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Stone Dust in Concrete: Effect on Compressive Strength

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***Abstract*- Stone dust is a waste material obtained from crusher plants. It has potential to be used as partial replacement of natural river sand in concrete. Use of stone dust in concrete not only improve the quality of concrete but also conserve the natural river sand for future generations. In the present investigation, an experimental program was carried out to study the workability and compressive strength of concrete made using stone dust as partial replacement of fine aggregate in the range of 10% - 100%. M25 grade of concrete was designed using Portland pozzolana cement (PPC) for referral concrete. Workability and Compressive strength were determined at different replacement level of fine aggregate viz a viz referral concrete and optimum replacement level was determined based on compressive strength. Results showed that by replacing 60% of fine aggregate with stone dust concrete of maximum compressive strength can be made as compared to all other replacement levels.**

***Index Terms*:- concrete, compressive strength, optimum, replacement, stone dust, workability.**

I. INTRODUCTION

Conventionally Concrete is a composite material made of cement, fine aggregate, coarse aggregate and water. At present construction industry is growing exponentially due to several other factor besides increasing developmental activities. This results in huge demand of construction materials. Concrete is most widely used construction material. Major components of concrete are aggregates which are usually available in natural form. Fine Aggregate used in concrete is usually river sand available locally or at nearby location. The naturally available source of fine aggregate is limited as such conservation of the same is unevitable. Going for alternative and supplementary material which can be used as partial or full replacement of conventional material can play a vital role in conservation of natural resources. The demand for river sand in the construction industry has consequently increased due to the extensive use of concrete resulting in the reduction of sand sources and increase in price. The large scale depletion of natural sand sources creates also the environmental problem such as erosion and failure of river banks, lowering of river beds, saline water intrusion into the land. Thus a investigation is needed to identify suitable substitute that is eco-friendly, inexpensive and better for strength and durability performance. In this connection the use of stone dust as fine aggregate with partial or full replacement may be a promising alternative in concrete making.

Quarry dust can be utilized in concrete mixtures as a good substitute for natural river sand giving higher strength at 50% replacement (Balamurgan *et al*., 2013). While using crushed stone dust as fine aggregate in concrete it is found that there is increase in compressive, flexural and tensile strength of concrete (Nagpal *et al*., 2013). It has been observed that 40% replacement of fine aggregate with stone dust is adaptable (Franklin *et al*., 2014). It was observed that the replacement of natural sand by crusher dust increased the compressive strength of concrete by 5-22% and it was also found that amongst all the mixes, the highest compressive strength was obtained for 40% replacement of sand by crusher dust (Quadri *et al*., 2013). The required slump could not be achieved by natural sand with given parameter of mix design. But with the use of manufactured sand with proper shape, surface texture, desirable grading to minimize void content, a highly workable mix with the given parameter of mix design, was achieved (M S Shetty, 2013). The compressive strength of concrete from stone powder showed 14.76% higher value than that of the concrete made of normal sand (Mahzuz *et al*., 2011). It is found that the compressive and flexural strength of concrete made of Quarry Rock Dust are nearly 10% more than the conventional concrete (Suribabu *et al*., 2015). In the present study it is proposed to investigate the optimum replacement of river sand with stone dust for concrete in term of compressive strength performance at 7 days and 28 days.

II. MATERIALS AND METHODS

A. Materials Used in the Present Investigation are Discussed Here in After:

1) Cement- In this study, Portland pozzolana cement (fly ash based) of single batch was used conforming to IS 1489(part I):1991 specification. Properties of PPC are as listed below in table 1.

Table 1- Properties of Portland Pozzolana Cement

Properties	**Result Value**
Standard consistency %	31 %
Initial setting time	250 minutes
Final setting time	325 minutes
Soundness(lechatelier expansion)	0.5 mm
Fineness (% retained on 90 µ is seive)	3.5 %
7^{th} day Compressive strength	32 MPa
28^{th} day Compressive strength	43 MPa
Specific gravity	2.71

2) Fine Aggregate- Fine aggregate (FA) used in this investigation was the natural river sand passing completely

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through 4.75 mm aperture size sieve and conforming to zone II as per IS:383-1970 specification. Its fineness modulus and specific gravity were 2.75 and 2.3 respectively. Particle size distribution as Grading curve of the recorded sieve analysis test result for the same is shown in figure 1 with Upper and Lower Permissible limits (UPL and LPL) as per codal recommendation.

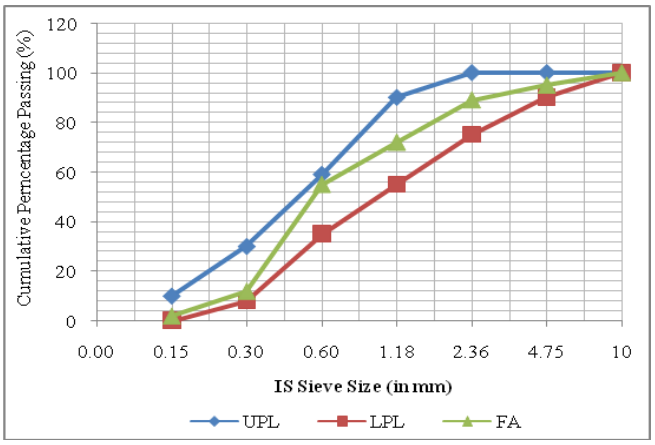

Figure 1- Grading curve of the Fine Aggregate

3) Coarse Aggregate- A Combined grading of the two individual 20 mm and 10 mm Nominal size coarse aggregate (20mm CA & 10mm CA) gradings was used with the ratio of these coarse aggregates as 60:40 respectively. Particle size distribution curve of the Achieved Combined coarse aggregate with these two (20 mm and 10 mm) coarse aggregate by the Recorded sieve analysis test result with permissible limits (UPL & LPL) is shown in figure 2. Properties of the Achieved Combined coarse Aggregate (CCA) of 20 mm Nominal size are shown in Table 2.

Table 2 – Properties of Coarse Aggregate

Properties		**Result value**
Fineness Modulus	10 mm Aggregate (10mm CA)	5.956
	20 mm Aggregate(20mm CA)	7.012
	Combined Coarse Aggregate (CCA)	6.548
Water absorption (%)		0.80
Specific Gravity		2.60

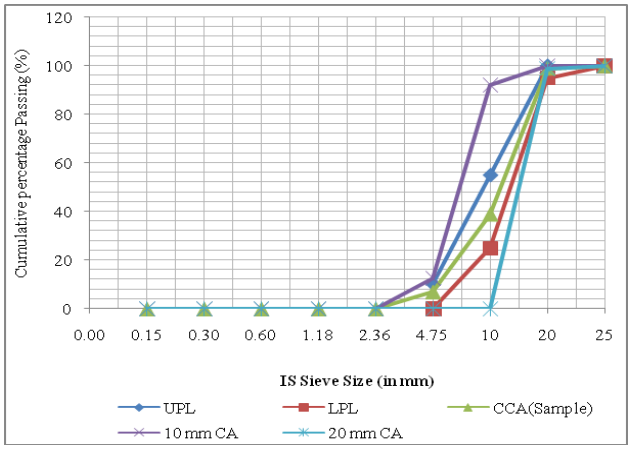

Figure 2 – Grading curve of the combined coarse aggregate.

4) Stone Dust- Stone dust obtained from the KABRAI crushing plant of Mahoba district in Uttar Pradesh with co-operation of the locally working VIL.Ltd highway and construction company was Grey in colour, dry in condition, used as thoroughly retained on 150 µm IS Sieve for entire investigation. Fineness modulus and Specific gravity of stone dust were 2.60 and 2.40 respectively. Particle size distribution curve of stone dust (SD) for the recorded sieve analysis test result with conforming to the grading zone II as per IS:383-1970 specification with upper and lower permissible limits (UPL & LPL) is shown in figure 3.

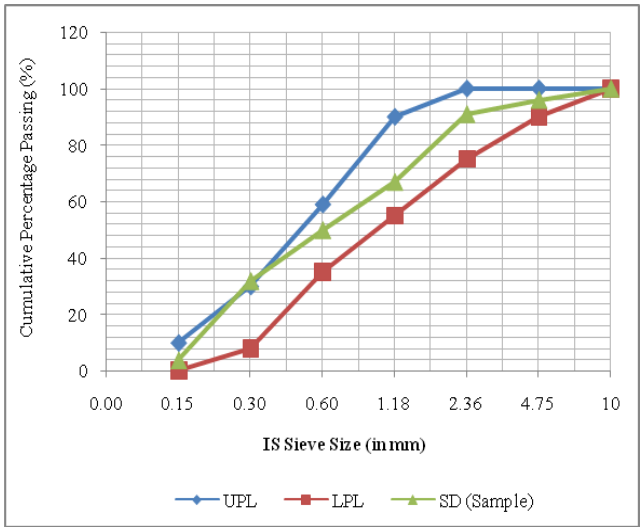

Figure 3- Grading curve for Stone dust.

5) *Super Plasticizer* – Sulphonated naphthalene formaldehyde (SNF) based Superplasticizer (KEM SUPLAST 101 S) of Chembond chemicals was used which conforms to IS:9103-1999 specifications. It was in liquid form compatible with the used Cement, brown in colour having specific gravity 1.2 and It showed good deflocculation and dispersion with cement particles to enhance the workability of concrete mix.

6) Mix Design of the Referral Concrete - M-25 grade of concrete conforming to IS:10262-2009 guidelines was designed as the referral concrete with the mix proportion of 1:1.54:3 and water-cement ratio of 0.42 by weight taking with 0.6% super plasticizer dose by weight of cement.

7) Water – Potable water was used for mixing the concrete mix in entire investigation and for curing the concrete in the determination of the optimal percentage of stone dust as fine aggregate replacement.

B. Methods –

Workability as slump test for consistency of each batch of concrete mix conforms to IS:1199-1959 specification was carried out. Slump measured was recorded in terms of millimeters of subsidence of the specimen during test.

Cube mould of standard size 150mm for making the test specimens and weight batching for weighing the materials were taken throughout the investigation with hand mixing to mix the constituents of concrete. Concrete mix was be filled into the cube mould in layers approximately 5 cm deep with ensuring a symmetrical distribution of it and each layers were be compacted by the Table vibrator. After 24 hr, the casted concrete cubes were demoulded for curing. At specified days,

concrete cubes were crushed by the compression testing machine (CTM) of capacity 2000KN conforming to IS:14858-2000 for determining the compressive strength.

Compressive strength of the concrete cube specimen was calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area. The average of three values of compressive strength was taken as the representative compressive strength. In test, cube specimen was placed in the CTM machine in such manner that the load was applied to the opposite sides of the concrete cube as cast, that is, not to the top and bottom as per IS:516-1959 specification

A total number of 66 concrete cube specimens as a group of six cubes (3 cubes for 7 days and 3 cubes for 28 days test) were cast with 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100% replacement of river sand with stone dust and immersed fully in potable water for curing and tested for 7 days and 28 days compressive strength.

Figure - A set-up of Compression testing machine (CTM)

Figure - Measurement of Slump (in mm)

III. RESULTS AND DISCUSSION

A. *Workability of Concrete with Stone Dust –*

Slump test for workability for the placing condition of concrete was conducted as per IS:1199-1991 specification. Degree of workability maintained was low, that is, slump was maintained between 25 mm to 75 mm throughout the investigation by adding the required doses of superplasticizer by weight of cement, because of abrupt fall in slump with adding stone dust as gradual increase replacement of sand in concrete mix. The maintained slump (mm) with required dose of superplasticizer and Slump (mm) at fixed dose of superplasticizer were evaluated with gradual increase percentage of stone dust as fine aggregate replacement in concrete are given in table 3.

Table 3 – Variation of Slump (in mm) with replacement level

Stone dust (%)	**Slump(mm) with Fixed dose of Superplasticizer (0.8%)**	**Slump(mm) with required dose of Superplasticizer given in bracket**
0	84	60 (0.60%)
10	70	55 (0.70%)
20	55	55 (0.80%)
30	40	50 (0.90%)
40	30	48 (1.00%)
50	20	45 (1.20%)
60	15	45 (1.50%)
70	5	40 (1.60%)
80	0	40 (1.80%)
90	0	38 (2.00%)
100	0	35 (2.20%)

B. *Investigation for the Optimum Replacement Level of Fine Aggregate with Stone Dust –*

It is observed that the Compressive strength of concrete specimens at 7 days and 28 days are increased with replacement level up to 60%. However it is decreased at 20% replacement level but become greater in strength than the strength of referral concrete. At replacement level more than 60% compressive strength of concrete made is less than the strength of concrete at 60% replacement level but become greater in strength than the strength of referral concrete. Table 4 and Graph in figure 4 are shown by the variation of compressive strength with gradual increase percentage of stone dust as fine aggregate partial or full replacement at interval of 10%.

Table 4 – Variation of compressive strength with stone dust %
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Concrete Cube Designation	**Replacement Level of Fine Aggregate with Stone dust (%)**	**7 days Average Compressive Strength (MPa)**	**28 days Average Compressive Strength (MPa)**
C1	0	24.79	35.25

C2	10	25.99	38.64
C3	20	27.70	38.16
C4	30	28.41	40.53
C5	40	27.34	41.71
C6	50	31.64	42.23
C7	60	31.10	44.86
C8	70	28.17	41.87
C9	80	26.83	41.21
C10	90	27.46	42.88
C11	100	25.04	40.17

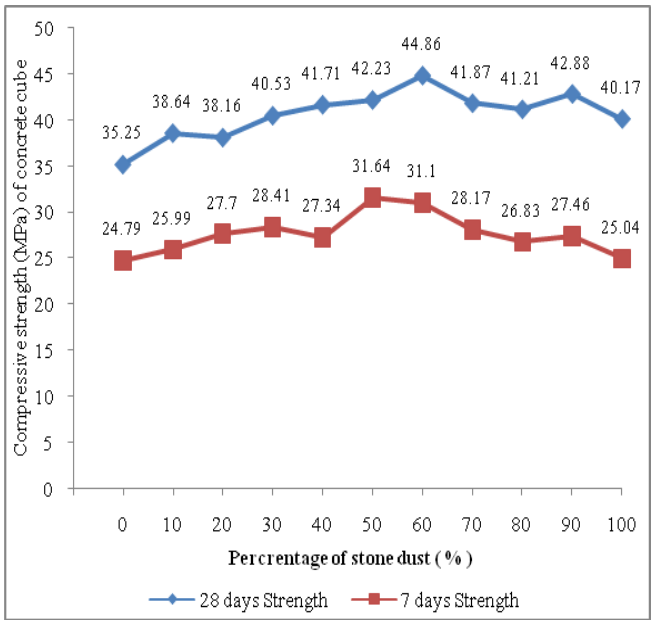

Figure 4 – Variation of compressive strength with gradual increase percentage of stone dust.

IV. CONCLUSIONS

On the basis of Results obtained during the experimental investigation, following conclusions are drawn

➢ Slump(mm) of concrete made using stone dust decreases abruptly with increase in replacement level of river sand.

➢ By replacing natural river sand with stone dust (10% - 100%) increased compressive strength (8% - 27%) can be achieved.

➢ Optimum replacement level of natural river sand with stone dust is 60%. However , strength of concrete made using stone dust is higher at every replacement level than the referral concrete.

➢ Stone dust can be used as an apposite substitute for fine aggregate in the case of non-availability of natural river sand at reasonable cost.

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