Experimental Investigationon Strength Properties of M50 Grade Concrete with Replacement of Fine Aggregate by M-Sand–A Comparative Study with and without using Admixture

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Abstract: ***In India, the conventional concrete is produced by mixing the cement, coarse aggregates and fine aggregates (river sand). In recent years, river sand has become a scarce material due to depletion of natural sources and creating environmental problem of water table depletion. it is essential toidentify an alternative material for fine aggregates (river sand). Mostcommonly indevelopmentof road sector such as theconstruction of high level bridges, elevated corridors and flyovers etc., the M50 Grade concrete is used extensively. Hence experimental investigationis carried out in respect ofworkability, strength and durability properties ofM50 concrete using manufacturedsand as fine aggregates and compared with the conventional concrete values. Using manufactured sand at 70% replacement of fine aggreagate, the compressive strength, split tensile strength and flexural strengthvalues increased by 12.09%, 12.50% and 16.67% respectively with super plasticizer compared to conventional concrete at 28days and 10.50%,11.36% and 11.20% respectivelywithout superplasticizer.Hence M50 concrete with manufacturedsand is found to be suitablefor concrete compared to conventional concrete with natural river sand.The use of manufactured sand is recommended with proper care in production of M50 Grade concrete by satisfying the requirement of gradation.***

Keywords: ***compressive strength,split tensile strength, flexural strength, workability of concrete,super plasticizer.***

I. INTRODUCTON

In India, currently huge number ofinfrastructural development projects are taken up such as highway projects, irrigation projects,power projects and industrial structuresetc., to meet the requirements of future needs. For these developments it is essentially to use large quantity of high strength concrete and in it fine aggregate requirements are about 30-35%. Due to scarcity of natural river sand, other alternative materialsto suit the natural sand properties are studied. Authors carried out investigations with use of 100% quarry dust in place of fine aggregate for conventional concrete grade such as M20, M30 and M40 [1,2, 3] with proper treatment of quarry dust before utilization.For M20, M30, M40 grade concrete gives higher compressive strength, flexural and split tensile strength with using steel fibres [4]. Studies were revealed that for M30 grade concrete better strength achieved by replacement of natual sand with M-sand [5].

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For concrete replacing 50% of natural sand with bottom ash [13] reports increase in compressive strength and flexural strength of concretes M20, M30 and M40 grade was marginally increase by 3.07%, 1.92% and 1.64% respectively.

In the present investiationmanufacturedsand considered for fine aggreageis used in M50 grade concrete. The manufactured sand physical properties are studied and compared with natural sand properties as per the BIS Standards. For the experimental purpose, concrete mix is designed for M50 with target strength of 60M Pa by 100% replacement of natural sand to manufactured sand (M-sand) in the increments of 10% and compared the strengthof concrete with control mix.Experimental investigation is carried out to find the optimum percentage replacement of natural sand by manufactured sand, which gives better strength and durability by with and without water reducing chemical admixture.

II. MATERIALS AND METHODS

2.1. Materials

2.1.1. Cement

Ordinary Port land cement of 53 grade confirming to IS 12269-1989 [7](Penna) is used in the present investigation. The properties of the cement are as follows: specific gravity - 3.15, initial setting time – 33 minutes, final seeting time – 385 minutes and compressive strength as 43.50N/mm2(for 7 days).

2.1.2. Coarse Aggregates

Natural granite with bulk density of 1510 kg/m3, fineness modulus as 6.12 and impact value of 12.50% with water absorption of 0.45% and specific gravity of 2.70 is used in the concrete Mix. The physical properties of coarse aggregate obtained fromtesting is given in Table 1.

2.1.3. Fine Aggregate (Natural river sand)

The natural river sand with specific gravity of 2.6, fineness modulus as 3.25, and water absorption and bulk density is 1.00 and 1460 kg/m3 respectively confirming to zone II of IS 383-1970 [8] is used in the concrete mix design.

2.1.4. Fine Aggregate (MSand)

ManufacturedSand obtained from SRC M-sand produced from VSI crusher, Salem is used in concrete cube, cylinder,and beams casting. The physical properties of M-sand obtained from testing as per Indian standards are given in Table 1.

Table 1. Physical properties of coarse and fine aggregates

S . No	Property	Coarse aggregate	Natural River Sand	M Sand	Test Method
1	Specific Gravity	2.70	2.60	2.45	IS 2386 – Part III - 1963
2	Bull density Kg/m^3	1510	1460	1556	-do-
3	Water absorption (%)	0.45	1.00	2.80	-do-
4	Moisture contents (%)	0.85	1.55	1.20	-do-
5	Fineness modules (%)	6.12	3.25	2.836	-do-
6	Fines less than 0.075 mm (%)	---	5.50	5.30	-do-
7	Sieve Analysis	---	Zone II	Zone II	IS 383 – 1970
8	Aggregate Impact value	12.50			

2.1.5.Admixture

Commercially available super plasticizer CeraPlast300RR(G) has been used to increase the workability and strength of fresh concrete.

2.1.6. Water

Fresh potable water free from organic and inorganic impurities with p^H value of 7 is used for making concrete and curing the concrete cubes, cylinders and beams.

III. METHODOLOGY

3.1. Mix Design

Since there is no specific standard design procedure for concrete mix using manufactured sand, in the current investigation concrete mix is designed using BIS 10262–2009 [9] and BIS456-2000 [10], by assigning the good degree of quality and moderate exposure conditions to achieve a target strength of 60MPa. The mix proportions adopted by weight batching are listed in Table 2.

3.2. Methodology

The methodology includes collection of materials, testing of materials for its physical properties, casting and testing of concrete cubes, cylinders and beams for 7, 14 and 28 days for compressive, split tensile and flexural strength as per BIS Standards.

Table 2. Mix Proportions for M 50 grade concrete for varying replacement of fine aggregate with M sand.

Mix details	Cement (kg/m^3)	Natural sand (kg/m^3)	M Sand (kg/m^3)	Coarse aggregate (kg/m^3)	Water (l/m^3)
M1	440	624	---	1204	154
M2	440	562	62	1204	154
M3	440	499	125	1204	154
M4	440	437	187	1204	154
M5	440	374	250	1204	154
M6	440	312	312	1204	154
M7	440	250	374	1204	154
M8	440	187	437	1204	154
M9	440	125	499	1204	154
M10	440	62	562	1204	154
M11	440	---	624	1204	154

3.3. Mix proportioning and mix details

Concrete mix was designed as per BIS:10262 – 2009 and BIS: 456 – 2000 guide lines for M50 concrete mixes with water cement ratio as 0.35% as per the designed curve and it reduced to 0.33% by adding the admixture(600ml/50kg of cement) to improve the workability and strength. Mix proportions for M50 grade concrete as per the design by replacement of natural sand to manufactured sand from 0%to 100% with increments of 10% is presented in Table No. 2.

3.4. Test specimens and Test procedures

The specimens cubes of sizes 150 mm x 150 mm x 150 mm, cylinders of size 150 mm diameter with 300 mm height and beams of size 100x100x500mm is casted for testing of compressive strength, split tensile strength and flexural strength of concrete. The specimenswere casted for M50 grade concrete by blending the 20 mm metal with 12.5mm metal toget the required gradation as per standards. The workabilityof fresh concreteis measured interms of slump values. For M50 mix the workability is measured without super placicizer and with super plasticizer (500ml/50kg of cement) and slump values are presented in Table. 3.The results of workability,compressive strength, split tensile strength and flexural strength with and without super plasticizer are discussed and compared.

The materials for concrete are properly mixed with concrete mixer machine to get homogenous concrete mix till uniform consistency isachieved. The cubes,cylinders, and beamsarecompacted in moulds properly in layers and is demoulded after 24 hours. It is cured for 7, 14 and 28 days. After proper curing the cubes, cylinders and beamsare tested for compressive, split tensile test and flexural strengthusing compressive testing machine and flexuraltesting machine as per BIS: 516-1959.

Table 3. Workability of M50 concrete for different mixes

Mix Details	Slump (mm)	
	Without superplasticizer	With superplasticizer
M1	51	58
M2	49	60
M3	49	62
M4	47	62
M5	45	65
M6	45	68
M7	42	70
M8	38	70
M9	36	72
M10	36	74
M11	35	74

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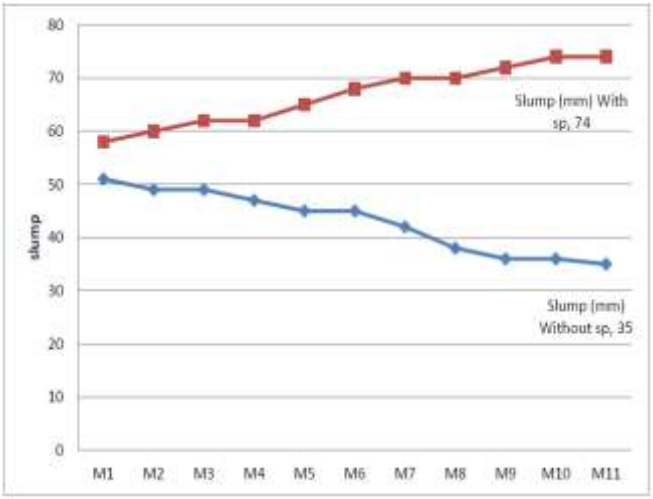

Fig. 1.Workability of concrete for different mixes.

IV. REUSLTS AND DISCUSSIONS

The experimental study shows that, 28 days compressive strength of M50 concrete mix using 100% river sand without admixture is 52.40MPa. However for M50 concrete with 70% replacement of natural sand by M-Sand gives compressive strength of 57.90 MPawhich is 10.50% higher than the controlled concrete.For M50 concrete mix using 100% river sand with admixture yields strength of 61.20MPa at 28 days, however with 70% replacement of natural sand by M-sand yields compressive strength of 68.60MPa with admixture, which is 12.09% higher than the controlled concrete.The compressive strength for M50 concrete for all mixes with age from 7 days,14days and 28days are increasing with M-sand (Table 4, Fig. 2 & Fig. 3). The current investigation reveals that for concrete beyond 70% replacement of replacement of river sand decreases but the strength is more than the required strength of M50. The optimal replacement of river sand is 70% with and without super plasticizer. Replacement of 100% for fine aggregates with M-Sand is also more than the required strength of M50 grade concrete of 53 MPa as per IRC 112-2011[11] and the designed target strength of 60MPa.Hence M-Sandis recommended for M50 concrete mix.

Table4. Compressive strength of various mixes of M50 concrete

S. No	Mix Details	Compressive strength (MPa)					
		7 days		14 days		28 days	
		Without SP	With SP	Without SP	With SP	Without SP	With SP
1	M1	40.00	44.44	50.20	56.80	52.40	61.20
2	M2	40.20	44.40	50.20	56.95	52.80	61.80
3	M3	40.30	45.20	51.14	57.10	52.50	62.50
4	M4	40.50	46.80	52.10	57.10	52.90	66.80
5	M5	40.87	47.40	52.60	58.60	53.50	67.50
6	M6	40.67	47.60	53.20	58.80	54.20	67.80
7	M7	42.92	48.20	54.10	61.50	55.20	67.60
8	M8	43.80	48.60	55.80	62.50	57.90	68.60
9	M9	41.50	45.60	55.60	59.60	56.80	67.50
10	M10	41.50	46.65	54.80	57.60	55.80	67.45
11	M11	41.60	45.85	54.60	56.20	53.60	67.20

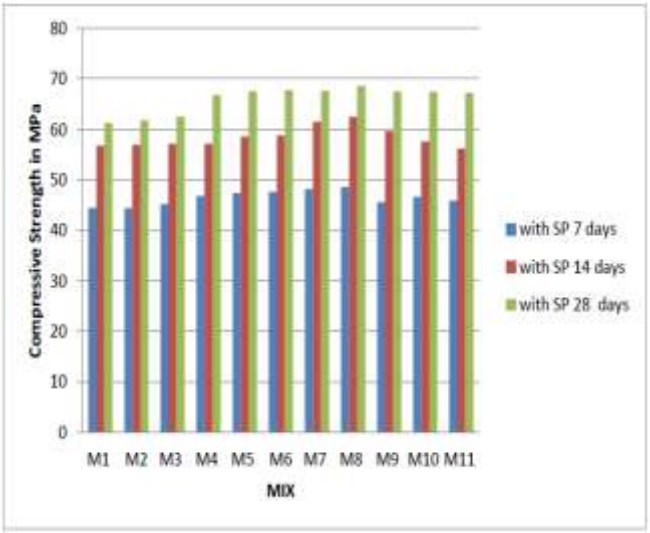

Fig. 2. Compressive strength of various mixes of M50 concrete (with SP)

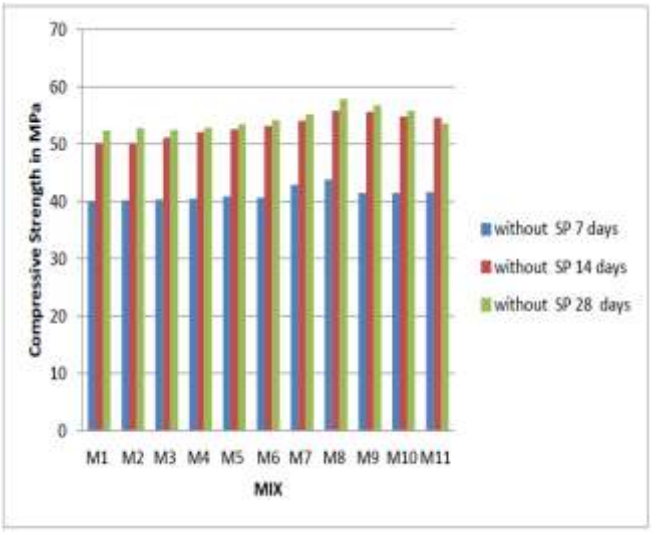

Fig. 3. Compressive strength of various mixes of M50 concrete (without SP)

The split tensile strength for M50 concrete mix with 70% replacement of river sand by M-sand and, with and without superplasticizer is 12.50% and 11.36% respectively, more than the controlled concrete (Table 5, Fig. 4 & Fig. 5). Also 100% replacement of river sand by M-sand yields split tensile strength of 7.2 MPa and 6.68 for with and without plasticizer shows required strength.

Table 5. Split tensile strengths of various mixes of M50 concrete.

Sl No	Mix Details	Split Tensile Strength (MPa)					
		7 days		14 days		28 days	
		Without SP	With SP	Without SP	With SP	Without SP	With SP
1	M1	4.32	4.93	4.96	5.87	6.60	6.80
2	M2	4.32	4.99	4.98	5.95	6.60	6.80
3	M3	4.36	5.08	4.98	6.10	6.65	6.85
4	M4	4.42	5.27	5.08	6.25	7.15	7.25
5	M5	4.48	5.35	5.16	6.25	7.25	7.40
6	M6	4.46	5.56	5.22	6.30	7.20	7.42
7	M7	4.76	5.72	5.28	6.32	7.25	7.45
8	M8	4.80	5.72	5.38	6.35	7.35	7.65
9	M9	4.62	5.29	5.36	5.85	6.85	7.60
10	M10	4.58	5.32	5.39	5.60	6.83	7.25
11	M11	4.52	5.30	5.20	5.75	6.68	7.20

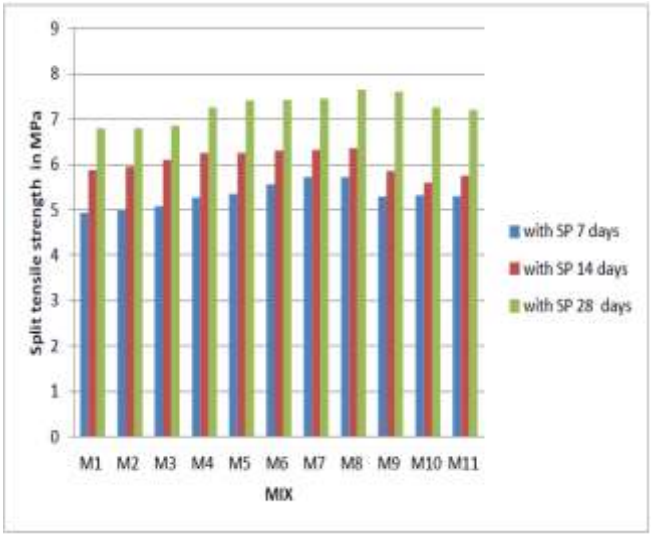

Fig. 4 : Split tensile strengths of various mixes of M50 concrete. (with SP)

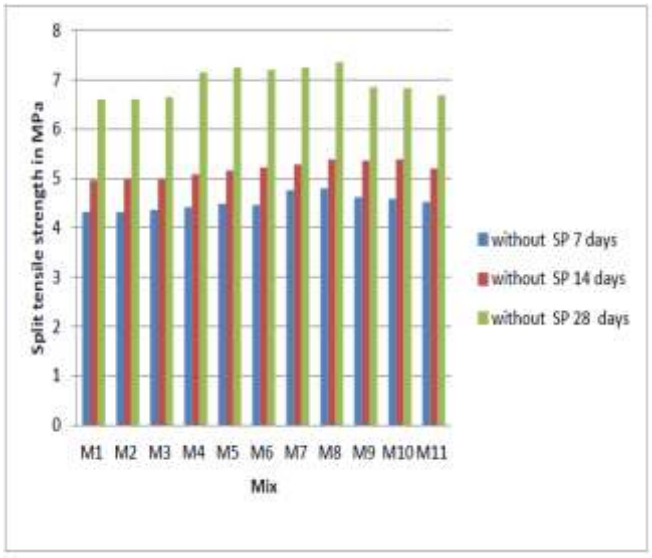

Fig. 5. Split tensile strengths of various mixes of M50 concrete (without SP)

The flexural strength for M50 concrete mix with 70% replacement of river sand by M-sand and, with and without superplasticizer is 16.67% and 11.20% respectively, more than the controlled concrete (Table 6, Fig. 6 & Fig. 7). Also 100% replacement of river sand by M-sand yields flexural strength of 7.2 MPa and 6.36Mpa for with and without plasticizer shows required strength as per BIS.

Table 6. Flexural Strength of various mixes of M50 Concrete

Mix	Flextural Strength MPa					
	7 DAYS		14 Days		28 DAYS	
	Without SP	With SP	Without SP	With SP	Without SP	With SP
M1	4.90	5.10	5.54	6.45	5.98	7.20
M2	4.92	5.22	5.60	6.50	6.15	7.20
M3	4.95	5.20	5.65	6.63	6.25	7.40
M4	5.10	5.30	5.65	6.65	6.28	7.60
M5	5.12	5.325	5.85	6.98	6.32	7.60
M6	5.12	5.535	5.88	6.985	6.35	7.80
M7	5.15	5.32	6.12	7.62	6.45	8.00
M8	5.20	5.585	6.32	7.80	6.65	8.40
M9	5.12	5.35	6.15	6.95	6.50	7.80
M10	5.10	5.40	6.08	6.85	6.48	7.80
M11	4.95	5.80	5.96	6.83	6.36	7.20

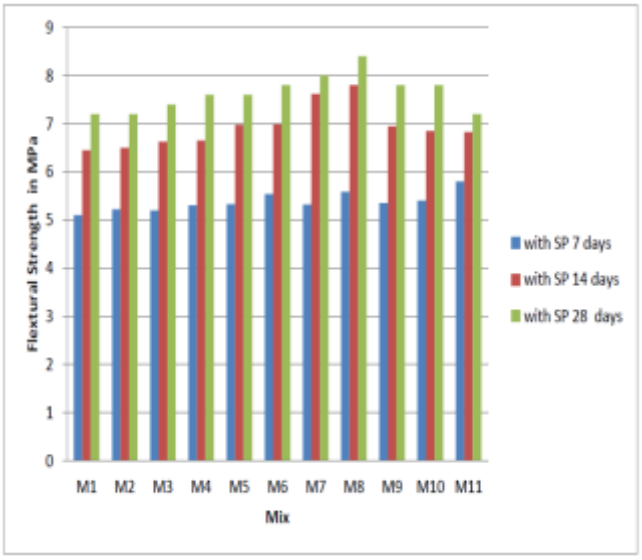

Fig. 6. Flexural Strength of various Mixes of M50 Grade Concrete(with SP)

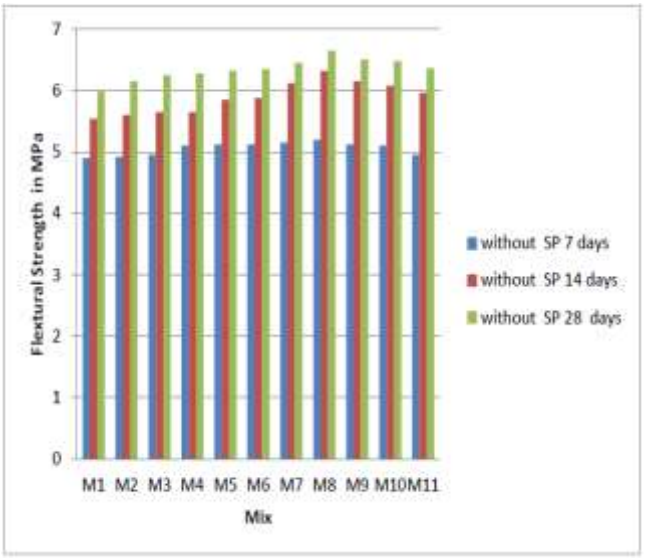

Fig. 6. Flexural Strength of various Mixes of M50 Grade Concrete (without SP)

Aforesaid results encourages the use of manufactured sand in M50 Grade concrete from its demonstatedstrength and workability. However, proper care should be taken in the crusher during crushing and while washing the micorfines of manufactured sand.

V. CONCLUSIONS

In the present study, experimental investigation is carried out for M50 concrete mix to find the optimum percentage replacement of natural sand by manufactured sand, which gives better strength and durability by with and without super placticizer.Conclusions drawn from the current investigations are as follows:

- Compressive strength for M50 concrete mix with 70% replacement of river sand by M-sand and, with and without superplasticizer is 12.09% and 10.50% respectively, more than the controlled concrete for 28 days.
- Split tensile strength for M50 concrete mix with 70% replacement of river sand by M-sand and, with and without superplasticizer is 12.50% and 11.36% respectively, more than the controlled concrete for 28 days.
- Similarly, flexuralstrength for M50 concrete mix with 70% replacement of river sand by M-sand and, with and without superplasticizer is 16.67% and 11.20% respectively, more than the controlled concrete for 28 days
- Even for 100% replacement of river sand by M-sand yields compressive strength, split tensile strength and flexural strength as per BIS.
- Better workability and strength observed for concrete with lower water cement ratio with super plasticizer.

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