$
= 126.72
For 1 m^3 concrete
Cement = $\frac{400}{3.15} \times \frac{1}{1000}$
= 0.126 m^3
Fly ash = $\frac{20}{2.6} \times \frac{1}{1000}$
= 0.007 m^3
Silica Fume = $\frac{60}{2.2} \times \frac{1}{1000}$
=.027 m^3
Water = $\frac{126.4}{1} \times \frac{1}{1000}$
= 0.1264 m^3
Aggregate volume = 1-(0.126+0.007+0.027+.1264)
= 0.713 m^3
Coarse aggregate = 0.45×0.713×2.9×1000
= 930.46 kg.
Fine aggregate = 0.55×0.713×2.8×1000
= 1098.02 kg
Water absorption calculation
For C.A. (2.26%)
= $\frac{2.26}{100} \times 930.46$
= 21.02kg
For fine aggregate (4.08%)
= $\frac{4.08}{100} \times 1098.02$
= 46.99 kg
Total Water = 126.72+21.02+46.99
= 194.73 kg

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Corrected aggregate
C.A. = 930.46-21.02=909.44 kg
F.A. = 1098.02 -46.99 = 1051.03kg
Quantities,
Cement = 400 kg
Fly ash = 20 kg
Silica Fume = 60kg
C.A = 909.44 kg
F.A. = 1051.03kg
Water = 194.73 kg
Sp. Dosage = 4 kg

VI. EXPERIMENTAL RESULTS

Mix composition, fresh and hardened properties of SCC for proportions of CA: FA 45:55 shown in below and their results for tests like L box, V funnel, J- Ring, inverted slump flow test etc.

Table no. I mix composition of m40 grade concrete with mineral admixture 20%

I	FS1 25:75	FS2 50:50	FS3 75:25	F1	S1
Cement (kg)	380	380	380	380	380
Fly Ash (kg)	19	38	57	76	-
Silica fume (kg)	57	38	19	-	76
CA (kg)	946.29	929.84	931.13	932.4	926.02
FA (kg)	1073.91	1076.86	1078.34	1079.81	1072.43
Free Water (kg)	120.38	120.38	120.38	120.38	120.38
W/C Ratio	0.37	0.37	0.37	0.37	.37
W/P Ratio	0.33	0.33	0.33	0.33	.33
S. P.(Litre)	3.8	3.8	3.8	3.8	3.8
Density	2533.67	2526.67	2529.83	2529.83	2536.55

Table no. Ii mix composition of m40 grade concrete with mineral admixture 30%

Ingredients	FS4 25:75	FS5 50:50	FS6 75:25	F2	S2
Cement (kg)	380	380	380	380	380
Fly Ash (kg)	28.5	57	86.5	114	-
Silica fume (kg)	86.5	57	28.5	-	114
CA (kg)	894.13	896.68	900.51	901.78	891.67
FA (kg)	1036.50	1038.45	1042.89	1044.36	1032.55
Free Water (kg)	130.41	130.41	130.41	130.41	130.41
W/C Ratio	0.37	0.37	0.37	0.37	0.37
W/P Ratio	0.33	0.33	0.33	0.33	0.33
S. P. (litre)	3.8	3.8	3.8	3.8	3.8
Density	2508.17	2510.25	2506.34	2507.45	2503.17

Table No.III Mix Composition M50 Grade Concrete Wit Mineral Admixture 20%

Ingredients	FS7 25:75	FS8 50:50	FS9 75:25	F3	S3
Cement (kg)	400	400	400	400	400
Fly Ash (kg)	20	40	60	80	-
Silica fume (kg)	60	40	20	-	80
CA (kg)	909.44	910.72	911.80	914.54	897.37
FA (kg)	1051.03	1054.7	1053.23	1059.13	1026.5
Free Water (kg)	126.72	126.72	126.72	126.72	126.72
W/C Ratio	0.37	0.37	0.37	0.37	.37
W/P Ratio	0.33	0.33	0.33	0.33	.33
S.P.(litre)	4	4	4	4	4
Density	2547.53	2546.58	2566.40	2571.91	2550.65

Table No.Iv Mix Composition M50 Grade Concrete With Mineral Admixture 30%

Ingredients	FS1025:75	FS11 50:50	FS12 75:25	F4	S4
Cement (kg)	400	400	400	400	400
Fly Ash (kg)	30	60	90	120	-
Silica fume (kg)	90	60	30	-	120
CA (kg)	873.72	875	880.10	881.61	871.17
FA (kg)	1011.87	1013.34	1019.25	1020.73	1008.91
Free Water (kg)	137.28	137.28	137.28	137.28	137.28
W/C Ratio	0.37	0.37	0.37	0.37	0.37
W/P Ratio	0.33	0.33	0.33	0.33	.33
S.P. (litre)	4	4	4	4	4
Density	2523.67	2517.85	2529.83	2528.50	2513.67

Table no. Vfresh properties of m40 grade concrete with mineral admixture 20%

Test	FS1 25:75	FS2 50:50	FS3 75:25	F1	S1
Slump Cone	660 MM	670 MM	672 MM	675 MM	678 MM
J-Ring	650 MM	660 MM	666 MM	667 MM	665 MM
J- Ring-Jh	6 MM	7 MM	7 MM	5 MM	7 MM
V-Funnel	8.5 sec	8.8 sec	8.6sec	7.9sec	7.5 sec
V-Funnel@T5	8.9 sec	9.7sec	9.8 sec	9 sec	8.4 sec
L-Box(H2/H1)	0.82	0.83	0.85	0.80	0.82
L-Box T20	1.8 sec	2.1 sec	2.1 sec	1.9 sec	2.2sec
L-Box T40	3.6 sec	4 sec	3.9 sec	3.8 sec	4sec

table no.vi fresh properties of m40 grade concrete with mineral admixture 30%

Test	FS4 25:75	FS5 50:50	FS6 75:25	F2	S2
Slump Cone	715 MM	725 MM	702 MM	710 MM	694 MM
J-Ring	675 MM	676 MM	695 MM	688 MM	675 MM
J- Ring- Jh	3 MM	4 MM	4 MM	3 MM	4 MM
V-Funnel	7 sec	7.5 sec	5 sec	6 sec	6.8 sec
V-Funnel@T5	9 Sec	9 sec	6.5 sec	7.4 sec	9 Sec
L-Box(H2/H1)	0.91	0.92	0.92	0.90	0.93
L-Box T20	1.5 sec	1.7 sec	1.5 sec	1.2 sec	1.5 sec
L-Box T40	2.8 sec	3 sec	3 sec	2.8 sec	2.8 sec

Table no. Vii fresh properties of m50 grade concrete with mineral admixture 20%

Test	FS7 25:75	FS8 50:50	FS9 75:25	F3	S3
Slump Cone	675 MM	676 MM	670 MM	688 MM	675 MM
J-Ring	665 MM	660 MM	655 MM	650 MM	665 MM
J- Ring- Jh	6 MM	7 MM	7 MM	6 MM	7 MM
V-Funnel	8.5 sec	8.8 sec	8.6sec	7.9sec	7.5 sec
V-Funnel @T5	8.9 sec	9.7sec	9.8 sec	9 sec	8.4 sec
L-Box(H2/H1)	0.82	0.80	0.81	0.83	0.81
L-Box T20	1.5 sec	1.6 sec	1.4sec	1.5 sec	1.5 sec
L-Box T40	3.4sec	3.2 sec	2.9 sec	3.2 sec	3.4sec

Table no. VIII fresh properties of m50 grade concrete with mineral admixture 30%

Test	FS1025:75	FS11 50:50	FS12 75:25	F4	S4
Slump Cone	720 MM	702 MM	730 MM	713 MM	718 MM
J-Ring	678 MM	673 MM	700 MM	685 MM	675 MM
J-Ring-Jh	3 MM	4 MM	3 MM	4 MM	4 MM
V-Funnel	6.8 sec	6 sec	5 sec	6.2 sec	6.5 sec
V-Funnel @T5	9 Sec	9 sec	7.5 sec	7.4 sec	9 Sec
L-Box(H2/H1)	0.92	0.93	0.90	0.91	0.93
L-Box T20	1.5 sec	2 sec	1.4 sec	1.6 sec	1.5 sec
L-Box T40	3.4 sec	3.6 sec	3 .2sec	3.4 sec	3.4 sec

VII. GRAPH

Following graph shows comparison of obtained results for different mix.

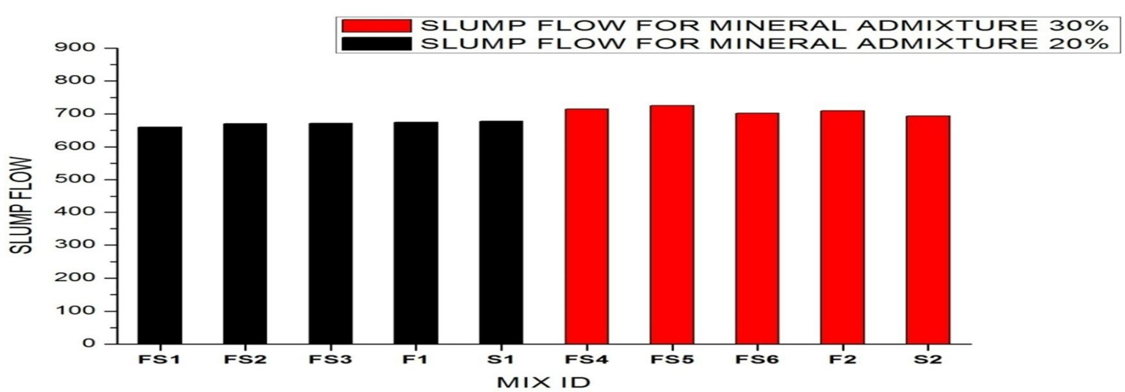

Fig. 1 Slump flow for M40 Grade of SCC

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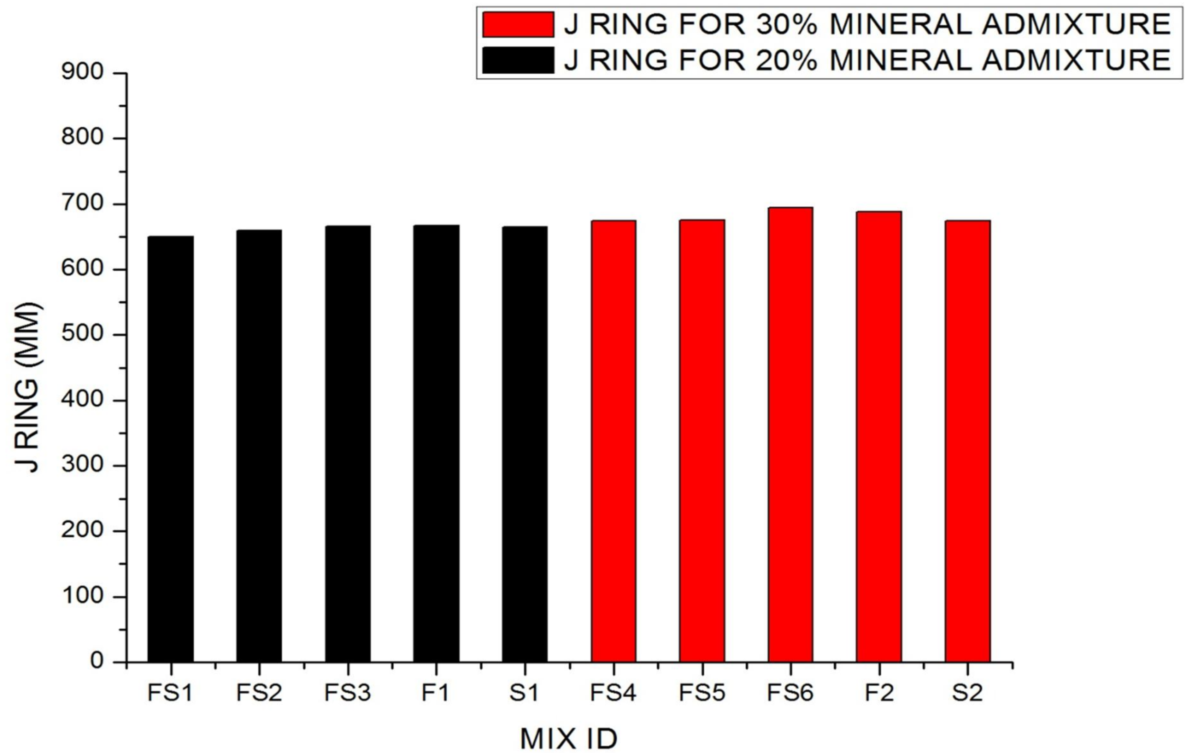

Fig. 2 J Ring for M40 Grade of SCC

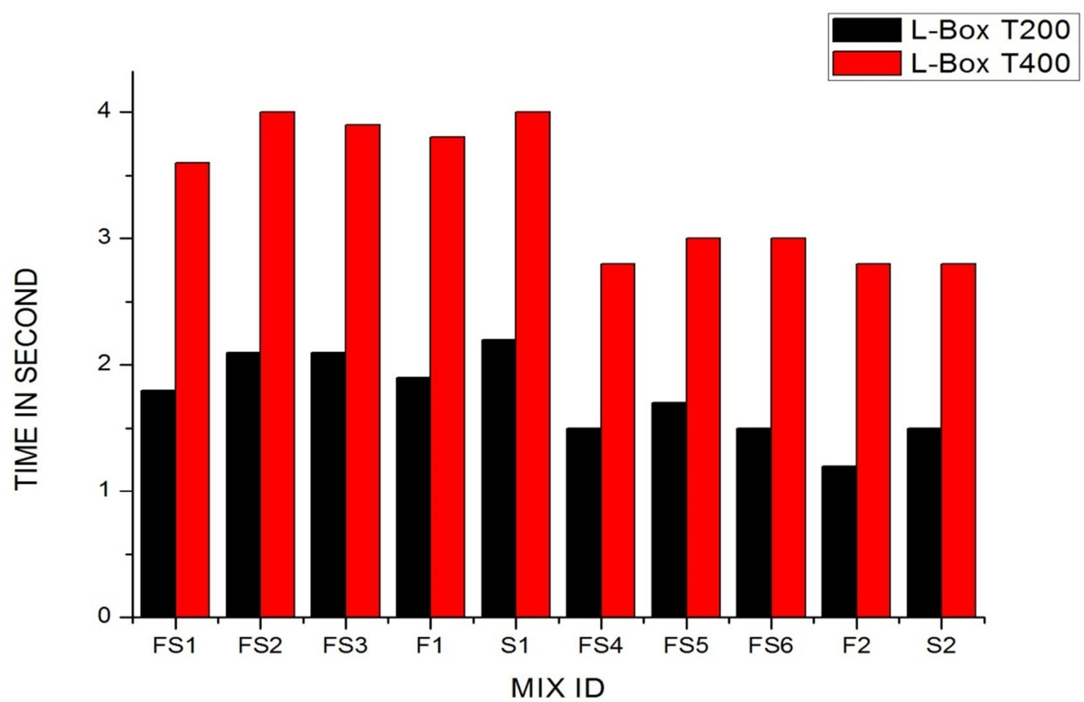

Fig. 3 L Box for M40 Grade of SCC

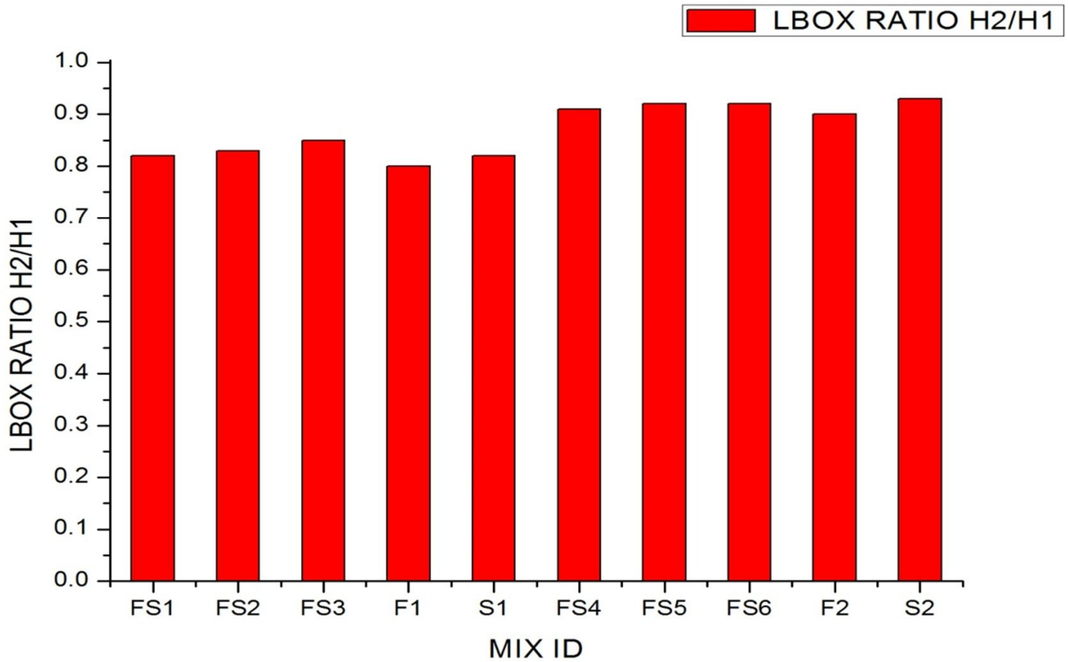

Fig. 4 L Box Passing/Blocking Ratio for M40 Grade SCC

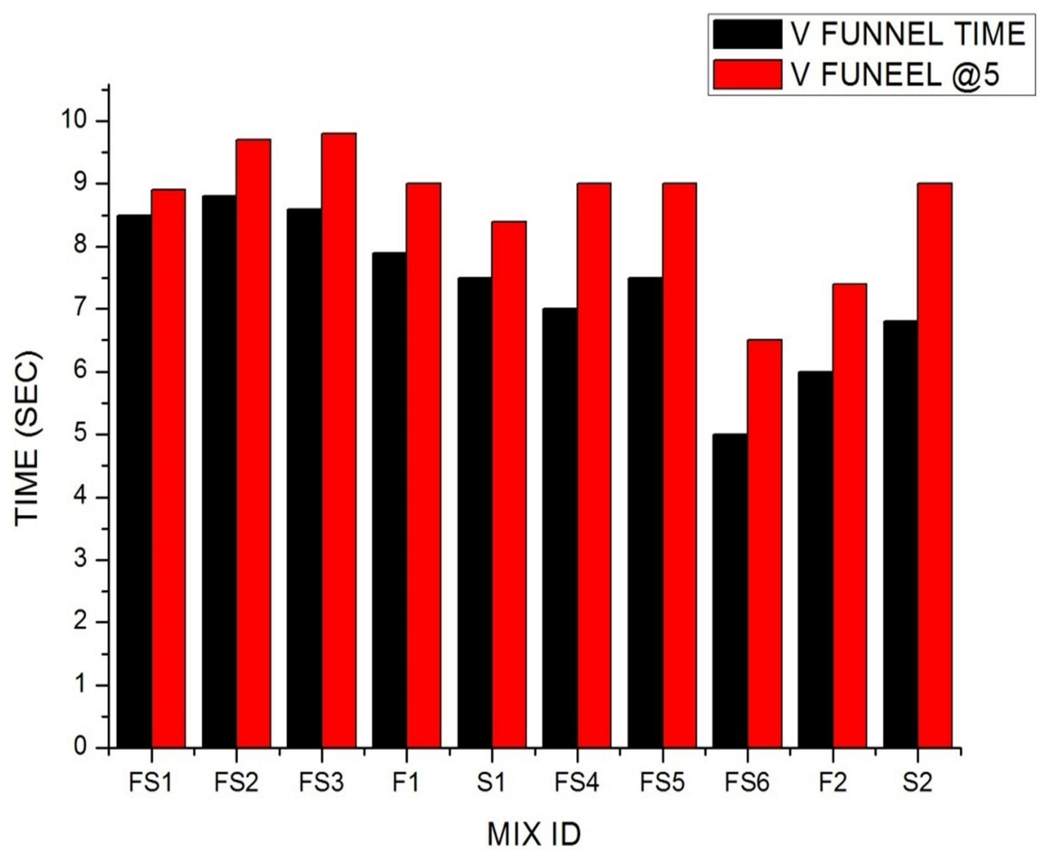

Fig. 5 V funnel time for M40 Grade of SCC

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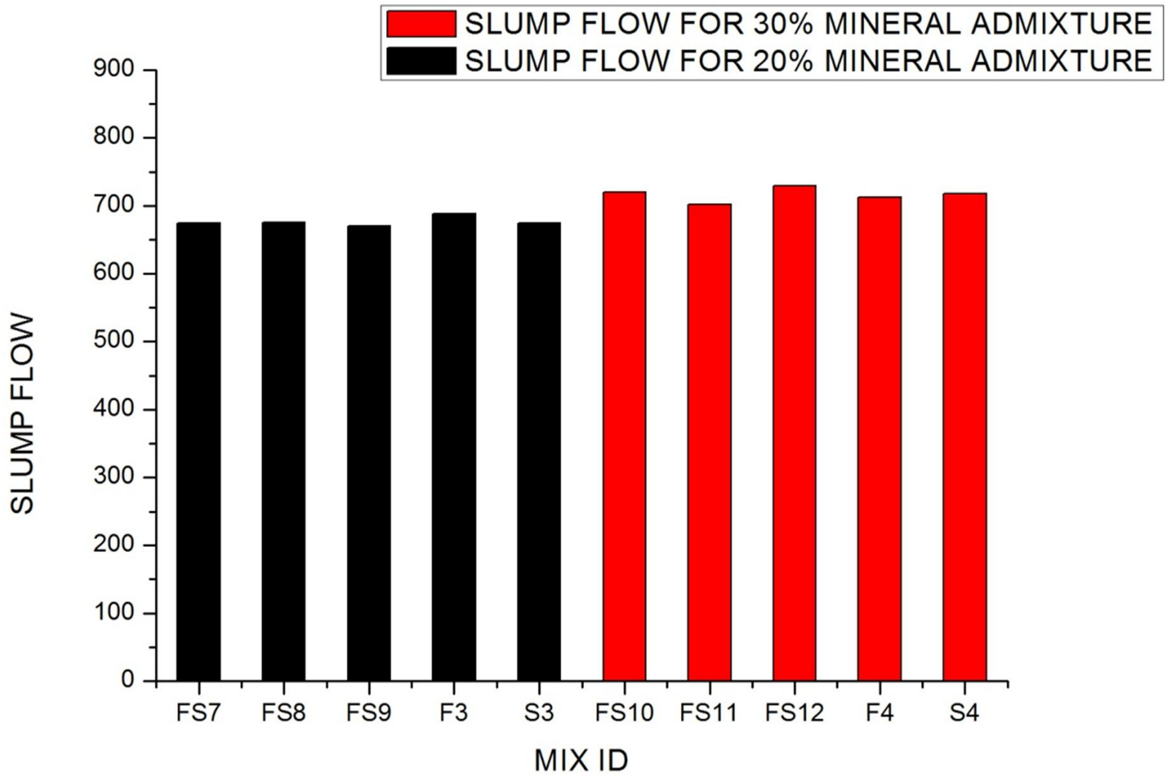

Fig. 6 Slump flow for M50 Grade

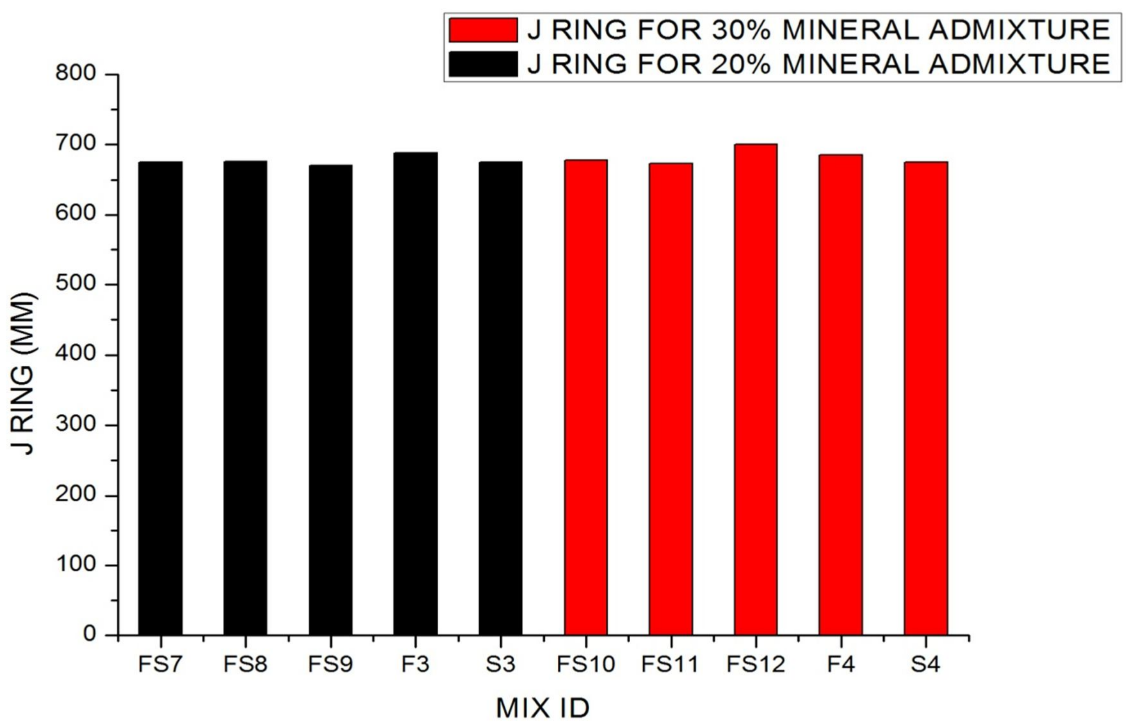

Fig. 7 J Ring for M50 Grade of SCC Concrete

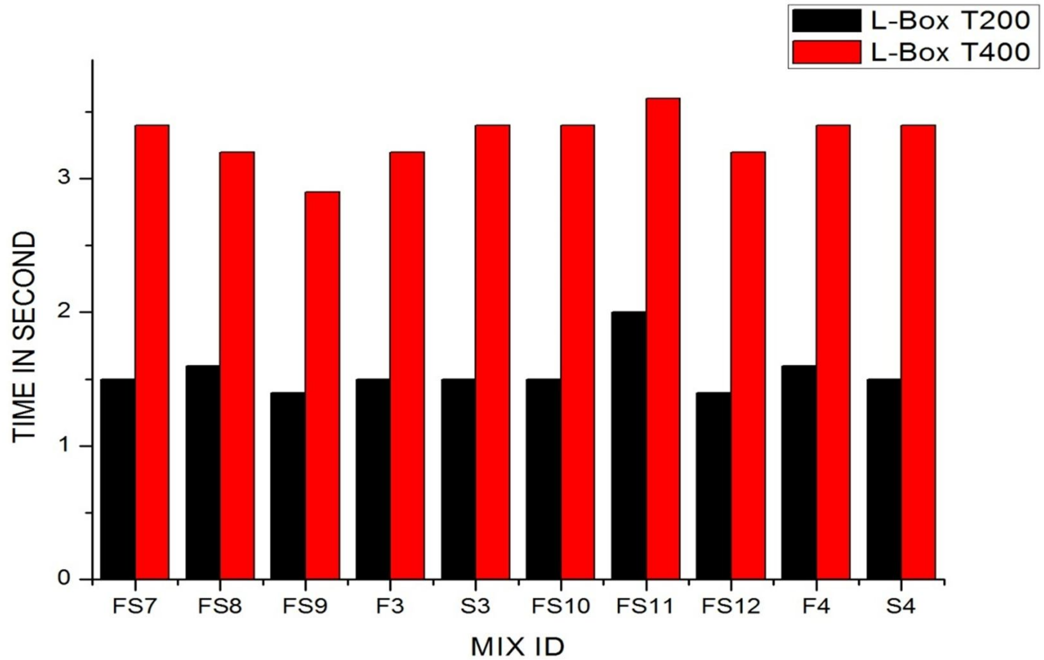

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Fig. 8 L Box for M50 Grade of SCC

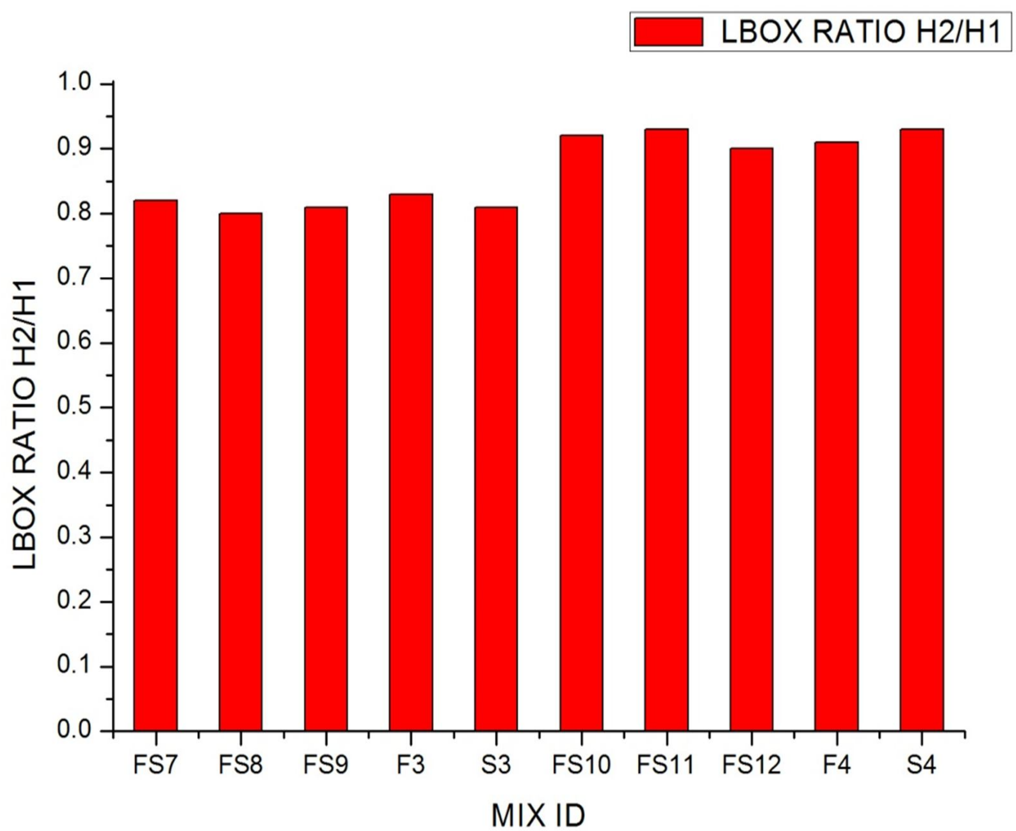

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Fig. 9 L Box Passing/Blocking for M50 Grade

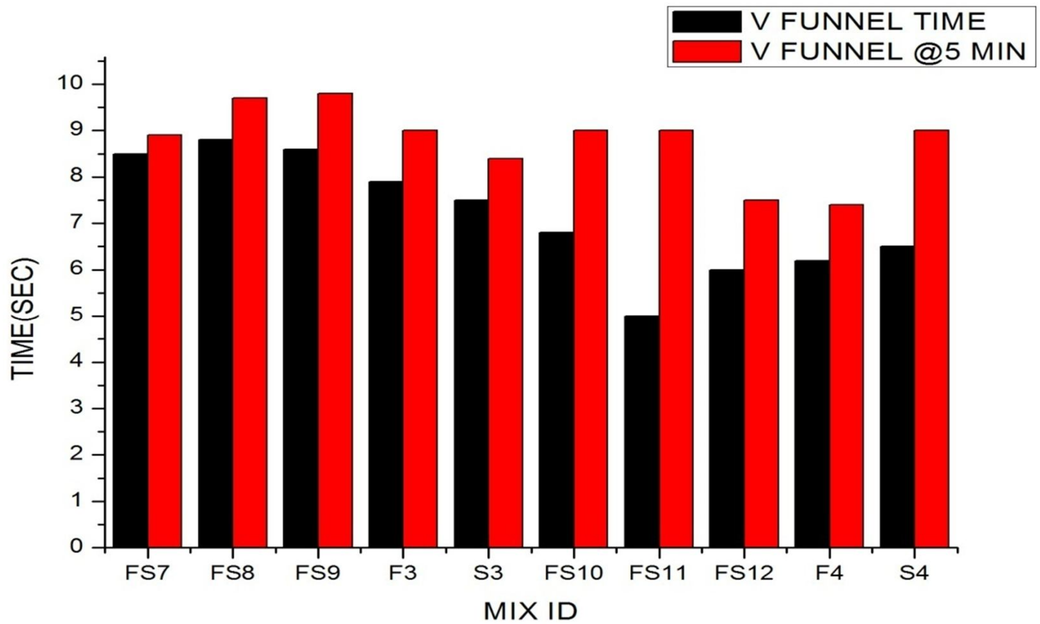

Fig. 10 V funnel time for M50 Grade of SCC

VIII. VALIDATION OF RESULTS

AS Per EFNARC the checklist for workability test for different method like L box, V funnel, J-Ring and inverted slump cone test with their property and typical minimum and maximum range values are given in Table NO. IX

Table No.Ix Efnarc Cheqelist

Sr. No.	Method	Unit	Typical Range of Values		Property	Obtained Results
1	L-Box test	$(h2/h1)$	0.8	1.0	Passing ability	0.82, 0.83
2	V-Funnel test	Sec	6	12	Filling ability & Segregation resistance	6.8 Sec, 6 Sec
3	J-Ring test	mm	0	10	Passing ability	3 mm, 4mm
4	Inverted slump cone test	mm	650	800	Filling ability	720 mm, 702 mm

IX. CONCLUSION

A. The SCC was casted for M40 & M50 grade of concrete for different proportions of fly ash to silica fume also for different proportion of cement to mineral admixture. The test result of scc in fresh state of the different proportion of cement &mineral admixture indicates that the slump flow increases as the powder content increases that is for 30% mineral admixture by the weight of cement for the both grades of concrete Thus the filling ability of the grade of concrete is improved.

B. The results of J Ring indicates that the passing ability of concrete for 30% addition of mineral admixture is more than the scc with 20% of mineral admixture by weight of cement but results for both the proportions are well above the standard given by the EFNARC[10]

C. The results of v funnel test indicate that the filling ability of concrete is good as the result of v funnel is within the range specified by EFNARC[10]. The results of v funnel time & after 5 minutes are also within the standards given by EFNARC[10] thus we can conclude that the concrete is good in segregation resistance also there was no visible segregation in slump & J Ring test.

D. The results of L box test are also within the standard specified by EFNARC[10] thus we can conclude that passing ability of concrete is also good. The L box ratio for concrete prepared 20% mineral admixture is more than the SCC prepared for the 30% mineral admixture by weight of cement. This is due to increasing mineral admixture.

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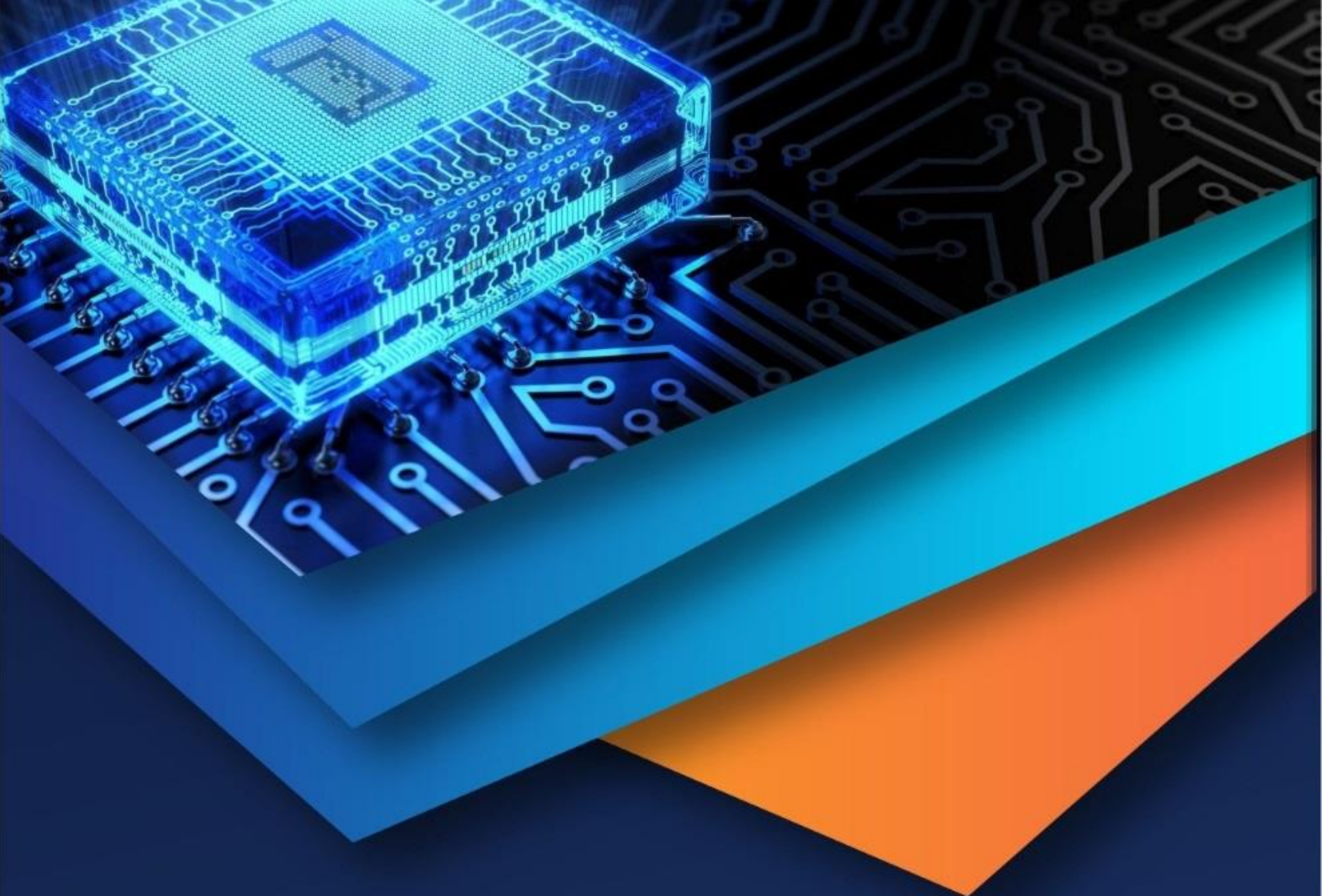

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