ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 8, Issue, 6, pp. 17733-17736, June, 2017

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

MECHANICAL CHARACTERISATION OF HIGH STRENGTH CONCRETE WITH PARTIAL REPLACEMENT OF QUARRY SAND

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DOI: http://dx.doi.org/10.24327/ijrsr.2017.0806.0413

ARTICLE INFO

Article History:

Received 15th March, 2017
Received in revised form 25th April, 2017
Accepted 23rd May, 2017
Published online 28th June, 2017

Key Words:

High strength concrete, Quarry sand, Compressive strength and Flexural strength

ABSTRACT

Concrete Technology has been already played a significant role in waste management system by employing the industrial wastes efficiently, without any compromise in the quality of end product. In this study, the utilization of Quarry sand as fine aggregate in the production of concrete is attractive and effective when this fine aggregate is competitive with the natural resources in relation to cost and quality. A high strength concrete M60 is designed. River sand is replaced with 10%, 20%, 30 %, 40%, 50% and 100% of quarry sand. The highest compressive strength of concrete is obtained for the 50% replacement of quarry sand. The flexural strength is found maximum in the 100 % replacement of quarry sand. This study gives a clear findings that quarry dust can be utilized as ingredient in high strength concrete as a substitute for river sand.

INTRODUCTION

One of the greatest technological challenges of the present time is to utilize the large amount of industrial and building wastes, which are generated as a result of the development of modern society. At present, only a merge amount of wastes are used meaningfully and the major portion is being deposited or used as filler material. With the increase in construction activities and shortage of suitable deposit sites, the industrial wastes are becoming a serious problem, which has forced the Civil Engineering professionals and Researchers to seriously think and develop methods of reuse of waste in new construction. Developing countries like India are facing a shortage in the supply of natural sand. The escalation in cost of sand due to administrative restrictions in India, demands comparatively greater cost. Hence, the expertise of construction industries is investigating the other alternatives to eliminate the demand of natural sand. Quarry dust is a byproduct of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying process, the quarry dust is generated and it is formed as waste and it causes air pollution. Hence, in this study it is decided to replace quarry sand with varying proportion in high strength concrete. The effect of compressive strength and flexural strength due to the partial and full replacement of river sand with quarry sand is investigated.

Shanmugapriya *et al*. (2012) concluded from experimental researchers that compressive and flexural strength of concrete can be improved by partial replacement of cement by silica fume and manufactured sand for natural fine aggregates. They suggested that optimum replacement of natural sand by manufactured sand is 50%.

Saeed Ahmad *et al*. (2008) have found that compressive strength of various mix ratios increased from 7% to 33% whereas workability decreased from 11% to 67% with increasing proportion of manufactured sand.

Experimental results of Shyam Prakash *et al*. (2007) shows that manufactured sand satisfies the requirements fine aggregates such as strength, gradation, shape angularity. It is also possible to produce manufactured sand falling into the desired grade. They say that the mechanical properties of manufactured sand depend upon the source of its raw material, i.e., parent rock. Hence the selection of the quarry is very important to quality fine aggregate.

Shanmugapriya .T and Uma .R. N. made an investigation on optimization of partial replacement of M-sand by natural sand in high performance concrete with silica fume. It was reported that M-sand and silica fume increased the flexural and compressive strength.

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MATERIALS AND METHODS

Cement

The Bureau of Indian Standards (BIS) has classified OPC in three different grades. The classification is mainly based on the compressive strength of cement-sand mortar cubes of face area 50 cm2 composed of 1 part of cement to 3 parts of standard sand by weight with a water-cement ratio arrived at by a specified procedure. There are 33 grade, 43 grade and 53 grade, the grade number indicates the minimum compressive strength of cement sand mortar in N/mm^2 at 28 days. As per IS 4031-1988 the different laboratory tests were conducted on cement to determine the standard consistency, initial and final setting time and compressive strength. In this work, 53 grade Ordinary Portland Cement is used.

Fine aggregate

Aggregate which passed through 4.75 mm IS Sieve and retained on 75 micron (0.075 mm) IS Sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Usually, the natural river sand is used as fine aggregate. Ordinary river sand conforming IS 383-1970 was used in this project.

Quarry dust which passes through the 4.75mm IS sieve and retained on 75 micron IS sieve is also used as fine aggregate. The properties of the fine aggregates are shown in table 1.

Table 1 Properties of fine aggregates

S.no	Properties	River sand	Quarry dust
1.	Specific Gravity	2.598	2.8
2.	Fineness modulus	3.2	2.6
3.	Dry density	1590.299 kg/m^3	1680 kg/m3

Coarse aggregate

The coarse aggregate for the works should be river gravel or crushed stone. Angular shape aggregate of size is 25 mm and below. The aggregate which passes through 75 mm sieve and retain on 4.75 mm are known as coarse aggregate.

It should be hard, strong, dense, durable, clean, dry and free from clay or loamy admixtures or quarry refuse or vegetable matter. Aggregate should be properly screened and if necessary washed clean before use. Coarse aggregate containing flat, elongated or flaky pieces or mica should be rejected. The grading of coarse aggregate should be as per specifications of IS 383-1970.

In this project, coarse aggregate of 20 mm was used as the normal maximum size.

Super plasticizer

Super plasticizers are technically called as High Range Water Reducer. The super plasticizers can reduce the water content of about 30% without reduction in the workability of the concrete. Some of the super plasticizers are based on Acrylic Polymer (AP), Copolymer of Carboxylic acid with acrylic ester (CAE), Cross linked Acrylic Polymer (CLAP) and Polycarboxylate Ester (PC) and so on. In this project, Polycarboxylate Ester is used as the Super Plasticizer

Mix Design

The Indian code had provided the mix design procedure for upto the grade of M55. Hence, the mix proportioning is done based on American Concrete Institute (ACI211.4R-93) recommendations.

The high strength concrete (M60) is achieved by having low water-cement ratio. The mix proportion is shown in table 2. The various volumes of materials for various replacements of Quarry Sand with natural River Sand is given in Table 3.

Table 2 Mix proportion

Cement	Fine aggregate	Coarse aggregate	Water	Super plasticizer
625.436 kg/m^3	484.5143 kg/m^3	1159.7205 kg/m^3	182.94 l/m^3	6.9 ml/kg of cement
1	0.7747	1.8543	0.2925	

Table 3 Volume of Materials for Various Percentage of Replacements

Description	0%	10%	20%	30%	40%	50%	100%
Water (l/m^3)	182.94	182.94	182.94	182.94	182.94	182.94	182.94
Cement (kg/m^3)	625.44	625.44	625.44	625.44	625.44	625.44	625.44
Coarse Aggregate (kg/m^3)	1159.63	1159.63	1159.63	1159.63	1159.63	1159.63	1159.63
River Sand (kg/m^3)	484.51	436.06	387.61	339.16	290.71	242.26	0
Quarry Sand (kg/m^3)	0	52.22	104.44	156.65	208.87	261.09	522.19
HRWR [ml(per kg of cement)]	6.9	6.9	6.9	6.9	6.9	6.9	6.9

RESULT AND DISCUSSION

Compressive Strength

Compressive test is carried out on cubical specimens adopting IS procedure at 7, 28 days. The compressive strength test results and discussions based on the test results are presented in table 4. From the testing machine we obtained the compressive load acting on the cube samples. The compressive strength is calculated by

$$Compressive\ Strengt \quad = \frac{Compressive\ load}{Contact\ Area}$$

Concrete cube specimens made of various percentage of Quarry Sand were tested at 7, 28 days respectively and the results are presented in the Table 4. The compressive strength increases gradually from 0% to the 50% replacements of Quarry Sand with the River Sand, yields the higher strength of 80.4MPa at 50% replacement and gradually decreases to the 100% replacement. The 100% replacement of Quarry Sand gave the poorer strength. The comparison between the compressive strength of the various replacements are presented in chart 1. The relevant photography is shown in figure 1.

Fig 1 Concrete cubes for compressive strength test

Table 4 Compressive strength test result

Description	Load(kN)		Compressive strength (MPa)		Mean (MPa)	
	7-day	28-day	7-day	28-day	7-day	28-day
0% Replacement						
0%-1	1410.000	1501.070	62.667	66.714		
0%-2	957.510	1739.960	42.556	77.332	49.025	71.400
0%-3	941.700	1578.470	41.853	70.154		
10% Replacement						
10%-1	884.640	1523.220	39.317	67.699		
10%-2	1042.760	1730.000	46.345	76.889	50.628	68.344
10%-3	1490.000	1360.000	66.222	60.444		
20% Replacement						
20%-1	1436.360	1815.000	63.838	80.667		
20%-2	1441.070	1570.000	64.048	69.778	61.791	73.758
20%-3	1293.450	1593.650	57.487	70.829		
30% Replacement						
30%-1	1445.940	1520.000	64.264	67.556		
30%-2	1222.350	1580.250	54.327	70.233	59.453	74.002
30%-3	1344.780	1894.860	59.768	84.216		
40% Replacement						
40%-1	1318.650	1537.250	58.607	68.322		
40%-2	1392.790	1859.750	61.902	82.656	59.281	77.172
40%-3	1290.000	1812.100	57.333	80.538		
50% Replacement						
50%-1	1464.410	1806.000	65.085	80.267		
50%-2	1521.640	1687.750	67.628	75.011	65.851	80.369
50%-3	1458.870	1931.130	64.839	85.828		
100% Replacement						
100%-1	1392.300	1550.000	61.880	68.889		
100%-2	1318.130	1350.000	58.584	60.000	57.406	62.222
100%-3	1164.460	1300.000	51.754	57.778		

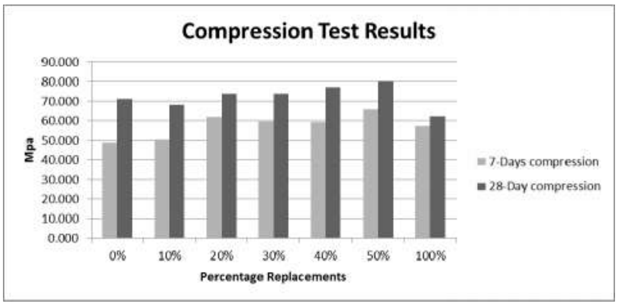

Chart 1 Comparison of compression strength

Flexural Strength

Concrete beam specimens were subjected to Flexural Test after 28days of curing in water and the results are presented in the following chapter.

The flexural test can be done in two methods

1. One-Point Method
2. Two-Point Method

From the testing machine we obtained the load acting on the beam samples. The flexural strength is calculated by

By One-Point Method

$$Flexural\ Strengt\ \ , f = \frac{3Wl}{2bd^2}$$

By Two-Point Method

$$Flexural\ Strengt\ \ , f = \frac{2Wl}{bd^2}$$

Concrete beam specimens made of various percentage of Quarry Sand were tested at 28 days respectively and the results are presented in the Table 5.

The flexural strength increases gradually up to 100% replacement of Quarry Sand over the River Sand, the flexural strength yields the higher strength of 12.4 MPa at the 100% replacement.

The comparison between the flexural strength of the various replacements are given in the chart 2. The relevant photography is shown in fig.2.

Table 5 Flexural strength test result

Description	Load (kN)	Flexural strength (MPa)	Mean (MPa)
		0%Replacement	
Sample-1	32.450	11.538	10.839
Sample-2	28.900	10.276	
Sample-3	30.100	10.702	
		10%Replacement	
Sample-1	29.850	10.613	11.188
Sample-2	30.950	11.004	
Sample-3	33.600	11.947	
		20%Replacement	
Sample-1	36.550	12.996	11.597
Sample-2	28.100	9.991	
Sample-3	33.200	11.804	
		30%Replacement	
Sample-1	28.150	10.009	11.277
Sample-2	34.000	12.089	
Sample-3	33.000	11.733	
		40%Replacement	
Sample-1	34.300	12.196	11.390
Sample-2	31.950	11.360	
Sample-3	29.850	10.613	
		50%Replacement	
Sample-1	36.300	12.907	11.905
Sample-2	32.550	11.573	
Sample-3	31.600	11.236	
		100%Replacement	
Sample-1	32.900	11.698	12.403
Sample-2	33.000	11.733	
Sample-3	38.750	13.778	

Fig 2 Concrete prism for flexural strength test

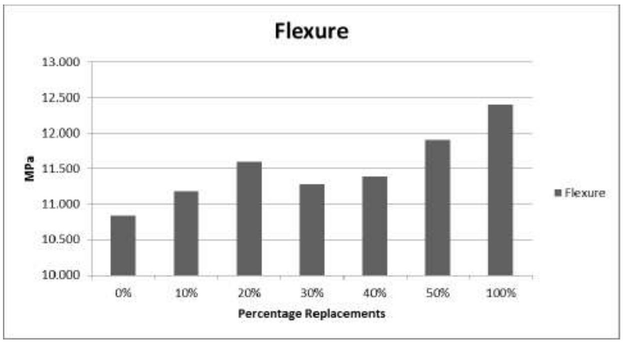

Chart 2 Comparison of flexural strength

CONCLUSION

The following are the conclusions made from this study,

- There is a gradual increase in compressive strength of High Strength Concrete with increase in the Quarry Sand upto 50%. There is 12.5% increase in the compressive strength is achieved when compared to the control concrete, which is 0% Quarry Sand. It is also found that there is decrease in compressive strength of High Strength Concrete at 100% replacement of Quarry Sand. It may be due to very low workability
- The same trend of gradual increase in flexural strength was noticed when the replacement of Quarry Sand approaches 100%. There is 14.3% increase in the flexural strength is achieved when compared to the control concrete. This may be due to the Quarry Sand particles are more flaky and highly cohesive compared to the River Sand.

From this study, it is evident that the Quarry Sand may be used as effective replacement over the natural River Sand for the production for high strength concrete upto 50% replacement with River Sand.

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How to cite this article:

Prakash R.2017, Mechanical Characterisation of High Strength Concrete With Partial Replacement of Quarry Sand. *Int J Recent Sci Res.* 8(6), pp. 17733-17736. DOI: http://dx.doi.org/10.24327/ijrsr.2017.0806.0413

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