International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463
Vol. 4 Issue 6, June-2015, pp: (129-133), Impact Factor: 1.252, Available online at: www.erpublications.com

Effect of Quarry Dust as Partial Replacement of Sand in Concrete

Poonam[1], Anoop Bishnoi[2], Manju Bala[3]

[1,3]Research scholar, Department of Civil Engineering, OITM Hisar (Haryana)
[2]Assistant Professor, Department of Civil Engineering, OITM Hisar (Haryana)

ABSTRACT: 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. Quarry dust, a by-product from the crushing process during quarrying activities is one of such materials. Granite fines or rock dust is a by-product obtained during crushing of granite rocks and is also called quarry dust. In recent days there were also been many attempts to use Fly Ash, an industrial by product as partial replacement for cement to have higher workability, long term strength and to make the concrete more economically available. 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.

Keywords: Quarry dust; workability; hardened concrete; durability.

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1 INTRODUCTION

Concrete is the most popular building material in the world. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy. River sand has been the most popular choice for the fine aggregate component of concrete in the past, but overuse of the material has led to environmental concerns, the depleting of securable river sand deposits and a concomitant price increase in the material. Therefore, it is desirable to obtain cheap, environmentally friendly substitutes for cement and river sand that are preferably by products. Fly ash (pulverized fuel ash) is used extensively as a partial replacement of cement. However, though the inclusion of fly ash in concrete gives many benefits, such inclusion causes a significant reduction in early strength due to the relatively slow hydration of fly ash. Nevertheless, fly ash causes an increase in workability of concrete. Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete.

When examining the above qualities of fly ash and quarry dust it becomes apparent that if both are used together, 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. The main objective is to provide more information about the effects of various proportion of dust content as partial replacement of crushed stone fine aggregate on workability, air content, compressive strength, tensile strength, absorption percentage of concrete. Attempts have been made to investigate some property of quarry dust and the suitability of those properties to enable quarry dust (Celik et. al., 1996) to be used as partial replacement material for sand in concrete. The use of quarry dust in concrete is desirable because of its benefits such as useful disposal of by products, reduction of river sand consumption as well as increasing the strength parameters and increasing the workability of concrete (Jain et. al., 1999). It is used for different activities in the construction industries such as road construction, manufacture of building materials, bricks, tiles and autoclave blocks.

2 Materials and Methodology:

(1) Materials

A. Cement:
The cement that is used is of OPC 53 grade as per the Standard Specifications of the country. The cement according to the Indian specification must satisfy the IS code IS 12269- 1987 (reaffirmed 1999). Ordinary Portland cement (OPC)

was used in which the composition and properties is in compliance with the Nigerian standard organization defined standard of cement for concrete production.

B. Fine Aggregates:

The natural fine aggregates are the river sand which is the most commonly used natural material for the fine aggregates that is used, but the recent social factor that created a shortage of the material created a great problem in the construction sector. For the studies the river sand of Zone-II is used in all the references.

C. Coarse Aggregate:

Ordinary granite broken stone aggregates of size greater than 12mm are used for the study.

D. Quarry Dust:

The dust is selected from the nearest source as raw materials without any processing of the dust from the quarry. The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.

E. Mixing of the Materials:

The normal grade of the concrete that is used is M20 for normal construction purposes in India. The mix deign is done separately for the quarry dust using the minimum void ratio methods and maximum density method.

(2) Methodology:

For each test that was conducted, cubes and cylinders were prepared as per BS 1881: Part 108:1983. Due to the compressive force, the cylinder is subjected to a large magnitude of compressive stress near the loading region. The larger portion corresponding to a depth of about 87% and length of cylinder is subjected to a uniform tensile stress acting horizontally. The rate of loading applied is 1.4 to 2.1 N/mm2 for 150x300 mm cylinders. The split tensile strength was computed by using expression fct = 2p/_ld, where fct is the split tensile strength in Mpa, p is the maximum compressive load on the cylinder (Newton) applied along length of cylinder (mm) and D is the diameter.

Flexural strength was computed using the expression, fb = (pl/bd2) where fb is the flexural strength in Mpa, p is the maximum node applied (N), L is the span length (mm) that is the distance between the line of fracture and the nearest support measured from the centre line of the tensile side of specimen, b is the width of the specimen (mm), d is the depth of specimen (mm). (When L is greater than 200mm for 150mm specimen or greater than 133mm for 100mm specimen).
The test for modulus of elasticity is done by using cylinders. The dial gauges were fixed to the cylinder with the help of a frame. The load is applied at constant rate in increment and at each incremental load; the dial gauges readings were taken. Knowing the displacements from the average dial gauge reading at each load points, the stress- strain curves were drawn and from the slope of the curve modulus of elasticity are calculated.
Cubes were dried at a temperature of approximately 1050c till it attains a constant weight (Wd) for water absorption test., and they are immersed in water at approximately 210+ 20 for 72 hours. The cubes were then taken out and their surface were dried and weighed. The water absorption of concrete was calculated as per following formula; Water absorption percentage = (Ww-Wd) / Wd x 100, where Ww is the saturated surface dry weight. In the present investigation durability studies were conducted on 150 mm cubes for M5 (50% quarry dust) concrete mixture. The concrete cubes were immersed in 5% solution of Magnesium Sulphate, 5% solution of sodium chloride and 2 N hydrochloric acid solution for 28 and 91 days. Effect of immersion in this solution on compressive strength and weights were observed at 28 and 91 days. The aggregate crushing value gives the relative measure of the resistance of an aggregate in bulk to crushing under a gradually applied compressive load.

3. Results and discussion:

A Workability (Slump value):

The workability is one of the physical parameters of concrete which affects the strength and durability and the appearance of the finished surface. The workability of concrete depends on the water cement ratio and the water absorption capacity if the aggregates. If the water added is more which will lead to bleeding or segregation of aggregates.

Figure showing the cone of the workability test

is more which will lead to bleeding or segregation of aggregates. The test for the workability of concrete is given by the Indian Standard IS 1199-1959 which gives the test procedure using various equipments. In our case we have used slump cone test for measuring the workability of concrete. We have measured the height of the fall of the cone of concrete for various water-cement ratios and recorded the values for ordinary concrete. Then the same procedure is done with the concrete having the partial replacement of sand with raw quarry dust at various percentages.

B Specific Gravity:

The Specific gravity of the aggregates that are used is tested by following the Indian Standards specification by following IS 2386 (Part III) – 1963. The specific gravity is one of the important factor that everything depends on the design mix also depends on the specific gravity of the materials that we use. As the particle size is less we will use pycnometer for sand. The empty weight of the pycnometer is measured and then it is filled with sand up to a mark and the weight is measured. Then water is filled with water and the weight is measured. Then weight of the pycnometer only with water is measured and the specific gravity of the fine aggregates used is calculated. The same method is used for determining the specific gravity of the raw quarry dust.

Figure showing the pycnometer with quarry dust, water

C Compressive Strength

The results of compressive strength of cubes for (7, 28, 91) days curing. It is observed that the compressive strength of cubes at 28 days curing for control mixture (M1) is 30.3 Mpa for 53 grade concrete and 28.6 Mpa for 33 grade concrete (Naidu et. al., 2003). Dust content increases to 30%, the 28 days compressive strength increases to a maximum of 30.5 Mpa for 53 grade and 29.7Mpa for 33 grade. For 20% dust content the 28 days compressive strength increases 34.2Mpa for 53 grades and 30.9Mpa for 33 grades. As the dust content exceeds 30% the compressive strength decreases (Babu et. al., 1977). For the specimen of dust content of 0% and 20% the dust particles amount is not enough to fill all the voids between cement paste and aggregate particles, hence they have lower compressive strength values than specimens of 30% dust content. It can be perceived that the compressive strength of cube at 28 days of curing for control mix (M1) is 30.2 Mpa and the strength increases by 12.9%, 3% for mix M2 & M3 respectively in comparison with control mix (M1) (BS: 1881, 1983). But for mix M4 and M5, the strength reduces by 3.6%, 12.9% in comparison with the control mix (M1) for 53 grade. Similarly, for 33 grade concrete the compressive strength of cube at 28 days curing for control mix (M1) is 29.3 Mpa and the strength increases by 5.9%, 3.3% for mix M2 and M3 respectively in comparison with control mix M1 but for M4, M5 the strength reduces by 3.1% and 13.9% in comparison with control concrete.

D Particle Size analysis

The Particle size analysis is done by following the procedure given in IS 2386 (Part I)-1963, the gradation of the aggregate material is important for determining the size and shape of the material The gradation is used to determine the fineness modulus of the plastic material that is used for casting of the cubes. In the first step the IS sieves are arranged in order(i.e. 4.75mm, 2.36mm,1.18mm, 600µ, 300µ,150µ) . take about 1.5kgs of fine aggregate and place them on the top most sieve and start sieving them for fifteen minutes and then note down the weight retained on each IS sieve and the values of fineness modulus is calculated. A graph is plotted between the particle size and the percentage fineness on a semi log graph sheet. The graph that is plotted is called gradation curve / particle size distribution curve(PSD) this is use full to know whether the sample of the aggregates is well graded or poorly graded. If the coarse aggregates is poorly graded it is not used in the construction.

RESULTS

The results of the physical properties like specific gravity, Particle Size analysis and bulking are the most needed for determining the mix design of the concrete. The results are as follows

A. Specific gravity:
The average values of the specific gravity of natural river sand is 2.296, the average values of the specific gravity of quarry dust is 2.322

B. Particle Size analysis:
The below given chart no.1 showing the particle size distribution curve of sand and the chart no.2 showing the particle size distribution of quarry dust.

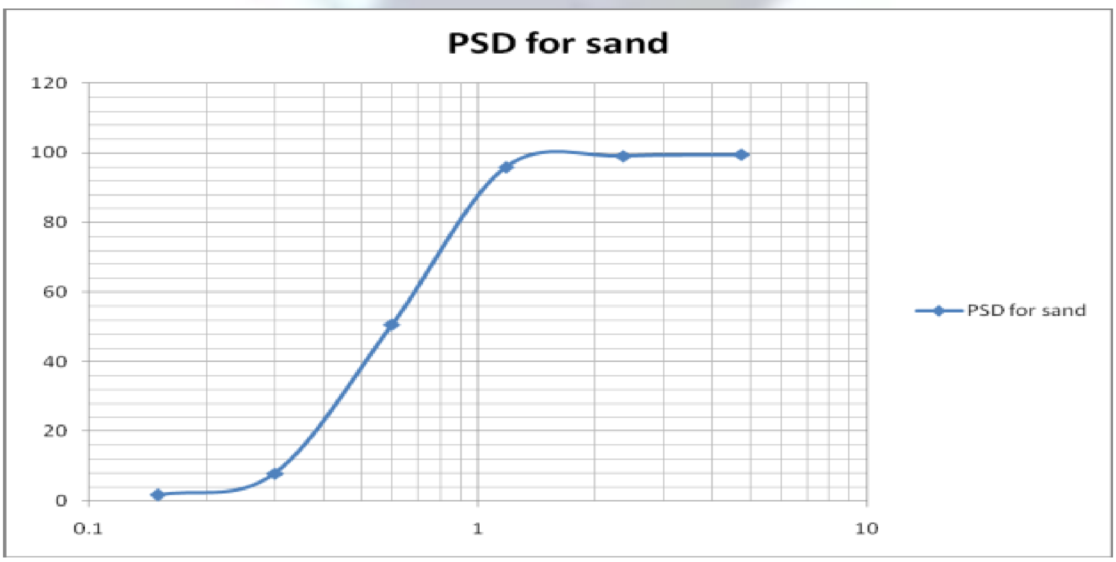

CHART NO. 1

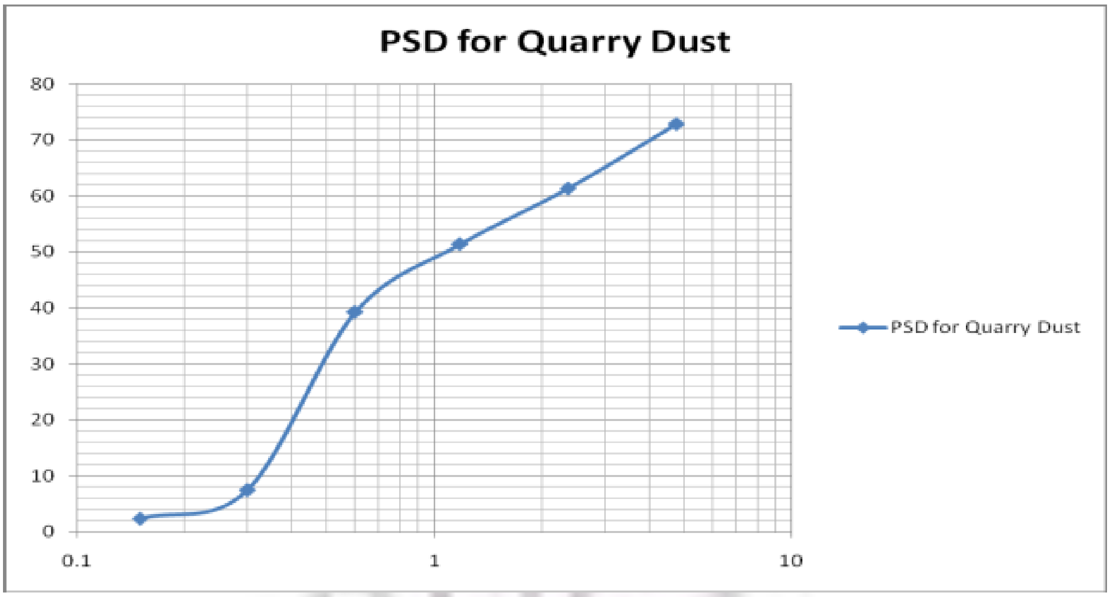

CHART NO. 2

CONCLUSIONS

1. The Replacement of the sand with quarry dust shows an improved in the compressive strength of the concrete.
2. 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 [5].
3. The specific gravity is almost same both for the natural river sand and quarry dust. The variation of the physical properties like particle size distribution and bulking is much varying parameter that which effect the mix design of the concrete.
4. The results show the decrease in the workability of concrete when the percentage of the replacement is increasing. The workability is very less at the standard water-cement ratio and the water that is required for making the concrete to form a zero slump with a partial replacement requires more water. The test conducted at 50% replacement showed that the water-cement ratio increased to 1.6 at which the slump cone failed completely.
5. The ideal percentage of the replacement of sand with the quarry dust is 55% to 75% in case of compressive strength.
6. The further increasing the percentage of replacement can be made useful by adding the fly ash along with the quarry dust so that 100% replacement of sand can be achieved.

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