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An Experimental Investigation on Strength Properties of Concrete Replacing Natural Sand by M-Sand Using Silica Fume as an Admixture

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Abstract— *Now a day's the volume of concrete is used by a civil industries is more all over the world. Sand is main ingredient used as fine aggregate in concrete-mix for constructions purpose. For the purpose of environment it is necessary for us to partially or complete replacement of sand by artificial sand as a fine-aggregate in high performance concretes (HPC). River sand was replaced with M-sand by six proportions that is 0%, 20%, 40%, 60%, 80% and 100% and with same aggregate binder ratio of 2.5 and water binding ratios of 0.30, 0.35 and 0.40 evaluating its Properties as per Indian Standards 516-1976.*

Cement is main ingredient of the concrete. The cement industry produces more about 6% of all carbon dioxide (CO_2) emission. So there is a great interest and implementation is necessary for reduce the population. For this reason micro silica is used in place of OPC with three proportions that is 0%, 10%, 20%.

Key words— Manufactured Sand, Silica Fume, Super Plasticizer, Strength properties.

1.INTRODUCTION

HPC can be defined as a concrete-mix made with appropriate materials (Super Plasticizer, Silica fume, Manufactured Sand and other admixtures) combined to provide excellent performance in some properties of concrete that is high strength, high density, impermeability, toughness and good resistance to prevailing environmental agents etc.

Since 1980's high performance concrete is mostly used as important material. They give high strength in compression more than 50Mpa obtained by adding a mixture of cement, with mineral admixture and super-plasticizers. The addition of mineral admixtures to the concrete gives better workability and durability. This admixture also gives good compactness to the cement paste. Silica-fume and super-plasticizers are used to achieve workability of the concrete.

HPC is the material for future because:

- Suitable for High Rise Constructions.
- Reduces column sizes.
- Speed of constructions.
- More economical than steel composite column.
- Good Workability.
- Pumpability.
- More economical material in term of time and money.
- Reduces depth of floor so that it reduces in overall building height
- High seismic resistance.
- Improved durability.
- Lower shrinkage.
- More than 100 years of life span.
- Reduces maintenance cost.

2. LITERATURE REVIEW

1. **T. Shanmugapriya1, R. N. Uma:** In their paper entitled with **"investigation of normal sand was replaced with artificial sand and OPC was replaced with micro silica".** The OPC will be replaced with micro silica by 1.5%, 2.5% and 5%. The sand will be replaced by artificial sand by varying proportions of 20% (up to 100%). From investigation the compressive test value will be increased by 20% and flexural test value will be increased by 15%. The maximum result will be obtained for 50% artificial sand used with 5% silica fume used in concrete.

2. **T. Subbulakshmi, B. Vidivelli:** In their paper entitled **"To find the harden properties of concrete by using robo sand using in place of sand".** The natural sand replaced with quarry dust with varying proportions of 0 %, 50% and 100% and cured for 3, 7, 14, 21, 28, and 60 days. The strength will be gradually increasing up to 28 days then remains constant. 50% of quarry dust with sand give maximum strength when compared with nominal mix.

3. **Priyadharshini, A.Krishnamoorthi:** In their paper entitled **"Find out the properties of HPC by using stone dust as Fine aggregate."** The sand were replaced by robo sand with different proportions. Also the OPC was replaced by micro silica and with adding steel fibres with different percentages i.e 0, 0.5, 1, and 1.5%. The M60 grade concrete will be designed by using ACI method. By using S.F the

compressive strength will be increases and by using steel fibres, tensile strength will be increases.

4. **Puneeth G T, Mamatha A:** In their paper **entitled "An Experimental Investigation on the performance of Concrete by Fractional Replacing of Cement by Micro Silica then F.A by Manufactured Sand".** Concrete specimen incorporated with 15% micro silica and 50% manufactured sand was found to be good in compressive which has 23.9% more than that of the conventional concrete when checked for 28days curing period.

3. MATERIALS USED IN CONCRETE

Cement: In this experiment work, UltraTech OPC-43 cement used agreeing to Indian Standard 8112-1989. The basic tests to be done as per Indian Standard 4031-1988. The properties of cement are, i) Specific gravity= 3.08, ii) Fineness= 4%, iii) Normal consistency= 28%, iv) Initial Setting Time= 90min, v) Final Setting Time= 9hr 30min

Silica Fume: It is a by-product of Ferrosilicon alloy. It is collected when the smoke comes from the operation of furnace. By using SF, alkali silica reaction will be reduces and it give good workability and smooth surface finishing. By using silica fume, it increases durability, it decreases the permeability of concrete and reduces the voids in concrete. It will resist the chloride attack, sulphates attack, acid attack and nitrate attacks. For this experiment M.S was collected from ELKEM'S South Asia privet limited Mumbai. Elkem's silica fume grade 920D agreeing to ASTM-C-1240.

Normally it is in the form of dry. Normally Silica fumes specific gravity is 2.4 and density of silica fume is 640kg/m^3.

Natural Sand: The sand will be collected in local available sources. The used sand in this project belongs to the Zone-II as per Indian Standard 383-1970 codal provision.

Manufactured Sand: If M.S will set in Zone II then the properties of manufactured sand will be same as to the natural sand. We collected manufactured sand in local stone crusher Nemkal village, Ballari. The properties of M.S are given below.

Table- 1: Properties of M-Sand and Natural Sand

Properties	M - sand	Sand
Specific gravity	2.56	2.60
Bulk density (Kg/m3) Compacted condition Loose condition	 1860 1.710	 1.860 1.650
Impurities Oversized material Clay and silt	 Nil Nil	 6-10% 5-20%
Fineness modulus	3.10	2.60
Grading zone	Zone – II	Zone - II

Coarse aggregates

For present investigation coarse aggregate are collected from local resources (SB Hukkeri construction (P) Ltd.) and these are passing from 20mm IS sieve and conforming IS 383-1970 specifications.

Table- 2: Properties of Coarse Aggregate

Properties	Coarse aggregates
Specific gravity	2.90
Bulk density (Kg/m3) Compacted condition Loose condition	 1691 850
Fineness modulus	7.19
Source	Naturally occurring basalt stone fragments

Water: Water used as per IS standards having pH value in between 6.5 to 8.5.

Super plasticizers: Conplast SP-430 super plasticizers manufactured by Forsoc chemicals (India) Pvt.Ltd, Bangalore were used in this experiment. The chemical name of SP-430 is Sulphonated naphthalene.

Table- 3: Properties of SP-430

Product Name	Conplast SP-430
Appearance	Brown Liquid
Chloride Content	Nil
Specific Gravity	1.14 – 1.21
Alkaline Content	Less than 55gms

4. Mix DESIGN DATA

Table- 4: W/B = 0.30, Silica-Fume = 0%

M-sand	0%	20%	40%	60%	80%	100%
Cement	719.88	754.65	762.71	835.34	882.52	935.35
SF	0	0	0	0	0	0
Water	215.96	226.39	266.95	250.6	264.76	280.6
C.A	863.86	905.58	915.25	1002.41	1059.02	1122.42
F.A	575.9	482.98	366.1	267.31	141.2	0
M-sand	0	120.74	244.07	400.96	564.81	598.62

Table- 5: W/B = 0.30, Silica-Fume = 10%

M-sand	0%	20%	40%	60%	80%	100%
Cement	643.63	674.5	708.48	746.07	787.87	834.63
SF	71.51	74.94	78.72	82.9	87.54	92.74
Water	214.54	224.83	236.16	248.69	262.62	278.21
C.A	858.17	899.34	944.64	994.76	1050.49	1112.84
F.A	572.12	479.65	377.86	265.27	140.07	0
M-sand	0	119.91	251.91	397.9	560.26	741.9

Table- 6: W/B = 0.30, Silica-Fume = 20%

M-sand	0%	20%	40%	60%	80%	100%
Cement	568.38	595.45	625.24	658.16	694.74	735.62
SF	142.09	148.86	156.31	164.54	173.68	183.9
Water	213.14	223.29	234.46	246.81	260.53	275.86
C.A	852.56	893.18	937.85	987.23	1042.1	1103.43
F.A	568.38	476.36	375.14	263.26	138.95	0
M-sand	0	119.09	250.09	394.89	555.79	735.62

Table- 7: W/B = 0.35, Silica-Fume = 0%

M-sand	0%	20%	40%	60%	80%	100%
Cement	694.87	727.21	762.71	801.85	845.22	893.56
SF	0	0	0	0	0	0
Water	243.2	254.52	266.95	280.65	295.83	312.75
C.A	833.84	872.65	915.25	962.22	1014.27	1072.27
F.A	555.9	465.41	366.1	256.59	135.24	0
M-sand	0	116.35	244.07	384.89	540.94	571.88

Table- 8: W/B = 0.35, Silica-Fume = 10%

M-sand	0%	20%	40%	60%	80%	100%
Cement	621.41	650.14	681.65	716.38	754.83	797.65
SF	69.05	72.24	75.74	79.6	83.87	88.63
Water	241.66	252.83	265.09	278.59	293.55	310.2
C.A	828.55	866.85	908.87	955.17	1006.44	1063.53
F.A	552.36	462.32	363.55	254.71	134.19	0
M-sand	0	115.58	242.37	382.07	536.77	709.02

Table- 9: W/B = 0.35, Silica-Fume = 20%

M-sand	0%	20%	40%	60%	80%	100%
Cement	548.88	574.09	601.72	632.15	665.82	703.29
SF	137.22	143.52	150.43	158.04	166.46	175.82
Water	240.13	251.16	263.25	276.57	291.3	307.69
C.A	823.32	861.13	902.58	948.23	998.74	1054.93
F.A	548.88	459.27	361.03	252.86	133.16	0
M-sand	0	114.82	240.69	379.29	532.66	703.29

Table- 10: W/B = 0.40, Silica-Fume = 0%

M-sand	0%	20%	40%	60%	80%	100%
Cement	671.54	701.70	734.69	770.94	810.95	855.34
SF	0.00	0.00	0.00	0.00	0.00	0.00
Water	268.62	280.68	293.88	308.38	324.38	342.14
C.A	805.85	842.03	881.63	925.13	973.14	1026.41
F.A	537.23	449.09	352.65	246.70	129.75	0.00
M-sand	0.00	112.27	235.10	370.05	519.01	547.42

Table- 11: W/B = 0.40, Silica-Fume = 10%

M-sand	0%	20%	40%	60%	80%	100%
Cement	600.67	627.48	656.78	688.96	724.45	763.8
SF	66.74	69.72	72.98	76.55	80.49	84.87
Water	266.97	278.88	291.9	306.2	321.98	339.47
C.A	800.9	836.63	875.71	918.61	965.94	1018.4
F.A	533.93	446.2	350.28	244.96	128.79	0
M-sand	0	111.55	233.52	367.44	515.17	678.93

Table- 12: W/B = 0.40, Silica-Fume = 20%

M-sand	0%	20%	40%	60%	80%	100%
Cement	530.67	554.2	579.91	608.13	639.22	673.67
SF	132.67	138.55	144.98	152.03	159.81	168.42
Water	265.34	277.1	289.96	304.06	319.61	336.84
C.A	796.01	831.3	869.87	912.19	958.84	1010.51
F.A	530.67	443.36	347.95	243.25	127.84	0
M-sand	0	110.84	231.97	364.88	511.38	673.67

5. RESULTS AND DISCUSSION

Testing on Fresh concrete: Slump Test:

Fig.1: Slump cone test.

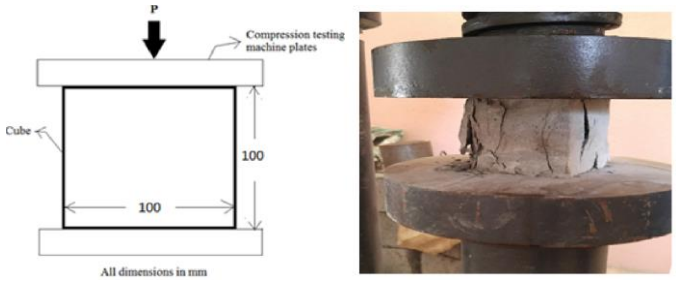
The slump is maintained in between 70 to 90 mm for better workability. The super plasticizer added based on workability (0.5% to 1.9% of cement).

Strength tests (Harden Concrete):

After 7 days and 28 days the cube, cylinder and prisms removed from the curing tank, allow for dry. Testing will be done as per IS 516-1959, the tests are,

Compressive strength: This test will be done using 100mm* 100mm* 100mm cubes.

Fig 2: Compressive test for Cubes



0% Silica Fume		7 days compressive strength in Mpa			28 days compressive strength in Mpa		
W/B Ratio		0.3	0.35	0.4	0.3	0.35	0.4
Sand	M.Sand						
100%	0%	44.22	43.11	41.55	53.55	52.44	50.72
80%	20%	45.33	43.77	42.06	55.26	53.55	52.33
60%	40%	47.11	45.66	43.17	58.55	57.07	54.11
40%	60%	50.66	47.36	45.24	59.88	58.44	57.66
20%	80%	47.33	45.22	43.72	57.42	56.42	54.43
0%	100%	45.11	43.88	42.24	54.36	53.17	52.11
10% of SF		7 days Cubes strength			28days cubes strength		
W/B Ratio		0.3	0.35	0.4	0.3	0.35	0.4
Sand	M.Sand						
100%	0%	50.44	49.11	46.72	59.33	56.62	53.17
80%	20%	52.36	50.32	48.66	61.11	58.11	55.68
60%	40%	55.33	52.11	49.88	63.78	61.14	57.88
40%	60%	58.67	54.88	52.04	66.82	63.92	60.18
20%	80%	55.04	52.33	50.77	63.55	60.04	57.11
0%	100%	51.55	50.62	47.44	60.24	57.06	54.55
20% of SF		7 days cube strength			28 days cube strength		
W/B Ratio		0.3	0.35	0.4	0.3	0.35	0.4
Sand	M.Sand						
100%	0%	42.44	40.88	38.22	50.77	48.24	47.05
80%	20%	43.77	41.22	39.77	52.92	50.33	48.14
60%	40%	45.33	43.55	41.44	55.06	52.76	51.04
40%	60%	48.11	45.66	43.77	57.62	55.06	52.55
20%	80%	45.77	43.02	40.88	54.84	51.92	50.33
0%	100%	42.88	40.92	39.44	51.33	48.66	48.02

Table 13: Compressive Strength of concrete cubes

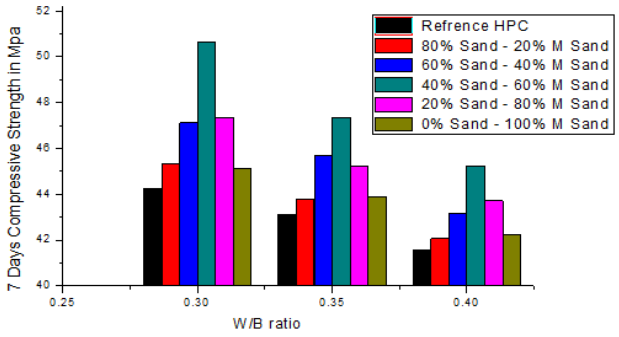


Fig.3: 7 Days Compression Strength of 0% SF

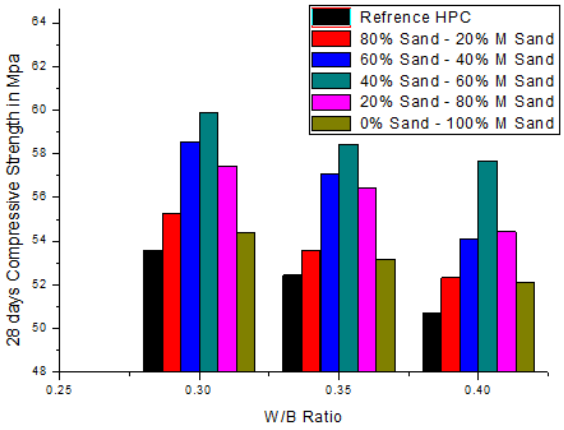


Fig.4: 28 Days Compression Strength of 0% SF

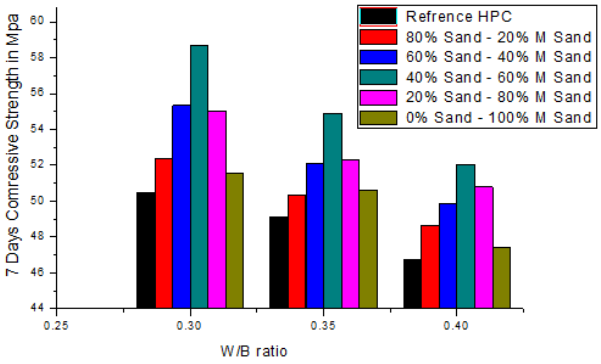


Fig.5: 7 Days Compression Strength of 10% SF

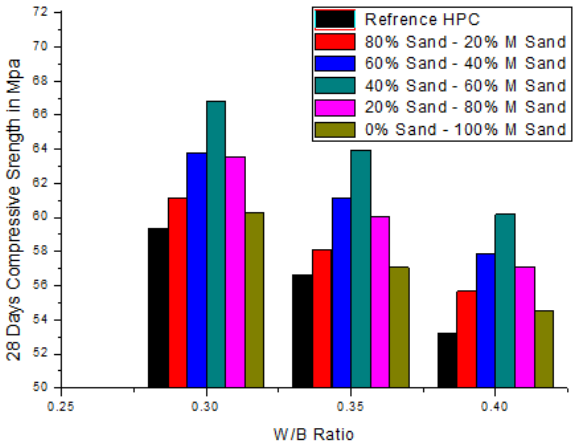


Fig.6: 28 Days Compression Strength of 10% SF

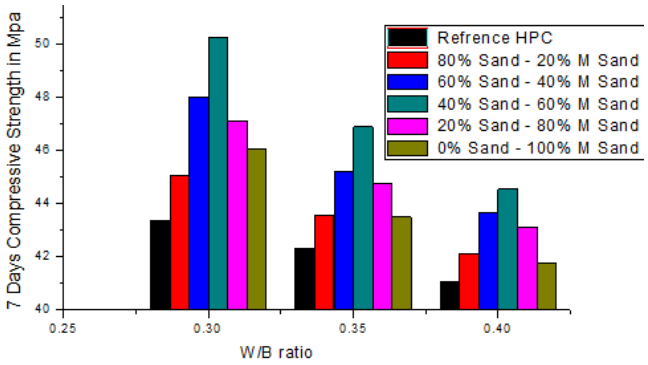


Fig.7: 7 Days Compression Strength of 20% SF

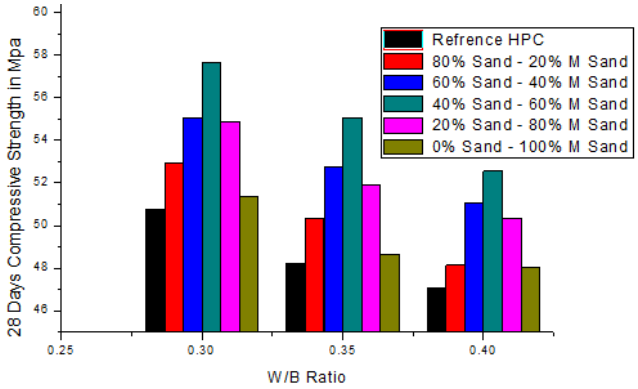


Fig.8: 28 Days Compression Strength of 20% SF

Split tensile strength: This test will be done by using cylinder of dimensions 150mm dia, 300mm height.

Table 14: Split Tensile Strength of concrete cylinders

0% SF		7days Strength(Mpa)			28day Strength(Mpa)		
W/C		0.3	0.35	0.4	0.3	0.35	0.4
Sand	MS						
100%	0%	4.16	4.02	3.84	4.84	4.55	4.44
80%	20%	4.26	4.11	3.96	5.03	4.78	4.52
60%	40%	4.48	4.34	4.07	5.25	4.96	4.74
40%	60%	4.67	4.42	4.22	5.33	5.21	4.92
20%	80%	4.44	4.26	4.11	5.24	4.92	4.71
0%	100%	4.11	4.08	3.92	4.92	4.64	4.55
10% SF		7days Strength in			28 days Strength in		
W/C		0.3	0.35	0.4	0.3	0.35	0.4
Sand	MS						
100%	0%	4.44	4.22	3.93	5.22	5.02	4.72
80%	20%	4.62	4.36	4.06	5.55	5.18	4.94
60%	40%	4.78	4.55	4.22	5.77	5.44	5.12
40%	60%	4.94	4.62	4.34	5.91	5.71	5.38
20%	80%	4.66	4.36	4.16	5.64	5.55	5.11
0%	100%	4.52	4.18	3.88	5.42	5.22	4.86

20%Silica		7days Strength in			28 days Strength in		
W/C		0.3	0.35	0.4	0.3	0.35	0.4
Sand	MS						
100%	0%	3.92	3.88	3.77	4.33	4.21	4.16
80%	20%	4.04	3.97	3.82	4.52	4.36	4.33
60%	40%	4.11	4.22	3.94	4.88	4.72	4.52
40%	60%	4.18	4.33	4.11	5.02	4.98	4.64
20%	80%	4.24	4.16	3.98	4.82	4.66	4.42
0%	100%	3.96	3.92	3.77	4.53	4.33	4.11

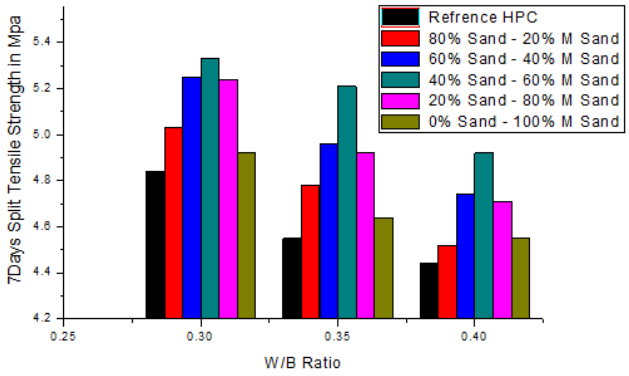


Fig.9: 7 Days Split tensile Strength of 0% SF

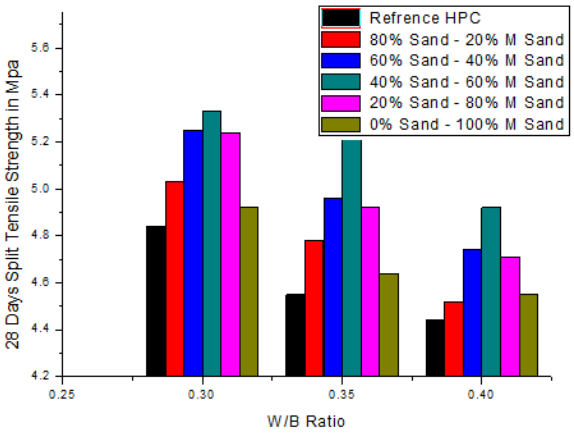


Fig.10: 28 Days Split tensile Strength of 0% SF

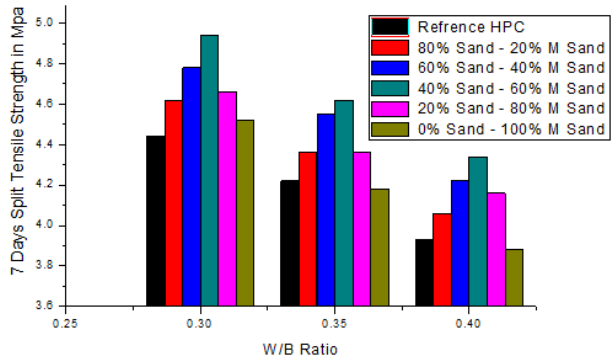


Fig.11: 7 Days Split tensile Strength of 10% SF

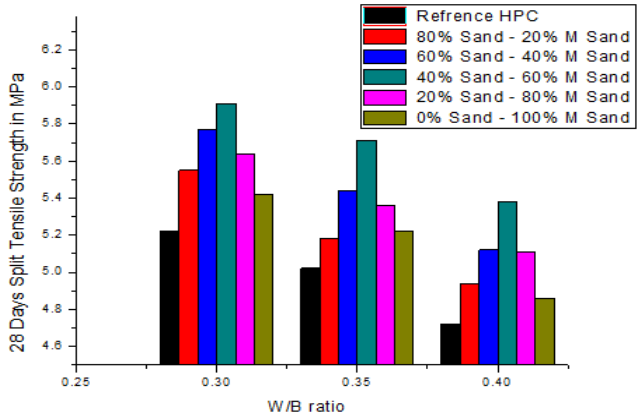


Fig.12: 28 Days Split tensile Strength of 10% SF

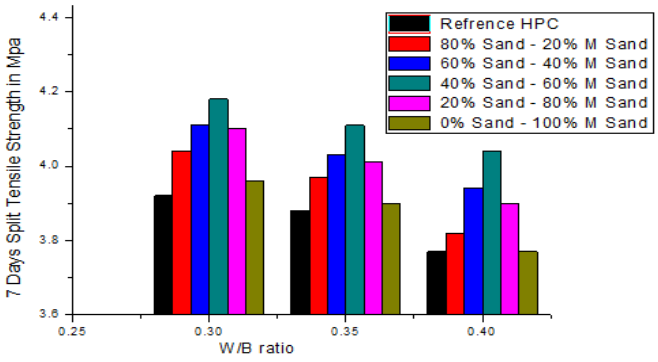


Fig.13: 7 Days Split tensile Strength of 20% SF

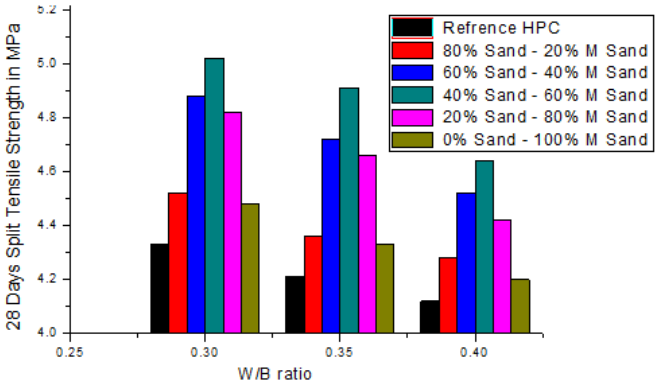


Fig.14: 28 Days Split tensile Strength of 20% SF

Flexural strength test: It can be find out by using 100mm X 100mm X 500mm beams. Under two point loading.

Table 15: Flexural Strength of concrete beams

0% SF		7days Strength(Mpa)			28day Strength(Mpa)		
W/C		0.3	0.35	0.4	0.3	0.35	0.4
Sand	MS						
100%	0%	6.82	6.55	6.06	12.1	11.88	11.44
80%	20%	6.94	6.77	6.33	12.6	12.06	11.77
60%	40%	7.33	6.88	6.66	13	12.44	12.03
40%	60%	7.77	7.22	6.82	13.3	12.92	12.52
20%	80%	7.22	6.77	6.42	12.7	12.55	12.11
0%	100%	6.92	6.33	6.18	12.3	12.03	11.66

10% SF		7days Strength in			28 days Strength in		
W/C		0.3	0.35	0.4	0.3	0.35	0.4
Sand	MS						
100%	0%	7.44	7.03	6.66	13.1	12.55	12.11
80%	20%	7.68	7.22	6.88	13.6	13.06	12.44
60%	40%	7.88	7.42	7.11	13.9	13.44	12.72
40%	60%	8.11	7.66	7.33	14.1	13.77	13.33
20%	80%	7.33	7.22	6.88	13.8	12.88	12.55
0%	100%	7.11	6.88	6.55	13.2	12.66	12.22

20%Silica		7days Strength in			28 days Strength in		
W/C		0.3	0.35	0.4	0.3	0.35	0.4
Sand	MS						
100%	0%	6.33	6.21	5.88	11.7	11.55	11.07
80%	20%	6.46	6.33	6.02	11.9	11.72	11.44
60%	40%	6.72	6.45	6.27	12.1	12.04	11.78
40%	60%	6.91	6.72	6.55	12.3	12.11	11.92
20%	80%	6.66	6.33	6.24	11.9	11.72	11.62
0%	100%	6.35	5.92	5.77	11.4	11.33	10.92

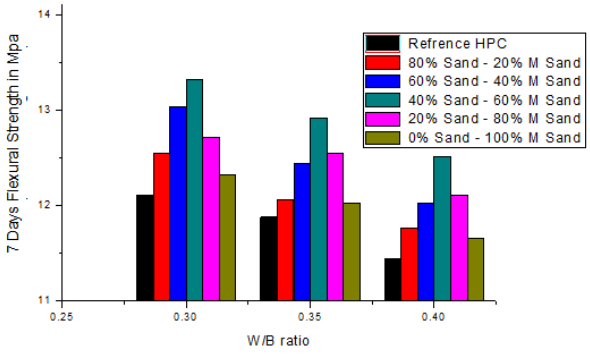


Fig.15: 7 Days Flexural Strength of 0% SF

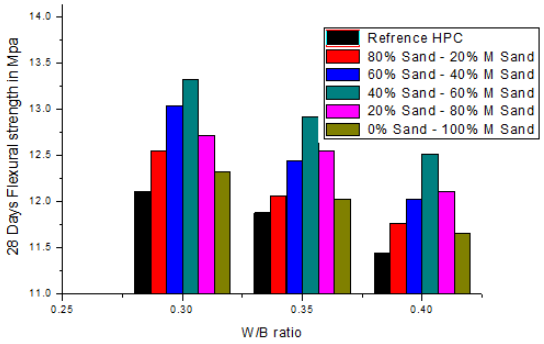


Fig.16: 28 Days Flexural Strength of 0% SF

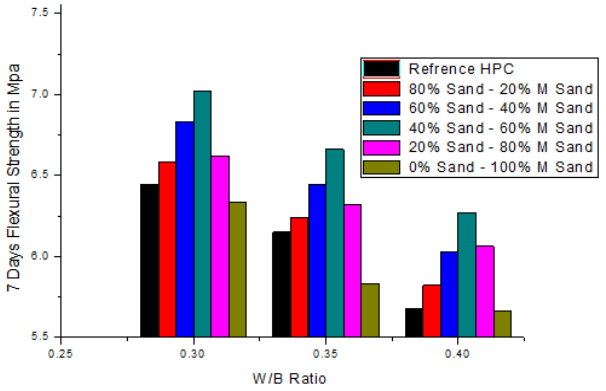


Fig.17: 7Days Flexural Strength of 10% SF

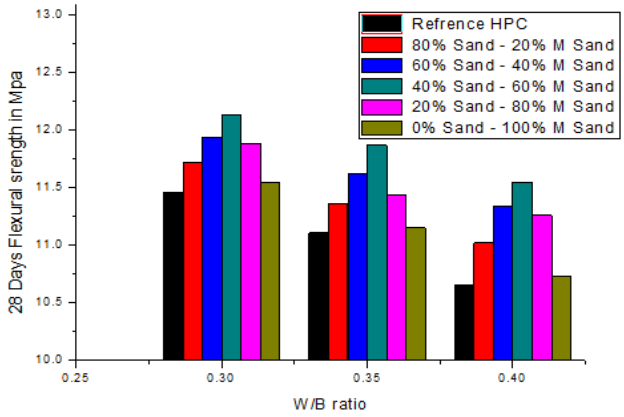


Fig.18: 28 Days Flexural Strength of 10% SF

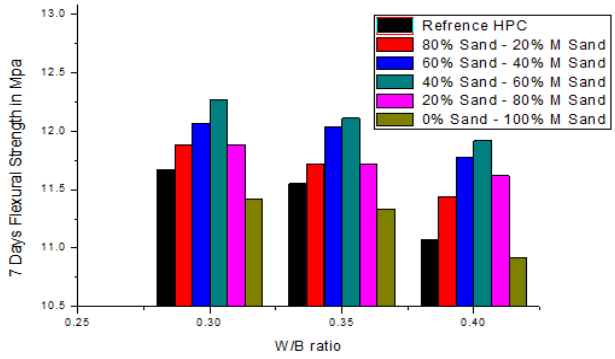


Fig.19: 7Days Flexural Strength of 20% SF

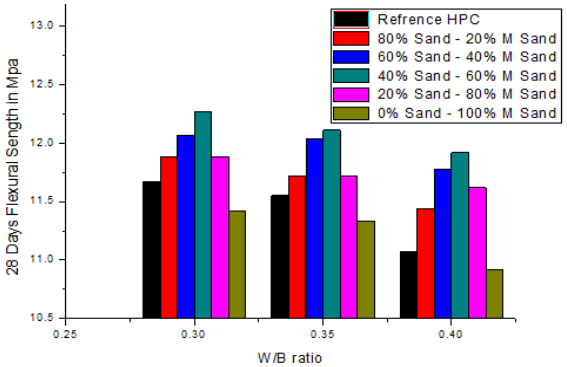


Fig.20: 28 Days Flexural Strength of 20% SF

6. CONCLUSION

1. From the results, 60% of M-Sand in place of river sand which increases 14.57% of compressive strength for 7 days and 11.28% of strength for 28 days when compared with nominal HPC.

2. 10% of Silica Fume replaced with Cement which increases 14.06% and 10.80% of compression strength for 7 and 28 days respectively when compared with nominal HPC.

3. Mix with 60% M-sand and 10% Silica fume gives high compression strength i.e. 24.08% and 24.78% higher strength than the nominal HPC for 7 and 28 days respectively.

4. As water binding ratio increases the compression strength of concrete goes on deceases. From this study are maximum results for 0.30 water binding ratio.

5. As increasing in silica fume content consumption of water will be more as compared to the nominal HPC.

6. The split tensile strength obtained at 60% replace of sand with M-Sand which increases 12.25% of Split tensile strength for 7 days and 10.12% of Split tensile strength for 28 days when compared with nominal HPC.

7. The split tensile strength obtained at 10% replace of cement with silica fume which increases 6.73% of Split tensile strength for 7 days and 7.85% of Split tensile strength for 28 days when compared with nominal HPC.

8. The split tensile strength obtained for the mix of 60% M-sand and 10% Silica fume gives maximum Split tensile strength for water binding ratio of 0.30 i.e. 19.47% and 22.10% higher Split tensile strength than the nominal HPC for 7 days and 28 days respectively.

9. The flexural strength obtained at 60% replace of sand with m-Sand which increases 13.93% of Flexural strength for 7 days and 10.07% strength for 28 days when compared with nominal HPC.

10. 10% of Silica Fume increases 9.09% of Flexural strength for 7 days and 8.25% strength for 28 days when compared with nominal HPC.

11. The flexural strength obtained for the mix of 60% M-sand and 10% Silica fume gives maximum strength for W/B ratio of 0.30 i.e. 18.91% and 16.51% higher strength than the nominal HPC for 7 days and 28 days respectively.

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