Experimental Investigation on Partial Replacement of Natural Sand by Quarry Dust with Chemical Admixtures

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***Abstract*: Concrete plays a major role in the construction industry and large quantum of concrete is being utilized. River sand, which is one of the constituent used in the production of conventional concrete, has become expensive and also scarce material. In view of this, there is a need to identify suitable alternative material from industrial waste in place of river sand. The utilization of quarry dust which is a waste material has been accepted as building material in many countries for the past three decades. Recycling involves processing used materials in to new products in order to prevent the waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air and water pollution by reducing the need for conventional waste disposal and to lower greenhouse gas emission as compared to virgin production. Recycling is the key component of modern waste management system and is the third component of waste hierarchy, "Reduce, Reuse, and Recycle". Concrete traditionally consists of cement, fine aggregate, coarse aggregate and water. We have to replace the fine aggregate with quarry dust with an objective of utilize the waste material. Quarry dust improves the mechanical properties of concrete when used along with super plasticizers.**

***Keywords*: Conglomerate stone, plasticizer, quarry dust, split tensile strength, flexural strength.**

2. Introduction:

Concrete is an artificial conglomerate stone made essentially of Portland cement, water, fine and coarse aggregates. The mixture of the materials results in a chemical reaction called hydration and a change in a mixture from plastic to a solid state occurs over a period of time. The cost concrete can be reduced by reducing cost of constituent materials. Cost reduction can also be achieved by using locally available alternative material, instead of conventional materials.
The present investigation is to evaluate the possibilities of using quarry dust as a replacement to fine aggregate along with super plasticizers at a dosage of 0.5 and 1% by weight of Cementitous material. During the present study, 10%, 20%, 30%, 40%, 50% and 100% of traditional fine aggregate will replaced with quarry dust. For each mix, 0.5 and 1% of super plasticizers by weight of cement was added. Compression, split tensile tests will determined after 7, 28 days of curing and the results will be tabulated and concluded.

3. Literature review:

Anitha selva sofia S D, Gayathri R, Swathi G, Prince arulraj G. (2013) Use of Quarry Dust to replace of Sand in Concrete. Based on this experimental investigation it is found that quarry dust can be used as alternative material to the natural river sand. The physical and chemical properties of quarry dust satisfy the requirements of the aggregate. It is found that quarry dust improves its mechanical property of concrete. Usage of quarry dust it will also reduce the cost of concrete because it is a waste material from quarry. Dust in concrete will also reduce the disposal problem. When conventional fine aggregate is completely replace with quarry dust.

G Balamurugan. (2013) Behaviour of concrete on the use of quarry dust to replace sand. This experimental study presents the variation in the strength of concrete when replacing sand by quarry dust from 0% to 100% in steps of 10%. M20 and M25 grades of concrete are taken for the study keeping a constant slump of 60mm. The compressive strength of concrete cubes at age of 7 and 28 days is obtained at room temperature. Split tensile strength and flexural strength of concrete are found at the age of 28 days. From the test results it is found that the maximum compressive strength, tensile strength and flexural strength are obtained only at 50% replacement. The results gives clear picture that quarry dust can be utilized in concrete mixtures as a good substitute for natural river sand at 50% replacement with additional strength than control concrete.

Chandana Sukesh, Katakam Bala Krishna, P. Sri Lakshmi Sai Teja, S. Kanakambara Rao. (2013) Partial Replacement of Sand with Quarry Dust in Concrete**.** Carried out an investigation on 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 concretes especially in Concrete. Granite fines or rock dust is a by-product obtained during crushing of granite rocks and is also called quarry dust. This present work is an attempt to use Quarry Dust as partial replacement for Sand in concrete. Attempts have been made to study the properties of concrete and to investigate some properties of Quarry Dust the suitability of those properties to enable them to be used as partial replacement materials for sand in concrete. The Replacement of the sand with quarry dust shows an improved in the compressive 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.

Lohani T.K, Padhi M, Dash K.P., Jena S. (2012). Optimum utilization of Quarry dust as partial replacement of sand in concrete. Carried out an investigation on the design mix of M20 grade concrete with replacement of 0%, 20%, 30%, 40%, and 50% of quarry dust organized as M1, M2, M3, M4 and M5 respectively have been considered for laboratory analysis viz. slump test, compaction factor test, compressive strength (cube, cylindrical sample), split tensile strength, flexural strength, modulus of elasticity, water absorption of hardened concrete. Mechanical properties of concrete with quarry dust. They reported that the quarry dust may be used as an effective replacement material for natural river sand which increased the strength.

R. Ilangovana, N. Mahendrana and K. Nagamanib.(2008) concrete Strength and Durability Properties of Containing Quarry Rock**.** It can be concluded that the replacement of natural sand with Quarry Rock Dust, as full replacement in concrete is possible. However, it is advisable to carry out trial casting with Quarry Rock Dust proposed to be used, in order to arrive at the water content and mix proportion to suit the requirement.

Md. Safiuddin,S.N. Raman and M.F.M. Zain (2007) Utilization of Quarry Waste Fine Aggregate in Concrete Mixtures. Quarry waste fine aggregate can be utilized in concrete mixtures as a good substitute of natural sand. The physical and chemical property of quarry dust satisfy the requirements of the aggregate. It improves the mechanical property of concrete. Usage of quarry dust it will also reduce the cost of concrete because it is a waste material from quarry. Dust in concrete will also reduce the disposal problem.

4. Objectives

1) To study the behaviour of concrete on which fine aggregate is replaced with quarry dust along with super plasticizer.
2) The main parameters studied will be compressive strength, split tensile strength and their results are studied and compared with control mix concrete.
3) To conduct experimental investigation to determine the mechanical properties and workability of the concrete.
4) The main objective of this project is to study the performance of concrete.
5) To conclude its suitability based on experimental results.

5. Methodology:

During the present study, 0%, 10%, 20%, 30%, 40%, 50% and 100% of traditional fine aggregate was replaced with quarry dust. For each of the mixes, two dosages of superplasticizer, 0.5% and 1% by weight of cement were added.

5.1 TESTS ON CEMENT

5.1.1 Fineness of Cement : The degree of fineness of cement is a measure of mean size of grains in cement. The rate of development of hydration of strength in cement depends on fineness of cement.

Table-1 Tabulation of fineness of cement

S.No	Weight of cement sample W1gms	Weight of cement retained W2gms	Fineness of cement =(W2/W1) * 100
1	100	6	6%
2	100	8	8%

Result: The fineness of cement sample is found to be 7%.

5.1.2 Normal Consistency Test:

Table-2 Tabulation of normal consistency test of cement

Mass of cement taken = **400 g**

Description	Trial-1	Trial-2	Trial-3
Percentage of water	26	28	30
Initial reading in mm	0	0	0
Final reading in mm	12	10	6
Height not penetrated in mm	12	10	6

Result: Standard consistency of cement = 30%

5.1.3 Specific Gravity Test

Table-3 Tabulation of specific gravity test of cement

Sl. no	Description	Trial - 1	Trail-2
1	Weight of empty specific gravity bottle, W_1 g	28	28
2	Weight of specific gravity bottle + distilled water, W_2 g	82	82
3	Weight of specific gravity bottle + kerosene, W_3 g	73	75
4	Weight of specific gravity bottle + cement + kerosene, W_4 g	110	111
5	Weight of cement, W_5 g	50	50
6	Specific gravity of cement	3.2	3.1

Specific Gravity of cement=$W_5(W_3-W_1)/(W_5+W_3-W_4)$ (W_2-W_1)

Average specific gravity of cement= (3.2+3.11)/2=3.15

Result: The specific gravity of cement is found to be **3.15**

5.1.4 Setting Time Test:

Table-4 Tabulation of initial setting time test of cement

SL No	Time in min	Initial reading, in mm	Final reading, in mm	Depth of penetration
1	0	0	0	0
2	10	0	14	14
3	20	0	13	13
4	30	0	12	12
5	40	0	10	10
6	50	0	8	8
7	60	0	8	8
8	80	0	6	6

Result: The Initial setting time of cement is found to be **80 minutes**.

5.2 TESTS ON COARSE AGGREGATE:

5.2.1 Specific Gravity of Coarse Aggregate

Table-5 Tabulation of specific gravity test of coarse aggregate

Sl No	Description	Trial - 1	Trial - 2
1	Weight of saturated aggregates suspended in water with basket W_1 g	3114	3120
2	Weight of basket suspended in water W_2 g	1279	1278
3	Weight of saturated aggregates in water $W_s = (W_1 – W_2)$ g	1835	1842
4	Weight of saturated surface dry aggregates in air W_3 g	2960	2956
5	Weight of water equal to volume of the aggregate W_4 g	2948	2924

6	Specific gravity of aggregates $S=W_4/(W_3-W_S)$	2.62	2.624
7	Water absorption in percent $W=100\times(W_3-W_4)/W_4$	0.405	0.547

Average specific gravity of coarse aggregate = (2.62+2.624)/2=2.62
Result: The specific gravity of coarse aggregate is found to be **2.62.**
The water absorption value of coarse aggregate is found to be **0.476 %.**

5.2.2 Sieve Analysis of Coarse Aggregate:
Table-6 Tabulation of sieve analysis test of coarse aggregates
Mass of coarse aggregate sample taken **= 5000 g**

Sieve size(mm)	Weight retained in (grams)	Percentage Weight retained	Cumulative Percentage Weight retained (C)	Percentage Weight passed 100-C
80	0	0	0	100
40	0	0	0	100
20	0	0	0	100
16	306	6.12	6.12	93.88
12.5	430	8.60	14.72	85.28
10	1888	37.76	52.48	47.52
6.3	2112	42.24	94.72	5.28
4.75	264	5.28	100	0
Pan	0	0	100	0

Result: The fineness modulus of coarse aggregate is found to be **7.68.**

5.3 TESTS ON FINE AGGREGATE
5.3.1 Specific gravity test:

Table-7 Specific Gravity of River Sand

Sl No	Description	Trial-1	Trial-2
1	Weight of empty pycnometer W1 g	600	600
2	Weight of pycnometer +1/3rd of sand W_2 g	965	970
3		1695	1700

	Weight of pycnometer + water + sand W3 g		
4	Weight of pycnometer + distilled water W4 g	1470	1470
5	Specific gravity of sand	2.61	2.64

Result: The specific gravity of river sand is found to be **2.625.**

Table-8 Specific Gravity of Quarry Dust

Sl No	Description	Trial-1	Trial-2
1	Weight of empty pycnometer W1 g	600	600
2	Weight of pycnometer + sand W2 g	980	990
3	Weight of pycnometer + water + sand W3 g	1696	1708
4	Weight of pycnometer + distilled water W4 g	1470	1470
5	Specific gravity of sand	2.46	2.56

Result: The specific gravity of quarry dust sis found to be **2.51.**

5.3.2 Fineness Modulus Test:

Table-9 Tabulation of Sieve Analysis Test of Fine Aggregates

Mass of fine aggregate sample taken = **1000 g**

Sieve size(mm)	Weight retained in (grams)	Percentage Weight retained	Cumulative Percentage Weight retained (C)	Percentage Weight passed (100-C)
4.75	50	5	5	95
2.36	90	9	14	86
1.18	300	30	44	56
0.60	400	40	84	16
0.30	90	9	93	7
0.15	50	5	98	2
Pan	20	2	100	0

Σ C = 438

Σ C= Sum of cumulative percentage weight retained

Fineness modulus = ∑C/**100** = 4.38

Result: The fineness modulus of sand is found to be **4.38.**

5.4 MIX DESIGN

DESIGN OF M30 CEMENT CONCRETE AS PER IS 10262:2009

1. STIPULATIONS FOR PROPORTION:

Grade designation: M30

Type of cement: OPC 53 Grade

Minimum cement content :320 kg/m^3

Maximum cement content :450Kg/m^3

Maximum nominal size of aggregate:20mm

Workability: 100 mm (slump)

Maximum water cement ratio:0.45

Exposure condition: Sever

Method of concrete placing: Manual

Degree of supervision: good

Type of course aggregate: Angular

Chemical admixture type: Super plasticizer

2. TEST DATA FOR MATERIALS:

Cement used: OPC 53

Specific gravity of cement: 3.15

Chemical admixture: Yes

Specific gravity of

Coarse aggregate: 2.62

Fine aggregate: 2.63

Water absorption: Surface dry

Free (Surface) moisture: Ni

TARGET STRENGTH FOR MIX PROPORTIONING

$\mathbf{f'_{ck} = f_{ck} + 1.65s}$

From table 1, Standard deviation, s= 5 N/mm^2.

Therefore, target strength = 30+1.65*5

=38.25 N/mm^2

SELECTION OF WATER CEMENT RATIO:

From table 5 of IS 456-2001, Maximum w/c ratio adopted 0.45

3. SELECTION OF WATER CONTENT:

From table 2,

4. CALCULATION OF CEMENT CONTENT:
5. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE:
6. MIX CALCULATIONS:
7. MIX PROPORTION FOR TRAILS:

Cement = 438Kg/m^3

Water = 197 kg/m^3

Fine aggregate = 662.34kg/m^3

Coarse aggregate= 1094.34 Kg/m^3

w/c ratio = 0.45

Cement: Fine Aggregate: Coarse Aggregate:

1: 1.51: 2.5

C0NCRETE QUANTITY CALCULATION

CUBES (150*150*150mm)

Super plasticizers for 0.5% of cement =7.8 grams
Super plasticizers for 1% of cement =12.2 grams
W/C ratio= 0.45

Water =0.45*2.44

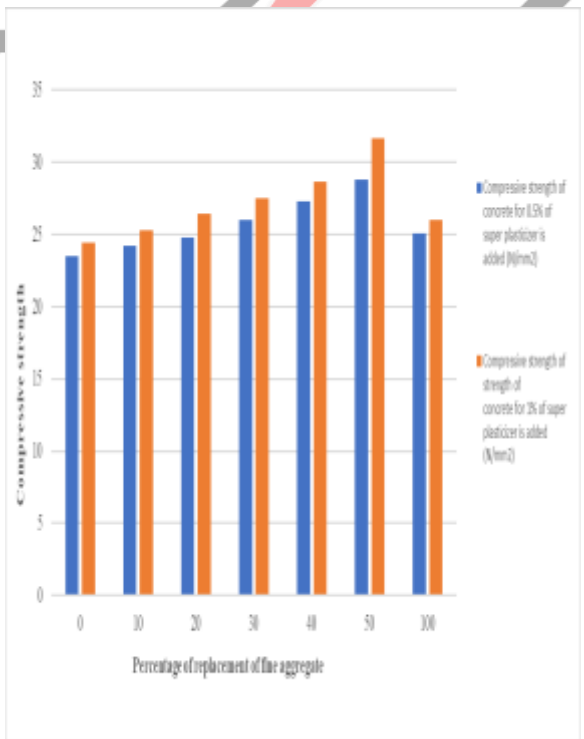
=1.098 Litres

TESTS ON CONCRETE

Compressive Strength Test

Table-10 Compressive strength of concrete with quarry dust were found after 7day of curing.

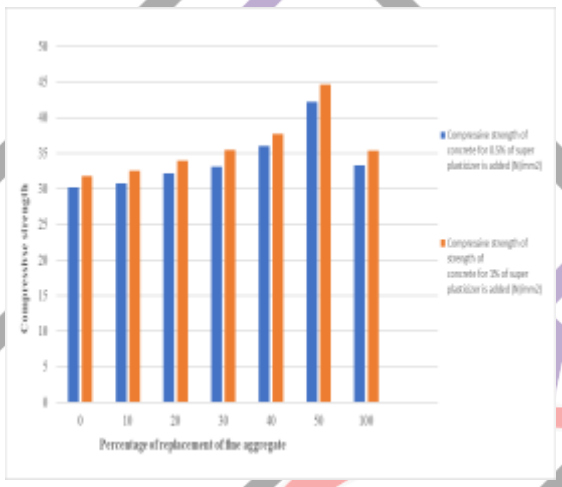
Percentage of replacement of quarry dust	Compressive strength of concrete for 0.5% of super plasticizer is added (N/mm^2)	Compressive strength of concrete for 1 % of super plasticizer is added (N/mm^2)
0	23.50	24.40
10	24.20	25.30
20	24.80	26.44
30	26.00	27.50
40	27.30	28.66
50	28.80	31.70
100	25.11	26.00



Graph-1 The compressive strength of concrete with quarry dust are also shown in Graph-1

Table-11 Compressive strength of concrete with quarry dust were found after 28 day of curing.

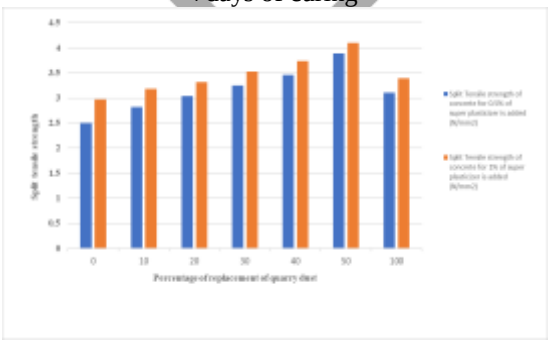
Percentage of replacement of quarry dust	Compressive strength of concrete for 0.5% of super plasticizer is added (N/mm^2)	Compressive strength of concrete for 1% of super plasticizer is added (N/mm^2)
0	30.20	31.77
10	30.80	32.6
20	32.20	34
30	33.11	35.50
40	36.00	37.7
50	42.20	44.6
100	33.30	35.33



Graph-2 Compressive Strength of Quarry Dust Concrete with Respect to Percentage Replacement.

5.6.2 Split Tensile Strength Test

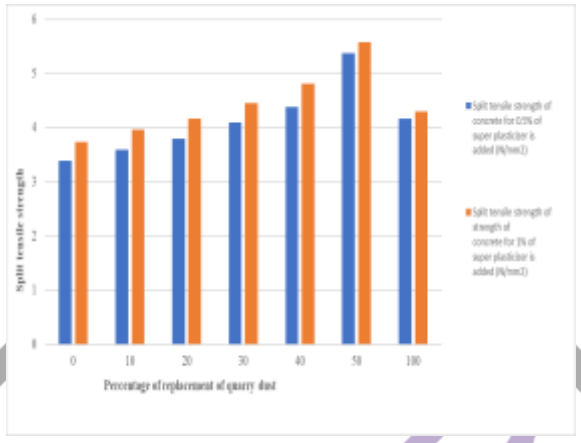
Table-12 Split Tensile Strength of Concrete with Quarry Dust were found after 7days of curing



The split tensile strength of concrete with quarry dust are shown in graph-3

Table-13 Split Tensile Strength of Concrete with Quarry Dust were found after 28 days of curing

Percentage of replacement of quarry dust	Split Tensile strength of concrete for 0.5% of super plasticizer is added (N/mm^2)	Split Tensile strength of concrete for 1% of super plasticizer is added (N/mm^2)
0	3.39	3.74
10	3.60	3.96
20	3.80	4.17
30	4.10	4.45
40	4.38	4.81
50	5.37	5.58
100	4.17	4.3



Graph-4 Split Tensile Strength of Quarry Dust concrete with Respect to Percentage Replacement.

CONCLUSION

1) Based on this experimental investigation, it is found that quarry dust can be used as an alternative material to the natural river sand.
2) The physical and chemical properties of quarry dust satisfy the requirements of fine aggregate.
It is found that quarry dust improves its mechanical property of concrete if used along with super plasticizer.
3) Usage of quarry dust it will also reduce the cost of concrete because it is a waste material from quarries.
4) Use of quarry dust in concrete will also reduce the disposal problem.
5) When the conventional fine aggregate is replaced with quarry dust along with 1 % dosage of super plasticizer increase in the compressive strength of concrete up to 50% replacement.

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Code books:

IS 456:2000, Plain and Reinforced Concrete code of practice.
IS 10262: 2009, Concrete mix proportioning -guideline.

Text books:

1. Concrete technology theory and practice - M S Shetty.
2. Building materials and construction- S S Bhavikatti.