Use of Quarry Fine as Partial Replacement of Concrete as a Replacement of Fine Aggregate in Concrete (Evaluation of Workability and Compressive Strength)

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Abstract— This paper is part of a study investigating the structural characteristics of concrete using various combinations of lateritic sand and quarry dust as complete replacement for conventional river sand fine aggregate. Samples of concrete cube were made using varying contents of laterite and quarry dust as fine aggregate. The quantity of laterite was varied from 0% to 100% against quarry dust at intervals of 25%. The samples were cured for specified periods and tested in the laboratory for compressive strength. Workability tests were earlier carried out to determine the optimum water/cement ratios for three different mixes. M20 mix was designed as per IS specification with water cement ratio 0.50.

***Keywords**: Concrete, Quarry Fines, Fine Aggregates, Sand*

I. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste [1].

Quarry dust has been used in and continues to be used for concrete production as a replacement for natural sands. Investigations have been undertaken using a crusher to produce manufactured quarry fines with an improved particle shape and grading, for use as a total or partial replacement for natural sands in concrete mixes. Detailed investigations have been carried out to quantify the particle shape improvement of the manufactured quarry fines together with assessment of gradings. The aim of the assessment was to optimise concrete mix design and be able to partially or totally accommodate the replacement of natural sands. The investigation was based on three types of quarry fines whereby it was used within a wide range of concrete applications and examined within a range of concrete tests [3].

This paper presents the feasibility of the usage of Quarry Rock Dust as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and beams to study the compressive, flexural strengths of concrete made of Quarry Rock Dust for three different proportions and five different methods. Durability Studies were done for concrete with Quarry Rock Dust and compared with the Conventional Concrete[1].

shortage of natural sand supplies for the concrete industry, regional sand shortages have encouraged an increased interest in the utilisation of quarry tines produced as a by-product of coarse-aggregate production in hard rock quarries. Depletion of existing sand reserves, the environmental impact of an eventual off-shore dredging or opening of new sand quarries, additional transportation and processing costs made the viability of manufactured quarry fines as distinct from quarry fines or crusher fines - a more attractive proposition than ever before. The perception that all quarry fines produced are a waste product is fundamentally incorrect as such products have been successfully incorporated as a supplement in asphaltic concrete, roadbase, concrete masonry, some pre-mixed concrete, drainage fill and other products[3].

II. LITERATURE REVIEW

Crushed rock aggregate quarrying generates considerable volumes of quarry fines, often termed “quarry dust”. The finer fraction is usually smaller than 5mm in size [6]. The use of quarry dust in concrete according to Chaturanga et al., [7] is desirable because of the benefits such as useful disposal of a by-product, reduction of river sand consumption and increase in strength. Quarry dust has rough, sharp and angular particles, and as such causes a gain in strength due to better interlocking. Quarry dust has been identified as possible replacement for sharp sand in concrete works. Jayawardena and Dissanayake [4, 5] in their paper “Use of quarry dust instead of river sand for future constructions in Sri Lanka” identified quartz, feldspar, biotite mica, hornblende and hypersthenes as the major minerals present in fresh rock which show mica percentages between 5% and 20%. They added that mica percentages in charnocktic gneiss and granitic gneiss are always less than 5%, similar to sand and therefore suitable for use in civil engineering construction. They reported that sand mining had been banned in some areas of major rivers in Sri Lanka because of its negative environmental impact. Granite rock is abundant in Nigeria giving rise to many quarry sites with large heaps of quarry dust. Hence, quarry dust can be reasonably used as alternative to river sand. Also, Shahul et al., [8] observed that natural sand is usually not graded properly and has excessive silt, while quarry rock dust does not contain silt or organic impurities and can be produced to meet desired gradation and fineness as per requirement. This consequently contributes to improve the strength of concrete. Agbede and Joel [9] described quarry dust as a cohesionless sandy material acquired either naturally (which is rare) or artificially by the mechanical disturbance of parents rocks (blasting of rocks) for construction purposes, composed largely of particles with a diameter range of

0.05mm to 5.00mm. They found in their study on "suitability of quarry dust as partial replacement for sand in hollow block production" that quarry dust is cheaper than River Benue sand during rainy season. Sridharan, et al., [10] conducted shear strength studies on soil-quarry dust mixtures and observed that 20- 25% of the total production in each crusher unit in India is left out as waste-quarry dust. This waste problem may be avoided as it could be converted into useful application in concrete production.

Concrete with quarry dust as fine aggregate In a study in Thailand by Khamput [11] on the compressive strength of concrete using quarry dust as fine aggregate and mixing with admixture type E, it was found that with 70% quarry dust the concrete produced compared well with normal concrete. He recommended quarry dust for replacement with sand in general concrete structures. Ilangovana et al., [12] studied the strength and durability properties of concrete containing quarry dust as fine aggregate and found that the compressive, flexural strength and durability studies of concrete made with quarry rock dust were nearly 10% more than the conventional concrete. Their workability results showed slump values ranging between 60 - 90mm and compacting factor 0.87 - 0.90 for grade 20 concrete. The range of 28 - day's compressive and flexural strengths for grade 20 concrete were found to be 23.7 - 34.50 N/mm2 and 3.45 - 6.40 N/mm2 respectively.[2]

III. METHODOLOGY

A. Material Used

1) Cement:

Ordinary Portland Cement of Grade 53 is used, which conforming IS 12269. 53 grade cement of ultra tech with a remarkably high CS3 (tricalcium providing long-lasting) durability to concrete structures. Produces highly durable and sound concrete due to very low percentage of alkalis chlorides, magnesia;

2) Fine Aggregate

Natural river sand conforming to Zone II as per IS 383 (1987) was used. The fineness modulus of sand used is 2.64 with a specific gravity of 2.59.

3) Coarse aggregate

Crushed granite coarse aggregate conforming to IS: 383 (1987) was employed. Coarse aggregate of size 20 mm down having the specific gravity of 2.77 and fineness modulus of 7.21 was applied.

4) Quarry Fines

borrow pit site at vidisha local government area of Cross River state at a depth of 2.5m. Quarry dust, the second fine aggregate used in this study was taken from the abundant deposits at Vidisha.

B. Mix Design

Mix design of the concrete is done strictly as per the specification of the IS 10262 : 2009. According to IS code specification mix of M20 grade is designed, 6 different types of mix are prepared with different percentage of quarry fines. CC mix are prepared with 0% of quarry fines or we can also say it controlled concrete, QF20 contains 20% of the quarry fines. While QF40, QF60, QF80, QF100 contains 40, 60, 80, 100 percentage of the quarry fines respectively.

C. Casting and Curing

Concrete cube of 15cm*15cm*15cm is casted according to IS 516 : 1959.For each cube there is mix 3 + 3 cubes(3 for 7 days of curing and another 3 for 28 days of curing) was casted and average of three was noted as a final result of the compressive strength. Curing is done strictly as per the specification of IS 156 : 1959, curing is done at the room temperature in curing tank filled with normal clean water.

D. Test Performed

1) Compressive Strength

Compressive strength is the capability of a material or social system to withstand loads tending to reduce size. It can be assessed by plotting applied force against deformation in a testing machine. Some material fracture at their compressive strength limit; others deforms irreversibly, so a dedicated measure of deformation may be regarded as the limit for compressive load. The compressive strength of concrete was determined using 150mm concrete cubes. The concrete was made by replacing 10, 15, 20% of the coarse aggregate by recycling aggregate and Coconut shells. Also concrete cubes without RA and CS were cast in comparison. Compressive strength is often measured on a universal testing machine; these range from very small tabletop systems to ones with over 53 MN capacity. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive forces are commonly described in relation to a specific technical standard

2) Workability

Workability is one of the physical parameters of concrete, which affects the intensity level and durability as well as the price of labor and appearance of the finished ware**.** Concrete is said to be workable when it is easily laid and compacted homogeneously Slump cone test was taken to determine the workability of concrete admixture. Metal molds, in the form of the frustum of a cone, open at both goals, and furnished with the handle, top internal diameter 4 in (102 mm), and bottom internal diameter 8 in (203 mm) with a peak of 1 foot (305 millimeter). A 2 foot (610 millimeter) long bullet nosed metal rod, 5/8 in (16 mm) in diameter. The examination is carried out employing a mold known as a slump cone or Abrams cone. The cone is positioned along a hard non-absorptive surface. This cone is filled with fresh concrete in three levels, each time it is tamped using a pole of standard dimensions. At the conclusion of the third phase, concrete is struck off flush to the height of the stamp. The cast is carefully lifted vertically upwards, so as not to stir up the concrete cone. Concrete subsides. This subsidence is termed as slump, and is appraised into the nearest 5 mm if the slump is <100 mm and measured to the nearest 10 mm if the slump is >100 mm.

IV. RESULT AND DISCUSSION

A. Workability

The variation of workability of fresh concrete is measured in terms of slump and reported in Tables 1 and in figure 1. For the given water/cement ratio, the highest slumps were recorded for the mixes designed by IS code method. The overall workability value of Quarry Rock Dust concrete is less compared to conventional concrete, it has been observed that workability of concrete is increased as we increase the percentage of quarry fines, where control concrete mix gives 20mm, QF20 45mm and QF 175mm slump which clearly shows that workability in concrete increase due to adding of quarry fines in concrete.

S.No.	Mix	Workability (in mm)
1	CC	20
2	QF20	45
3	QF40	70
4	QF60	105
5	QF80	140
6	QF100	175

Table 1: Workability of Concrete of different mixes

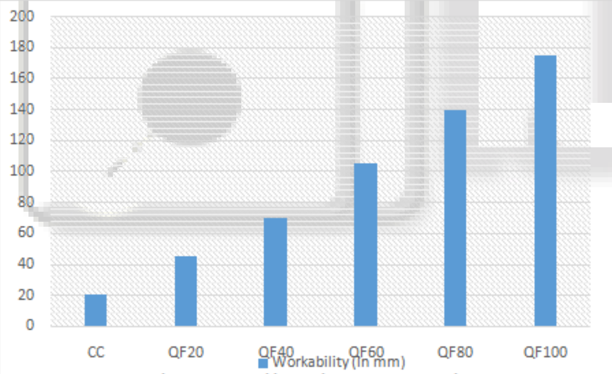

Figure 1: workability of different concrete mixes

B. Compressive Strength

Compressive strength of Quarry fines concrete with a comparison of control concrete is reported in Table 2 and in figure 2 with 7 days and 28 days of curing. It has been observed that compressive strength of concrete mix is increased when we replace the quarry fines by the fine aggregate but upto 80% and when increase percentage of quarry fines in concrete to upto 100 percentage, compressive strength of concrete goes down, it is also observed that 40-50 percentage of the strength in initial 7 days of curing. QF40 mix gives highest compressive strength while QF60 and QF80 also possess excellent compressive strength in 28 days of curing.

S.No.	**Mix**	**Compressive Strength**	
		7 Days	**28 Days**
1	**CC**	**11.224**	**18.26**
2	**QF20**	**11.778**	**18.08**
3	**QF40**	**13.15**	**26.13**
4	**QF60**	**12.624**	**22.34**
5	**QF80**	**13.813**	**22.6**
6	**QF100**	**12.522**	**15.49**

Table 2: Compressive Strength of different Mixes of Concrete

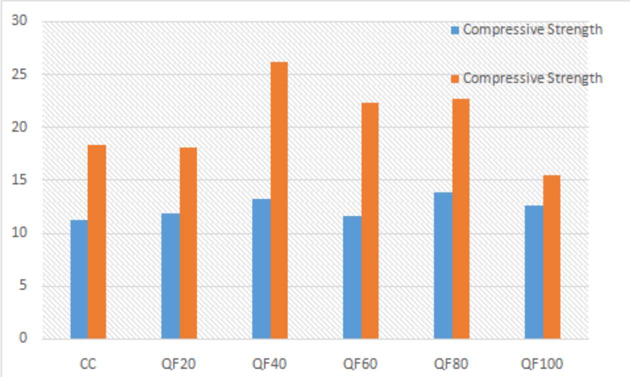

Figure 2: Compressive Strength of Different Concrete Mixes

V. CONCLUSION

It can be seen from the results of this study that the combination of quarry fines to replace the conventional river sand in the production of concrete for the construction industry in India and other tropical countries of the world results in structures with reasonable structural characteristics, and should be encouraged where there is comparative cost advantage. The following conclusions can be made from this study:

(1) The workability of the mix increased when replacement percentage of the quarry fine with natural river sand. So we can also decrease the water cement ratio, with quarry fines good workability of the concrete is achieved with low water cement ratio.
(2) The compressive strengths of concrete using lateritic sand and quarry dust were measured in the laboratory. Compressive strength was found to increase with age as for normal concrete. The 28 -day compressive strength was found to range from 15.49 – 26.13 N/mm2 for different mixes. The above strength properties were found to compare closely with normal concrete. The proportion of 40% laterite to 80% quarry fines produced higher values of compressive strength. For the same proportion of 40% laterite and 80% quarry dust at M20 mix and 0.5 water/cement ratio, a logarithmic model has been developed for predicting the compressive strength of concrete between 0 and 28 days.
(3) Further work is required to get data for other structural properties of the experimental concrete. These include: flexural strength, tensile strength, shear strength, water absorption, resistance to

impact, creep, etc. The knowledge of the above properties will greatly assist engineers, builders and designers when using the materials for construction works.

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