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Use of Crushed Stone Sand in Lieu of Natural Sand for Making of Concrete

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Abstract:
This paper deals with assessing suitability of crushed stone sand in replacement of natural sand for making of concrete. For an internal study at Maharashtra Engineering Research Institute Nashik, five types of concrete specimens were cast in the laboratory using natural sand & OPC 43 conforming to IS 8112 – 1989. Likewise, exactly five similar types of concrete specimens were cast using crushed stone sand & OPC 43. Applying the same concept, similar five types of concrete specimens with same mix proportions as used above were cast using natural sand & PPC conforming to IS 1489 (Part 1) - 1991. Likewise, exactly five similar types of concrete specimens were cast using crushed stone sand & PPC. Thus, an equal opportunity was provided to natural sand and crushed stone sand for making of all ten sets of concrete specimens. Compressive strengths at various ages were observed for each concrete specimen. Also, flexural strength at 28th day was observed for every concrete specimen. Comparative study reveals that crushed stone sand can be used in replacement of natural sand for making of concrete if it satisfies the specifications laid down in IS 383 – 1970 (revised in 2019) and also it is available at lower price as compared to natural sand.

Keywords*: Crushed stone sand, natural sand, OPC, PPC, compressive strength*

INTRODUCTION

Necessity of the Research

It is observed that availability of natural sand is being reduced day by day due to construction of various dams having un-gated or inadequately gated spillways. Also the demand is continuously increasing due to rapid infrastructure development. So, acute shortage of natural sand is to be overcome by provision of alternative fine aggregate i.e. crushed stone sand.

Methodology for Experimental Study

For effective comparison, equal opportunity was provided to natural sand & crushed stone sand and their performances were noted in terms of compressive strengths and flexural strengths. Hence, taking all other ingredients in same quantity (cement, coarse aggregates & water), one mix was cast using natural sand and the other mix was cast using crushed stone sand.(8,9) Total 6 sets of mixes were cast using natural sand as fine aggregate (one each for M10, M15 & M20 using OPC 43 as the binder and one each for M10, M15 & M20 using PPC as the binder) as per the nominal mix design proportions given in table no. 9 of I.S. 456 - 2000.(6) Likewise, total 6 sets of mixes were cast using crushed stone sand as fine aggregate (one each for M10, M15 & M20 using OPC 43 and one each for M10, M15 & M20 using PPC) as per the nominal mix design proportions given in table no. 9 of I.S. 456 - 2000.(3) In addition to these, 4 sets of concrete mixes of higher grades were cast in the laboratory using natural sand as fine aggregate (two with OPC & the other two with PPC).

May-June 2020
ISSN: 0193-4120 Page No. 9334 - 9337

Likewise, 4 sets of concrete mixes of higher grades were cast in the laboratory using crushed stone sand as fine aggregate (two with OPC & the other two with PPC). For M10 & M15 grade concretes, nominal mix proportions were adopted in totality as per guidelines mentioned in the clause no. 9.3, table 9, p. no. 23 of IS 456 – 2000.(4,5) But for M20 grade concrete, quantity of water used was kept less than the maximum allowable limit. Electrically operated tilting type batch mixer was used for concrete mixing. Concrete cube specimens were compacted using table vibrator(10,11). Proportions & properties of all concrete grades referred above are mentioned in table no. 2. For comparison, strengths of various types of concrete mixes cast using natural sand & crushed stone sand are shown in graphs 1 to 5.(2,7)

Computation of Target Mean Compressive Strength

(As per guidelines in clause no. 3.2, IS 10262 - 2009)

f'ck = fck + 1.65 s

f'ck = Target mean compressive strength @ 28 days in N/mm^2

fck = Characteristic compressive strength @ 28 days in N/mm^2

s = Standard deviation in N/mm^2

Assume, s = 3.5 for M10 & M15

s = 4.0 for M20 & M25.

s = 5.0 for M30 to M55.

Table 1 : Computation of Target Mean Compressive Strength(1)

Grade of concrete	**s** (N/mm^2)	**fck** (N/mm^2)	**f'ck** (N/mm^2)
M10	3.5	10	**15.78**
M15	3.5	15	**20.78**
M20	4.0	20	**26.60**
M25	4.0	25	**31.60**
M30	5.0	30	**38.25**
M35	5.0	35	**43.25**
M40	5.0	40	**48.25**

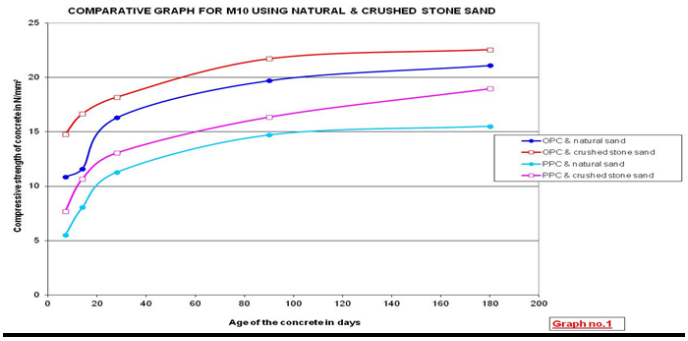
I. Table 2 : Mix proportions of concrete, Slump, Flexural strength & Compressive strengths

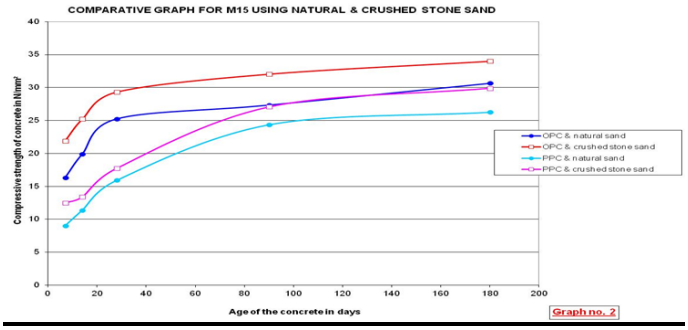
Sr No	Notation of the concrete Mix.	Quantity of various ingredients in Kg.									Slump in mm	Flexural strength in N/mm^2	Compressive Strength of concrete in N/mm^2					Expected grade of concrete	Observed grade of concrete
		Cement		Water	Coarse Aggregate			Fine Aggregate		Plasti-cizer (in ml)			7 days	14 days	28 days	90 days	180 days		
		OPC 43	PPC	(Litre)	40 MSA	20 MSA	10 MSA	Natural sand	Crushed stone sand										
1	NO-10	50	-	34	106.667	106.667	106.667	160	-	-	0	3.07	10.87	11.6	16.29	19.7	21.09	M10	M10
2	CO-10	50	-	34	106.667	106.667	106.667	-	160	-	0	3.15	14.76	16.64	18.18	21.71	22.55	M10	M10
3	NP-10	-	50	34	106.667	106.667	106.667	160	-	-	0	1.80	5.50	8.06	11.29	14.71	15.51	M10	M7.5
4	CP-10	-	50	34	106.667	106.667	106.667	-	160	-	0	2.06	7.69	10.67	13.06	16.35	18.96	M10	M7.5
5	NO-15	50	-	32	73.333	73.333	73.333	110	-	-	35	3.35	16.31	19.91	25.24	27.33	30.64	M15	M15
6	CO-15	50	-	32	73.333	73.333	73.333	-	110	-	20	3.9	21.91	25.20	29.33	32.05	34.01	M15	M15
7	NP-15	-	50	32	73.333	73.333	73.333	110	-	-	30	2.70	9.02	11.38	15.91	24.35	26.25	M15	M10
8	CP-15	-	50	32	73.333	73.333	73.333	-	110	-	30	2.80	12.49	13.38	17.73	27.05	29.89	M15	M10
9	NO-20	50	-	26.11	55.555	55.555	55.555	83.33	-	-	65	4.70	21.42	27.33	32.22	39.47	42.07	M20	M25
10	CO-20	50	-	26.11	55.555	55.555	55.555	-	83.33	-	50	4.90	20.93	26.98	33.47	41.80	43.75	M20	M25
11	NP-20	-	50	26.11	55.555	55.555	55.555	83.33	-	-	50	4.06	17.42	20.70	25.01	38.04	40.51	M20	M15
12	CP-20	-	50	26.11	55.555	55.555	55.555	-	83.33	-	40	4.25	19.64	21.69	29.07	40.20	41.68	M20	M20
13	NO-25	50	-	22.62	Nil	71.430	71.430	71.43	-	-	45	5.87	28.19	30.98	40.20	48.86	54.43	M25	M30
14	CO-25	50	-	22.62	Nil	71.430	71.430	-	71.43	-	17	6.00	27.54	30.67	41.03	50.90	56.70	M25	M30
15	NP-25	-	50	22.62	Nil	71.430	71.430	71.43	-	-	50	4.27	20.67	25.73	33.47	41.75	48.02	M25	M25
16	CP-25	-	50	22.62	Nil	71.430	71.430	-	71.43	-	15	5.33	21.42	28.22	36.49	44.38	50.25	M25	M25
17	NO-40	50	-	19.05	Nil	71.430	71.430	71.43	-	280	13	6.00	42.87	45.63	50.75	59.45	67.71	M40	M40
18	CO-40	50	-	19.05	Nil	71.430	71.430	-	71.43	280	0	6.20	41.65	43.37	53.89	62.28	69.84	M40	M40
19	NP-40	-	50	19.05	Nil	71.430	71.430	71.43	-	280	20	5.47	31.99	38.03	44.13	54.05	62.01	M40	M35
20	CP-40	-	50	19.05	Nil	71.430	71.430	-	71.43	280	0	5.60	32.56	39.79	46.90	54.80	63.14	M40	M35

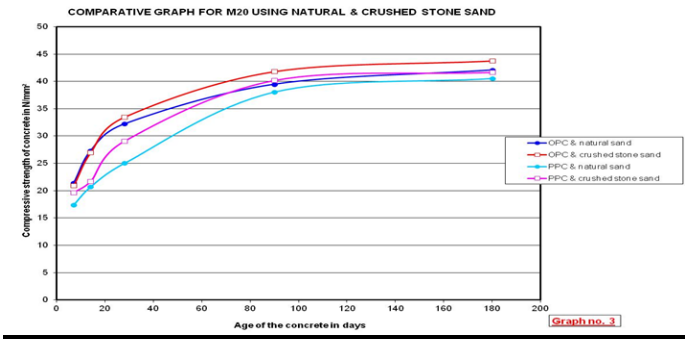
May-June 2020
ISSN: 0193-4120 Page No. 9334 - 9337

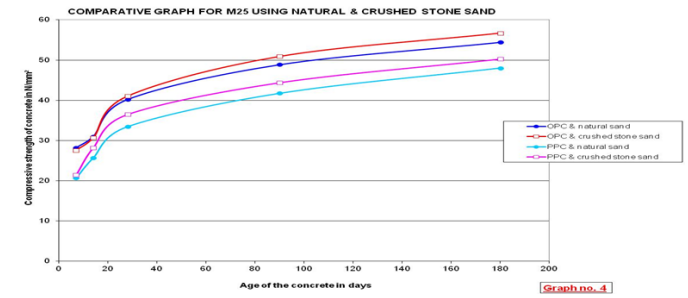
NO - Concrete made with natural sand & OPC
CO - Concrete made with crushed stone sand & OPC
NP - Concrete made with natural sand & PPC
CP - Concrete made with crushed stone sand & PPC

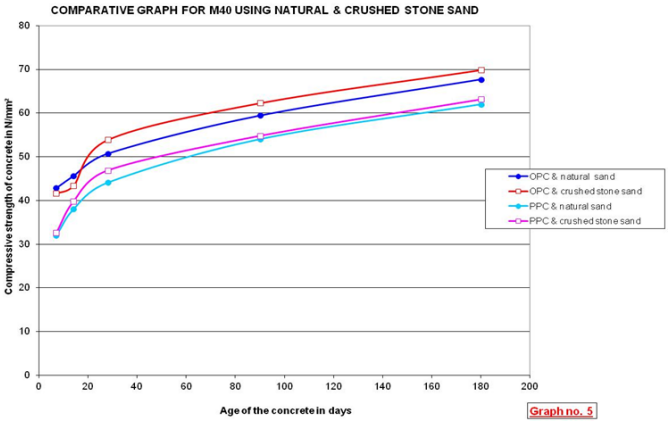
Results and Graphs











6 Conclusion

1) Crushed stone sand based concrete has shown (on an average) 6.80 % more 28 days laboratory compressive strength as compared to the natural sand based concrete.
2) Crushed stone sand based concrete has shown (on an average) 44.94 % less slump as compared to the natural sand based concrete.
3) Crushed stone sand based concrete has shown (on an average) 5 % more flexural strength as compared to the natural sand based concrete.
4) Crushed stone sand based concrete has shown (on an average) 2.63 % more density as compared to the natural sand based concrete.
5) Crushed stone sand may be used in lieu of natural sand for concrete making if it satisfies all the specifications given in IS 383 – 1970 (revised in 2019) and also it is available at lower price as compared to natural sand.

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May-June 2020
ISSN: 0193-4120 Page No. 9334 - 9337

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