A STUDY ON PROPERTIES OF SELF-COMPACTING CONCRETE USING SILICA SAND AS PARTIAL REPLACEMEN OF FINE AGGREGATE

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ABSTRACT— The use of alternative aggregate like Silica sand is a natural step in solving part of depletion of natural aggregates. The investigation on alternative material for self- compacting concrete making started in recent times. Concrete made from Silica sand waste as fine aggregate will be studied for workability, compressive strength, Split tensile strength and Flexural strength. Further, study of its durability will ensure greater dependability in its usage. So here in this project, Silica sand has been used as replacement of fine aggregate by different percentage for making concrete of M- 25 and M-30. The percentage replacement will be 0%, 10%, 20%, 30%, 40%, and 50% with natural fine aggregates. Cubes, beams and cylinders will be casted and tested compressive strength, Split tensile strength, and flexural strength as well as for durability properties. Optimum replacement of Silica sand can be used in structural concrete.

Key words: Silica Sand; Self-compacting concrete; Workability; Compressive strength; etc…

A. INTRODUCTION

Every years waste material deposited in huge quantity on valuable land. This problem of utilization waste material can be solved up to certain level if people start use of it. Here, they had studied about use of waste Silica Sand as partial replacement of fine aggregate in self-compacting concrete.

The Self-Compacting Concrete is the modern concrete which does not require compaction and vibration for placing of it," It is able to flow under its own weight and completely filling formwork and achieving full compaction even in closely spaced Steel designed.'' The harden SCC has same engineering properties and durability as tradition vibrated concrete. It is also eco-friendly.

Self-Compacting Concrete was first developed in Japan in early 1980. The flow ability is the main property of SCC so that it can be placed under its own weight without any type of mechanical vibration and compaction. In order to make SCC of high fluidity without bleeding or segregation during the transportation or placing, the use of high powder content, super plasticizers (SP) and viscosity modifying admixtures (VMA) used for making this type of concrete. However, the cost of this type of concrete is slightly higher than normal vibrated concrete.

B. MATERIALS

B.1 CEMENT

Ordinary Portland Cement (OPC) of Sanghi Cement conforming of IS 12269-1987 grade cement was used.

B.2 FINE AGGREGATE AND COARSE AGGREGATE

Fine Aggregate used for study as conforming to zone I of IS: 383, 1987.Fine aggregate size less than 4.75mm.Coarse aggregate size is maximum 20mm used for study as conforming to IS: 383, 1970.

	FINE AGGREGATES	FINE AGGREGATES
Specific gravity	2.56	2.77
Water Absorption	1.0%	0.40%
Moisture Contents	NIL	NIL

B.3 WATER

Potable water available in the college was used in Casting and curing.

B.4 FLY ASH

Class F fly ash which satisfies ASTM C618 & 92a, 1994, obtained from Mundra thermal power plant was used for Production of SCC.

B.5 SUPER PLASTICIZER

The important admixtures are the SP, used with a water reduction greater than 20%. Admixture conforming to IS 9103.Admixture is most important constitute of SCC to achieving flow ability and passing ability. In this experimental study, Glenium sky 8784 is used.

B.6 VMA

Viscosity Modified Agent (VMA) is uses in SCC for separation opposition purpose. VMA Cuts threat of segregation and bleeding of concrete. We had uses "Chryso fluid optima S830" in our study work.

B.7 Silica Sand

Silica sand is obtained from the raw material. After washing the raw material the Silica sand is separated by sieve size 1.18 of raw material. Raw material is washed for taking out the clay material which is useful for making the tiles. In the raw material about 10% is clay which is supplied to the ceramic factories.

Physical Properties of Silica Sand

Fineness modules	2.567
Specific gravity	2.577
Water absorption	0%
% passing 75 µ	0.6%
Bulk density	1.685 kg/m3

Chemical Properties of Silica Sand

Sr. No	Test description	Obtain Value in %
1	Loss on ignition as LOI	0.06
2	Silicon dioxide as Sio2	99.57
3	Aluminium oxide as Al2O3	0.10
4	Iron oxide as Fe2O3	0.08

5	Calcium oxide as Cao	0.07
6	Magnesium oxide as Mgo	0.02

C. Mix Design Of M-30 Grade Concrete

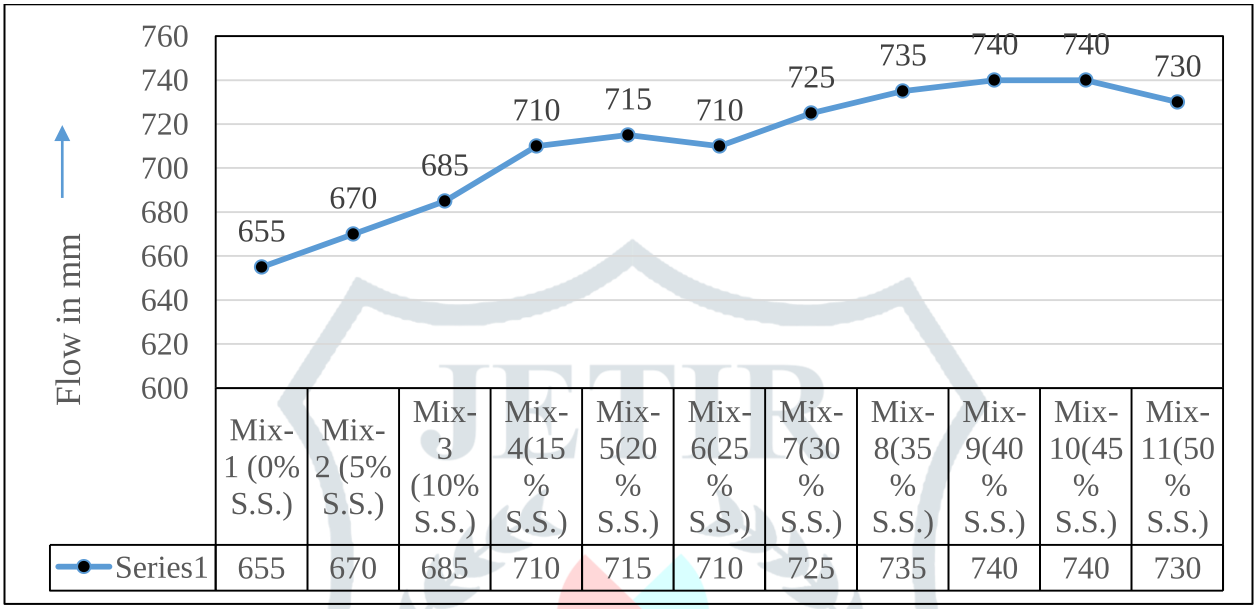
Sr.No.	Type of Mix	W/P ratio	Total Binder (kg/cum)	Cement (kg/cum)	Fly ash (kg/cum)	Coarse aggregate (kg/cum)	Fine aggregate (kg/cum)	Silica sand	Water (liter/cum)	S.P.(1%) (kg/cum)	VMA (0.25%)(kg/cum)
1	0% S.S, 100% F.A.	0.36	500	350	150	741.69	955.12	0	180	5	1.25
2	5% S.S, 95%F.A	0.36	500	350	150	741.69	907.36	47.77	180	5	1.25
3	10% S.S, 90% F.A	0.36	500	350	150	741.69	859.6	95.51	180	5	1.25
4	15% S.S, 85% F.A.	0.36	500	350	150	741.69	811.85	143.26	180	5	1.25
5	20% S.S, 80%F.A	0.36	500	350	150	741.69	764.09	191.02	180	5	1.25
6	25% S.S, 75% F.A	0.36	500	350	150	741.69	716.34	238.78	180	5	1.25
7	30% S.S, 70% F.A.	0.36	500	350	150	741.69	668.58	286.53	180	5	1.25
8	35% S.S, 65%F.A	0.36	500	350	150	741.69	620.82	334.29	180	5	1.25
9	40% S.S, 60% F.A	0.36	500	350	150	741.69	573.07	382.04	180	5	1.25
10	45% S.S, 55% F.A.	0.36	500	350	150	741.69	525.31	429.8	180	5	1.25
11	50% S.S, 50% F.A	0.36	500	350	150	741.69	477.56	477.56	180	5	1.25

D. Fresh Properties of SCC

Sr. No.	Type of Mix	Slump (mm)	V-Funnel (sec)	L- Box (H2/H1)	J-Ring test
	Range	**650-800 mm**	**6-12 sec**	**0.8-1**	**0-10 mm**
1	Mix-1 (0% S.S, 100% FA)	655	11.2	0.81	9.5
2	Mix-2 (5% S.S, 95%FA)	670	10.8	0.83	9.5
3	Mix-3 (10% S.S, 90% FA)	685	10.7	0.83	9.3
4	Mix-4(15% S.S, 85% F.A)	710	10.1	0.87	8.9
5	Mix-5(20% S.S, 80%F.A)	715	9.7	0.86	8.8
6	Mix-6(25% S.S, 75% F.A)	710	9.5	0.88	8.9
7	Mix-7(30% S.S, 70% F.A)	725	9.3	0.9	8.6
8	Mix-8(35% S.S, 65%F.A)	735	8.7	0.93	8.6
9	Mix-9(40% S.S, 60% F.A)	740	8	0.95	8.7
10	Mix-10(45% S.S, 55% F.A)	740	7.6	0.94	8.4
11	Mix-11(50% S.S, 50% F.A)	730	7.2	0.93	8.4

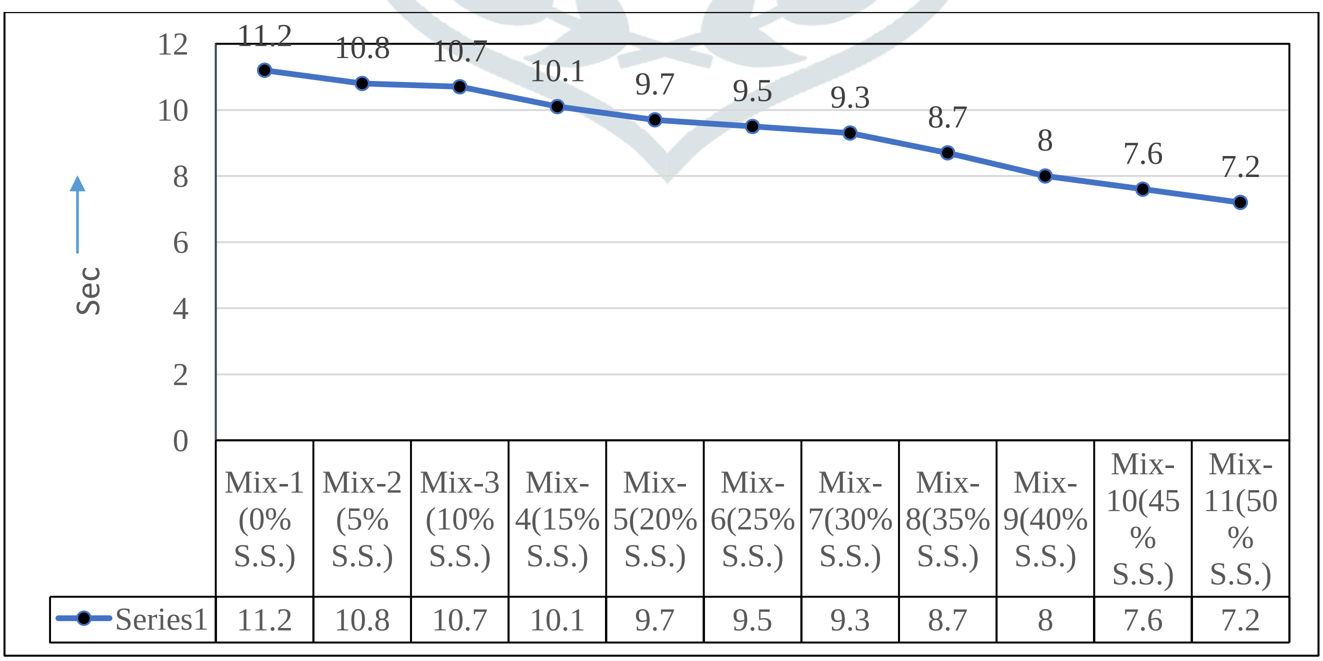
1. Slump Flow Test

Filling ability and fluidity of the Self-consolidation mixtures are to test using the slump flow test. The slump flow is the mean diameter of the horizontal spread of the concrete which flow on surface, after lifting the slump cone if the flow value is higher than it has greater fluidity to fill formwork under its self-weight. A value of at least 650 mm min and 800mm max is required for SCC.



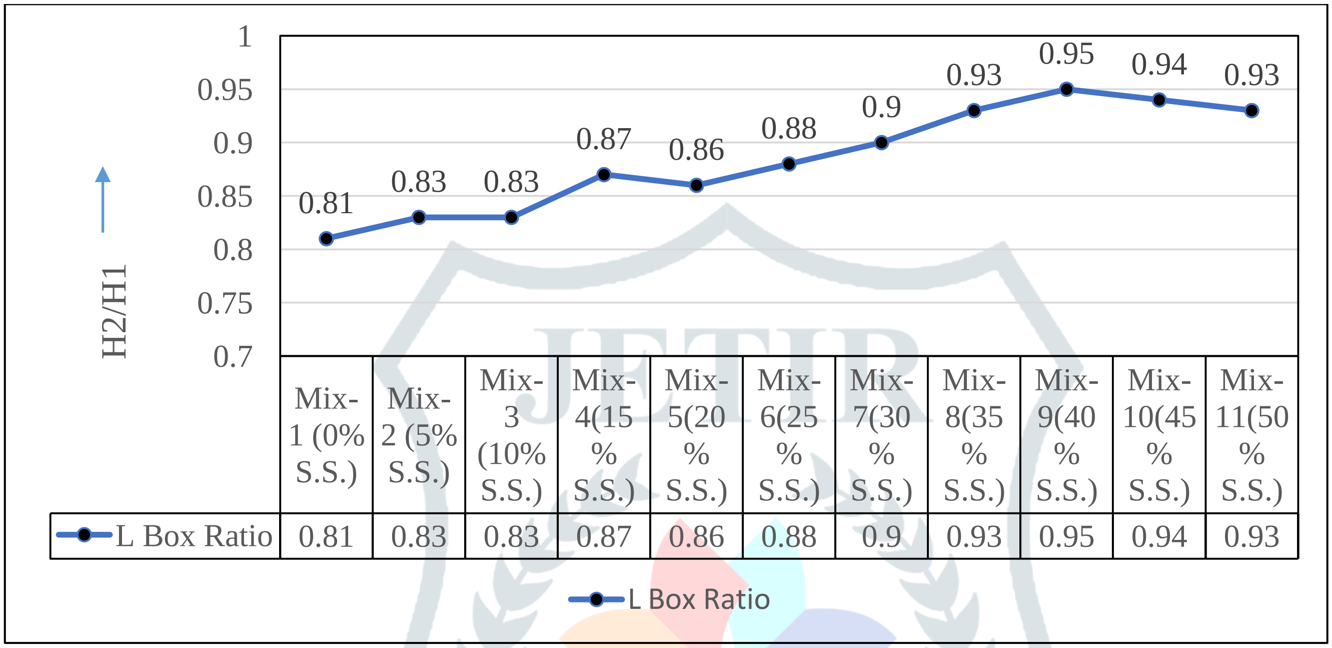
2. V- Funnel Test

The V-funnel test is an alternative method to use flow ability, which indicates the period of a defined volume of SCC needs to empty the funnel by narrow opening. Filling ability of self-consolidation concrete is also evaluated using the V-funnel test by measuring the time (T in seconds) taken for the mixture to completely empty the V-funnel, which had a rectangular opening of 75 mm x 65 mm. The target V-funnel time of self-consolidation concrete mixes is ranging between 6 to 12 seconds.



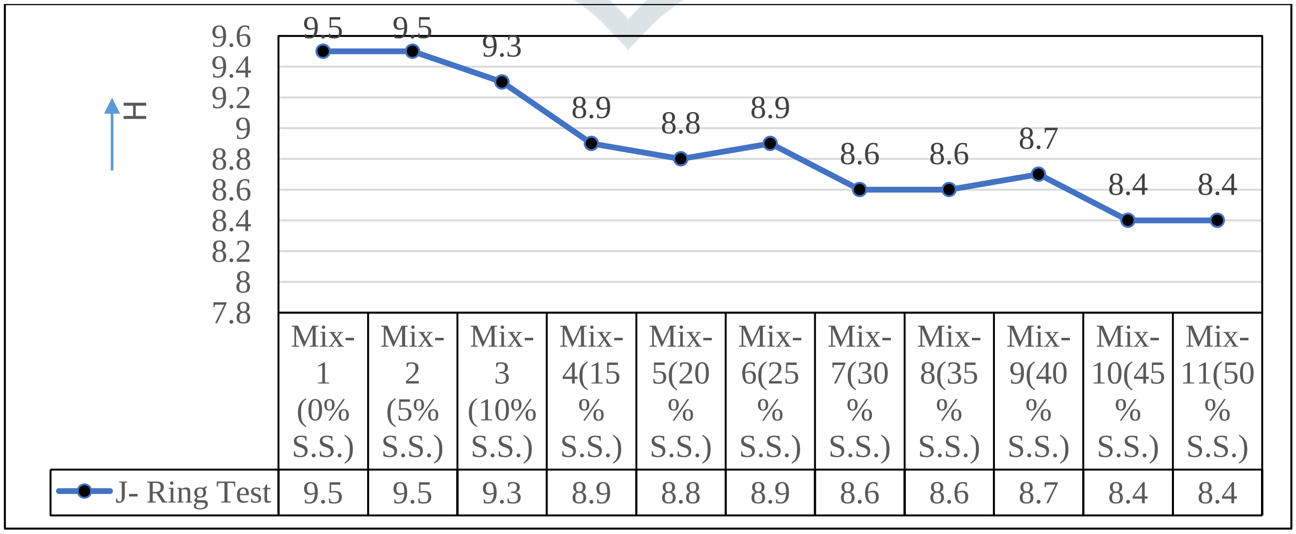
3. L- Box Test

The L-box test is used to evaluate the passing ability of SCC mix. L-box was fabricated in the laboratory as per the dimensions given in European guideline EFNARC, 2005. The vertical part of the box was filled with about 12 liters of concrete. Then the open the gate and the concrete flows out of the vertical part into the horizontal part through the reinforcement bars under its self-weight. H1 and H2, after the concrete has stopped flowing. The height ratio of H2/H1, called the blocking ratio (BR), was evaluate to determine the ability of passing.



4. J – Ring Test

This test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar as shown below. Measure the final diameter of the concrete in two perpendicular directions. Measure the difference in height between the concrete just inside the bars and that just outside the bars.

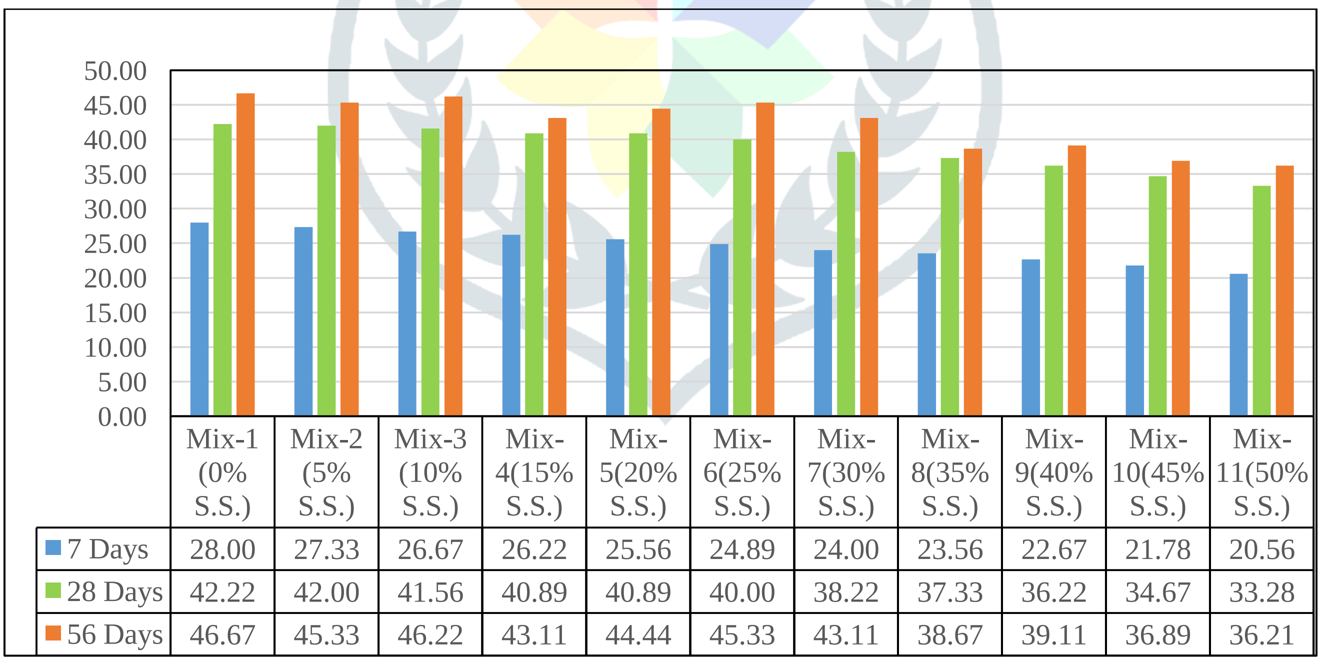


E. Hardened Properties of SCC

1. Compressive strength result:

The compressive strength of self-compacting concrete is decreases with increase the percentage of Silica Sand. Compressive strength of SCC is lower at early age but comparable at later age due to fly ash content. The result of compressive strength of SCC is show as below.

Compressive Strength for M-30 Grade in Mpa				
(Target mean strength-38.25)				
Sr. No.	**Type of Mix**	**7 days**	**28 days**	**56 days**
1	Mix-1 (0% M.S, 100% FA)	28	42.22	46.67
2	Mix-2 (5% M.S, 95%FA)	27.33	42	45.33
3	Mix-3 (10% M.S, 90% FA)	26.67	41.56	46.22
4	Mix-4(15% M.S, 85% F.A)	26.22	40.89	43.11
5	Mix-5(20% M.S, 80%F.A)	25.56	40.89	44.44
6	Mix-6(25% M.S, 75% F.A)	24.89	40	45.33
7	Mix-7(30% M.S, 70% F.A)	24	38.22	43.11
8	Mix-8(35% M.S, 65%F.A)	23.56	37.33	38.67
9	Mix-9(40% M.S, 60% F.A)	22.67	36.22	39.11
10	Mix-10(45% M.S, 55% F.A)	21.78	34.67	36.89
11	Mix-11(50% M.S, 50% F.A)	20.56	33.28	36.21

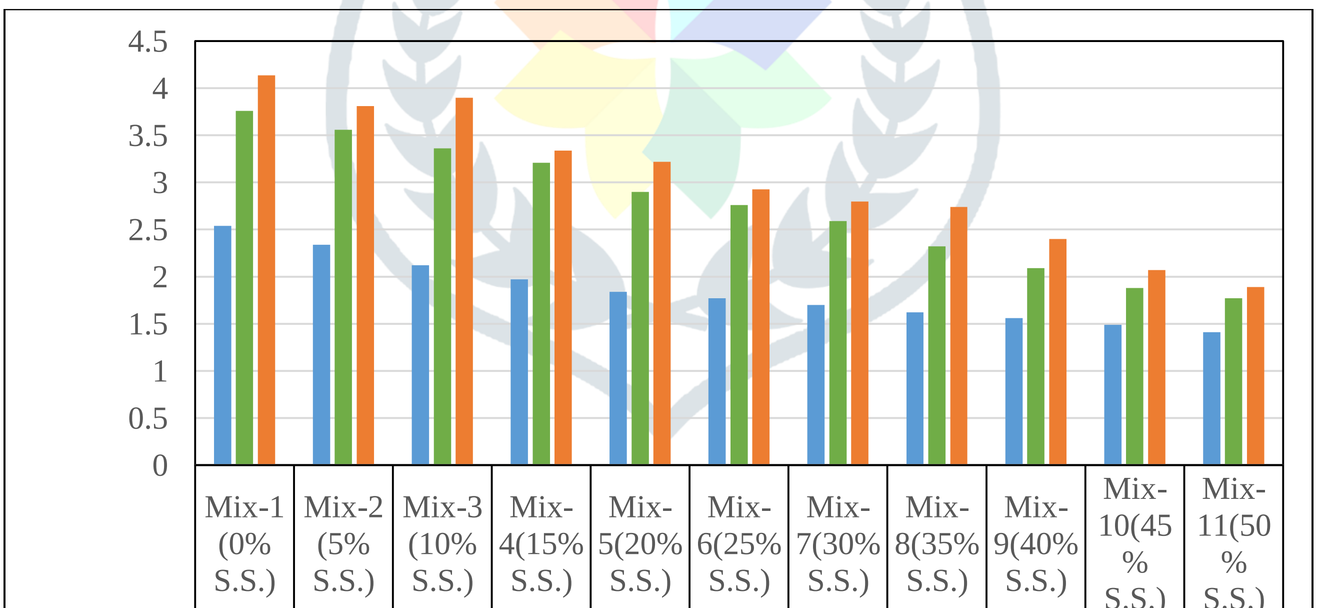


Graphical Representation Of Compressive Strength Results

2. Split Tensile strength result:

The Split tensile strength of SCC with Silica Sand and fly ash is decreases with increase the percentage of Silica Sand. Split tensile strength of SCC is lower at early age but comparable at later age due to fly ash content. The results of split tensile strength of SCC are show as below.

Split tensile strength for M-30 Grade in Mpa				
Sr. No.	**Type of Mix**	**7 days**	**28 days**	**56 days**
1	Mix-1 (0% S.S, 100% FA)	2.54	3.76	4.14
2	Mix-2 (5% S.S, 95%FA)	2.34	3.56	3.67
3	Mix-3 (10% S.S, 90% FA)	2.12	3.36	3.90
4	Mix-4(15% S.S, 85% F.A)	1.97	3.21	3.34
5	Mix-5(20% S.S, 80%F.A)	1.84	2.90	3.22
6	Mix-6(25% S.S, 75% F.A)	1.77	2.76	2.93
7	Mix-7(30% S.S, 70% F.A)	1.70	2.59	2.80
8	Mix-8(35% S.S, 65%F.A)	1.62	2.32	2.74
9	Mix-9(40% S.S, 60% F.A)	1.56	2.09	2.40
10	Mix-10(45% S.S, 55% F.A)	1.49	1.88	2.07
11	Mix-11(50% S.S, 50% F.A)	1.41	1.77	1.89



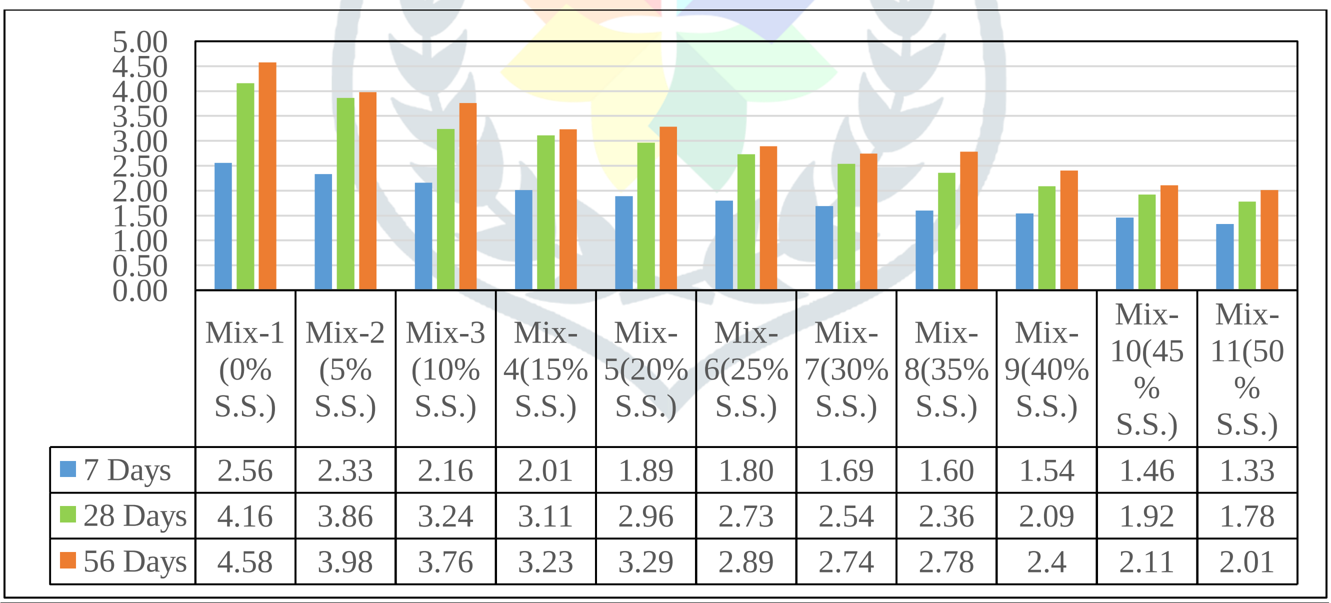
	Mix-1 (0% S.S.)	Mix-2 (5% S.S.)	Mix-3 (10% S.S.)	Mix-4(15% S.S.)	Mix-5(20% S.S.)	Mix-6(25% S.S.)	Mix-7(30% S.S.)	Mix-8(35% S.S.)	Mix-9(40% S.S.)	Mix-10(45 % S.S.)	Mix-11(50 % S.S.)
7 Days	2.54	2.34	2.12	1.97	1.84	1.77	1.7	1.62	1.56	1.49	1.41
28 Days	3.76	3.56	3.36	3.21	2.9	2.76	2.59	2.32	2.09	1.88	1.77
56 Days	4.14	3.81	3.90	3.34	3.22	2.93	2.80	2.74	2.4	2.07	1.89

Graphical Representation Of Split Tensile Strength Results

3. Flexural strength result:

The flexural strength of SCC with Silica Sand and fly ash is decreases with increase the percentage of Silica Sand. Flexural strength of SCC is lower at early age but comparable at later age due to fly ash content. The result of flexural strength are shown as below:

Flexural strength for M-30 Grade in Mpa				
Sr. No.	**Type of Mix**	**7 days**	**28 days**	**56 days**
1	Mix-1 (0% S.S, 100% FA)	2.56	4.16	4.58
2	Mix-2 (5% S.S, 95%FA)	2.33	3.86	3.98
3	Mix-3 (10% S.S, 90% FA)	2.16	3.24	3.76
4	Mix-4(15% S.S, 85% F.A)	2.01	3.11	3.23
5	Mix-5(20% S.S, 80%F.A)	1.89	2.96	3.29
6	Mix-6(25% S.S, 75% F.A)	1.8	2.73	2.89
7	Mix-7(30% S.S, 70% F.A)	1.69	2.54	2.74
8	Mix-8(35% S.S, 65%F.A)	1.6	2.36	2.78
9	Mix-9(40% S.S, 60% F.A)	1.54	2.09	2.40
10	Mix-10(45% S.S, 55% F.A)	1.46	1.92	2.11
11	Mix-11(50% S.S, 50% F.A)	1.33	1.78	2.01



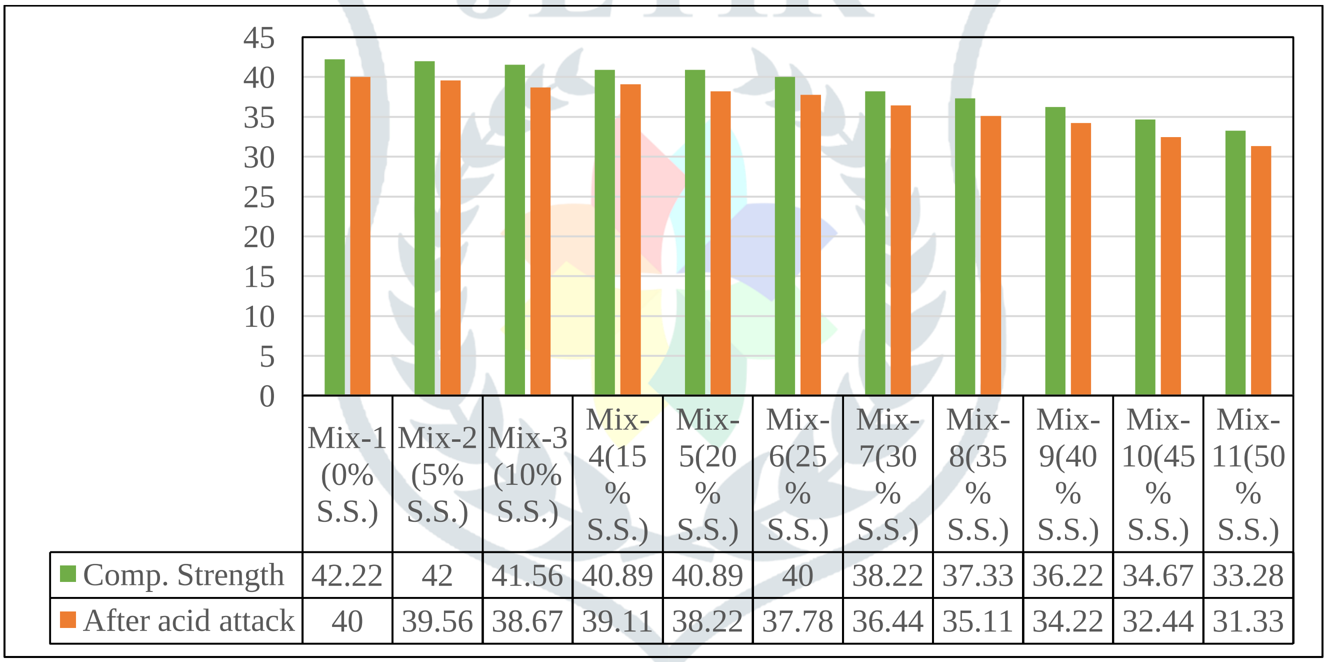
Graphical Representation Of Flexural Strength Results

F. Durability Properties of SCC

1. Acid attack test:

The result shows compressive strength of SCC in HCL solution curing are partially greater than the normal water curing. The percentage of weight loss of specimen in this solution is negligible. The graph gives the value of Acid test of concrete specimen of various proportion of mix design.

Sr No.	Mixes	Comp. Strength Mpa	after acid attack Mpa	Avg. loss of com strength (%)
1	Mix-1 (0% S.S, 100% FA)	42.22	40	5.26
2	Mix-2 (5% S.S, 95%FA)	42	39.56	5.82
3	Mix-3 (10% S.S, 90% FA)	41.56	38.67	6.96
4	Mix-4(15% S.S, 85% F.A)	40.89	39.11	4.35
5	Mix-5(20% S.S, 80%F.A)	40.89	38.22	6.52
6	Mix-6(25% S.S, 75% F.A)	40.00	37.78	5.56
7	Mix-7(30% S.S, 70% F.A)	38.22	36.44	4.65
8	Mix-8(35% S.S, 65%F.A)	37.33	35.11	5.94
9	Mix-9(40% S.S, 60% F.A)	36.22	34.22	5.52
10	Mix-10(45% S.S, 55% F.A)	34.67	32.44	6.42
11	Mix-11(50% S.S, 50% F.A)	33.28	31.33	5.85

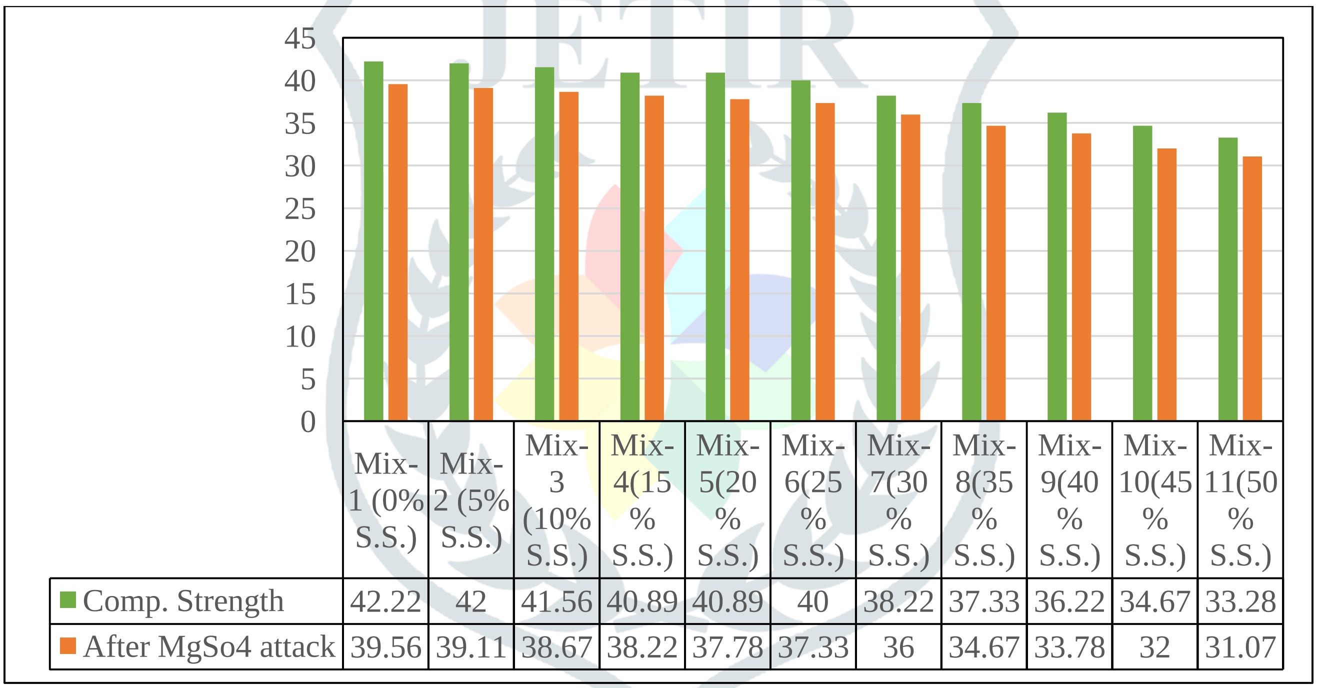


Graphical Representation Of Acid attack test Results

2. Sulphate Attack

The cubes are casted with the size of 150mm x 150mm x 150mm and kept at ambient temperature for 24 hours. After 28days, the cubes are immersing in a solution of magnesium sulphate (MgSO4).After 28 of curing, the specimens has taken and are washed in water. During sulphate attack test, it can observe that there was less effect on the concrete cube surface and the top surface of cube remained same as before. Specimens gained weight in most cases. The magnesium solutions readily react with the calcium hydroxide present in Portland cement pastes to form soluble salts of calcium. There is no surface cracking due to action of sulphate acting on the surface of concrete hence good resistance to sulphate.

Sr No.	Mixes	Comp. Strength Mpa	Comp. strength after MgSo4 attack Mpa	Avg. loss of com strength (%)
1	Mix-1 (0% S.S, 100% FA)	42.22	39.56	6.31
2	Mix-2 (5% S.S, 95%FA)	42	39.11	6.88
3	Mix-3 (10% S.S, 90% FA)	41.56	38.67	6.96
4	Mix-4(15% S.S, 85% F.A)	40.89	38.22	6.52
5	Mix-5(20% S.S, 80%F.A)	40.89	37.78	7.61
6	Mix-6(25% S.S, 75% F.A)	40	37.33	6.67
7	Mix-7(30% S.S, 70% F.A)	38.22	36.00	5.81
8	Mix-8(35% S.S, 65%F.A)	37.33	34.67	7.13
9	Mix-9(40% S.S, 60% F.A)	36.22	33.78	6.74
10	Mix-10(45% S.S, 55% F.A)	34.67	32.00	7.70
11	Mix-11(50% S.S, 50% F.A)	33.28	31.07	6.64



Graphical Representation of Sulphate attack test Results

G. Conclusion

- Silica sand has no negative effect in properties of SCC.
- There is improvement in fresh properties of SCC with the increment of Silica Sand.
- In Slump flow test, the result shows that, by replacing the Silica Sand with 50% in fine agg, there is increase in the slump flow up to 11.49%.
- In V-Funnel Test, The result shows that, by replacing the Silica Sand 50% by fine agg. So there will be decreases the time of V-Funnel test 35.71% which means it improve fresh properties of SCC.
- In L-Box Test, The result shows that, replacing the the Silica Sand 50% by fine agg, there will be increases the ratio (H2/H1) of L-box test 14.81%.
- In J- Ring Test, The result shows that, by replacing the Silica Sand 50% by fine agg. So there will be decreases in the height of concrete 11.58% which means it improve fresh properties of SCC.

- In Hardened property such as Compressive strength, Flexural strength and Split tensile strength, Silica Sand can be used up to 30% with Fly ash 30% to achieve target mean strength of concrete for M 30 grade.
- In Compressive Test, The result shows that, by replacing 50% Silica Sand in fine agg, there is decrement in the comp strength of concrete by 21.17% at 28 Days of Casting.
- In Flexure Test and Split tensile test, The result shows that, by replacing 50% Silica Sand in fine agg, there is decrement in the comp strength of concrete by 57.21% and 44.94% respectively at 28 days of casting.
- In Durability test using HCL solution and MgSo4 Solution in M-30 grade of concrete, Results shows that there is **minimum** % loss in HCL was 4.35% at mix 4 (15% S.S. & 85% FA) and in MgSo4 was 5.81% at mix 7 (30% S.S. & 70% FA).
- In Durability test using HCL solution and MgSo4 Solution in M-30 grade of concrete, Results shows that there is **maximum** % loss in HCL was 6.93% at mix 3 (10% S.S. & 90% FA) and in MgSo4 was 5.81% at mix 10 (45% S.S. & 55% FA).

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