

Performance Evaluation of Quarry Dust by replacement of Natural Sand in terms of Compressive Strength

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Abstract:

In the present world, population is increasing drastically day by day, as like in construction field also construction of structures or buildings also increasing. For construction, materials like cement, sand and coarse aggregates are required. As the requirement of natural or river, sand for construction is increasing but the availability of sand in nature decreasing and the cost of sand also increasing significantly in market. This results in invention of alternative material for sand in construction field. Hence, the utilization of Quarry Dust by replacing the river sand is came into existence. The present study describes the importance of Quarry Dust in the construction of buildings and in minimizing the construction cost. Results from the study reveal replacement of sand by Quarry Dust up to 30-40% gives the better compressive strength.

Key words: Quarry Dust, Sieve Analysis, Compressive Strength

1. INRODUCTION:

In present world, researchers made best attempts in successful utilization of different industrial waste products as by-products (such as fly ash, silica fume, rice husk ash, foundry waste) for other purposes to save environmental pollution. Apart from this the replacement of material in concrete made good effort towards it. The construction consumes huge amount of cement and other natural resources like sand, there by cause's environmental losses. Developing countries are involved in finding the alternate material for fine aggregate and in without reducing the strength or properties of concrete after utilizing the material. This condition creates researchers to identify the additional by-product materials as substitutes for constituent materials in construction industry. In such various by-products quarry dust also one of the by-product.

The byproduct or the waste material produced after cutting and crushing process of stones in quarry mine used as fine aggregate in construction is the Quarry dust. In stone mining industry after blasting big stones along with this fine material left behind. The disposal of fine material in environment and the erosion of this material is also a big problem for the stone mining owners. Quarry dust available in different grades it has to sieve according to required grade material used for the project and most of the cases less than 4.75mm size material is used.

The applications of Quarry Dust are:

- Quarry dust used as a fine aggregate in construction industry.
- It gives good workability and strength.
- Quarry dust used as surface dressing material in highway made with bitumen material.
- Quarry dust used in manufacturing of building materials like bricks, tiles etc.
- Quarry dust is free of organic matter and cost effective.

2. Materials and Methodology:

Cement: The cement used for experimental work is OPC of Ultratech 43 grade. The cement should satisfy the IS code provisions.

Fine aggregates: The aggregates size less than 4.75mm are fine aggregates.

- Natural Sand: The sand obtained from Tungabhadra River near Harihar to carry out project
- Quarry Dust: The quarry dust obtained from nearest quarry site.

The properties of both river sand and quarry dust obtained after the experiment are as shown in the below table:

Table 1: Properties of materials

Tests	Cement	Sand	Quarry dust
Specific Gravity	3.2	2.51	2.68
Fineness Modulus	3.33%	2.06	3.44

2.1 Tests on Cement:

Normal Consistency: In order to know the initial setting, final setting and soundness of cement, strength normal consistency test is used.

Fineness of Cement: The test carried to know the fineness of selected grade cement for project.

Specific gravity of cement: To know the specific gravity of selected cement this test carried out.

2.2 Tests on Aggregates:

Sieve Analysis: It is a phenomenon used to find the particle size distribution of a granular material by passing through a series of sieves.

Specific Gravity: The ratio of unit weight of soil solids to unit weight of water.

Bulking of Sand: The increase in volume of sand after adding water.

2.3 Test on Mortar:

Compression Test: Compressive test carried on 7.05cmx7.05cmx7.05cm sized mortar blocks.

- Compressive test of mortar cubes conducted as per BIS method.
- Different mortar cubes were prepared by mixing Natural sand and Quarry dust in the ratios 100:0, 80:20, 60:40, 40:60, 20:80, 0:100.
- The prepared mortar cubes taken out of water after the end of curing period (ie, 3 cubes of each proportion after 3, 7, 14 and 28 days,).
- The cubes were individually tested using compression testing machine.
- The average of the ultimate load of three cubes was calculated.
- The compressive strength calculated by using following relation:

$$\text{Compressive Strength} = \frac{(\text{Ultimate load})}{(\text{Area of the specimen})}$$

3. Results and Discussions:

3.1 Test Results of Materials:

a) Cement:

Table 2: Result of different properties of cement

Sl. No.	Test	Result
1	Consistency	33%
2	Fineness	3.33%
5	Specific gravity	3.2

By conducting series of experiments, it is possible to know the properties of cement. Some of the tests carried out to know the properties are normal consistency, fineness modulus and specific gravity. From the tests, the obtained results for normal consistency of 33%, fineness modulus of 3.33% and specific gravity 3.2 for cement.

i) Fineness of Cement:

Table 3: Result for fineness of cement

Sl No.	Description	Trials		
		1	2	3
1	Weight of 90 μ sieve (W_1 gm)	316	316	316
3	Weight of Cement retained (W_2 gm-)	3	4	3
4	% fineness= $\frac{W_1}{W_2} \times 100$	3	4	3
4	Average % fineness	3.333		

By conducting 3 trials of experiments for fineness of cement the obtained results are 3, 4, 3 and the average of these results is 3.33 and it is depicted in the above table.

ii) Specific gravity of cement:

Table 4: Result of Specific Gravity for Cement:

Sl. No.	Description	Trial 1
1.	Weight of density bottle, (W_1) gm	17
2.	Weight of density bottle + Cement, (W_2) gm	25
3.	Weight of density bottle + Cement + kerosene, (W_3) gm	43
4.	Weight of density bottle + kerosene, (W_4) gm	37
5.	Weight of density bottle + Water, (W_5) gm	42
6.	Specific Gravity of cement w.r.t. kerosene, $G_{CK} = (W_2 - W_1) / ((W_4 - W_1) - (W_3 - W_2))$	4.0
7.	Specific Gravity of Kerosene, $G_K = (W_4 - W_1) / (W_5 - W_1)$	0.8
8.	Specific Gravity of cement w.r.t. Water, $G = G_{CK} * G_K$	3.2

The above table shows the specific gravity for cement and the result obtained from the experiment is 3.2.

b) Natural Sand:

Table 5: Result of Sieve Analysis for Sand

Result of Sieve Analysis for Sand				
IS Sieve Size	Wt. Retained (gm)	% Wt. Retained	Cumulative % Wt. Retained	Cumulative % passing
4.75mm	30	3	3	97
2.36mm	65	6.5	9.5	90.5
1.18mm	119	11.9	21.4	78.6
600 μ	283	28.3	49.7	50.3
300 μ	345	34.5	84.2	15.8
150 μ	154	15.4	99.6	0.4
<150 μ	4	0.4	100	0
Total			367.4	
F.M. = $367.4/100 = 36.74$				

From the sieve analysis test the obtained result for fineness, modulus is 36.74

Table 6: Result of Specific Gravity for Sand

Result of Specific Gravity for Sand						
Sl. No.	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	G	Gavg
1	566	1033	1718	1430	2.61	2.51
2	566	960	1670	1430	2.56	
3	566	970	1663	1430	2.36	

To know the specific gravity of sand, 3 trials are carried out in a lab and the result obtained from the experiment is 2.51.

c) Quarry Dust:

It is important to aware about properties of the selected quarry dust. Hence, various tests conducted. Commonly, sieve analysis and Specific Gravity tests carried out and the results obtained from test are 33.68 for fineness modulus and specific gravity is 2.68. The below two tables depict the experimental results of sieve analysis and specific gravity for quarry dust.

Table 7: Result of Sieve Analysis for Quarry Dust

Result of Sieve Analysis for Quarry Dust

IS Sieve Size	Wt. Retained (gm)	% Wt. Retained	Cumulative % Wt. Retained	Cumulative % passing
4.75mm	11	1.1	1.1	98.9
2.36mm	92	9.2	10.3	89.7
1.18mm	182	18.2	28.5	71.5
600 μ	178	17.8	46.3	53.7
300 μ	203	20.3	66.6	33.4
150 μ	174	17.4	84	16
<150 μ	160	16	100	0
Total			336.8	
F.M.= 336.8/100 = 33.68				

Table 8: Result of Specific Gravity for Quarry Dust

Result of Specific Gravity for Quarry Dust

Sl. No.	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	G	Gavg
1	566	920	1650	1430	2.64	2.68
2	566	975	1680	1430	2.57	
3	566	920	1660	1430	2.85	

iii) Compressive Strength test Results:

For the compressive strength test, it is necessary to prepare the cubes in order to this, cement mortar cubes of size 7.05cmX 7.05cm X 7.05cm were prepared and tested by using the compressive testing machine. Cubes of 1:3 ratio mix proportions of cement, sand and quarry dust used. For the first test, 100% of sand used and test conducted further for each test replacement of quarry dust by the 20% done. The test conducted for different ages in order to find out whether the strength is decreases or increases. i.e. for 7 days, 14 days, 21 days and 28 days. The below tables indicate the results of compressive strength for replacement of quarry dust by 20% at different ages.

Table 9: Results for Compressive Strength Test for Quarry Dust mix Concrete (7 Days)

AREA OF CUBES mm ²	PERCENTAGE OF SAND		BREAKING LOAD KN	COMPRESSIVE STRENGTH N/mm ²	AVERAGE COMPRESSIVE STRENGTH N/mm ²
	M	N			
70.5x70.5	0	100	65	13.08	12.74
			65	13.08	
			60	12.07	
	20	80	85	17.1	14.75
			70	14.08	
			65	13.08	
	40	60	85	17.1	14.87
			75	15.28	
			60	12.23	
	60	40	20	4.02	5.7
			35	7.04	
			30	6.04	
	80	20	40	8.05	8.05
			35	7.04	
			45	9.05	
	100	0	35	7.04	7.04
			40	8.05	
			30	6.04	

Table 10: Results for Compressive Strength Test for Quarry Dust mix Concrete (14 Days)

AREA OF CUBES IN mm ²	PERCENTAGE OF SAND		BREAKING LOAD IN KN	COMPRESSIVE STRENGTH IN N/mm ²	AVERAGE COMPRESSIVE STRENGTH IN N/mm ²
	M	N			
70.5x70.5	0	100	65	13.08	13.08
			60	12.07	
			70	14.08	
	20	80	80	16.1	18.11
			100	20.12	
			90	18.11	
	40	60	105	21.13	18.11
			80	16.1	
			85	17.1	
	60	40	65	13.08	12.07
			50	10.06	
			65	13.08	
	80	20	65	13.08	12.41
			55	11.07	
			65	13.08	
	100	0	45	9.05	9.05
			45	9.05	
			45	9.05	

Table 11: Results for Compressive Strength Test for Quarry Dust mix Concrete (14 Days)

AREA OF CUBES (mm ²)	PERCENTAGE OF SAND		BREAKING LOAD (KN)	COMPRESSIVE STRENGTH (N/mm ²)	AVERAGE COMPRESSIVE STRENGTH IN (N/mm ²)
	M	N			
70.5x70.5	0	100	145	29.17	29.84
			130	26.15	
			170	34.2	
	20	80	135	27.16	27.5
			120	24.14	
			155	31.18	
	40	60	135	27.16	25.15
			95	19.11	
			145	29.17	
	60	40	85	17.1	19.11
			95	19.11	
			105	21.13	
	80	20	70	14.08	13.75
			70	14.08	
			65	13.1	
	100	0	55	11.1	11.43
			55	11.1	
			60	12.1	

Table 12: Results for Compressive Strength Test for Quarry Dust mix Concrete (14 Days)

AREA OF CUBES IN mm ²	PERCENTAGE OF SAND		BREAKING LOAD IN KN	COMPRESSIVE STRENGTH IN N/mm ²	AVERAGE COMPRESSIVE STRENGTH IN N/mm ²
70.5x70.5	0	100	170	34.2	32.2
			155	31.18	
			155	31.18	
	20	80	140	28.16	26.82
			125	25.15	
			135	27.16	
	40	60	155	31.18	28.16
			135	27.16	
			130	26.15	
	60	40	40	8.05	12.41
			70	14.08	
			75	15.1	
	80	20	55	11.1	13.1
			65	13.1	
			75	15.1	
	100	0	65	13.1	12.43
			60	12.1	
			60	12.1	

4. Conclusion:

From the experimental results, we come to know that the decreases for replacement of quarry dust more than 40%. This is same for other different ages also. Hence, the conclusion is the replacement of sand by quarry dust up-to 40% gives better strength and further increase of quarry dust will decreases the strength.

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