STUDY ON CONCRETE BY PARTIAL REPLACEMENT OF FINE AGGREGATE WITH QUARRY DUST

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ABSTRACT

In the current experimental investigation, 100% quarry dust is used in place of natural sand to create concrete with grades of M40. The primary source of worry is the non-renewable quality of natural sand and the building industry's rising demand for it. River sand, one of the primary components used to make concrete, is becoming more costly and rare. It is now necessary to search for an alternative to river sand. Therefore, quarry dust may be substituted for river sand in many applications. Quarry dust is recognised as a construction material because it has characteristics with river sand. The goal of the current study is to determine the highest amount of quarry dust that may replace river sand in M40 mix designations, with equal percentages ranging from 0% to 50%. The slump cone technique is used to determine viability. To find the concrete's compressive strength, tests are carried out using cubes formed in each percentage.

Keywords: slump cone test, compressive strength, and quarry dust

1. INTRODUCTION

1.1 General

Concrete is mostly used as a material for construction work and consist cementing material and aggregate in relevant proportion. India, around 60 lacs tons of waste are released from various marble processing, cutting etc. Waste from marble industry is utilized as fine constituents in concrete with replacement with sand. Marble waste dust is generally related to problem caused to environmental problem which are dust dangles in air, flies and deposition on vegetable and crop. Other side sand requires for making concrete require mining operation which exhaust natural resources. To overcome this problem, Quarry Dust is one solution which is replaced to full extent in concrete with sand.

Concrete is a commonly used building material in the world. Conventional concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Compare to all other ingredients, aggregates occupy 75 to 80 % of the total volume of concrete and affect the fresh and hardened properties of concrete. In the total composition of concrete, 25 to 30 % was engaged by the fine aggregate in volume.

Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar. The global consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc are few examples. In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction. In this situation research began for inexpensive and easily available alternative material to natural sand.

2. LITERATURE REVIEW

Rubaninbacheran & Ganesan (2014) conducted tests on Durability of Fibre Concrete Using Partial Replacement of Cement by Granite.25%, 30%, 35% granite powder specimen having chloride ion permeability in low range proves to be more economical than all other specimen.25% granite powder specimen having highest residual compressive strength was the most durability against fire.25% granite powder specimen having the least sulphate deterioration factor, was the most economical of the specimen.

Talah et al. (2015) have presented the effect of Quarry Dust on High Performance Concrete Behaviour. Quarry Dust could be used as partial replacement of Portland cement up to 15% in composite cement. The durability test on the concrete containing Quarry Dust consisted of immersion in running water, chloride solution, in all cases, structural changes to the samples were noted. In all cases the addition had improved the physical characteristics of concrete relatively to the reference concrete sample. The addition of Quarry Dust contributes to the reduction of chloride ion penetration and oxygen permeability and increase the durability of concrete. They concluded that Quarry Dust had positive influence on the properties of concrete under hydrochloric mediums.

Bacarji et al. (2013) investigated the effect of marble residue and granite residue as filler in concrete. The replacement of Portland cement by marble and granite residues was studied. Experimental research has been conducted where 5%, 10% and 20% of the cement was replaced by residues and the mechanical performance was determined by means of compressive strength tests, elastic modulus tests and water adsorption tests. They concluded that the X-ray diffraction analysis shows a crystalline nature and due to its non-reactive nature, in general, adding residue as a cement replacement leads to a relative reduction of the compressive strength.

Huajian Li et al. (2016) studied the effect of granite dust on mechanical and durability properties of manufactured sand concrete for the replacement of fly ash. When granite dust is utilized, a lower superplasticizer dosage is needed to obtain the same slumps. Concrete early strengths are reduced by introducing granite dust. When the replacement ratio is controlled within 20%, the manufactured sand concrete possesses higher long term compressive strengths, bending strengths and elastic modulus.

Marmol et al. (2018) presented the use of granite sludge wastes for the production of coloured cement-based mortars. The composition of granite sludge wastes, the main components of which are SiO2, Al2O3, Cao and Fe2O3 based compounds, together with their small particle size. The compressive strength was increased gradually replacing CaCO3 filler withs. Conversely, 10% cement can be replaced with GS without loss of 28-day compressive strength. GS can be readily converted into reddish pigments simply by calcination.

3. OBJECTIVE AND METHODOLOGY

3.1 Objective

Industrial waste use is utilized generally as substitute constitute in partially or fully materials. WQD (waste Quarry Dust) is associated with environmental risk, so their proper disposal has become a problem and attracted a lot of attention of the environmentalists in the previous years. For proper disposal of such marble waste, recycle technique is playing predominant role. Without the proper disposal of this powder material, the resulting stockpiles would cause major health risks for the public and the environment.

Therefore, project's objective is to:

1. Study the possibility to incorporate marble waste dust as fine aggregate material in concrete and the properties of the final product and reducing the hazardous effects of Quarry Dust.
2. Utilization of waste Quarry Dust with replacement of sand and comparing workability, compressive strength.

3.2 Methodology

Three concrete proportions (0%, 10%, 20%, 30%, 40% and 50%) are prepared for checking the effect of replaced industrial waste Quarry Dust with sand as an aggregate to check strength and properties of concrete. The cement used for this test was OPC 53 grade. The waste comes out from the marble industry can be directly used as a material which replace with sand. The size of Coarse Aggregate is 20 mm generally. Fine sand is used for study generally passing through 4.75mm sieve. Mixing and compaction of concrete is done manually. Upper surface of concrete is levelled and surface becomes finished smooth.

Properties of control concrete and concrete with Quarry Dust:

a. Workability (ASTM C - 1437)

Concrete slump and compaction factor is used for measurement of workability mostly of fresh concrete. Generally, use for measurement of the consistency of the concrete. Consistency is nearly related to term workability. This is a term which describes the state of fresh concrete. The ease at which concrete flow is described as workability. It describes concrete wetness. it is mainly affected by consistency i.e. more w/c or wet mixture has more workability than dry mixer.

b. Compressive Strength Test (ASTM C - 109)

Compression test of concrete is measured by cube with CTM testing machine. The specimen for each sample is mixed properly and sample is tested in cube testing machine. Compression test is generally done for measurement of strength of concrete.

4. EXPERIMENTAL WORK

4.1 General

For developing Quarry Dust based concrete mix, it is important to select proper ingredients, evaluate their properties and understand the interaction among different materials for optimum usage. The materials used for this investigation were the same as that used for the normal strength concrete such as cement, coarse aggregate, fine aggregate, water except Quarry Dust, which is generally not used in Conventional Cement Concrete.

Effective production of M40 grade concrete is achieved by carefully selecting, controlling and proportioning of all ingredients. In order to achieve good strength of concrete, optimum proportions must be selected by considering the characteristics of cementitious materials, aggregate quality, paste proportion, aggregate paste interaction, dosage and cautious care in mixing and handling.

Table. 1: The particle size distributions of quarry dust and river sand.

Sieve size	River sand % passing	Quarry Dust (QD) % passing
4.75	100	100
2.36	93	100
1.18	82	93
600	76	76
300	46	54
150	18	35
75	5	15

Table. 2: Physical properties of cement, quarry dust and coarse aggregate.

Material	Property	Referred code
Cement	Fineness: 4%	IS 1489 (Part 1)-1991
	Specific gravity: 3.15	IS 1489 (Part 1)-1991
	Normal consistency: 31%	IS 1489 (Part 1)- 1991/ IS 4031(Part 5)-1999
	Initial setting time: 45min	
	Final setting time: 325 min	

Fine aggregate	Specific gravity: 2.67	IS 2386 (Part 3)-1963
	Water absorption: 1.1%	
Coarse aggregate	Specific gravity: 2.74	
	Water absorption: 0.9%	
Quarry Dust	Specific gravity: 2.2	
	Water absorption: 1.5 %	

4.2 Mix proportion

Table. 3: Quantities of materials in cement concrete.

Material	**Quantity** (kg/m^3)
Cement (grade 53)	438.13
Fine aggregates	643.47
Coarse aggregates	1131.62
Water	197.16
Water: cement	0.45

The final mix proportions are:

Cement: fine aggregate: coarse aggregate = **1: 1.46: 2.56**

To get the optimum proportions, trial mixes have arrived by replacing fine aggregate by Quarry Dust of 0%, 10%, 20%, 30%, 40% and 50%

Volume of the cube = 1.1 X (0.003375) = 0.0037125 m^3

Table. 4: Quantities of materials in preparation of 1 cube.

MIX (%)	**CEMENT (kg)**	**FA (kg)**	**MW (kg)**	**CA (kg)**	**WATER (lit)**
0	1.62	2.38	0	4.20	0.72
10		1.428	0.952		
20		1.309	1.071		
30		1.19	1.19		
40		1.071	1.309		
50		0.952	1.428		

4.3 Casting of specimen

The test specimens were cast in cast-iron moulds. The inside of the mould were applied with oil to facilitate the easy removal of specimens. For obtaining the binder content, the cement and silica fume were thoroughly mixed with one another in dry condition. The fine aggregate and Quarry Dust were thoroughly mixed with one another in dry condition. The coarse aggregate, fine aggregate and the binder content were placed in a concrete mixer machine and then mixed thoroughly in dry condition. For addition of water initially 75% of the mix water is added to the dry mix and mixed thoroughly. The remaining 25% of the mix water and added to the mix and then the mixing was carried out about 2 to 3 minutes. The concrete was then placed in the moulds in three layers of equal thickness and each layer was vibrated. For each series of test specimens, specimens were cast to study the strength related properties of the M40 mixes. After 24 hours, the test specimens were demoulded. The set of specimens was placed in the normal water curing, until the age of test. The casted specimen mentioned in below:

- 54 Nos of cube specimens of size 150mmx150mmx150mm

Fig. 1: Water curing of samples.

4.4 Testing of specimen

4.4.1 Fresh properties of concrete (Workability)

Slump test is the most commonly used method for measuring the consistency of concrete. It can be employed either in the laboratory or at the site. The test is popular owing to its simplicity. The apparatus for conducting slump test consists of a mould in the form of a frustum of a cone having internal dimensions as per IS 1199-1959. The slump cone is placed on a clean non-absorbent tray. The mix concrete is filled in the slump cone in four layers, compacting each layer by tamping 25 times using the standard tamping rod. Care is taken to distribute the strokes evenly over the cross section. After filling the fourth layer, the top surface is leveled off using a trowel. Immediately, the slump cone mould is removed from the concrete by raising it slowly in a vertical direction. This allows the concrete to subside. The subsidence is referred to as the slump of concrete. The difference in level between the height of the mould and the highest point of the subsided concrete is measured in millimetres. This difference in height in "mm" is referred to as the slump of concrete.

4.4.2 Harden properties of concrete

The strength related tests were carried out on hardened cement concrete to determine the strength related properties such as cube compressive strength.

Compressive strength

For cube compression tests on concrete, cube of size 150mm were employed. All the cubes were tested in saturated condition after wiping out the surface moisture from the specimen. For each trial mix combination, three cubes were tested at the age of 7, 14 and 28 days of curing using 400 Ton capacity compression testing machine (CTM) as per BIS: 516-1959.The tests were carried out at a uniform stress after the specimen has been centred in the testing machine. Loading was continued until the dial gauge needle just reserves its direction of motion. The reversal in the directions of motion of the needle indicates that the specimen has failed. The dial reading at the instant was noted, which is the ultimate load. The ultimate load divided by the cross - section area of the specimen is equal to the ultimate cube compressive strength.

$$Compressive\ strength = Load / Area\ (N/mm^2)$$

5. RESULTS AND DISCUSSIONS

5.1 General

The results of the strength and workability tests that were carried out on the five trial mixes of M40 grade concrete to evaluate their workability, strength related properties were presented in this chapter. The effects of Quarry Dust on the properties of the concrete mixtures were discussed separately in this chapter.

5.2 Experimental outputs

5.2.1 Workability of concrete (Slump cone test)

Table. 5: Result of slump test.

S. No	% Of QD	Slump (mm)
1	0	100
2	10	106
3	20	113
4	30	119
5	40	123
6	50	130

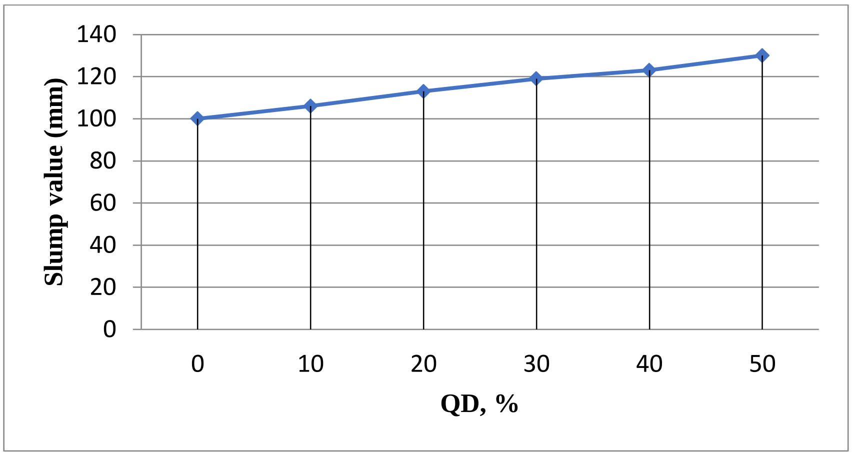

Fig. 2: Slump test results.

The above figure shows the slump results. It was observed that, the slumps increase as the Quarry Dust content were increased in the mix.

5.2.2 Compressive Strength of Concrete (in N/mm^2)

The 7, 14, 28 days compressive strength was studied and the values of 3 samples studied are shown in the tabular form. Table 5.2 shows the data of 7, 14, 28 days compressive strength obtained. Below tables gives the 7, 14, 28 days compressive strength of concrete with maximum nominal size of aggregates 20mm. The 7, 14, 28 days compressive strength was also plotted Fig 5.2 by taking the average of these three values overall an increase in the compressive strength was observed with addition of Quarry Dust as compared to conventional concrete.

Table. 6: Compressive strength of concrete.

% Of QD	**Avg Compressive strength (N/mm2)**		
	7days	**14days**	**28days**
0	23.7	34.5	43.1
10	28.6	44.9	51.3
20	29.8	43.7	53.4
30	**31.9**	**45.5**	**55.3**
40	27.4	40.1	49.5
50	23.2	33.8	42.1

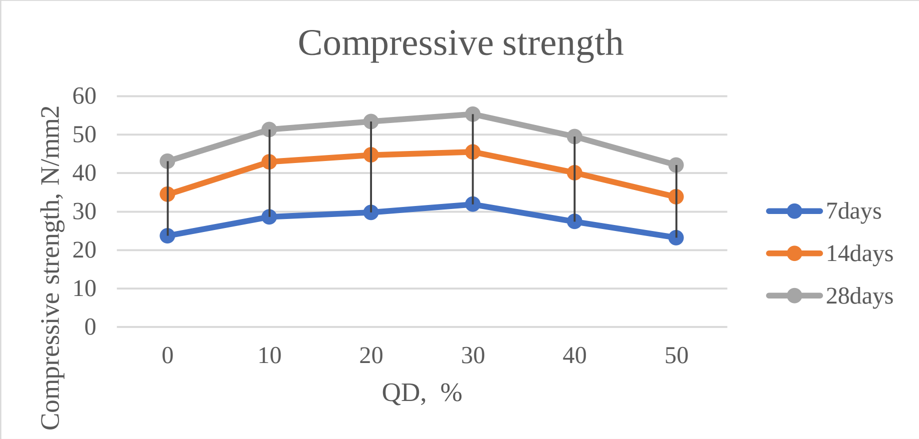

Fig. 3: Effect of quarry dust on 7-, 14- and 28-days compressive strength.

From the above figure, it was observed that up to 30% Quarry Dust the compressive strength was better than that of conventional concrete (i.e. at 0% replacement

5. CONCLUSIONS

The following findings were drawn from the experimental studies and are detailed under the several areas below, for example: Impact of Quarry Dust on the Fresh and Hardened Properties of Concrete.

When fine aggregates were substituted for quarry dust in the concrete mixture, the slump value increased in comparison to the control mix. The greatest droop was produced when 50% of the fine aggregate in the concrete preparation was replaced with quarry dust.

At all ages, the replacement concrete with up to 50% quarry dust and fine aggregates had a higher compressive strength than the control mix. When 30% of the fine aggregate in the concrete preparation process was replaced with quarry dust, the maximum compressive strength was produced.

The compressive strength increased by 22.6% when 30% of the fine aggregate was replaced with quarry dust compared to regular concrete.

The use of industrial waste materials in concrete often results in a little increase or decrease in the parameters measuring strength. Therefore, it was acceptable to utilise waste materials as a partial replacement in concrete from an environmental standpoint in order to properly dispose of it and make efficient use of the valuable minerals found in waste materials.

REFERENCES

[1] Aalok D. Sakalkale "Study on use of waste Quarry Dust in concrete" international journal Of Engineering research and applications ISSN : 2248 9622 , Vol 4, October 2014

[2] R. C. Chipa "Opportunities for Quarry Dust waste as an eco-friendly use in adaptive construction materials" international journal of education & applied science research, Vol 1, June 2014

[3] Hasan Sahan Arel " Re use of Waste Marble in Producing Green Concrete" international Scholarly and scientific research & innovation 2016

[4] Hasan A. MohaQDien "The effect of Quarry Dust and silica fume as a partial replacement For cement and mortar" international journal of civil and structural engineering Vol 3, 2012

[5] Ankit Nileshchandra Patel, Dr. jayeshkumar pitroda, ―Stone Waste in India for Concrete with Value Creation Opportunities", International Journal of Latest Trends in Engineering and Technology (IJLTET) Vol. 2, 2 March 2013.

[6] Taner Kavas, AsimOlgun, ―Properties of cement and mortar incorporating Quarry Dust and crushed bricks.", Department of Ceramic Engineering, Afyonkocatepe University, Afyon, Turkey, February 21, 2007.

[7] Abdulla anwar, Sabih ahmad syed mohd, Ashraf husain, Syed aqeel ahmad "Replacement of Cement by Quarry Dust And Ceramic Waste In Concrete For Sustainable Development" International Journal of Innovative Science, Engineering & Technology, Vol. 2, June 2015.

[8] BabooRai ―Influence of Quarry Dust granules in Concrete mix, International Journal of Civil and Structural Engineering Volume 1, No 4, 2011.

[9] Prof P. A. Shirulea (2012) "Partial Replacement of Cement with Quarry Dust Powder‖, International Journal of Advanced Engineering Research and Studies E-ISSN2249–897. Nuno Almeida, Fernando Branco, Jorge de Brito & Jose Roberto Santos 2007, „High-performance concrete with recycled stone slurry", Cement and Concrete Research, vol. 37, pp. 210–220.

[10] Nuno Felixkala, T & Partheeban, P 2010, „Granite powder concrete", Indian Journal of Science and Technology,vol. 3, no. 3, pp. 311-317.

[11] Abukersh, SA & Fairfield, CA 2011, „Recycled aggregate concrete produced with red granite dust as a partial cement replacement", Construction and Building Materials, vol. 25, pp. 4088–4094.

[12] Divakar, Y, Manjunath, S & Aswath, MU 2012, „Experimental investigation on behaviour of concrete with the use of granite fines", International Journal of Advanced Engineering Research and Studies, vol.1, no.4, pp. 84-87.

[13] Vijayalakshmi, M, Sekar, ASS & Ganesh prabhu 2013, „Strength and durability properties of concrete made with granite industry waste", Construction and Building Materials, vol. 46, pp. 1–7.