Study on Natural Sand to Quarry Dust as Partial Replacement of Cement

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Abstract— India has currently undertaken a major initiative on development of infrastructures such as express highways, industrial structures, commercial structures, in order to meet the requirement of globalization in its vision 2020. Concrete plays the key role towards this development and a large quantum of concrete is being utilized in every construction practice. River sand, which is one of the major constituents used in the production of concrete, has become very expensive and also becoming scarce due to the depletion of river sand beds. Quarry dust has very recently gained good attention to be used as an effective filler material instead of sand. The use of quarry dust as a fine aggregate decreases the cost of concrete production in terms of the complete replacement and even partial replacement of natural river sand. The environmental impact of river sand mining on river beds, the expensive and rising cost of manufactured sand, the cheap and good accessibility of quarry dust, are the main motivations behind the undertaking of such a project. This research will report the experimental study which investigates the proportions by weight of quarry dust to acquire similar concrete strength with 100% river sand replacement. The focus of this research is applicable to M20 and M25 nominal mix concrete only.

Key words: High Strength Concrete, Natural Sand, Quarry Dust, Compressive & Flexural Strengths

I. Introduction

Concrete is the most widely used building material in the world due to its versatility, low cost and durability. The most commonly used fine aggregate is natural river sand. Natural sand takes millions of years to form and is not replenish-able. Because of its limited supply and excessive cost of transportation from natural sources the cost of natural sand has sky rocketed and its consistent supply cannot be guaranteed. The large scale depletion of these sources also creates environmental problems. Erosion and failure of river banks, lowering of river beds, damage to the bridge foundations and other structures situated closer to the rivers, saline water intrusion into the land and coastal erosion are the major adverse effects due to intensive river sand mining. The Government has already banned sand mining due to environmental problems in identified areas of major rivers. Therefore, it becomes necessary to explore the possibilities for alternative sources to minimize river sand extraction. Thus, an investigation is needed to identify a suitable substitute that is eco- friendly and inexpensive and in this connection the use of quarry dust as fine aggregate

A. Civil Engineering Research Foundation (CERP)

High performance construction materials and systems: An essential program for American and infrastructure. HPC is a concrete in which some or all of the following properties have been enhanced

1) Ease of placement
2) Long term mechanical properties
3) Early age strength
4) Toughness
5) Volume stability
6) Extended service life in severe environments.

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B. Properties of material

1) Quarry/Stone Dust

Quarry dust is the product of the crushing process of concentrated materials used to the fine aggregates for concreting purpose. The rock has been crushed into the various sizes; and during the process the dust generated is called quarry dust and formed waste in quarry activity.

Most often it is made out of crushed granite; limestone; trap rock gneiss, or a combination of the aforementioned. In quarrying activities, the rock has been crushed into various sizes; during the process due to dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. The Most of developing countries are under pressure due to replace fine aggregate in tothe concrete adding by alternate material also to some extent or totally without compromising the quality of concrete. Quarry dust has been used to the different activities in to the construction industry; such as building materials, due to tiles and bricks, aggregates, road development materials The concept of replacement of natural fine aggregate due to quarry dust. the study could boost the consumption of quarry dust generated. By replacement of quarry dust, the requirement of land fill area can be reduced and can also solve the problem of natural sand scarcity. The availability of sand at low cost as a fine aggregate in concrete is not suitable so that and that is the reason to search for an alternative material. Quarry dust satisfied the reason behind the alternative materials as a substitute for sand at very low cost. It even causes to dump the crusher dust at one place which causes environmental pollution. it is concluded due to results of experimental investigation when the quarry dust can be used for replacement of fine aggregate 40% replacement of the fine aggregate gives maximum result in the strength than normal concrete and decrease till 50%.

C. Different Alternatives to Replace Natural Sand

The world is resting over a landfill of waste hazardous materials which may substitute for natural sand. Irrespective of position, location, scale, type of any structure, concrete is the base for the construction activity. In fact, concrete is the second largest consumable material after water, which used nearly three tones annually by each person on the earth. Value of construction industry grew at a staggering rate of 15 % annually even in the economic slowdown and has contributed

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to 7-8 % of the country's GDP (at Common people who talk about greening the industry have no practical answer for this very critical question. In fact, we have been sitting over a landfill of possible substitutes for sand.

Industrial waste and bio-products from almost all industry, which have been raising hazardous problem like environment, agricultural and human health, are used in construction activity which may be useful for not only from the economy point of view but also to preserve the environment as well. Some of the researchers did the research to find the natural sand and the concluded from different industrial waste and their ability to replace the much sought after natural riverbed sand.

D. Methods for achieving High Performance

In general, better durability performance has been achieved by using high strength, low w/c ratio concrete. Though in this approach the design is based on strength and the result is better durability, it is desirable that the high performance, namely, the durability, is addressed directly by optimizing critical parameters such as the practical size of the required materials. Two approaches to achieve durability through different techniques are as follows.

1) Reducing the capillary pore system such that no fluid movement can occur is the first approach. This is very difficult to realize and all concrete will have some interconnected pores. (2) Creating chemically active binding sites which prevent transport of aggressive ions such as chlorides is the second more effective method

1) Physical & Chemical Properties

The chemical and physical properties from quarry dust obtained from testing due to the sample tests as per the Indian Standard

a) Stone Dust

Fig. 1: Stone Dust

Property	Quarry rock dust	Natural sand	Test method	
Specific gravity	2.60	2.68	IS: 2386	(Part-III) -1963
Bulk relative density (kg/m3)	1700	1550	IS: 2386	(Part-III)-1963
Moisture content (%)	Nil	1.50	IS: 2386	(Part-III) -1963
Fine particle less than 0.075mm (%)	14	06	IS: 2386 (Part I)-1963	
Sieve Analysis	Zone-III	Zone-III	IS: 383 – 1970	

Table 1: Typical Chemical Composition of quarry dust and natural sand

Constituents	(%) Quarry dust	Sand (%)	
SiO_2	62.48	80.78	
Al_2O_3	18.72	10.52	
Fe_2O_3	6.54	1.75	
CaO	04.83	03.21	1968 4032 IS:
MgO	02.56	00.77	
Na_2O	Nil	01.37	
K_2O	03.18	01.23	
TiO_2	01.21	Nil	
Ignition Loss	00.48	00.37	

Table 2:

E. Background

The uses of mineral admixtures have been studied by many researchers. Among many additives, Mineral Admixtures (MAs) were utilized for the production offs. It has been possible to produce concrete mixes in laboratory conditions using such MAs that produced compressive strength which exceeded 180 MPa. The in place strength in some tall buildings has attained a compressive strength of approximately 125 MPa (Haqueand Kayali, 1998). The most often used MAs in the production of HSC are SF and FA. These MAs are either pozzolanic or both pozzolanic and self-cementitious to a degree. Fortunately, most of these MAs are industrial by products, so their utilization not only produces economically and technically very superior concrete but also prevents environmental contamination by means of proper waste disposal. SF has a high content of silicon dioxide (SiO_2) and consists of very small solid spherical particles. FA can improve concrete properties such as workability, durability and ultimate strength in hardened concrete. FA with high fineness exhibits high pozzolanicactivity and can be used to produce HSC (Haque andKayali, 1998

1) Apparatus Used on Tests:

1) Pycnometer
2) Cube Moulds
3) Compression Testing Machine

II. Discussion

A. Workability

From the results of workability tests namely, slump and flow, it is observed that slump and flow values of all the grades of HPC mixes significantly increase with increase in humidity at a constant temperature.

B. Compressive Strength

From the results of compressive strength test it is observed that the compressive strength of it is significantly affected by the variation in temperature and humidity. The Results indicate that the compressive strengths of mixes decreases for increased relative humidity levels under a specific constant temperature. This implies that the combined effect of humidity and temperatures on mixes is necessary to be taken into account while proportioning mixes at site, particularly in the context of tropical countries.

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III. PROPOSED MIX DESIGN METHOD

A. 2009 As Per Is 10262

- Type of cement: OPC43 grade
- Type of NS: QS type conforming to IS2116 (1980)
- Max size of aggregate: 20mm
- Minimum cement content contact: 400kg/m^3
- Max w/c ratio: 0.50
- Workability: 100mm slump
- Exposure condition: severe (IRC)
- Degree of Supervision: good
- Specific of stone dust: 2.83
- Specific of natural sand: 2.78
- Specific gravity of fine aggregate: 2.69
- Specific gravity of coarse aggregate (20mm): 2.71
- Specific gravity of coarse aggregate (10mm): 2.72

IV. TEST RESULTS AND DISCUSSION

A. Specific Gravity Test

1) Specific Gravity Test on Stone dust

- Equipment

Pycnometer, Balance, Spoon, Funnel, Stone dust sample

- Calculations:

1) W1= Weight of empty pycnometer= 0.633 kg
2) W2= Weight of dry sample= 0.932 kg
3) W3= Weight of sample + water= 1.672 kg
4) W4= Weight of water = 1.479kg

Specific gravity of soil= [(W2- W1)/ {(W4 - W1) – (W3 - W2)}]

- Result

Specific Gravity for stone dust is found to be 2.83.

Specific Gravity Test on Natural Sand:

- Calculations

1) W1= Weight of empty pycnometer= 0.632 kg
2) W2= Weight of dry sample= 0.682 kg
3) W3= Weight of sample + water= 1.510 kg
4) W4= Weight of water = 1.477 kg kg

- Result

Specific Gravity for natural sand is found to be 2.78

Particle-size-distribution-test

Size Distribution Test on stone dust

- Equipment

Balance, Set of sieves, Sieve shaker, Beaker.

I.S sieve size (in mm)	Wt. Retained in each sieve (gm)	Percentage on each sieve	Cumulative %age retained on each sieve	% Finer
2.36	193	19.3	19.4	81.8
1.19	88	8.8	27.6	72.4
0.7	167	16.9	44.4	55.8
0.525	255	25.4	69.9	30.9
0.4	132	18	82.8	17.9
0.17	145	14.5	96.8	3.4
0.076	28	2.8	99.9	0.9
< 0.075	9	0.9	100	0

Table 3: Particle Size Distribution Graph

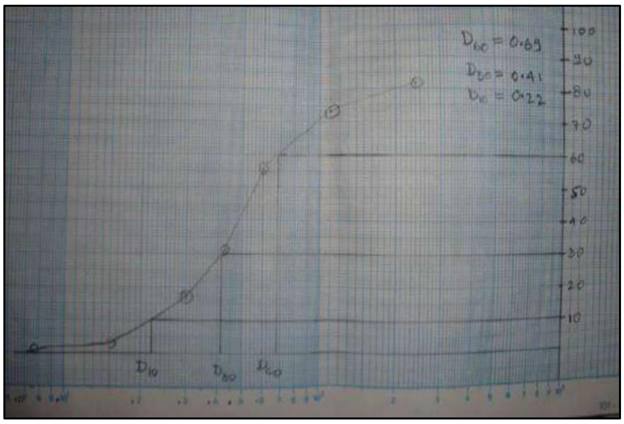

Fig. 1:

I.S sieve size (in mm)	Wt. Retained in each sieve (gm)	Percentage on each sieve	Cumulative %age retained on each sieve	% Finer
2.36	42	4.2	4.2	95.6
1.18	186	18.6	22.6	77.5
0.6	198	19.8	42.4	57.6
0.425	114	11.4	53.8	46.2
0.3	66	6.6	60.4	39.6
0.15	150	15.0	75.4	24.6
0.075	146	14.6	90.1	9.9
< 0.075	99	9.9	100	0

Table 4: Particle Size Distribution for natural sand

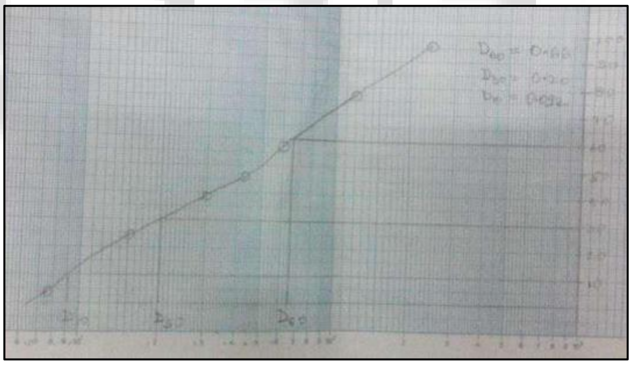

Fig. 2: Particle size distribution Graph

%NS-QS	7days	14days	28days
0%	7.3	8.93	18.25
5/5%	10.5	16.43	20.7
5/10%	14.5	10.5	25.58
5/15%	23.2	23.04	24
10/5%	16.37	18.89	20.8
10/10%	29.88	29.58	31.51
10/15%	26.55	27.45	28.25
15/5%	29	30.67	32.88
15/10%	28.43	29.16	33.56
15/15%	29.5	32.15	34.19

Table 5: Variation Compressive Strength with Natural Sand, and Quarry Dust at 7, 14 and 28 days

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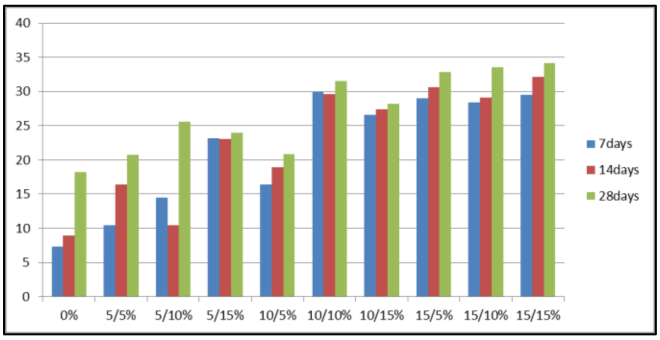

Fig. 3: Flexural strength at 7, 14 and 28 days

%NS-QS	7days	14days	28days
0%	2.09	1.89	3.56
5/5%	2.91	3.18	3.49
5/10%	2.27	2.67	3.98
5/15%	3.19	2.88	3.95
10/5%	4.44	4.83	4.94
10/10%	3.86	3.8	3.96
10/15%	3.67	3.74	4.98
15/5%	3.89	3.93	4.01
15/10%	3.83	3.88	4.05
15/15%	3.9	3.99	4.97

Table 6:

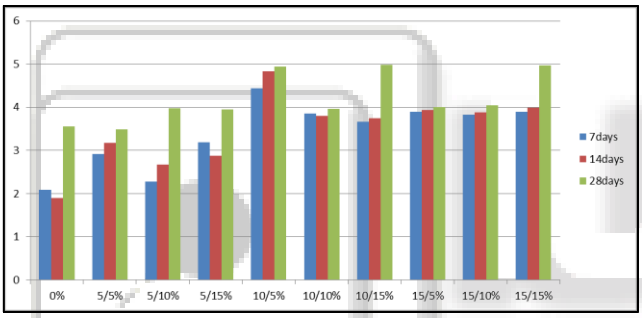

Fig. 4:

V. Conclusions

The experimental data shows that the addition of the quarry dust improves the concrete properties. These results are of great importance because this kind of innovative concrete requires large amount of fine particles. Due to its high fineness of quarry dust it provided to be very effective in assuming very good cohesiveness of concrete. From the above study it is concluded that: The quarry dust may be used as a replacement material for fine aggregate. Quarry dust has been used for different activities in the construction industry one such by product is quarry dust such as units is a serious consideration road construction and manufacturing of building materials such as light weight aggregates, bricks, tiles and auto clave blocks. However its use as rigid pavement is much limited. As the properties are good as sand, the quarry dust is used as fine aggregate in replacement with sand in the cement concrete. From the various laboratory investigations made for characteristics study of quarry dust concrete and make a quirry dust concrete based on the studies conducted the following conclusions are drawn.

Quarry fine waste products provided as the to use natural sand in cement mixture fine aggregates which can be used to produce good quality concrete of high strength. From the table it can be seen that, there is an increase in compressive strength.

Were satisfied only for the following mixes NS 0%, NS5%, NS10%, NS15% , and QS 0%, QS 5%, QS 10%, QS 15% Compressive strength of high performance concrete increases with the amount of quarry dust and brick dust by 20% and 10% as a replacement for fine aggregate respectively. Optimum compressive strength is obtained for NQS30% replacement levels, based on the idea of more replacement. After that strength gradually slips while increasing Natural Sand and Quarry Dust. Peak compressive strength obtained at QS 15% is 34.9 MPa & BKD 10% is 28MPa and maximum split tensile strength obtained at SF 15% is 4.48 MPa & BKD 10% is 4.97 MPa respectively.

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