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A Study on Effect of Fineness of Quarry Dust on Compressive Strength of Concrete

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Abstract: River sand has been the most popular choice for the fine aggregate component of concrete in the past, but overuse of the material has led to environmental concerns. In the current study effect of variation of fineness modulus of quarry dust for varying percentage replacement of river sand by it on the compressive strength of concrete are studied. Tests were carried on mortar cubes to study mortar compressive strength and on concrete specimens. Two basic mixes M20 and M25 were considered in the study. Tests indicate the relation between variations of compressive strength with the fineness of quarry dust.

I. INTRODUCTION

Concrete is the most widely used construction material today. The constituents of concrete are coarse aggregate, fine aggregate binding material and water. Rapid increase in Construction activities lead to acute shortage of conventional construction materials.Overuse of the material has led to environmental concerns. Lack of proper planning and sand management cause disturbance of marine ecosystem and also upset the ability of natural marine processes to replenish the sand. The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to sand as fine aggregates in the production of concrete. The cost of concrete can be reduced by reducing the cost of any one material in the concrete matrix. The cost reduction may also be achieved by using locally available materials. Mainly the world wide consumption of fine aggregate in the production of concrete is very high and several countries have encountered difficulties meeting this need and have opted for alternative material.

Quarry dust, a by-product from the crushing process during quarrying activities is one of such materials since it is available abundantly and economically from the quarry industry. They generally represent less than 1% of aggregate production [1].Quarry waste fine aggregate, which is generally considered as a waste material after the extraction and processing of rocks to form fine particles less than 4.75mm, causes an environmental load due to disposal problem. Hence, the use of quarry waste fine aggregate in concrete mixtures will reduce not only the demand for natural sand but also the environmental burden [2]. The incorporation of quarry waste fine aggregate will offset the production cost of concrete. In brief, the successful utilization of quarry waste fine aggregate will turn this waste material into a valuable resource.

Dehwah.H.A.F studied the mechanical properties of self compacting concrete incorporating quarry dust powder, silica fume or fly ash and found introduction of Quarry dust in SCC mix improves the mechanical properties of SCC[3].Appraisal of crushed stone dust as fine aggregate in structural concrete was studied by Kode et al and reported that beams with stone crusher dust and sand both developed same ultimate strength[4].Sahu, et al replaced sand by quarry dust by 20 and 40% and found concrete made with this replacement can attain the same compressive strength as control concrete[5] .Babu et al compressive strength of brick masonry with alternative aggregate mortar incorporating quarry dust and found all the mortars prepared satisfied the 28 day compressive strength requirement[6].Jaafar et al studied the effect of using quarry dust as a cement replacement on the mechanical properties as well as durability characteristics in high strength concrete[7].Nagaraj et al have studied the effect of rock dust and pebble as aggregate in cement and concrete[8]. Narasimhan et al studied the performance of concrete with quarry dust in conjunction with different standard code[9]

Many researchers have studied the replacement of quarry dust partially and also fully. The results indicate that quarry dust can be used in mortar and concrete without significant difference in strength and workability compared to conventional concrete.The main objective of the study is to investigate the behavior of fineness of quarry dust on the cement matrix.

II. OBJECTIVE OF THE STUDY

The main objective of the study is to determine the effect of fineness of quarry dust on the compressive strength of concrete. Also study the influence of grading of quarry dust on the compressive cement mortar

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III. EXPERIMENTAL PROGRAM

In the current study ordinary Portland cement of 43 grade from Bagalkot cement was used. The physical and mechanical properties of the cement used in the study are tabulated in Table 1

Table 1: *Properties of cement*

Sl.no	Description	Value
1	Standard consistency	30%
2	Initial setting time	112 min
3	Specific Gravity	3.009
4	Final setting time	172 min
5	7 day strength	34.8021 mpa
6	28 day strength	45.7466 mpa

Locally available clean river sand was used for the current study. The sieve analysis results and other physical properties are represented below in Table 2 and Table 3

Table 2: *Sieve Analysis results for sand*

Sieve analysis of fine aggregates		
1000gm		
Sieve size	**Weight retained(gm)**	**cumulative % passing**
10mm	2	99.8
4.75mm	24	97.4
2.36mm	34	94
1.8mm	120	82
600µ	382	43.8
300µ	282	15.6
150µ	146	1
Pan	10	0
F.M=2.66		

Table 3: *Properties of sand*

Sl.no	Description	Value
1	Specific Gravity	2.606
2	Grading Zone	Zone II
3	Fineness Modulus	2.66

Quarry dust was obtained from local quarries. Quarry dust with fineness modulus 2.952, 3.254, 2.80 was considered for the study, the sieve analysis results and other properties are tabulated below in Table 4 to 7

Table 4: *Sieve Analysis results for Quarry dust 0f fineness 2.952*

Sieve analysis of fine aggregates		
1000gm		
Sieve size	**Weight retained(gm)**	**cumulative % passing**
10mm	1	99.899
4.75mm	11	98.797
2.36mm	127	86.072
1.8mm	169	69.138
600µ	295	39.579
300µ	296	9.919
150µ	86	1.302
Pan	13	0
F.M=2.952		

Table 5: *Sieve Analysis results for Quarry dust of fineness 3.254*

Sieve analysis of fine aggregates		
1000gm		
Sieve size	**Weight retained(gm)**	**cumulative % passing**
10mm	0	100
4.75mm	30	96.969
2.36mm	158	81.010
1.8mm	270	53.737
600µ	220	31.515
300µ	214	9.898
150µ	84	1.414
Pan	14	0
F.M=3.254		

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Table 6: *Sieve Analysis results for Quarry dust of fineness 2.80*

Sieve analysis of fine aggregates		
1000gm		
Sieve size	**Weight retained(gm)**	**cumulative % passing**
10mm	0	100
4.75mm	18	98.2
2.36mm	48	93.4
1.8mm	274	66
600µ	248	41.2
300µ	214	19.8
150µ	184	1.4
Pan	14	0
F.M=2.80		

Table 7: *Properties of Quarry dust*

Sl.no	Description	Value
1	Specific Gravity	2.62
2	Grading Zone	Zone II of soil
3	Percentage Passing through 75 micron sieve	6gm of 1000gm
4	Fineness Modulus	2.952
5	Water absorption	1.86

Crushed granite angular aggregates of 20mm down size were used as coarse aggregate. Properties of coarse aggregate are tabulated below in Table 8

Table 8: *Properties of coarse aggregate*

Sl.no	Description	Value
1	Specific Gravity	2.88
2	Water absorption	0.6%
3	Fineness modulus	7.07

From Table4.It is observed that about 14% of quarry dust is retained in sieves 2.36 mm. Also about 40% of quarry dust is passing through 600µ sieve .In the present study 3 types of quarry dust were used

Type 1: quarry dust with fineness modulus 5.09 obtained from particles retained in 2.36mm sieve

Type 2:quarry dust with fineness 1.748 obtained from particles passing through 600µ sieve

Type 3: quarry dust obtained directly from quarry of fineness 2.952

Cement mortar was then prepared for various fineness and subjected to mortar compressive strength tests. The effect of fineness on cement mortar is studied.

Control mix for concrete was cast to achieve target strength of 20 and 25 N/mm^2.The Control mix was casted without any replacement of quarry dust and compressive strength was studied for 7and 28 days. River sand was then replaced by quarry dust from two other quarries of fineness tabulated in table 5 and 6

IV. RESULTS AND DISCUSSIONS

A. Effect of quarry dust fineness on compressive strength of Mortar cubes

Initially sieve analysis was done and quarry dust particles were separated based on sieve size to obtain quarry dust of different fineness modulus. This quarry dust was introduced into cement instead of sand in different ratios and compressive strength was carried out on the mortar cubes for 3, 7 and 28 days. In this study the water cement ratio is kept constant for all the mixes. The water content is given bythe relation P/4+3%,where P is the nominal consistency of cement paste

Table 9: *Mortar strength incorporating Quarry dust of Fineness modulus 5.09*

Cement: Quarry dust	3 day	7 day	28 day
1:3	18.63	33.29	43.31
1:4	17.21	31.63	40.62
1:5	16.3	32.86	41.53
1:6	14.72	33.43	40.18
1:7	14.03	30.63	38.36
1:8	14.63	29.81	37.86
1:9	8.2	27.6	34.39

Table 10: *Mortar strength incorporating Quarry dust of Fineness modulus 2.947*

Cement: Quarry dust	3 day	7 day	28 day
1:3	17.36	30.36	44.58
1:4	18.16	27.36	42.18
1:5	16.21	22.61	40.98

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1:6	13.93	23.08	40.18
1:7	12.61	23.63	36.51
1:8	12.42	24.96	37.18
1:9	13.21	24.53	31.38

Table 11: *Mortar strength incorporating Quarry dust of Fineness modulus 1.748*

Cement: Quarry dust	3 day	7 day	28 day
1:3	14.38	17.83	33.62
1:4	14.38	16.37	31.68
1:5	14.68	16.41	32.833
1:6	9.73	14.26	33.62
1:7	12.69	15.36	30.86
1:8	10.89	15.31	29.2
1:9	10.05	14.20	26.36

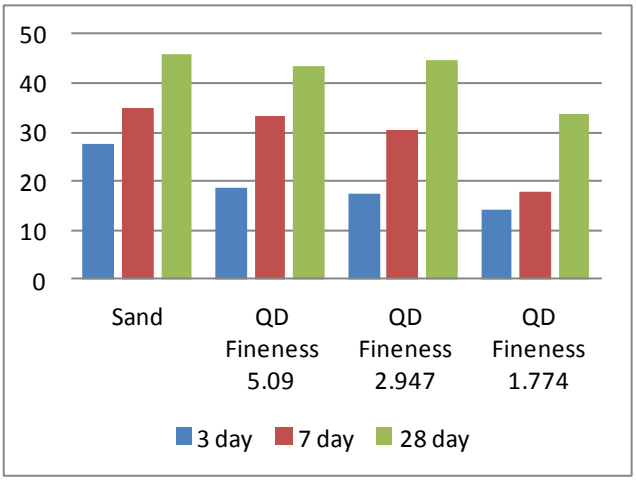

Figure 1: *Graphical representation of compressive strength test*

From Table 9,10,11 it is observed that the quarry dust specimens of fineness 2.947 and 5.09 show almost same strength as that of natural sand for 1:3 proportion but as the fineness increases there is about 26% reduction in strength. Specimens with fineness 5.09 and 2.947 show about 2-7% variations in strength up to a proportion of 1:6 but specimen with fineness 1.748 show a variation of 21%.It can be seen that reduction in strength from mix proportion 1:3 to 1:6 is about 6-10%. Reduction in strength from 1:6 to 1:9 is about 14-22%.These phenomenon are observed because the mixes with fineness 1.748 have greater surface area, excess of material less than 150 μ in size and associated increase in water demand which intern effects the strength of cement mortar. It can be said that quarry dust of fineness close to that of sand can be used safely for many constructional activities in spite having low workability up to a proportion of 1:6.

B. Effect of quarry dust fineness on compressive strength concrete

Two grades M20 and M25 having proportion 1:1.5:3 and 1:1:2 respectively are used by weight and w/c ratio is kept constant to 0.5 for all the combinations. Concrete was cast in 150X150X150mm moulds. Slump value was noted for each mix. 50mm slump was observed in sand but no slump was observe in mixes with 100% quarry dust. Compressive strength was studied for 7 and 28 days

Table 12*: Compressive strength of control mix with sand*

Fineness Modulus	Average strength (Strength in Mpa)			
	M20		M25	
	7day	28day	7 day	28day
Sand 2.66	18.369	23.631	22.420	29.764

Table 13*: Compressive strength for M20 for 100% replacement of sand by quarry dust*

Fineness Modulus	Average strength (Strength in Mpa)	
	7 day	28 day
2.952	15.050	18.856
3.254	17.484	18.732
2.80	15.374	18.520
1.774	12.406	15.672

Table 14*: Compressive strength for M25 for for 100% replacement of sand by quarry dust*

Fineness Modulus	Average strength (Strength in Mpa)	
	7 day	28 day
2.952	17.460	27.014
3.254	17.058	27.636
2.80	16.672	27.350
1.774	14.301	21.742

From Table 12 to 14 presence of quarry dust reduces the strength of the concrete significantly with quarry dust of fineness 1.774 giving the least strength

For M20 mix with sand replaced by quarry dust of fineness ≈3 for same water cement ratio show about 20% decrease in strength.

For M25 mix with sand replaced by quarry dust of fineness ≈3 for same water cement ratio show 10% decrease in strength

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For M20 mix with sand replaced by quarry dust of fineness ≈1.774 there is about 33% decrease in strength
For M25 mix with sand replaced by quarry dust of fineness ≈1.774 there is about 36% decrease in strength

V. CONCLUSION

1) It is observed that 28 day compressive strength of the mortar decreases with the decrease in fineness modulus.
2) The quarry dust specimens of fineness 2.947 and 5.09 show almost same strength as that of natural sand for 1:3 proportion but as the fineness increases there is about 26% reduction in strength
3) Quarry dust with fineness close to that of sand can be used safely for many constructional activities in spite having low workability up to a proportion of 1:6.
4) Quarry dust from different quarries show almost the same strength gain for both 7 and 28 days
5) For M20 mix with sand replaced by quarry dust of fineness ≈3 for same water cement ratio show about 20% decrease in strength.
6) For M25 mix with sand replaced by quarry dust of fineness ≈3 for same water cement ratio show 10% decrease in strength
7) For M20 mix with sand replaced by quarry dust of fineness ≈1.774 there is about 33% decrease in strength
8) For M25 mix with sand replaced by quarry dust of fineness ≈1.774 there is about 36% decrease in strength
9) Since the availability of quarry dust is in abundance with suitable mix design the construction coast can be reduced without affecting the strength

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