International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.5., Issue.2, 2017
March-April

RESEARCH ARTICLE

ISSN: 2321-7758

AN EXPERIEMNTAL STUDY ON QUARRY DUST AS PARTIAL REPLACEMENT TO FINE AGGREGATE IN HIGH STRENGTH CONCRETE

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ABSTRACT

River sand, a common material used as fine aggregate in concrete. It is commonly available at river beds which is a natural resource for sand. Rapid depletion of these sources causes to think alternatives for substitute or replacement to fine aggregate. As the demand of sand is high, it leads to increase in its price and large excavations causes failures in river beds. Quarry rock dust, which is a waste material produced from quarrying and dressing of stones can be an economic alternative to the river sand. Quarry rock dust has fine particles less than 4.75mm. Usually, quarry rock dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated elements. In this study, the quarry dust is used as partial replacement to sand in the preparation of high strength concrete of M40 grade. The aim of this study is to find the percentage of quarry dust as partial replacement to sand in concrete. Quarry dust of 0%, 20% and 40% were added by weight of sand. Slump cone test was carried out on fresh concrete while Compressive Strength test was carried out on hardened 150mm concrete cubes. Durability tests like acid-alkali attack test were also conducted for concrete cubes after curing in acid and alkali solution for 28days

Keywords : Quarry rock dust, High strength concrete, super plasticizer

1. INTRODUCTION

1.1 GENERAL

The utilization of quarry rock dust has been accepted as building material in the developing countries for the past three decades. The use of quarry dust in India has not been much developed, due to lack of awareness among people and lack of significant research on quarry dust.

Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Experiments shows that Quarry dust can increase the strength of concrete over the concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete.

When examining the above qualities of quarry dust it becomes apparent that if we use it as a replacement to fine aggregate, the loss in early strength due to one may be alleviated by the gain in strength due to the other, and the loss of workability due to the one may be partially negated by the improvement in workability caused by the inclusion of the other.

1.2 OBJECTIVES OF THE STUDY

- The principal objective of this study is to prepare M40 grade concrete by adding

quarry dust in different weight proportions (0%,20%,40%) of fine aggregates.

- To investigate the fresh properties of concrete like workability on M40 grade concrete by replacement of FA with quarry dust.
- To investigate the mechanical properties such as compressive strength, tensile strength of M40 grade concrete by replacement of FA with quarry dust.
- To investigate the durability properties by conducting acid and alkali attack tests on M40 grade concrete by replacement of FA with quarry dust.
- To compare the mechanical and durable behaviour of M40 grade concrete with and without replacement of FA with quarry dust.

2. EXPERIMENTAL PROGRAM

2.1. MATERIALS USED: The different materials used in this investigation are:

- Cement
- Fine Aggregate
- Coarse Aggregate
- Quarry Dust
- Chemical Admixture-super plasticizer
- Water

2.1.1. CEMENT: Cement is a binding material, which is the combination of two raw materials called calcareous and argillaceous materials. KCP-53 grade ordinary Portland cement conforming to IS: 12269 was used.

The physical properties of the cement are listed in Table-1 : Properties of Ordinary Portland cement

S.No	Properties	Results	IS : 12269-1987
1.	Specific gravity	3.15	--
2.	Normal consistency	32%	--
3.	Initial setting time	35	Minimum of 30min
4.	Final setting time	600	Maximum of 600min
5.	Compressive strength at A. 3 days B. 7 days C. 28days	 29.4Mpa 42.5Mpa 56.1Mpa	 Minimum of 27Mpa Minimum of 40Mpa Minimum of 53Mpa

2.1.2.FINE AGGREGATES: The standard sand used in this investigation was obtained from pennar river, Nellore. The standard sand shall (100 percent) pass through 2-mm IS sieve and shall be (100 percent) retained on 90-micron IS Sieve and the sieve shall conform to IS 460 (Part: 1): 1985.

The physical properties of sand are shown in Table-2

Table. 2 Properties of Fine aggregate

S.No	Properties	Observation
1.	Colour	Grayish White
2.	Specific gravity	2.67
3.	Shape of grains	Angular

2.1.3 COARSE AGGREGATES: The coarse aggregate procured from quarry was sieved through the sieves of sizes 20 mm and 10 mm respectively. The aggregate passing through 20 mm IS sieve and retained on 10 mm IS sieve was taken.

The physical properties of CA are shown in Table-3

Table .3 Properties of Coarse aggregate

S.No	Properties	Observation
1.	Colour	Grayish White
2.	Specific gravity	2.80
3.	Absorption in24 hours	0.80%
4.	Shape of grains	Sub angular

2.1.4 QUARRY DUST : The crusher plants located in Nellore are the sources for collecting quarry dust used in this study. The crusher plants are equipped with roller or jaw type crushed and crushed stone metals of different sizes are collected after sieving them through rotary sieves, which are cylindrical in shape and placed in an inclined position. Starting from higher end of the screening unit, they have in general openings of sizes 3.2, 9.5, 12.7, and 25.4mm. The material passing through 3.2mm sieve is known as crusher dust or quarry dust and is collected. Quarry dust is collected from vendhodu (v), Nellore district.

Fig.1. Quarry Rock Dust.

The comparison of physical properties of quarry dust and natural sand as per the Indian Standards are listed in the Table-4.

Table.4 Physical properties of quarry dust and natural sand

S.No	Property	Quarry Dust	Natural Sand	Test method
1.	Specific gravity	2.4	2.60	IS2386(Part III)- 1963
2.	Bulk density (kg/m3)	1810	1460	IS2386(Part III)- 1963
3.	Absorption (%)	1.50	Nil	IS2386(Part III)- 1963
4.	Moisture Content (%)	Nil	1.50	IS2386(Part III)- 1963
5.	Fine particles less than 0.075 mm (%)	12	6	
6.	Sieve analysis	Zone-II	Zone-II	IS 383-1970

2.1.5.CHEMICAL ADMIXTURE :

2.1.5.1.SUPER PLASTICIZER : The chemical Admixture used in this study was VARAPLAST SP123. VARAPLAST SP 123 is a chloride free, Superplasticising admixture based on selected synthetic polymers. It is supplied as a brown solution and is instantly dispersible in water. VARAPLAST SP 123 can provide very high level of water reduction and hence major increase in strength can be obtained coupled with good retention of workability to aid placement.

INSTRUCTIONS FOR DOSAGE: The optimum dosage of VARAPLAST 123 should be determined by site trials with actual site conditions. As a guide, the dosage is normally: 0.50 - 1.0 litres/100 kg cementatious material, for flowing concrete. 0.80 - 1.50 litres/100 kg cementatious material, for high strength concrete. Overdosing: An overdose by double of the intended amount of VARAPLAST 123 will result in very high workability as compared to that normally obtained. Provided that adequate curing is maintained, the ultimate compressive strength will not be impaired.

Fig.2. Super Plasticizer [VARA PLAST SP 123]

2.1.7. WATER: Portable water was used in the experimental work for both preparing and curing. The pH value of water taken is not less than 6.

3. MIX DESIGN FOR PRESENT INVESTIGATION.

In the present work, the IS METHOD has been used to get proportions for M40 grade concrete. The concrete mix design for M40 were carried out according to I S recommendation method.

MIX PROPORTION FOR M40

Cement	Fine aggregate	Coarse aggregate	Water
528 Kg/m3	716Kg/m3	1063 Kg/m3	197 Kg/m3
1	1.35	2.01	0.375

4. RESULTS AND DISCUSSIONS 4.1WORKABILTY TEST RESULTS

Table.5 Slump test results

% of Quarry Dust added	Slump in ''mm''
	M40
0%	70mm
20%	60mm
40%	62mm

DESCRIPTION OF CODINGS FOR M40 GRADE CONCRETE:

In the present study, we are considered the following coding.

C - Conventional concrete

Q1 - Combination of 20% quarry dust

Q2 - Combination of 40% quarry dust

S1 - Combination of 20% quarry dust+0.8% of super Plasticizer

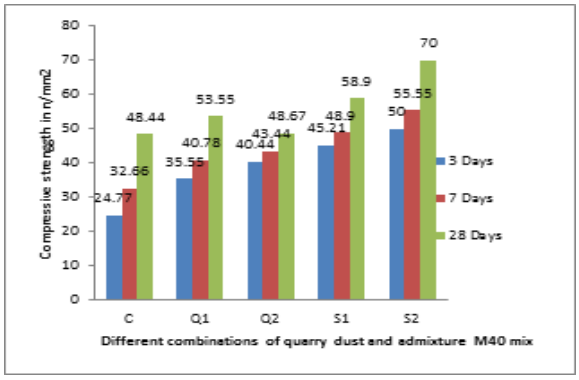
S2 - Combination of 40% quarry dust+0.8% of super Plasticizer

4.2 TESTS ON MECHANICAL PROPERTIES OF CONCRETE

4.2.1 COMPRESSIVE STRENGTH TEST

Table.6 Compressive strength test results

Codings	Compressive strength at 3 days(MPa)			Compressive strength at 7 days(MPa)			Compressive strength at 28 days(MPa)		
	Cube no			Cube no			Cube no		
	1	2	Avg	1	2	Avg	1	2	Avg
C	24.66	24.88	24.77	33.33	32	32.66	48	48.88	48.44
Q1	36	35.11	35.55	40.44	41.11	40.78	53.33	53.78	53.55
Q2	41.33	39.55	40.44	43.55	43.33	43.44	51.11	46.22	48.67
S1	46.88	43.55	45.21	47.33	50.44	48.9	57.77	60	58.9
S2	44.88	47.11	50	57.78	53.33	55.55	68.88	71.11	70

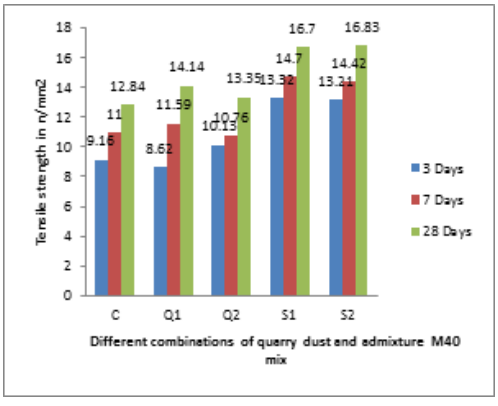


Graph.1 Compressive strength test results

4.2.2 TENSILE STRENGTH TEST

Table.7 Tensile strength test results

coding	Tensile strength at 3 days(MPa)			Tensile strength at 7 days(MPa)			Tensile strength at 28 days(MPa)		
	Cylinder no			Cylinder no			Cylinder no		
	1	2	Avg	1	2	Avg	1	2	Avg
C	9	9.33	9.16	10.75	11.2	11	12.67	13.01	12.84
Q1	7.92	9.33	8.62	10.75	12.44	11.59	13.58	14.71	14.14
Q2	10	10.2	10.13	10.2	11.32	10.76	12.56	14.14	13.35
S1	12.78	13.86	13.32	14.14	15.27	14.7	17.54	15.84	16.7
S2	12.56	13.86	13.21	14.71	14.14	14.42	16.69	16.97	16.83



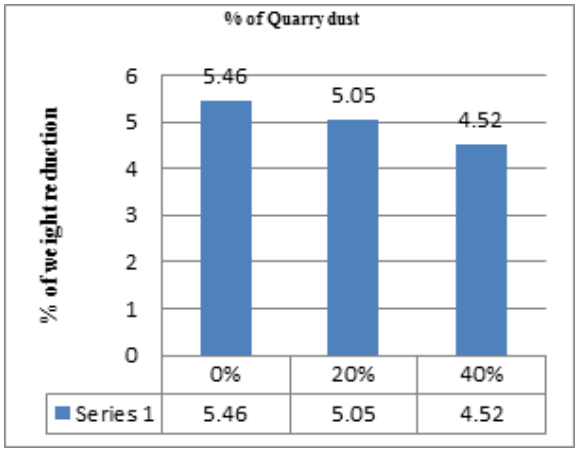
Graph.2 Tensile strength test results

4.2.3 ACID ATTACK TEST

(a) %LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS ACID CURING:

Table.7 % loss of weight reduction of cubes in acid curing after 28 days

% of Quarry dust added	Fine aggregate replacement		
	Initial weight	Final weight	% loss in weight
0%	8.6	8.13	5.46
20%	8.5	8.07	5.05
40%	8.4	8.02	4.52

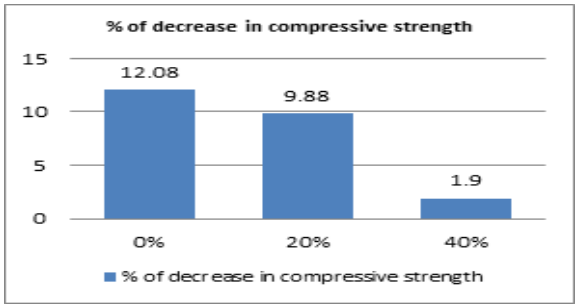


Graph.3 % loss of weight reduction of cubes in acid curing after 28 days

(b) %LOSS OF COMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS ACID CURING:

Table.8 % loss of compressive strength reduction of cubes in acid curing after 28 days

% of Quarry dust added	Fine aggregate replacement		
	compressive strength with water curing	compressive strength after acid curing	%loss in compressive strength
0%	48.00	42.2	12.08
20%	53.33	48.06	9.88
40%	51.11	50.13	1.9



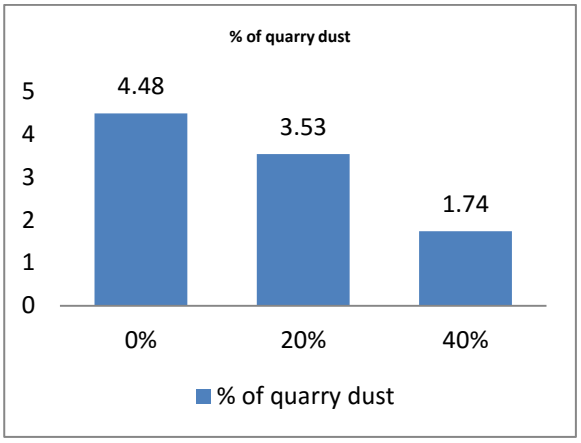
Graph.4 % loss of compressive strength reduction of cubes in acid curing after 28 days

4.2.4 ALKALI ATTACK TEST:

(a) %LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS ALKALI CURING:

Table .9 % loss of weight reduction of cubes in alkali curing after 28 days

% of Quarry dust	Fine aggregate replacement		
	Initial weight	Final weight	% loss in weight
0%	8.02	7.66	4.48
5%	8.8	8.5	3.53
10%	8.6	8.45	1.74

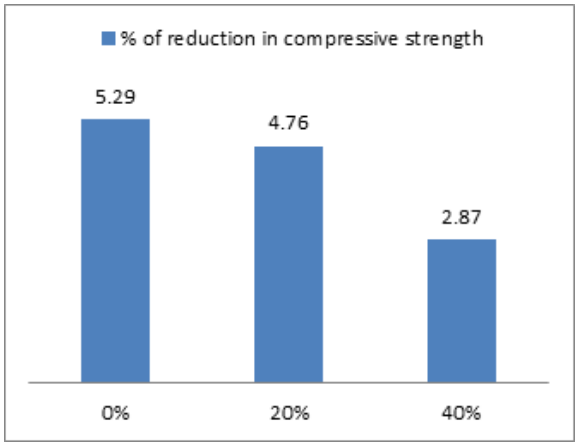


Graph.5 % loss of weight reduction of cubes in alkali curing after 28 days

(b) %LOSS OF COMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS ALKALI CURING:

Table .10 % loss of compressive strength reduction of cubes in alkali curing after 28 days

% of Quarry dust	Fine aggregate replacement		
	compressive strength with water curing	compressive strength after alkali curing	% loss in compressive strength
0%	48	45.46	5.29
20%	53.33	50.79	4.76
40%	51.11	49.64	2.87



Graph.6 % loss of compressive strength reduction of cubes in alkali curing after 28 days

5. CONCLUSIONS

The following conclusions are arrived at based on the experimental investigation carried out in the present study:

- Quarry dust concrete has slightly higher strength than reference concrete of M40. This shows that quarry dust concrete can be used with confidence as a building material.
- Quarry dust Concrete acquires maximum increase in compressive and tensile strengths at 20% and 40% sand replacement when compared with concrete with only river sand.
- The workability of quarry dust concrete decrease at 20% and 40% sand replacement when compared with concrete with only river sand.
- The percentage loss of weight and compressive strength after acid- alkali curing is high in concrete prepared by common river sand when compared to quarry dust concrete.
- It can concluded that 40% quarry dust as partial replacement to fine aggregate in concrete can improve the mechanical and durability properties of concrete but decreases concrete workability.
- The workability of the quarry dust concrete can be improved by adding suitable super plasticiser.
- Hence the Quarry dust obtained from Nellore District satisfies the requirements specified in IS standards.

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