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AN EXPERIMANTAL INVESTIGATION OF CONCRETE WITH ARTIFICIAL SAND

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Abstract - *The growth in construction, infrastructural development demands huge quantity of sand. This demand of sand increases progressively with each year. The collection of sand from river beds, stream beds creates environmental problems. Availability of natural sand is getting depleted and costly. This increasing demand and decrease in natural resources consequently necessitate alternative to natural sand. Artificial sand manufactured by granulating good quality stone metal by VSI crusher gives cubical, smooth textured, well graded sand with minimum dust. This overcomes the drawback of natural sand like irregular particle size, improper grading, presence of silt and organic impurities. This paper puts forward the applications of artificial sand as an attempt towards sustainable development. It will help to find viable solution to the declining availability of natural sand and to maintain eco-balance. The purpose of this research is to experimentally investigate properties of concrete with artificial sand by replacing natural sand. The investigation is carried out by conducting various testes on concrete like compressive strength test, flexural strength test, split tensile strength, shear strength test, bond strength test and non- destructive tests like rebound hammer, ultrasonic pulse velocity.*

***Key Words*: Compressive strength, Artificial sand, Rebound hammer, Split tensile test, Flexural strength, Shear strength, Ultrasonic pulse velocity test, Bond strength.**

1. INTRODUCTION

The collection of sand from river beds, stream beds creates environmental problems, such as meandering of water courses, denudation of river banks, interference with natural flow pattern of rivers and streams. availability of natural sand is getting depleted and costly. This increasing demand and decrease in natural resources consequently necessitate alternative to natural sand. Artificial sand manufactured by granulating good quality stone metal by VSI crusher gives cubical, smooth textured, well graded sand with minimum dust. This overcomes the drawback of natural sand like irregular particle size, improper grading, presence of silt and organic impurities. The use of artificial sand will be one of the most preferred alternatives for natural sand. Increasing use of artificial sand is very essential in production of concrete.

2. RESERCH SIGNIFICANCE

The main objective of the present work is to study the properties of concrete with artificial sand, by replacing natural sand with artificial sand partially and fully (from 10% to 100% with an increment of 10% for each mix). The mix design is done for M20 and M45 grade of concrete by using IS 10262:1982. The effect of artificial sand on workability also studied and super plasticizers are used to improve workability. The investigation is carried out by conducting various tests on concrete at plastic stage and hardened stage.

3. MATERIALS AND MATERIALS PROPERTIES

Aggregate- Fine aggregates i.e. Artificial Sand is available from local sources, and Natural sand from local suppliers

Coarse aggregates (CA I = 10mm and CA II = 20mm) are used.

Table No 1: Summary of Material Properties- Artificial sand and Natural sand

Properties	Artificial sand	Natural sand
Specific Gravity	2.76	2.70
Fineness Modulus	2.99	2.76
Water Absorption	3.6%	3.2%
Particle shape	Angular-Cubical	Rounded-Cubical
Surface texture	Smooth to partly rough	Smooth

Table No 2: Summary of Material Properties- CA II(20mm) and CA I(10mm)

Properties	Coarse aggregate CA II (20mm)	Coarse aggregate CA I (10mm)
Specific Gravity	2.88	2.90
Fineness Modulus	7.24	6.33
Water Absorption	0.9%	1%
Particle shape	Angular-Cubical	Angular-Cubical
Surface moisture	Nil	Nil
Surface texture	Rough	Rough

Table No 3: Summary of Material Properties- Cement Ordinary Portland Cement of 53 grade

Properties	Results	IS 12269: 1987 Specifications
Specific Gravity	3.15	-
Fineness	3.5%	Not exceed 10%
Standard consistency	29%	25% to 30%
Soundness	4%	Not exceed 10%
Initial setting time	105 min	More than 30 min
Final setting time	205 min	Less than 600 min

4. EXPERIMENTAL PROGRAMME

Mix design was done for M20 and M45 concrete as per the Indian standard code specifications (IS 10262-2007) The mix proportion is 1:1.43:3.11 for M20 and 1:2.3:3.2 for M45.

Table No 4: Quantities of Materials required for Concrete

Materials	M20 (kg per m^3)	M45(kg per m3)
Cement (kg)	383	362
Fine Aggregate (kg)	549	838
Coarse Aggregate (kg)	1193	1157
Water (lit)	191	160

Table No 5: Results of workability of concrete for M20 (W/C ratio: 0.5)

% Of A.S	Slump in mm Without super plasticizer	Compaction Factor	Admixture Dose in %	Slump after super Plasticizer addition
0	70	0.90	0	70
10	64	0.88	0.1	72
20	57	0.87	0.2	74
30	49	0.85	0.3	70
40	38	0.84	0.4	68
50	29	0.82	0.5	66
60	24	0.81	0.6	64
70	20	0.80	0.7	64
80	16	0.79	0.8	62
90	12	0.78	0.9	60
100	8	0.77	1	60

i. Compressive strength-

The specimens of standard cube of (150mm x 150mm x 150mm) are used to determine the compressive strength and of concrete. Three specimens were tested for 7,14,28 days with replacement of natural sand by artificial sand from 10% to 100% with an increment of 10% for each mix.

ii. Split Tensile Test-

Splitting tensile strength is an indirect method used for determining the tensile strength of concrete. Tests are carried out on 150mm x300mm cylinders conforming to IS 5816: 1976.

iii. Flexural strength Test-

Two-point loading method used for determining the flexural strength of concrete. Tests are carried out on 150mm x 150mm x 700mm beam specimens conforming to IS 516: 1959.

iv. Shear strength Test-

Tests are carried out on 150mm x 150mm x 450mm push off specimens.

5. EXPERIMENTAL RESULTS

Table No 6: Compressive Strength for M20 (0% A.S and 100% N.S)

Sample No.	Age of specimen	Mark	Load at Failure (Ton)	load in (KN)	Compressive Strength (MPa)	Avg. Compressive Strength (MPa)
1.	7 days	C1	36	353.16	15.696	17.294 > 13.5 (IS recommended)
2.		C2	40	392.40	17.440	
3.		C3	43	421.83	18.748	
1.	14 days	C1	46	451.26	20.056	21.800 > 17.5 (IS recommended)
2.		C2	50	490.50	21.800	
3.		C3	54	529.74	23.544	
1.	28 days	C1	58	568.98	25.288	26.741 > 20 (IS recommended)
2.		C2	61	598.41	26.596	
3.		C3	65	637.65	28.340	

Table No 7: Compressive Strength for M20 (60% A.S and 40% N.S)

Sample No.	Age of specimen	Mark	Load at failure (Ton)	Load in (KN)	Compressive Strength (MPa)	Avg. Compressive Strength (MPa)
1.	7 days	C1	51	500.31	22.236	22.381 > 13.5 (IS recommended)
2.		C2	52	510.12	22.672	
3.		C3	51	500.31	22.236	
1.	14 days	C1	58	568.98	25.288	25.869 > 17.5 (IS recommended)
2.		C2	59	578.79	25.724	
3.		C3	61	598.41	26.596	
1.	28 days	C1	72	706.32	31.392	31.828 > 20 (IS recommended)
2.		C2	74	725.94	32.264	
3.		C3	73	716.13	31.828	

Table No 8: Compressive Strength for M20 (100% A.S and 0% N.S)

Sample No.	Age of specimen	Mark	Load at failure (Ton)	Load in (KN)	Compressive Strength (MPa)	Avg. Compressive Strength (MPa)
1.	7 days	C1	42	412.02	18.312	18.457 >13.5 (IS recommended)
2.		C2	40	392.40	17.440	
3.		C3	45	441.45	19.620	
1.	14 days	C1	56	549.36	24.416	24.125 > 17.5 (IS recommended)
2.		C2	53	519.93	23.108	
3.		C3	57	559.17	24.852	
1.	28 days	C1	69	676.89	30.084	29.648 > 20 (IS recommended)
2.		C2	67	657.27	29.212	
3.		C3	68	667.08	29.648	

Table No 9: Split Tensile Strength for M20 (0% A.S and 100% N.S)

Sample No.	Age of specimen	Mark	Maximum load (Ton)	Load in (KN)	Tensile Strength (MPa)	Avg. Tensile Strength (MPa)
1.	7 days	C1	10	98.10	1.388	1.388
2.		C2	11	107.91	1.527	
3.		C3	9	88.29	1.249	
1.	14 days	C1	15	147.15	2.082	2.082
2.		C2	16	156.96	2.221	
3.		C3	14	137.34	1.943	
1.	28 days	C1	22	215.82	3.053	3.006
2.		C2	22	215.82	3.053	
3.		C3	21	206.01	2.914	

Table No 10: Split Tensile Strength for M20 (60% A.S and 40% N.S)

Sample No.	Age of specimen	Mark	Maximum load (Ton)	Load in (KN)	Tensile Strength (MPa)	Avg. Tensile Strength (MPa)
1.	7 days	C1	16	156.96	2.221	1.989
2.		C2	15	147.15	2.082	
3.		C3	15	147.15	2.082	
1.	14 days	C1	22	215.82	3.053	2.960
2.		C2	23	225.63	3.192	
3.		C3	24	235.44	3.331	
1.	28 days	C1	25	245.25	3.608	3.423
2.		C2	27	264.87	3.470	
3.		C3	26	255.06	3.192	

Table No 11: Tensile Strength for M20 (100% A.S and 0% N.S)

Sample No.	Age of specimen	Mark	Maximum load (Ton)	Maximum load (KN)	Tensile Strength (MPa)	Avg. Tensile Strength (MPa)
1.	7 days	C1	11	107.91	1.527	1.527
2.		C2	12	117.72	1.665	
3.		C3	10	98.100	1.388	
1.	14 days	C1	15	147.15	2.082	2.221
2.		C2	17	166.77	2.359	
3.		C3	16	156.96	2.221	
1.	28 days	C1	24	235.44	3.331	3.285
2.		C2	23	225.63	3.192	
3.		C3	24	235.44	3.331	

Table No 12: Flexural Strength for M20 (0% A.S and 100% N.S)

Sample No.	Age of specimen	Mark	Maximum load (KN)	Maximum load (N)	Flexural Strength (MPa)	Avg. Flexural Strength (MPa)
1.	7 days	C1	8.160	8160	1.692	1.538
2.		C2	6.870	6870	1.425	
3.		C3	7.220	7220	1.498	
1.	14 days	C1	11.65	11650	2.416	2.246
2.		C2	10.00	10000	2.074	
3.		C3	10.84	10840	2.248	
1.	28 days	C1	15.91	15910	3.300	3.345 > 3.13 (IS recommended)
2.		C2	15.65	15650	3.246	
3.		C3	16.82	16820	3.489	

Table No 13: Flexural Strength for M20 (60% A.S and 40% N.S)

Sample No.	Age of specimen	Mark	Maximum load (KN)	Maximum load (N)	Flexural Strength (MPa)	Avg. Flexural Strength (MPa)
1.	7 days	C1	9.350	9350	1.939	1.871
2.		C2	8.740	8740	1.813	
3.		C3	8.970	8970	1.860	
1.	14 days	C1	15.240	15240	3.161	2.992
2.		C2	14.120	14120	2.929	
3.		C3	13.910	13910	2.885	
1.	28 days	C1	19.215	19215	3.985	3.986 > 3.13 (IS recommended)
2.		C2	19.835	19835	4.114	
3.		C3	18.610	18610	3.860	

Table No 14: Flexural Strength for M20 (100% A.S and 0% N.S)

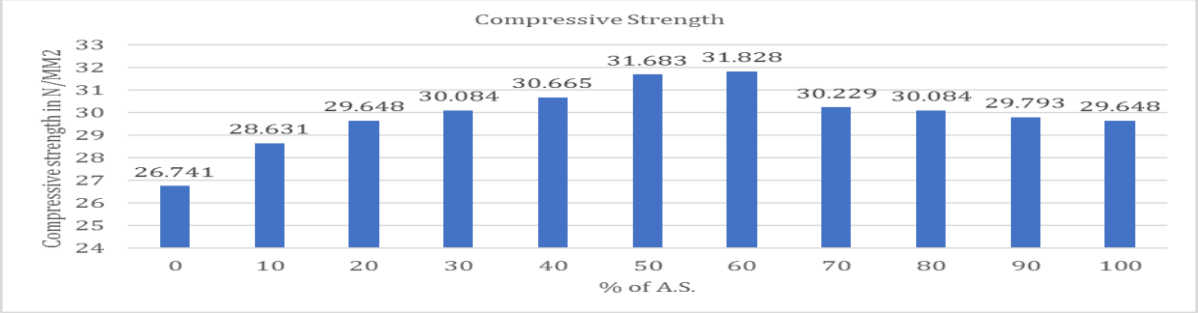
Sample No.	Age of specimen	Mark	Maximum load (KN)	Maximum load (N)	Flexural Strength (MPa)	Avg. Flexural Strength (MPa)
1.	7 days	C1	8.770	8770	1.819	1.614
2.		C2	7.420	7420	1.539	
3.		C3	7.160	7160	1.485	
1.	14 days	C1	12.500	12500	2.592	2.412
2.		C2	11.650	11650	2.416	
3.		C3	10.750	10750	2.229	
1.	28 days	C1	18.650	18650	3.868	3.667 > 3.13 (IS recommended)
2.		C2	16.880	16880	3.501	
3.		C3	17.500	17500	3.630	

Table No 15: Shear Strength for M20 (60% A.S and 40% N.S)

Sample No.	Age of specimen	Mark	Maximum load (KN)	Maximum load (N)	Shear Strength (MPa)	Avg. Shear Strength (MPa)
1.	7 days	C1	44.040	44040	1.957	1.994
2.		C2	44.870	44870	1.994	
3.		C3	45.690	45690	2.031	
1.	14 days	C1	66.260	66260	2.945	2.961
2.		C2	67.630	67630	3.006	
3.		C3	65.980	65980	2.932	
1.	28 days	C1	76.820	76820	3.414	3.455
2.		C2	77.910	77910	3.463	
3.		C3	78.480	78480	3.488	

Table No 16: Shear Strength for M20 (100% A.S and 0% N.S)

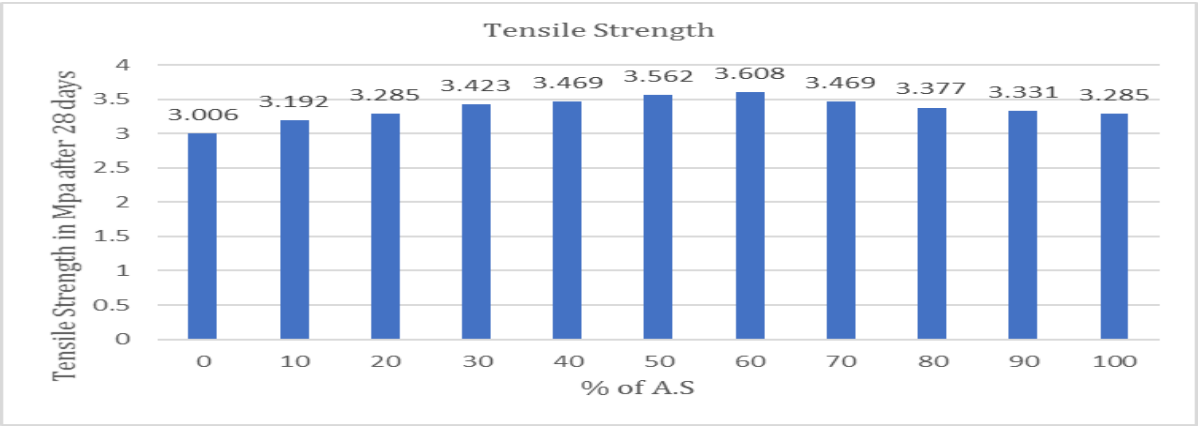
Sample No.	Age of specimen	Mark	Maximum load (KN)	Maximum load (N)	Shear Strength (MPa)	Avg. Shear Strength (MPa)
1.	7 days	C1	40.600	40600	1.804	1.862
2.		C2	43.800	43800	1.946	
3.		C3	41.375	41375	1.838	
1.	14 days	C1	64.500	64500	2.867	2.774
2.		C2	61.900	61900	2.751	
3.		C3	60.870	60870	2.705	
1.	28 days	C1	72.350	72350	3.216	3.188
2.		C2	71.860	71860	3.194	
3.		C3	70.970	70970	3.154	



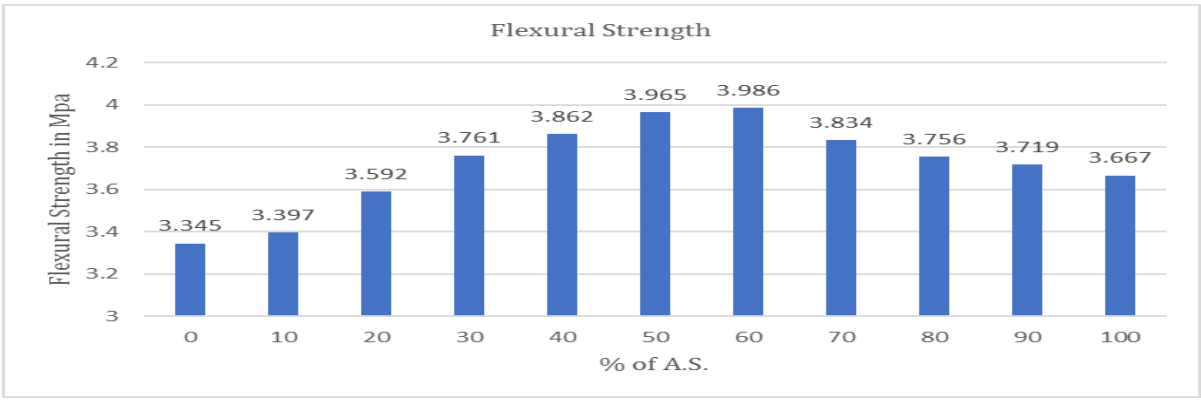
Graph-1: Variation of Compressive Strength w.r.to % of Artificial Sand

Fig 1: Compressive Test for Stress-Strain

Fig 2: Flexure Test for Load-Deflection



Graph-2: Variation of Tensile Strength w.r.to % of Artificial Sand



Graph-3: Variation of Flexural Strength w.r.to % of Artificial Sand

Fig 3: Reinforcement for shear specimen

Fig 4: Testing of shear specimen

6. RESULTS DISCUSSION AND CONCLUSIONS

1) Maximum Compressive strength observed at 60% replacement of natural sand by artificial sand and increase in strength is 19.02%. At 100% replacement of natural sand by artificial sand strength is 10.88% more than mix with natural sand. As the percentage of artificial sand increases compressive strength also increases linearly up to 60%. At 100% replacement of natural sand by artificial sand compressive strength is still higher than that obtained with natural sand.

2) Tensile Strength for mix with 60% artificial sand strength is maximum and 20% more than mix with natural sand. At 100% replacement of natural sand by artificial sand is 9.28% more than mix with natural sand. As the percentage of artificial sand increases tensile strength also increases linearly up to 60% of artificial sand. After that further increase of artificial sand causes reduction in tensile strength, at 100% replacement of natural sand by artificial sand tensile strength is still higher than that obtained with natural sand.

3) Strength for mix with 60% artificial sand strength is maximum and 19.163% more than mix with natural sand. At 100% replacement of natural sand by artificial sand strength is 9.6% more than mix with natural sand. As the percentage of artificial sand increases flexural strength also increases linearly up to 60%.

4) Shear strength for mix with 60% artificial sand is maximum and 14.253% more than mix with natural sand. At 100% replacement of natural sand by artificial sand strength is 5.42% more than mix with natural sand. As the % of artificial sand increases shear strength also increases linearly up to 60%.

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