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Behaviour of Concrete on the Use of Quarry Dust and Superplasticizer to Replace Sand

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Abstract: *With the increase in population, the demand of river sand for construction is increasing at a very rapid pace. If sand is continuously extracted from rivers it would lead to severe damage to rivers and in turn reducing the filtration property of river that reduces the quality of water available. River sand is available in scare amount, thus to fulfill the demand of construction industry, an alternative material must be proposed which help prevent the environmental causes associated with the river. Quarry dust can be used for this purpose. Quarry dust being non-biodegradable material, it takes years to decompose, therefore its use in construction industry reduces the space required for landfilling the quarry dust. The chemical composition of river sand and quarry dust are almost similar. In this we study the efficiency of using quarry dust in concrete by comparing compressive strength of concrete in which river sand is partially replaced by quarry dust (10%,20%,25%,35%,40%) with control concrete of M20 & M25 grade. To compensate for the strength lost due to replacement, super plasticizer is used depending upon the weight of cement.*

Keywords: *Quarry dust, Superplasticizer, Compressive strength, Slump value, Concrete (M20&M25)*

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I. Introduction

Use of waste material in civil engineering has a huge scope as there are many means of fulfilling the quality standards lost due to waste usage. Using waste material reduces the load on environment as well as reduces cost of production.

In the construction industry, quarry dust is used as an aggregate substitute especially for sand in a concrete mixture. The application of quarry dust can reduce the cost of construction The research done for the cost of construction proved that using quarry dust is cheaper than sand. Quarry dust is also used in the construction of sub base in highways. Due to its high fines of quarry dust, it provides to be very effective in assuring very good cohesiveness of concrete.

So, sand in concrete is partially replaced by quarry dust in various percentages (15%,25%,35%,40%,50%) along with the use of super plasticizer in required quantity (0.20 times the weight of cement).

II. Material used

1. OPC: Ordinary Portland cement of grade 43 was used in concrete. OP cement does not contain any pozzolanic material.
2. Fine aggregate: Zone III fine aggregate was used locally available. It was sieved through 2.36mm IS sieve.
3. Coarse aggregate: It is broken granite rocks of size 10mm and 20mm which were used.
4. Quarry dust: The quarry dust used in this research was bought from 'Kabrai' district near Hamirpur (UP)
5. Super Plasticizer: These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio and thus increasing the compressive strength of mixture, not affecting the workability of the mixture, and high performance concrete. .
6. Water: Normal tap water was used.

III. Methodology

Following is the method adopted to prepare test specimen: -

1. First, we collect the materials required as explained earlier.

Figure 1: Materials used

2. Testing on materials is performed to check their quality.
3. Mix design of concrete is done. M20 grade of concrete has proportion 1:1.5:3 (Cement: fine aggregate: coarse aggregate).
4. Taking shrinkage factor as 1.57, 8 bags of cement, 0.43 m^3 of fine aggregate and 0.86 m^3 of coarse aggregate is required for 1 m^3 of concrete.
5. Now, fine aggregate is replaced in different percentages (0%, 5%, 10%, 15%, 20%, 25%). For example if 15 % replacement specimen is to be made then fine aggregate content in the mix will be 0.0645 m^3 of plastic and 0.3655 m^3 of fine aggregate for 1 m^3 of concrete (along with 100 gm of iron fibres in 1 test cube) (rest of the materials remaining same). 9 cubes are casted for every percentage of replacement. The dimension of test cube is 0.15m x 0.15m x 0.15m. According to the volume of material required for 9 cubes, materials are gathered and are mixed to prepare the concrete.
6. The prepared concrete is then casted in the form of test cubes. The cube while being filled is tamped by tamping rod to reduce the number of voids in concrete.
7. The cube is left for 1 day to gain shape.
8. Then after 24 hours of casting, the concrete cubes are obtained from the mould of test cubes. These are then left for curing.
9. Then, these cubes are tested for compressive strength on 7, 14 and 28 days from casting.
10. The test result obtained is then analysed.

Figure 2: Steps of casting

IV. Result and Discussion

Table 1: Test results of cement

Initial setting time	100 min.
Final setting time	220 min.
Consistency	38%
Compressive strength (28 days)	47.57Mpa

Table 2: Test results of fine aggregate

Bulking of sand	4.35%

Table 3: Test results of coarse aggregate

Aggregate impact value	12.12%
Aggregate crushing value	24.27%
Aggregate abrasion value	32.2%
Aggregate water absorption	0.295%

Table 4: Weight of different materials used in required proportion (M20 grade)

GRADE OF CONCRETE	RATIO OF SAND : QUARRY DUST	WEIGHT OF CEMENT (KG)	WEIGHT OF SAND (KG)	WEIGHT OF AGGREGATE (KG)	WEIGHT OF QUARRY DUST (KG)	WEIGHT OF SUPER-PLASTICISER (ml)
M20	100 : 0	3 KG	4.5 KG	9 KG	0	7
M20	85 : 15	3 KG	3.825 KG	9 KG	0.675 KG	7
M20	75 : 25	3 KG	3.375 KG	9 KG	1.125 KG	7
M20	65 : 35	3 KG	2.925 KG	9 KG	1.575 KG	7
M20	60 : 40	3 KG	2.7 KG	9 KG	1.8 KG	7

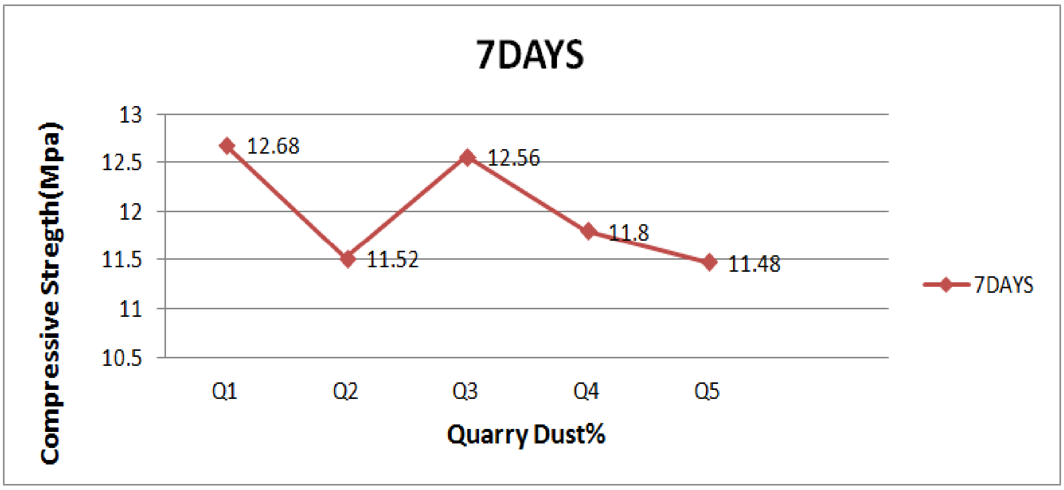
Table 5: Weight of different materials used in required proportion (M25 grade)

GRADE OF CONCRETE	RATIO OF SAND : QUARRY DUST	WEIGHT OF CEMENT (KG)	WEIGHT OF SAND (KG)	WEIGHT OF AGGREGATE (KG)	WEIGHT OF QUARRY DUST (KG)	WEIGHT OF SUPER-PLASTICISER (ml)
M25	100 : 0	4.25KG	4.25 KG	8.5 KG	0	7
M25	85 : 15	4.25KG	3.61KG	8.5 KG	0.63KG	7
M25	75 : 25	4.25KG	3.18 KG	8.5 KG	1.06 KG	7
M25	65 : 35	4.25KG	2.76 KG	8.5 KG	1.48KG	7
M25	60 : 40	4.25KG	2.55KG	8.5KG	1.7KG	7

Table 6: Compressive strength testing of concrete M20 cubes (.15x.15x.15 m)

S.NO	Sand: Quarry dust	M20	
		7DAYS	28DAYS
Q1	100:00	12.68	21.36
Q2	85:15	11.52	22.40
Q3	75:25	12.56	22.78
Q4	65:35	11.80	21.04
Q5	60:40	11.48	19.54

Graph 1: Graph Showing Compressive Strength of M20 at 7days



Graph 2: Graph Showing Compressive Strength of M20 at 28days

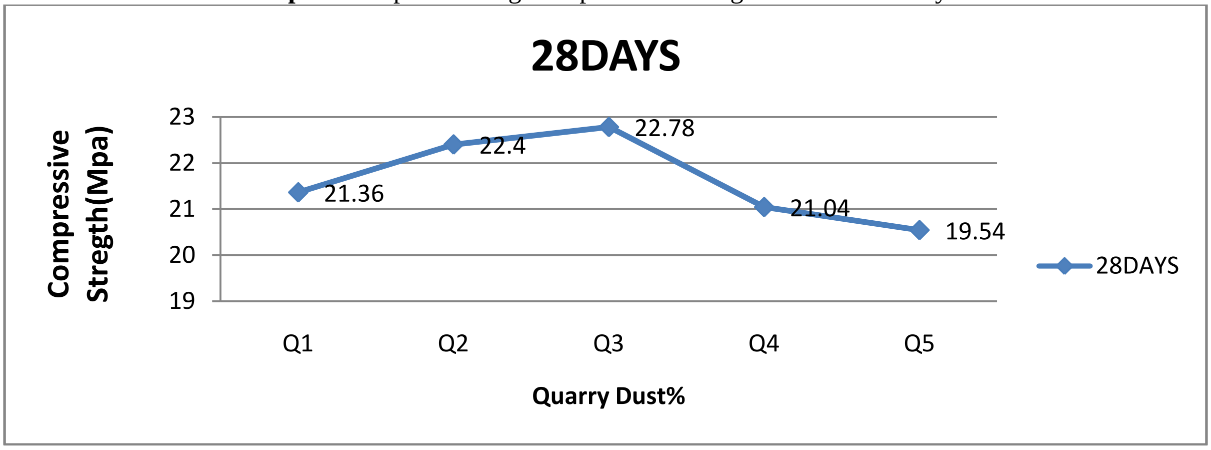
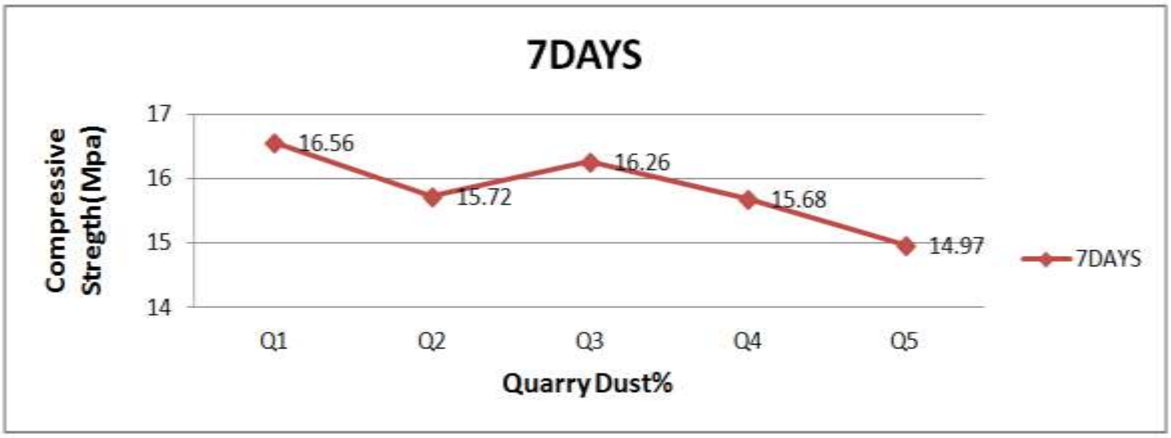


Table 7: Compressive strength testing of concrete M25 cubes (.15x.15x.15 m)

S.NO	Sand: Quarry dust	M25	
		7 DAYS	28 DAYS
Q1	100 : 0	16.56	24.86
Q2	85 : 15	15.72	24.61
Q3	75 : 25	16.226	24.20
Q4	65 : 35	15.68	22.58
Q5	60 : 40	14.97	20.90

Graph 3: Graph Showing Compressive Strength of M25 at 7days



Graph 4: Graph Showing Compressive Strength of M25 at 28days

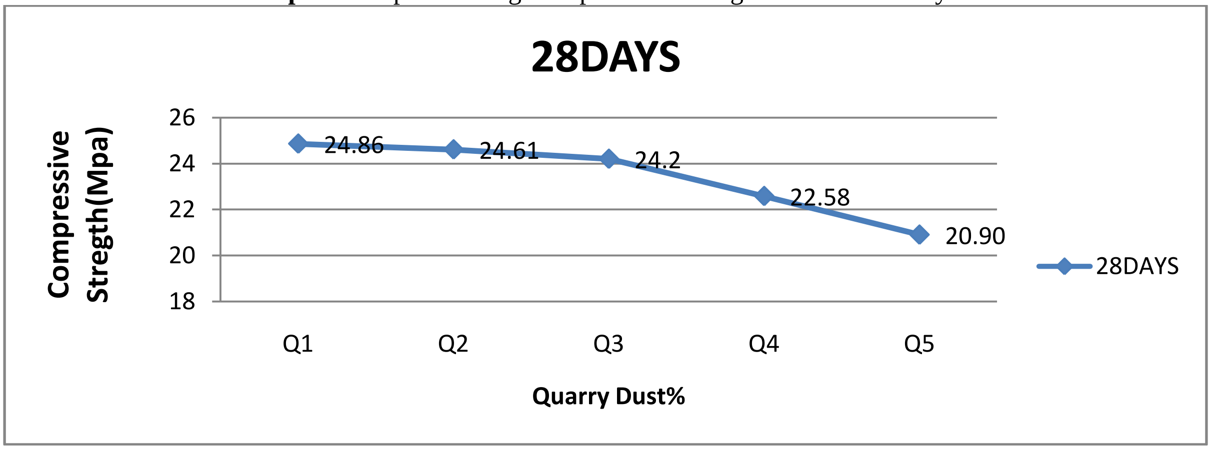


Figure 3: Compressive strength test of sample Figure 4: Cube after failure

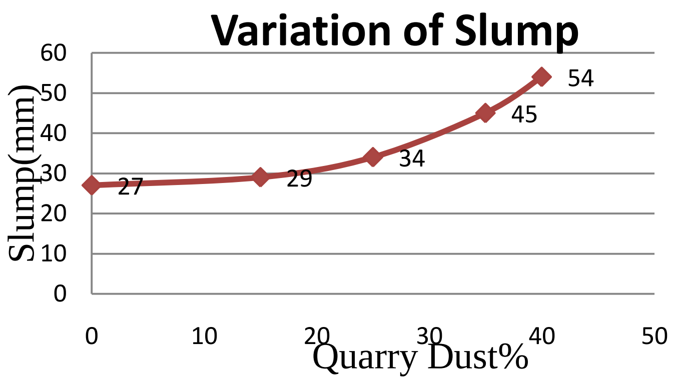
Comparative study:

It is observed that the slump value increases with increase in percentage replacement of sand with quarry dust for the same w/c ratio. Concrete does not give adequate workability with increase of quarry dust. It can be due to the extra fineness of quarry dust Increased fineness require greater amount of water for the mix ingredients to get closer packing, results in decreased workability of the mix. The above slump value corresponds to low degree of workability as per IS: 456-2000.

The measured slump values of quarry dust with constant water/cement ratio i.e. w/c ratio (0.50) are for M20 mixes replacement such as

Q1 (0% quarry dust)	27mm
Q2 (15% quarry dust)	29mm
Q3 (25% quarry dust)	34mm
Q4 (35% quarry dust)	45mm
Q5 (40% quarry dust)	54mm

Graph 5: Graph showing the variation of slump in M20



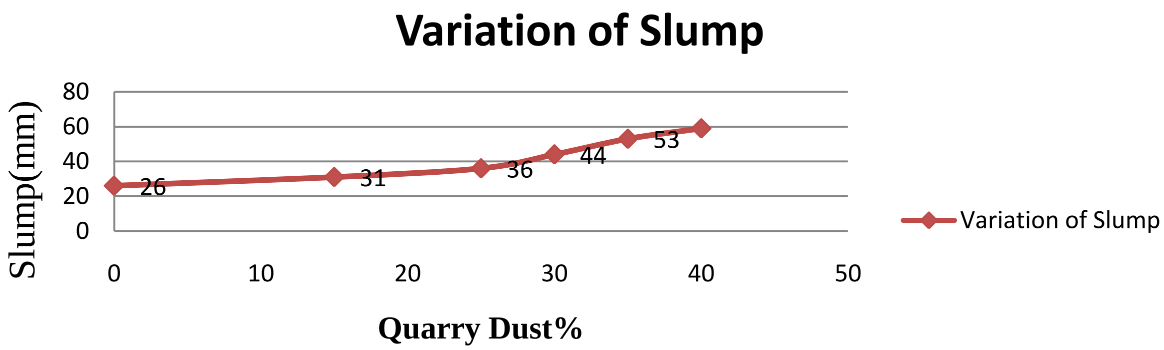
The measured slump values of quarry dust with constant water/cement ratio i.e. w/c ratio (0.50) are for M25 different mixes such as

Q1	(0%quarry dust)	26mm
Q2	(15%quarry dust)	31mm
Q3	(25% quarry dust)	36mm
Q4	(35% quarry dust)	44mm
Q5	(40% quarry dust)	53mm

The variations of slump value with quarry dust percentage are shown in chart. It is observed that the slump value increases with increase in percentage replacement of sand with quarry dust for the same w/c ratio.

Concrete does not give adequate workability with increase of quarry dust. It can be due to the extra fineness of quarry dust Increased fineness require greater amount of water for the mix ingredients to get closer packing, results in decreased workability of the mix. The above slump value corresponds to low degree of workability as per IS: 456-2000.

Graph 6: Graph showing the variation of slump in M25



Why compressive strength decrease after 35% replacement?
As the dust particles exceeds 35%, flaky particles or higher fines increase water demand which leads to higher water cement ratio and segregation of concrete results in non-uniform distribution of cement paste. This consequently leads to a decrease in compressive strength.
The Replacement of the sand with quarry dust shows an improved in the compressive and tensile strength of the concrete.
As the replacement of the sand with quarry dust increases, the workability of the concrete is decreasing due to the absorption of the water by the quarry dust.
The specific gravity is almost same both for the natural river sand and quarry dust.
The results from the table show the decrease in the workability of concrete when the percentage of the replacement is increasing. The workability is very less at the standard water-cement ratio and the water that is required for making the concrete to form a slump with a partial replacement requires more water.

V. Conclusions

1. The compressive strength of concrete keeps on decreasing as the percentage of Quarry dust is increased in concrete as a replacement of sand.
2. A concrete mixture made of 40% Quarry Dust had lowest compressive strength at 28 days curing age that was 17.8% below the value of the conventional concrete mixture and a maximum slump value thus making it unfavourable for use.
3. The workability of concrete reduces with the increase in amount of Quarry dust thus increasing the slump value. Thus to keep workability intact, superplasticizer is used.
4. Best compressive strength is obtained at 25% sand replacement with Quarry Dust and using superplasticizer.
5. The materials used make the concrete mix eco-friendly as well as cost effective as compared to conventional concrete used in the industry.

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