A Study On Properties Of Concrete Using Industrial Waste Sand As Partial Replacement Of Fine Aggregate

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Abstract: Concrete is composed of different materials like cement, fine aggregate, coarse aggregate, water, admixture etc. Replacement technique is reliable technique for economical concrete. More over utilization of waste material enhance sustainable development. Several studies have been conducted to investigate effect of utilization of waste material in concrete. So in these study the utilization of industrial waste sand in concrete have been investigated. The natural sand was replaced by 0%, 10%, 20%, 30%, 40%, 50%, 60%. The Series of tests like workability test (Slump test, Compaction Factor Test), Compressive strength test, Split tensile test, Flexural test, were carried out for M-30, M-45 and M-60 grade concrete. In order to check durability of concrete, acid attack test, sulphate attack test, sea water attack test were performed. The result of fresh properties of concrete indicates that there was improvement in workability of concrete when content of waste sand increased. The result of hardened properties of concrete indicates that target mean strength was achieved up to 30% replacement of waste sand with fine aggregate.

Key words: Industrial Waste Sand; Slump Test, Compaction Factor Test, Harden property, Durability property, etc…

1. Introduction

Waste material deposited in huge quantity by open dumping on valuable land. If we start use this waste sand by utilising this sand in concrete, the problem can be solved. This paper is about the use of waste Sand as partial replacement of fine aggregate in concrete. Now a day, sustainable infrastructural growth demands the alternative material that should satisfy technical requirements of natural aggregate. The waste material also should be available large quantity. The cheapest and the easiest way of getting substitute for natural aggregates is use of industrial waste materials which has somehow similar properties with desired size and grade.

2. Materials

2.1 Cement

The OPC 53 Grade cement of sanghi cement conforming of IS 12269-1987 was used for all concrete mixes.

2.2 Aggregates

Fine aggregates used for this study was conforming of IS 383-1987. Fine aggregate size was less than 4.75mm. Coarse aggregates used for this study was conforming of IS 383-1970. Coarse aggregate size was less than 20mm.

Sr no	Coarse aggregate		Fine aggregate	
1	Specific gravity	2.7	Specific gravity	2.77
2	% water absorption	0.8	% water absorption	1.11
3	Moisture contents	nil	Moisture contents	nil

2.3 Water

Potable water available in the collage was used in casting and curing of concrete.

2.3 Industrial waste sand

Ashapura Industries is one of leading industry in the field of making of Kaolin, Bentonite, Bauxite exports and one of the leading bleaching Clay producer. This industry creates lot of waste material from the manufacturing process of raw materials. Sand size 2.36 mm to 4.75 mm can be used in making concrete mix as the partial replacement of fine aggregate.

Sr. No.	Test name	Test result
1	Fineness modules	2.6
2	Specific gravity	2.577
3	Water absorption	0%
4	% passing 75 µ	0.6%

3. Mix Design of Concrete

3.1 Mix Design of Concrete M-30 grade

Sr.No.	Type of Mix	W/C ratio	Cement (kg/cum)	Coarse aggregate (kg/cum)	Fine aggregate (kg/cum)	Waste sand	Water (liter/ cum)
1	0% W.S, 100% F.A.	0.45	380	1174.74	720	0	180
2	10% W.S, 90%F.A	0.45	380	1174.74	72	648	180
3	20% W.S, 80% F.A	0.45	380	1174.74	144	576	180
4	30% W.S, 70% F.A	0.45	380	1174.74	216	504	180
5	40% W.S, 60% F.A	0.45	380	1174.74	288	432	180
6	50% W.S, 50% F.A	0.45	380	1174.74	360	360	180
7	60% W.S, 40% F.A	0.45	380	1174.74	432	288	180

3.2 Mix Design of Concrete M-45 grade

Sr.No.	Type of Mix	W/C ratio	Cement (kg/cum)	Coarse aggregate (kg/cum)	Fine aggregate (kg/cum)	Waste sand	Water (liter/ cum)
1	0% W.S, 100% F.A.	0.42	412	1074.60	706	0	178
2	10% W.S, 90%F.A	0.42	412	1074.60	635.4	70.6	178
3	20% W.S, 80% F.A	0.42	412	1074.60	564.8	141.2	178
4	30% W.S, 70% F.A	0.42	412	1074.60	494.2	211.8	178
5	40% W.S, 60% F.A	0.42	412	1074.60	423.6	282.4	178
6	50% W.S, 50% F.A	0.42	412	1074.60	353	353	178
7	60% W.S, 40% F.A	0.42	412	1074.60	282.4	423.6	178

3.3 Mix Design of Concrete M-60 grade

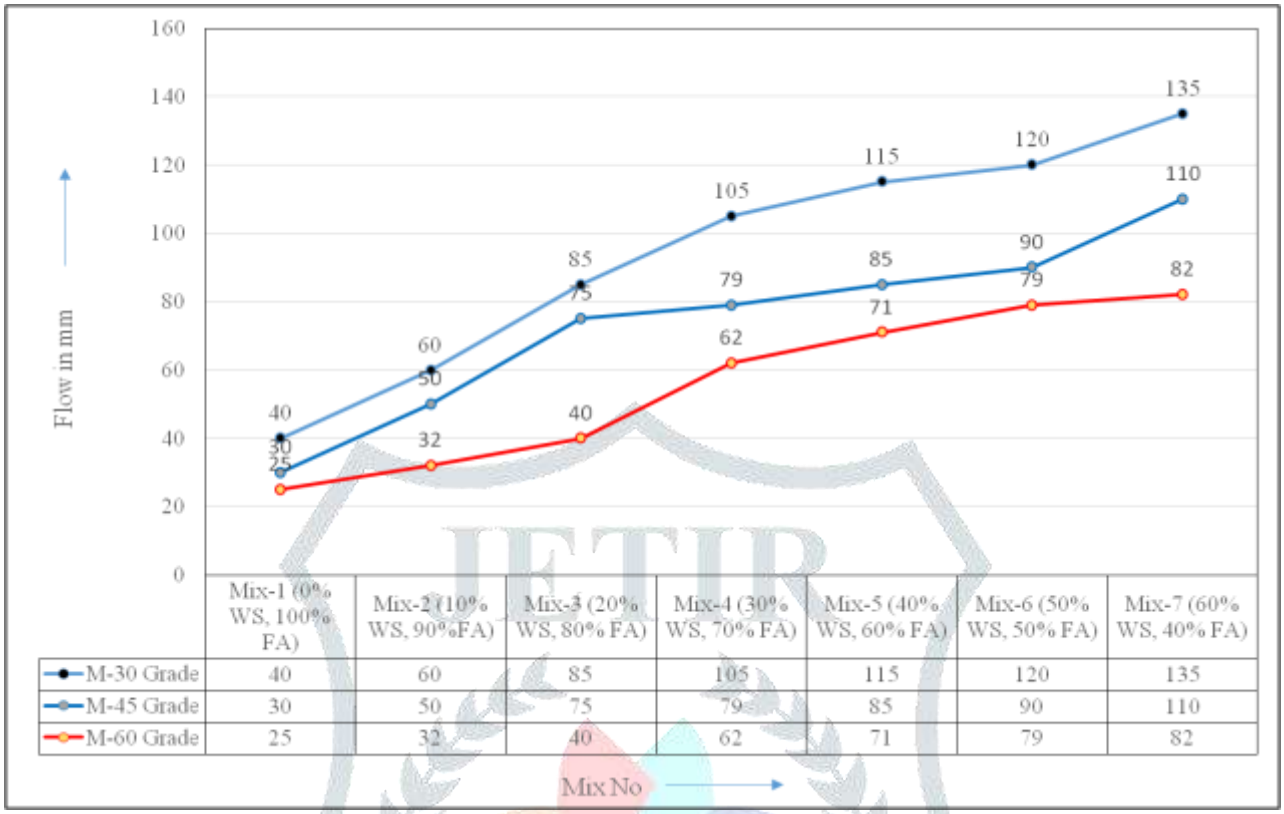
Sr.No.	Type of Mix	W/C ratio	Cement (kg/cum)	Coarse aggregate (kg/cum)	Fine aggregate (kg/cum)	Waste sand	Water (liter/ cum)
1	0% W.S, 100% F.A.	0.39	430	946	831	0	174
2	10% W.S, 90%F.A	0.39	430	946	747.9	83.1	174
3	20% W.S, 80% F.A	0.39	430	946	664.8	166.2	174
4	30% W.S, 70% F.A	0.39	430	946	581.7	249.3	174
5	40% W.S, 60% F.A	0.39	430	946	498.6	332.4	174
6	50% W.S, 50% F.A	0.39	430	946	415.5	415.5	174
7	60% W.S, 40% F.A	0.39	430	946	332.4	498.6	174

3. Fresh properties test results:

		M-30 grade		M-45 grade		M-60 grade	
Sr. No.	Type of Mix	Slump (mm)	Compaction Factor	Slump (mm)	Compaction Factor	Slump (mm)	Compaction Factor
1	0% W.S, 100% F.A.	40	0.85	30	0.82	25	0.79
2	10% W.S, 90%F.A	60	0.857	50	0.83	32	0.81
3	20% W.S, 80% F.A	85	0.885	75	0.87	40	0.86
4	30% W.S, 70% F.A	105	0.915	79	0.9	62	0.88
5	40% W.S, 60% F.A	115	0.925	85	0.92	71	0.9
6	50% W.S, 50% F.A	120	0.933	90	0.925	79	0.91
7	60% W.S, 40% F.A	135	0.947	110	0.94	82	0.92

3.1 Slump test:

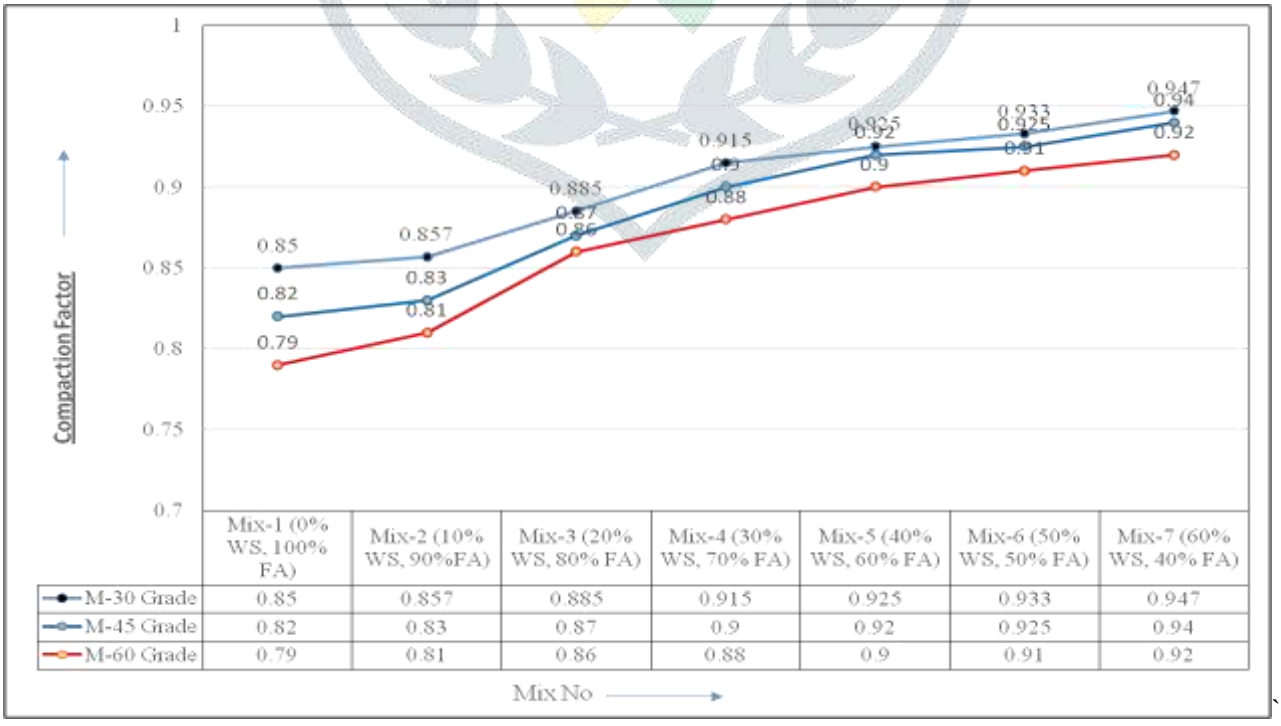
The concrete slump test is used to measures the workability of fresh concrete before it sets. The ease of concrete with which concrete flows. It is also be used as an indicator of an improperly concrete mixed batch. The test is popular due to the very simple steps of using apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions of concrete.



	Mix-1 (0% WS, 100% FA)	Mix-2 (10% WS, 90%FA)	Mix-3 (20% WS, 80% FA)	Mix-4 (30% WS, 70% FA)	Mix-5 (40% WS, 60% FA)	Mix-6 (50% WS, 50% FA)	Mix-7 (60% WS, 40% FA)
M-30 Grade	40	60	85	105	115	120	135
M-45 Grade	30	50	75	79	85	90	110
M-60 Grade	25	32	40	62	71	79	82

3.1 Compaction Factor Test:

It measures the degree of compaction for the standard amount of work and there for offers a direct measurement of the workability of concrete. the test require calculation of the weight of the partially and fully compacted concrete in Kg and the ratio the partially compacted weight to the fully compacted weight is known as compaction factor. Which has always lesser value one. For the normal range of concrete the compacting factor have values between 0.8 - 0.92.



	Mix-1 (0% WS, 100% FA)	Mix-2 (10% WS, 90%FA)	Mix-3 (20% WS, 80% FA)	Mix-4 (30% WS, 70% FA)	Mix-5 (40% WS, 60% FA)	Mix-6 (50% WS, 50% FA)	Mix-7 (60% WS, 40% FA)
M-30 Grade	0.85	0.857	0.885	0.915	0.925	0.933	0.947
M-45 Grade	0.82	0.83	0.87	0.9	0.92	0.925	0.94
M-60 Grade	0.79	0.81	0.86	0.88	0.9	0.91	0.92

4. Harden properties test results:

4.1 Compressive strength result:

The compressive strength of concrete is decreases with increase the percentage of waste Sand. The result of compressive strength of concrete was show as below.

Target mean strength		38.25 MPa	53.25 MPa	68.25 MPa
Sr. No.	**Type of Mix**	**M-30**	**M-45**	**M-60**
1	0% W.S, 100% F.A.	42.67	58.22	74.67
2	10% W.S, 90%F.A	41.78	56.89	73.33
3	20% W.S, 80% F.A	36.89	56.44	72.44
4	30% W.S, 70% F.A	39.11	53.78	68.89
5	40% W.S, 60% F.A	31.56	42.93	55.56
6	50% W.S, 50% F.A	29.78	40.89	52.44
7	60% W.S, 40% F.A	27.56	37.33	48.44

4.2 Flexural Strength result:

The flexural strength of concrete with waste Sand is decreases with increase the percentage of waste Sand. The result of flexural strength are shown as below.

Sr. No.	Type of Mix	M-30	M-45	M-60
1	0% W.S, 100% F.A.	4.16	5.68	7.28
2	10% W.S, 90%F.A	3.86	5.26	6.77
3	20% W.S, 80% F.A	3.24	4.96	6.36
4	30% W.S, 70% F.A	3.11	4.28	5.48
5	40% W.S, 60% F.A	2.96	4.03	5.21
6	50% W.S, 50% F.A	2.73	3.75	4.81
7	60% W.S, 40% F.A	2.54	3.44	4.46

4.3 Split Tensile strength result:

The Split tensile strength of concrete with waste Sand and fly ash is decreases with increase the percentage of waste Sand. The results of split tensile strength of concrete are show as below.

Sr. No.	Type of Mix	M-30	M-45	M-60
1	0% W.S, 100% F.A.	4.5	6.14	7.87
2	10% W.S, 90%F.A	3.76	5.12	6.60
3	20% W.S, 80% F.A	3.78	5.78	7.42
4	30% W.S, 70% F.A	3.44	4.73	6.06
5	40% W.S, 60% F.A	3.2	4.35	5.63
6	50% W.S, 50% F.A	2.81	3.86	4.95
7	60% W.S, 40% F.A	2.64	3.58	4.64

5. Durability test results:

5.1 Acid attack test:

The result shows compressive strength of concrete in HCL solution curing are decreses then the normal water curing.

Sr No.	Mixes	M-30			M-45			M-60		
		Comp Str Mpa	Comp str. after acid attack Mpa	Avg loss of com strength (%)	Comp. Str. Mpa	Comp. stre after acid attack Mpa	Avg loss of com strength (%)	Comp Str. Mpa	Comp stre after acid attack Mpa	Avg loss of com strength (%)
1	0% W.S, 100% F.A.	42.32	40.21	4.99	58.06	56.22	3.17	72.29	70.21	2.88
2	10% W.S, 90%F.A	41.26	39.45	4.39	57.02	55.23	3.14	72.33	69.78	3.53
3	20% W.S, 80% F.A	40.03	38.25	4.45	56.58	53.99	4.58	71.71	68.41	4.60
4	30% W.S, 70% F.A	39.47	37.88	4.03	55.26	52.55	4.90	70.81	67.78	4.28
5	40% W.S, 60% F.A	33.87	31.89	5.85	46.21	43.12	6.69	62.23	59.46	4.45
6	50% W.S, 50% F.A	30.74	29.45	4.20	42.28	39.45	6.69	57.43	54	5.97
7	60% W.S, 40% F.A	28.24	27	4.39	38.77	36.45	5.98	50.32	47.22	6.16

5.2 Sulphate Attack

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.

Sr No.	Mixes	M-30			M-45			M-60		
		Comp Str. Mpa	Comp str. after Sulphate attack Mpa	Avg. loss of com strength (%)	Comp Str Mpa	Comp stre after Sulphate attack Mpa	Avg loss of com strength (%)	Comp Str. Mpa	Comp stre after Sulphate attack Mpa	Avg loss of com strength (%)
1	0% W.S, 100% F.A.	42.32	40.54	4.21	58.06	56.31	3.02	72.29	70.52	2.45
2	10% W.S, 90%F.A	41.26	39.56	4.12	57.02	55.26	3.09	72.33	70.01	3.21
3	20% W.S, 80% F.A	40.03	38.35	4.20	56.58	54.61	3.48	71.71	68.59	4.35
4	30% W.S, 70% F.A	39.47	37.94	3.87	55.26	53.12	3.87	70.81	67.84	4.20
5	40% W.S, 60% F.A	33.87	32.71	3.42	46.21	44.26	4.21	62.23	58.99	5.20
6	50% W.S, 50% F.A	30.74	29.69	3.41	42.28	39.65	6.21	57.43	54.11	5.78
7	60% W.S, 40% F.A	28.24	27.20	3.69	38.77	36.65	5.47	50.32	47.56	5.48

5.2 Sea Water Attack on Concrete

Cubes were immersed in sea water having PH value 8.2 for 28 days. After 28 days of sea water curing of cubes, compressive strength of that cube was calculated. The results obtained are as shown below.

Sr No.	Mixes	M-30			M-45			M-60		
		Comp Str. Mpa	Comp str. after Sulphate attack Mpa	Avg. loss of com strength (%)	Comp Str. Mpa	Comp str. after Sulphate attack Mpa	Avg. loss of com strength (%)	Comp Str. Mpa	Comp str. after Sulphate attack Mpa	Avg. loss of com strength (%)
1	0% W.S, 100% F.A.	42.32	41.81	1.21	58.06	57.42	1.11	72.29	71.60	0.96
2	10% W.S, 90%F.A	41.26	40.86	0.96	57.02	56.59	0.76	72.33	71.70	0.87
3	20% W.S, 80% F.A	40.03	39.72	0.78	56.58	56.15	0.76	71.71	71.18	0.74
4	30% W.S, 70% F.A	39.47	39.03	1.12	55.26	54.70	1.02	70.81	70.13	0.96
5	40% W.S, 60% F.A	33.87	33.21	1.96	46.21	45.43	1.69	62.23	61.32	1.47
6	50% W.S, 50% F.A	30.74	30.09	2.10	42.28	41.48	1.89	57.43	56.46	1.69
7	60% W.S, 40% F.A	28.24	27.55	2.45	38.77	37.95	2.12	50.32	49.37	1.89

6. Conclusion:

- Waste sand has no negative effect in properties of concrete.
- There is improvement in fresh properties of concrete with the increment of waste Sand.
- There is extreme decrement after 30 % replacement of waste sand with fine aggregate.
- In Slump flow test, the result shows that, by replacing the waste sand in fine aggregate, there is increase in the slump.
- In Compaction factor test, the result shows that, by replacing the waste sand in fine aggregate, there is increase in the value of compaction factor.
- In Compressive strength, the results were satisfactory up to 30% replacement. But after 30% replacement the compressive strength was below the target mean strength which is not acceptable.
- In split tensile strength and flexure strength, the results were satisfactory up to 30% replacement. But after 30% replacement the compressive strength was below the target mean strength which is not acceptable.
- In Durability test using HCL solution and MgSo4 Solution in concrete, Results shows that there is **minimum** % loss in HCL was 4.35% at mix 4 (30% W.S. & 70% FA) and in MgSo4 was 6.31% at mix 7 (0% W.S. & 100% FA).
- In Durability test using HCL solution and MgSo4 Solution in concrete, Results shows that there is **Maximum** % loss in HCL was 6.96% at mix 4 (20% W.S. & 80% FA) and in MgSo4 was 7.61% at mix 7 (40% W.S. & 60% FA).
- Sea Water Attack test it was found that there was slight decrease in compressive strength of concrete but one major conclusion found in this test is after curing on sea water, cracks on surface on cube was found. This is not acceptable in construction purpose because cracks on surface of cube will lead to corrosion of steel.

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