Suitability of Stone Dust in Concrete

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***Abstract* - Presently fast-growing construction industries require huge amount of building materials. Concrete is one of them which cover large portion of construction materials segment and contains cement, fine aggregate, coarse aggregate, water and admixtures if needed. The contribution of coarse aggregate and fine aggregate in concrete is nearly 80 percent of total mass. For fulfillment of the above demand over exploitation of mines and rock is imperative .In crusher plant huge amount of stone dust is generated which is thrown in land fill abundance as waste. This waste in certain fraction may be used in concrete making as partial replacement of fine aggregate. Present study taken in view to check the suitability of stone dust in concrete as partial replacement of conventional fine aggregate (natural sand). To accomplish this specimen were cast for different replacement level. Results show that at all the replacement level compressive strength is more than that of referral concrete.**

***Index Term* - Compressive Strength, Density, Workability, Stone Dust Replacement.**

I. INTRODUCTION

Concrete being most used construction material consists of cementing material, fine aggregate, coarse aggregate and required quantity of water. Sand is normally used as fine aggregate. The contribution of coarse aggregate and fine aggregate is nearly 80 percent of the total mass. Due to rapid growth of infrastructure development activities, the available sources of natural material getting exhausted as very fast rate. The only way is to search alternative materials for construction industries. Use of stone dust as partial replacement of fine aggregate in concrete may be an attempt to use of alternative waste material in construction as partial replacement. Stone dust is well appropriate in terms of strength and economy over normal sand for medium grade concrete (Mahzuz et al 2011). Compressive strength at 50 percent replacement of fine aggregate with stone dust is comparable to the referral concrete (Abbas et al 2015).Workability of concrete decreases within 1 – 6 percent with increase in quantity of crusher dust as partial replacement of natural sand (Pofale et al 2013). This investigation present experimental result carried out to or determine workability, density (fresh and harden state) and compressive strength of concrete made using stone dust as partial replacement of fine aggregate up to 80 percent at an interval of 10 percent.

II. MATERIALS AND METHOD

A. Cement

Portland Pozzolana Cement of single batch confirming to IS 1489 (Part 1) - 1991 was used in this study. The physical properties of cement is shown in table I.

Characteristics	Test Results	IS 1489 (Part 1) – 1991 Requirements
Standard Consistency	31%	-
Initial Setting Time	240 minutes	30 minutes (min.)
Final Setting Time	315 minutes	600 minutes (max.)
7 days Compressive Strength	33 N/mm^2	22 N/mm^2 (min.)
28 days Compressive Strength	44 N/mm^2	33 N/mm^2 (min.)
Fineness	342 m^2/kg	300 m^2/kg (min.)

TABLE I: PROPERTIES OF CEMENT

B. Fine Aggregate

Yamuna river sand available in Allahabad confirming to IS 383-1970, zone II was used in the present study. Properties and sieve analysis of fine aggregate mentioned in table II and 3 respectively.

TABLE II : PROPERTIES OF MATERIALS

Characteristics Value	Fine Aggregate	Coarse Aggregate		Stone Dust
		10 mm	20 mm	
Fineness Modulus	2.76	6.9	7.7	2.83
Specific Gravity	2.3	2.6	2.6	2.4

C. *Coarse Aggregate*

Locally available coarse aggregate with fraction of 20 mm and 10 mm were used in the present study. Both the fraction completely passed through 20 mm sieve and 10 mm sieve individually. In mix the ratio of these aggregates was 60:40 respectively. Water absorption for both the aggregate was 0.8 percent. The properties and combined sieve analysis of coarse aggregate are shown in table II and IV respectively.

TABLE III: SIEVE ANALYSIS OF FINE AGGREGATE

IS Sieve Size	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
10 mm	0	0	0	100	100
4.75 mm	0.025	0.025	5.0	95.0	90 – 100
2.36 mm	0.029	0.054	10.8	89.2	75 – 100
1.7 mm	0.036	0.009	18.0	82.0	
1.18 mm	0.049	0.139	27.8	72.2	55 – 90
600 □	0.085	0.224	44.8	55.2	35 – 59
300 □	0.216	0.440	88.0	12.0	8 – 30
150 □	0.060	0.500	100	0	0– 10

TABLE IV: SIEVE ANALYSIS OF COMBINED COARSE AGGREGATE

IS Sieve Size	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
25 mm	0	0	0	100	100
20 mm	0.023	0.023	0.46	99.54	95 – 100
12.5 mm	2.500	2.523	50.46	49.54	
10 mm	0.250	2.773	55.46	44.54	25 - 55
4.75 mm	2.227	5	100	0	0– 10

D. Stone dust

Grey colour 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. The sieve analysis of the stone dust is shown in table V.

TABLE V: SIEVE ANALYSIS OF STONE DUST

IS Sieve Size	Weight Retained (kg)	Cumulative Weight Retained (kg)	Cumulative Percentage Retained	Cumulative Percentage Passing	IS 383-1970 Requirements
10 mm	0	0	0	100	100
4.75 mm	0.022	0.022	4.4	95.6	90 – 100
2.36 mm	0.02	0.042	8.4	91.6	75 – 100
1.7 mm	0.048	0.09	18	82	
1.18 mm	0.07	0.16	32	68	55 – 90
600 □	0.092	0.252	50.4	49.6	35 – 59
300 □	0.098	0.35	70	30	8 – 30
150 □	0.15	0.5	100	0	0– 10

E. Super plasticizer

Sulphonated naphthalene based synthetic super plasticizer brand name KEM SUPLAST 101 S having specific gravity 1.2 was used in the study.

For this investigation M25 grade of concrete is used as bench mark which was designed as per IS 10262 - 2009 guidelines. The proportion of materials was 1:1.54:3 with water cement ratio 0.42 and dose of super plasticizer 0.6% by weight of cement. A combination of 40:60 individually sieved aggregate by 10 mm and 20 mm IS sieve was used for mix preparation. Same zone of fine aggregate and stone dust confirm IS 383 – 1970 was used in the study. Total 72 specimen cubes of size 150 mm were casted during this investigation. 18 cubes were casted for mix design calculation contained 380 kg cement per cubic meter of concrete with varying water cement ratios. And 54 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 each 7 and 28 days. The mixture was manually mixed and the workability of fresh concrete was measured with slump cone. Uniformity was maintained during mixing process. Specimen cube was filled in two parts with this mixture and vibrated on a table vibrator. Bulk weight of fresh concrete was weighted. After 24 hours cubes were demoulded and put in water bath for curing. The compressive strength of concrete for 7th and 28th days were tested on analogue compression testing machine of capacity 2000kN confirm to IS 14858 – 2000. The compression testing machine with a tested specimen is shown in figure 2.

Fig.1: Workability Measured by Slump Test

Fig.2: Compression Testing Machine

III. RESULT AND DISCUSSION

A. Workability:

The workability of fresh concrete was measured by the slump test. It was observed that the slump value decreased with increment of stone dust in concrete. The graphical representation of slump values for different percentage of stone dust with constant dose of super plasticizer (i.e., at 0.8% by weight of cement) in concrete as shown in figure 3. It indicates at a constant dose the workability of concrete at high percentage of stone dust is much lower than the previous due to rough surface texture and angular shape of stone dust. So for maintain workability the dose of super plasticizer was increased. Table VI shows the dose of super plasticizer at which the targeted slump value 50 – 75 mm achieved for different replacement level of fine aggregate.

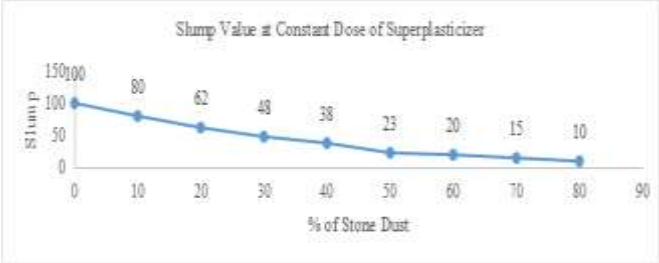

Fig.3: Graphical Representation of Workability at Constant Dose of Superplasticizer

TABLE VI: WORKABILITY OF CONCRETE

% of Stone Dust in Concrete	% Dose of Super Plasticizer by Weight of Cement	Moderate Slump Value (in mm)
0	0.6	65
10	0.7	70
20	0.8	60
30	0.9	54
40	1.1	60
50	1.3	52
60	1.45	55
70	1.6	58
80	1.7	51

B. Density:

The density of fresh concrete is slightly greater than the density of harden concrete. The density of concrete with stone dust initially decreased in comparison to referral concrete this may be due to region of specific gravity of stone dust is slightly more than the fine aggregate .On equivalent weight basis stone dust cover less volume than that of fine aggregate which may be leads to the more voids in concrete over bulk density is lower than conventional concrete. At the 50 -60 percent bulk density is higher than that of referral concrete. It shows that at the replacement level voids in concrete. Thereby increased bulk density is obtained. Bulk density varies within 4 percent and the density of harden concrete varies within 3.66 percent throughout the replacement level. The average bulk density of concrete is 2469 kg/m^3 and harden density is 2464 kg/m^3. And the maximum density attains at 60 percent stone dust in concrete .The variation of density with stone dust in concrete at different percentage shown in figure 4 and 5 for fresh concrete and hardens concrete respectively.

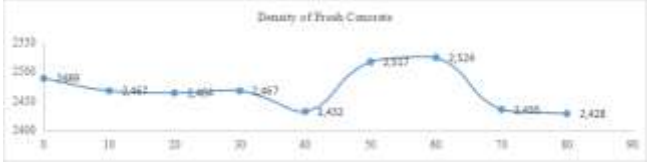

Fig.4: Graphical Representation of Density of Fresh Concrete

Fig.5: Graphical Representation of Density of Harden Concrete

C. Compressive Strength:

The compressive strength of concrete was tested as per IS 516 – 2004. The average compressive strength of concrete for 7th and 28th days are shown in figure 6. It was observed that the variation in strength at 7th days within 18 percent and maximum strength obtained at 30 percent replacement of natural sand with stone dust. The 28th days result shows compressive strength of samples were more than the referral value throughout the replacement level of natural sand. The results shows strength of concrete increases within 5-12 percent up to 50 percent replacement and after attains maximum value it decreases within variation of 8 percent. The maximum strength obtained at 60 percent of stone dust in concrete at this level the density of concrete was also maximum. From figure it is observed that the best fit polynomial equation for 28th days compressive strength is $y = -0.0013x^2 + 0.1535x + 35.522$, the correlation coefficient $R^2 = 0.6992$.

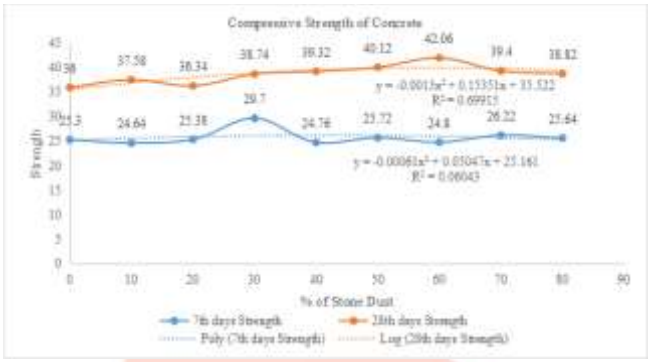

Fig.6: Graphical representation of Compressive Strength of Concrete

The replacement of fine aggregate with stone dust gives beneficial results in term of strength and density. But it badly affects the workability on increment level of stone dust. So for workable concrete different dose of super plasticizer was used. The extra dose of super plasticizer affects the setting time and nearly doubled in comparison of conventional concrete. Hence, it can be stated that the use of stone dust in concrete as partially replacement of fine aggregate is beneficial in different manner such as environmental aspects, non-availability of good quality of fine aggregate, strength criteria etc.

IV. CONCLUSION

On the basis of this study it can be concluded that –

- The compressive strength of concrete with stone dust as fine aggregate replacement is greater value (up to 16.8%) in comparison of referral concrete for all replacement level.
- Stone dust can be used in place of natural sand in concrete without affecting compressive strength.
- Maximum compressive strength and maximum density attains at 60 percent replacement of natural fine aggregate.
- The workability of concrete was decreased at increment level of stone dust may be due to angular shape and rough surface texture of stone dust particles in comparison of smooth sand.
- The workability of concrete with stone dust can be achieved with an extra dose of super plasticizer.
- It can be used where setting time is not much important because excess dose of super plasticizer increase the final setting time.
- The average bulk density and harden density of concrete is nearly same having value of 2469 kg/m^3 and 2464 kg/m^3 respectively.

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