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Utilization of Stone Dust as Fine Aggregate Replacement in Concrete

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***Abstract*—Owing to increased construction activities for different regions and utilities scaring of natural resources is being forced due to its over exploitation. Depleting natural resources posed threat to the environment. Hence conservation of natural resources is great challenge for civil engineers since construction activities cannot be diminished as it is intimate able. The only way is to search alternatives material which can fully or partially replaced naturally available material in construction. Stone dust is such an alternative material which can be effectively being used in construction as partial replacement of natural sand. In the present investigation an experimental programme was carried out to study the suitability and potential use of stone dust as partial replacement of fine aggregate in concrete. To accomplish this specimen were cast for different replacement level at an interval of 10 percent to determine workability and compressive strength of concrete at different level of fine aggregate with stone dust. Results show that optimum replacement with stone dust is 60 percent based on compressive strength.**

Keywords—Stone dust replacement, workability, compressive strength, fine aggregate, coarse aggregate

I. INTRODUCTION –

Concrete is commonly used construction material due to its ease of availability, mouldable, rigidity and durability. It consists of binding material, fine aggregate, coarse aggregate and required quantity of water, where sand is normally used as fine aggregate. Due to rapid growth of construction activity, the available sources of natural sand are getting exhausted. Hence conservation of natural resources is great challenge for civil engineers since construction activities cannot be diminished as it is intimate able. The only way is to search alternatives material which can fully or partially replaced naturally available material in construction. Stone dust is such an alternative material which can be effectively being used in construction as partial replacement of natural sand. This is a waste product obtained from aggregate crushing plant. Stone dust is well appropriate in terms of strength and economy over normal sand for medium grade concrete (Mahzuz et al 2011). 40 percent fine aggregate can be effectively replaced with stone dust (Franklin et al 2014). The compressive strength of concrete mix had increased by 22% with the use of crusher dust at 40% replacement of natural sand (Pofale et al 2013).The present study aimed to utilizing stone dust as fine aggregate in concrete in place of natural fine aggregate. For that an experimental programme was carried out to study the suitability and potential use of stone dust as partial replacement of fine aggregate in concrete. To accomplish this specimen were cast for different replacement level at an interval of 10 percent to determine workability and compressive strength of concrete at different level of fine aggregate with stone dust. The percentage of stone dust was gradually increased in concrete and investigates its effect in sense of workability and compressive strength. The study shows that compressive strength of concrete made using stone dust as fine aggregate replacement having greater value in comparison of conventional concrete whereas the workability of concrete was decreased rapidly with the increment of stone dust in concrete. It may be due to the more water absorption capacity of stone dust in comparison of natural aggregate or lack of surface moisture in stone dust. So a dose of super plasticizer was used. But increment of stone dust also affected the workability of concrete which was maintained by different doses of super plasticizer.

II. Materials and method -

A. Cement -

Portland Pozzolana Cement (fly ash based) brand name Birla Gold confirming to IS 1489 (Part 1) - 1991 was used in this study. The properties of cement was shown in table1.

Table1. *Properties of Cement*

Standard Consistency	31%
Initial Setting Time	240 minutes
Final Setting Time	315 minutes
7 days Compressive Strength	33 N/mm^2
28 days Compressive Strength	44 N/mm^2
Specific Gravity	2.72

B. Fine Aggregate -

River sand available in Allahabad confirming to IS 383-1970, zone II used in the study. It was completely

passed by 4.75 mm IS sieve. Fineness modulus and specific gravity was 2.76 and 2.3 respectively. Particles size distribution graph of this aggregate shown in fig.1 with permissible values specified by code.

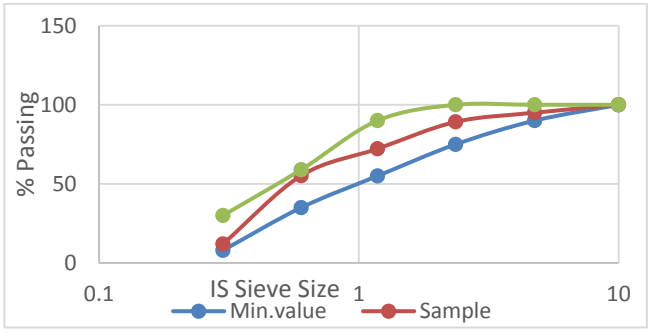

Fig.1. *Particle Size Distribution of Fine Aggregate*

C. Coarse Aggregate -

Locally available coarse aggregate having two fraction 20mm and 10mm sizes individually sieved was used in the present study. One fraction completely passed through 20 mm sieve and another 10 mm sieve. For mix the ratio of these aggregates was 60:40 respectively. The combined particle size distribution of coarse aggregate and properties are shown in fig.1 and table 2 respectively.

TABLE 2.*Properties of Coarse Aggregate*

Fineness Modulus of 10 mm Aggregate	6.9
Fineness Modulus of 20 mm Aggregate	7.7
Water Absorption	0.8
Specific Gravity	2.6

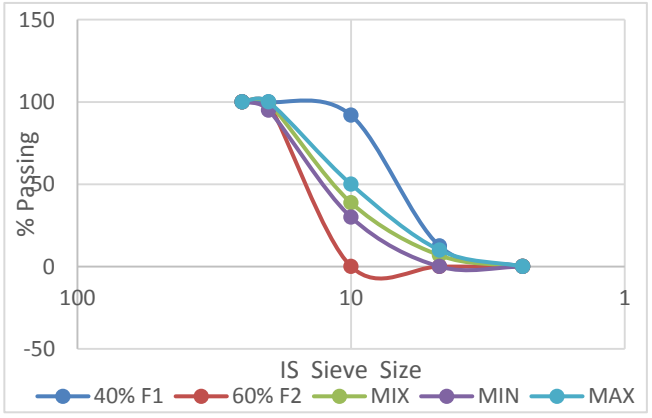

Fig. 2. *Particle Size Distribution of Coarse Aggregate*

D. Stone dust -

Grey col our stone dust was collected from local stone crushing units of Bharatpur, Rewa road, Uttar Pradesh. It was initially dry in condition and thoroughly retained on IS 150 μ sieve before preparation of mix. Fineness modulus and specific gravity was 2.85 and 2.4 respectively. The particle size distribution curve is shown in fig. 3.

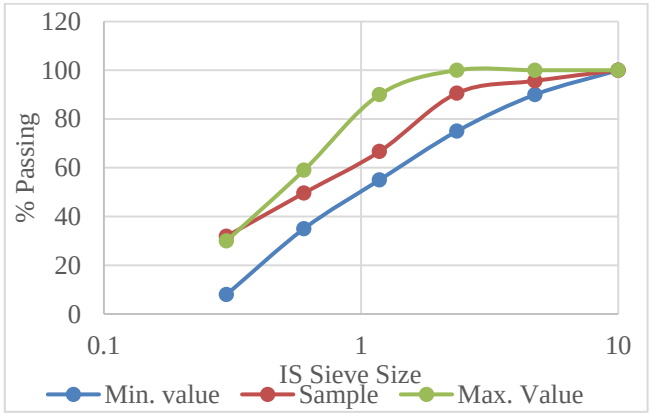

Fig. 3. *Particle Size Distribution of Stone Dust*

E. Super plasticizer -

KEM SUPLAST 101 S super plasticizer manufactured by Chembond Chemicals was used in the study. It was synthetic super plasticizer based on sulphonated naphthalene and instantly dispersible in water having specific gravity 1.2.

M25 grade of concrete is used as bench mark which was designed as per IS 10262 - 2009 guidelines for this investigation. The proportion of materials was 1:1.54:3 with water cement ratio 0.42 and dose of super plasticizer was 0.6% by weight of cement. The coarse aggregate used in a combination of 40:60 individually sieved with IS sieve size 10 mm and 20 mm respectively. Used fine aggregate and stone dust confirm same zone according to IS 383 – 1970 in the study. Total 84 specimens of size 150 X 150 X 150 mm were casted during this investigation. At first 18 cubes were casted for mix design calculation contained 380 kg cement per cubic meter of concrete with varying water cement ratios. After that 66 cubes of same size were casted for replacement of fine aggregate with stone dust at different percentage level. For a percentage replacement 6 cubes were casted, 3 for 7 days and 3 for 28 days strength calculation. The mixture was manually mixed and workability was measured with slump cone. The cone was filled in four parts with tamped by a steel tamping rod. Uniformity was maintained during mixing process. After workability measured the cube was filled in two parts with this mixture and vibrated on a table vibrator. At 24 hours cubes were demoulded and put in water bath for curing. The compressive strength of concrete for 7th days and 28th days were tested on analogue compression testing machine conform to IS 14858 – 2000 of capacity 2000kN. The compression testing machine with a tested specimen shown in fig. 4.

Fig. 4. *Compression Testing Machine*

Fig. 5. *Workability Measured by Slump Test*

III. Result and discussion -

A. Workability:

The workability of fresh concrete was measured by the slump test. The slump test indicates the behavior of a compacted concrete cone under the action of gravitational forces. The slump values for different percentage of stone dust in concrete as shown in table 3. It indicates at a constant dose of super plasticizer (i.e., at 0.8% by weight of cement) the workability of concrete decreases rapidly with increment of stone dust in mixture. At high percentage level of stone dust the slump is zero (i.e., no slump) due to more water absorption capacity of stone dust. So for maintain workability the dose of super plasticizer was increased. Fourth column of the table shows the dose of super plasticizer at which the targeted slump value 50 – 75 mm achieved for different replacement level of fine aggregate.

TABLE 3.*Workability of Concrete*

Sample Designation	Slump Value (mm) at Dose of Super Plasticizer 0.8% by Wt. of Cement	% Replacement with Stone Dust	% Dose of Super Plasticizer by Weight of Cement at which Slump Maintained 50 – 75 mm
W0	100	0	0.6 (65mm)
W1	81	10	0.7 (70 mm)
W2	60	20	0.8 (60 mm)
W3	48	30	0.9 (54 mm)
W4	38	40	1.1 (60 mm)
W5	22	50	1.3 (52 mm)
W6	20	60	1.45 (55 mm)
W7	20	70	1.6 (58 mm)
W8	15	80	1.7 (51 mm)
W9	0	90	1.8 (53 mm)
W10	0	100	2.2 (50 mm)

B. Compressive Strength -

The compressive strength of different specimens for same concrete mix is different. So average compressive strength of three specimen sample were used for strength calculation. The average compressive strength of concrete for 7th days and 28th days were tested as per IS 516 - 2004 are tabulated in table 4 and graphical view shown in fig. 6. It was observed that the maximum strength obtained at 30 percent replacement level in 7 days and variation of strength within 18 percent throughout the replacement level of natural sand. The 28 days compressive strength of samples were more than the designed value throughout the replacement level and maximum strength was obtained at 60% replacement of fine aggregate with stone dust. The results shows strength of concrete increases within 5-12 percent up to 50 percent replacement of fine aggregate. And at 60 percent stone dust in concrete the maximum value of compressive strength is obtained which is 17 percent more than referral concrete (concrete with zero percent stone dust). After that the strength decreases within variation of 10 percent. The variation in compressive strength may be due to different dose of super plasticizer, different water absorption of stone dust and sand, different angularity of particles etc.

The replacement of fine aggregate with stone dust does not give any harm on strength, it gives beneficial results. But it badly affects the workability on increment level of stone dust. So for maintain workability the dose of concrete was increased which affect the setting time and nearly doubled with comparison of conventional concrete. For attain good

strength in this study the concrete with above 50% replacement level of stone dust casted on 1 - 1.5% dose of super plasticizer with slump vale of 25 – 35 mm. Finally it can be stated that the stone dust is to be used in concrete with partially or fully replacement of fine aggregate.

TABLE 4. *Compressive Strength of Concrete*

Concrete Cube Group Designation	% of Stone Dust	Average Compressive Strength (N/mm^2)	
		7 days	28 days
B0	0	25.30	36
B1	10	24.64	37.58
B2	20	25.38	36.34
B3	30	29.70	38.74
B4	40	24.76	39.32
B5	50	25.72	40.12
B6	60	24.80	42.06
B7	70	26.22	39.40
B8	80	25.64	38.82
B9	90	25.05	41.32
B10	100	23.56	38.64

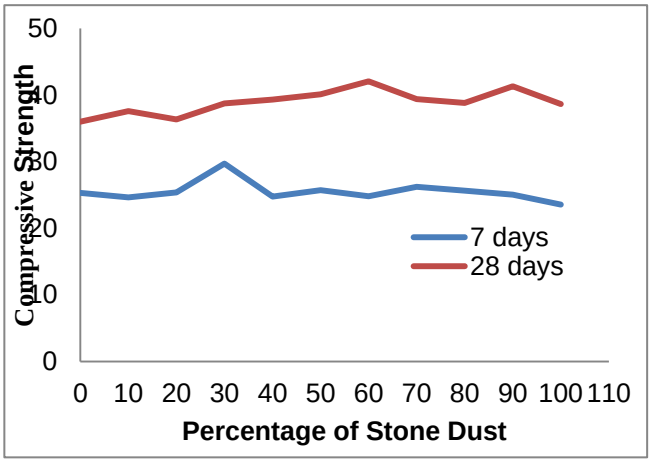

Fig. 6. *Compressive Strength of Concrete*

2. Conclusion -

On the basis of the study it can be concluded that:

- Stone dust is to be used as partial or full replacement of natural fine aggregate in concrete.
- The use of stone dust in concrete is beneficial in different manner such as environmental aspects, non-availability of good quality of fine aggregate, strength criteria etc.
- The workability of concrete was decreased at increment level of stone dust in concrete which can be maintained by extra dose of super plasticizer.
- It can be used where setting time is not much important because excess dose of super plasticizer increase the setting time.

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