Stone Dust in Concrete: Effect on Compressive Strength

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Abstract— Stone dust may be a waste obtained from crusher plants. it's potential to be used as partial replacement of natural river sand in concrete. Use of stone dust in concrete not only improve the standard of concrete but also conserve the natural river sand for future generations. In the present investigation, an experimental program was administered to review the workability and compressive strength of concrete made using stone dust as partial replacement of fine aggregate within 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 are often made as compared to all or any other replacement levels.

Keywords: Quarry Dust River Sand, Compressive Strength, Cement, Quarry Dust, Concrete

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 factors 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 intrinsically conservation of an equivalent is un evitable. Going for alternative and supplementary material which may be used as partial or full replacement of conventional material can play an important role in conservation of natural resources. The demand for river sand within the housing 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 like 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 are often utilized in concrete mixtures as an honest 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 (Quadriet 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 (MS Shetty, 2013). The compressive strength of concrete from stone powder showed 14.76% higher value than that of the concrete made from 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. LITERATURE SURVEY

The Physical properties like specific gravity, fineness modulus etc. of stone dust and fine aggregate should be comparable in order to use stone dust as a replacement of fine aggregate. Studies shows that optimum replacement of fine aggregate with stone dust gives maximum compressive strength, durability, flexure strength and other mechanical properties.

Manchiryal R.K., Dewangan A. and Gupta D.P. investigated that the physical and chemical properties of stone dust satisfied IS-2386 which could be used as replacement material of fine aggregate. Authors concentrated on cube compressive strength and beam flexure strength in order to give significance to their work. Ordinary Portland cement of 43 grade, Natural River sand with fineness modulus of 2.51 and granite aggregate as a course aggregate were used in the experiments. Quarry dust was obtained from local resource. In the experiments, river sand was 100% replaced by quarry dust and variation in strength was compared. It was concluded that compressive strength from concrete with quarry dust was comparatively 10% -12% more than the conventional concrete. They also concluded that durability under the influence of sulphate and acid attack of quarry dust concrete was higher than conventional concrete. Permeability of concrete decreased due to better relative density of quarry dust than that of conventional concrete.

Reddy, M.V. (2010) carried out some experiments using waste product like stone dust and ceramic scrap as partial and full replacement of fine aggregate. He prepared six samples of nconcrete in which first sample was prepared by replacing 100% fine aggregate by stone dust. Other samples were prepared by replacing 10%, 20%, 30%, 40%,

50% and 100% replacement of coarse aggregate by ceramic scrap. Mix proportion of M25 and water cement ratio of 0.48 was chosen for the investigation. He casted cubes of 150mm size, cylinders of 150*300mm size and prisms of 100*100*500mm. These samples were subjected under experimental test of compressive strength, split tensile strength and modulus of elasticity. From the result of experiment, he concluded that stone dust can be effectively used as replacement of fine aggregate but ceramic scrap should not be replaced more than 20% of coarse aggregate in order to achieve significant structural strength.

Patel, A.N. and Pitroda J.K. investigated the strength properties and economic feasibility of concrete, when it was prepared using stone dust as a partially replacement of cement. Portland Pozzolana cement of grade 53 was used for mix design. They prepared mix of M25 using 0.40 water cement ratio. Six samples of concrete were prepared. While controlling the mix design, 10%, 20%, 30%, 40% and 50% of cement is replaced by stone dust. Cube specimens of concrete of size 150*150*150mm were cast and 7days, 14 days and 28 days compressive strength was analyzed. It was found that compressive strength of cubes decreased as the percentage of replacement of cement was increased. On the other hand, the research showed economically feasible as the cost in preparation of cube is reduced by replacing cement by stone dust7.

III. 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.

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 %
7th day Compressive strength	32 MPa
28th day Compressive strength	43 MPa
Specific gravity	2.71

Table 1: Properties of Portland Pozzolana Cement

2) Fine Aggregate

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

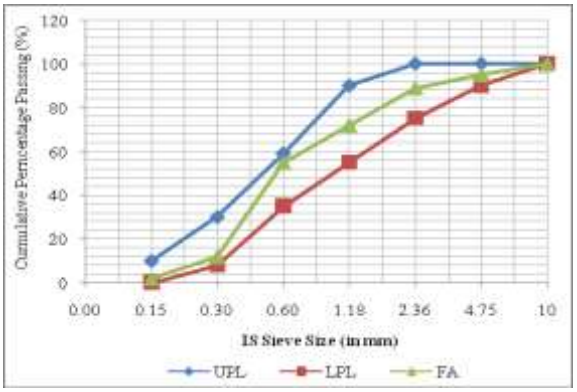

Fig. 1: Grading curve of the Fine Aggregate

3) Coarse Aggregate

A Combined grading of the two individual 20 mm and 10 mm Nominal size coarse aggregate (20mm CA & 10mm CA) grading 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.

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

Table 2: Properties of Coarse Aggregate

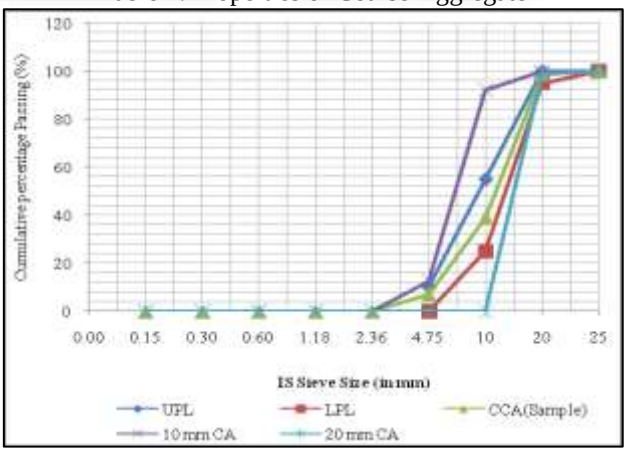

Fig. 2: Grading curve of the combined coarse aggregate.

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.

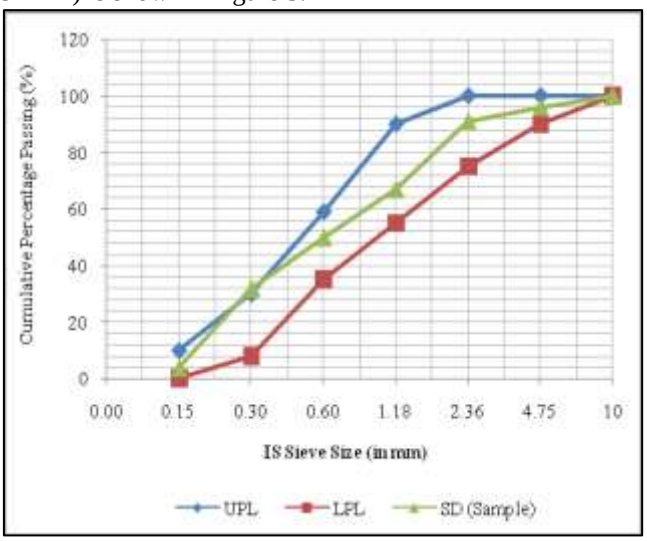

Fig. 3: Grading curve for Stone dust.

5) Super Plasticizer

Sulphonated naphthalene formaldehyde (SNF) based Super plasticizer (KEM SUPLAST 101 S) of Chambord 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.

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.

6) 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 remolded 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.

Fig. 3: A set-up of Compression testing machine (CTM)

Fig. 4: Measurement of Slump (in mm)

IV. METHODOLOGY

In order to establish the stone powder produced during stone crushing as an alternative of normal sand a lots of laboratory test are conducted and compared with the same obtained result from the normal sand concrete. For these purposes the compressive strength of mortar (2" x 2") and concrete (6" x 6") (for 3, 7 and 28 days) is tested as per British standard. 3 samples were prepared for every single test. Therefore 9 specimens were made for one mix ratio. The concrete and mortar block were made by a standard method with proper curing and tempering. The blocks are then tested by compression testing machine. As the study focuses on the adequacy of fine aggregate and hence the fineness modulus

(Figure 1) of stone powder and sand was calculated and rest of sample remained constant. The obtained result is analyzed and then discussion is prepared depending on the result obtained.

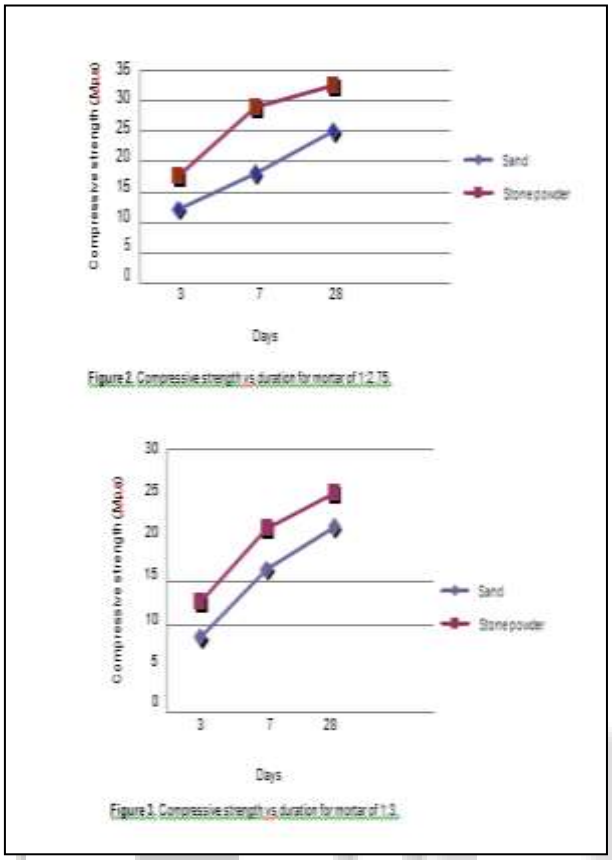

Figure 2. Compressive strength vs duration for mortar of 1:2.75.

Figure 3. Compressive strength vs duration for mortar of 1:3.

V. RESULT

This study shows that the compressive strength both for mortar and concrete using stone powder gives impressive result than that of normal sand for the ratio of 1:2.75, 1:3 and 1:3.5. Figure 2 shows that for the ratio of 1:2.75, for 3 days the compressive strength of mortar (2" x 2") sand is 12.17 Mpa and of stone powder are 17.51 Mpa. For 7 days it is increased by 37.64% from sand to stone powder (17.96 to 28.8 Mpa). The highest value of compressive strength of mortar is tasted for stone powder is 32.45 Mpa for 28 days whereas mortar made by sand shows a value of 24.98 which is 23.02% smaller than the value of stone powder. Figure 3 shows the compressive strength of mortars of 1:3 and it is evident that for 3 days the compressive strength of stone powder is increased by 32.85% from normal sand. The compressive strength of sand for 7 days is 16.25 Mpa which is 22.84% smaller value of stone powdered mortar compressive strength. For 28 days mortar shows the highest value for this ratio and stone powder is increased by 18.2% from normal sand value. Figure 4 shows the compressive strength of mortar sand is 7.95 Mpa for 3 days whereas 10.38 Mpa has been tasted for stone powder. For 7 days it is 13.38 and 18.9 Mpa for normal sand and stone powder accordingly. Finally for 28 days 20.52% of compressive strength is increased from normal sand to stone powdered mortar. Figure 5 shows that for the ratio of

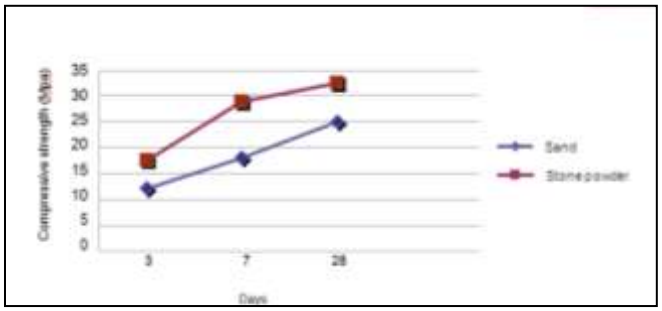

Fig. 3: Compressive strength vs duration for mortar of 1:2.75.

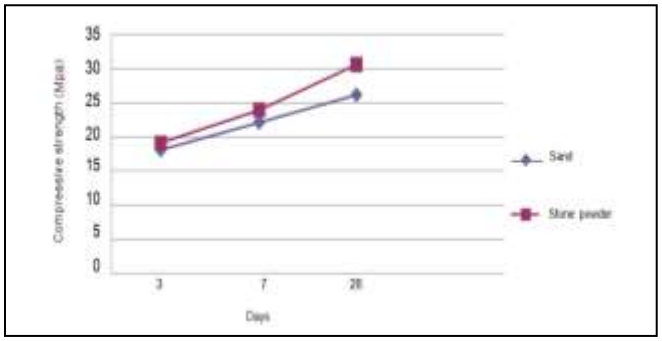

Fig. 4: Compressive strength vs duration for concrete (crushed stone) of 1:1.5:3

1:1.5:3 compressive strength of concrete by stone chip with normal sand and stone powder is quite close for 3 days which is 4.62% increased value from normal sand to stone powdered concrete. For 7 days the compressive strength of sand concrete is 22.21 Mpa whereas for stone powder it is 23.97 which is 7.34% higher value from normal sand concrete. For 28 days compressive strength of stone powdered concrete is 14.76% higher than the compressive strength of normal sand concrete. Figure 6 shows a close value for compressive strength of concrete for the duration of 3 and 28 days for the ratio of 1:2:4. For 3 days the value is 15.26 and 16.01 Mpa for sand and stone powder respectively and for 28 days it is 21.11 and 22.01 Mpa accordingly. For 7 days the compressive strength value of normal sand is 16.78 Mpa where as stone powder shows 19.87% higher value. Figure 7 shows that using 1:2.5:5 mix ratios in concrete, compressive strength for 3 days for normal sand is 12.025 Mpa and for stone powder the compressive strength is 14.21 Mpa. For 7 days it is increased by 16.63% from sand to stone powder (14.04 to 16.84 Mpa). The highest value of compressive strength of concrete is tasted for stone powder is 21.16 Mpa for 28 days whereas concrete made by sand shows a value of 18.95 which is 10.44% smaller than the value of stone powder. Figure 8 shows that the compressive strength of normal sand and powder sand of brick chip is quite close for 3 days. For 7 days the compressive strength of normal sand concrete by brick chip is 15.8Mpa whereas for stone powder it is 17.23 which is 8.3% higher value from normal sand concrete. For 28 days compressive strength of stone powdered concrete is 13.74% higher than the compressive strength of normal sand concrete. Figure 9 shows a smooth increasing of the compressive strength of concrete of normal sand to stone powder. For 3 days the value is 11.82 and 13.13 Mpa for sand and stone powder respectively and for 28 days it is 19.33 and 21.94 Mpa accordingly. For 7 days the compressive strength value of normal sand is 15.25 Mpa

where as powder sand shows 9.06% higher value. Figure 10 shows that for 3 days the compressive strength of concrete of normal sand is 9.63 Mpa and of stone powder are 9.5 Mpa which are very close value. For 7 days it is increased by 8.32% from sand to stone powder (12.89 to 14.06 Mpa). The highest value of compressive strength of concrete is tasted for stone powder is 19.05 Mpa for 28 days whereas concrete made by sand shows a value of 17.96 which is 5.72% smaller than the value of stone powder.

VI. CONCLUSION

This literature shows that many researchers have conducted many experiments on stone dust as a replacement material for fine aggregate. All the researches shows the definite effect on the property of concrete. Following significant points can be concluded form their study:

Concrete shows higher compressive strength after replacing fine aggregate by stone dust. So stone dust can be used as an additive in concrete preparation.

Workability of concrete increases with the use of stone dust. iii. Stone dust can be used as an alternate material of fine aggregate both in lean concrete as well as in high strength concrete. It is reported in this paper that stone dust increases the strengthen properties of concrete. However other parameters like temperature, humidity, climate conditions, air-entrapped etc. also effects the same.

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