EFFECT OF REPLACING SHARP SAND WITH STONE DUST AS FINE AGGREGATE IN CONCRETE

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ABSTRACT

Concrete is very variable material, having a wide range of strengths and stress-strain curve. Concrete composite material whose basic properties are related to the characteristic of constituent element, especially the aggregate. This research aimed to investigate the effect of replacing sharp sand with stone dust as an alternative to only river sand. Sieve analysis was carried out on the aggregate to determine the size of particle distribution. Slump test was carried out to compare the batches of concrete for the grade, water content between batches of concrete and amount of aggregate. Compressive strength test was carried out on concrete cubes made from sharp sand and concrete cubes made from replacement of sharp sand with stone dust also concrete made from ordinary stone dust at constant of free water/cement ratio 0.5. To check the properties of concrete produced with different materials, the tests were done for 7, 14, 21 and 28 days. The result obtained indicated that the strength of using sharp sand with stone dust in concrete production was higher than the strength of stone dust in concrete also higher than the strength of using sharp sand in concrete.

1. INTRODUCTION

Concrete has been considered to be very durable material requiring a little or no maintenance. The assumption is largely true, except when it is subjected to highly aggressive environments. Concrete structures are built in highly polluted urban and industrial areas, aggressive marine environments, harmful sub-soil water in coastal area and many other hostile conditions where other materials of construction are found to be non-durable (Agbede 2002., Ducatz 1995 and Ubi et al. 2020). For the past decades concrete structures have spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failure of number of structures in the recent past. Concrete is the most extensively used man made structural material. It is the product of chemical reaction between cement, sharp sand (fine aggregate), coarse aggregate and water (Fowler and Constantino 1997). The aggregate may make up to three quarters of the volume of concrete. The most durable properties of concrete are workability, high compressive strength and aesthetics. These properties are to a large degree determined by types of material used in concrete mix, especially the type and the size of aggregate. Sharp sand has been used as fine aggregate in concrete work for many years now (Nagaraji and Zahida, 1999). This is because it readily available and there has been no substitute for material. From the confined

usefulness of concrete, there exist some proportion of limitations on the use of sharp sand with stone dust as a possible replacement for sharp sand in concrete, this is very important in view of the engineering consideration. Environmental and economic problems arising from increasing volume of stone dust accumulating and taking up space in quarry site (Owoiabi 1996). The problems of environmental degradation caused by the continuous exploitation of sand from marina sources. Hence, this paper sought to investigate the effect of replacing sharp sand with stone dust as fine aggregate in concrete. Rao et al (2002) investigated the effect of replacing sharp sand with stone dust in concrete. The tests showed strength in compression at 3 - 7 and 28 days and also strength in split tension and flexure for 7 and 28 days. The test result showed that concrete with sharp sand as fine aggregate develop a strength of 28mpa on the 28th day while quarry concrete at the same age developed a strength of 32.8mpa indicating a 17% more compressive strength of the stone dust over the sharp and concrete (Prakash and Kumar 2004). In addition, the stone dust concrete had 7% more split tensile strength and 20% flexural strength (modules of mixture) than the concrete produce using sharp sand (Pofale and Kulkarni 1998). The result also shown that under two point loading condition, concrete with stone dust carried 6% more load and developed smaller deflections and strains than concrete, with sharp sand with stone dust. Based on the foregoing, Rao et al (2002), of reducing the cost of concrete by 20%. However, the internet has also provided many experimental facts regarding the use of quarry in concrete works reflecting the large amount of academic and industrial researches in this area. The purpose of this study research is to ascertain the current state of knowledge concerning the use of stone dust in concrete and most importantly to determine the structural and cost implication of replacing sharp sand with stone dust in concrete work and present the information in a form that would be easily understood and accessed by the student and the professional in the Civil Engineering Industry alike.

2. MATERIALS AND METHODS

The various materials and methods used for the research paper were adopted based on the British Standard (BS). The following materials were used: ordinary Portland cement (type 1), Fine aggregates (Sharp sand and stone dust), crushed aggregates, Sea water.

2.1. EXPERIMENT PROCEDURES

The grade of concrete used for the experimental project are grade $20N/mm^2$ and $25N/mm^2$. The mix design used of various grade and materials were based on weight and not on volume. Firstly, the cubes produced by sharp sand help to control the case of $20N/mm^2$ and $25N/mm^2$. Second round, the replacement of a sharp sand with stone dust as find aggregate in concrete. Thirdly, stone dust used to produce concrete cubes.

2.2. CURING

The purpose of curing was to control temperature and moisture into concrete, which has helped in keeping the concrete saturated as possible until the originally filled space in the fresh cement paste is occupied to the desired product of hydrated cement.

2.3. LABORATORY TEST

Variation test were carried out in the laboratory and this includes:

2.4. SLUMP TEST

Slump test is the most commonly used method of measuring consistency of concrete which can be employed in laboratory or construction site. The slump test is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Repeated batches of the same mix, brought to the same slump, will have the same water content and water cement ratio, provided the weights of the aggregate, cement and admixtures are uniform and aggregate grading is within acceptable limits. Additional information on workability

and quality of concrete can be obtained by observing the manner in which concrete slump. Quality of concrete can also be further assessed by giving a few tapings or blows by tampering rod to the based plate. The deformation shows the characteristics of concrete with respect to tendency for segregation. The slump test gives fairly good consistent results for a plastic-mix. This test is not sensitive for a stiff-mix, in case of dry-mix, no variation can be detected between mixes of different workability. In the case of rich mixes, the value is often satisfactory, their slump being sensitive to variation in workability. IS 456 of 2000 suggests that in the "very low" category of workability where strict control is necessary for workability by determination of compacting factor will be more appropriate than slump and a value of 0.75 to 0.80 compacting factor is suggested. The bureau of Indian standards, in the past, generally adopted compacting fact or test values for denoting workability. Even in the IS 10262 of 1982 dealing with recommended guide lines for concrete mix design, adopted compacting factor for denoting workability. But now in the revision of IS 456 to 2000 the code has reverted back to slump value to denote the workability rather than compacting factor. It shows that slump test has more practical utility than the other test for workability.

2.5. SIEVE ANALYSIS

Sieve analysis involved dividing a sample of aggregate into various fractions, each consisting of particles of the sample size. Sieve analysis was conducted to determine the particle size distribution in a sample of aggregate, which we call gradation. A convenient system of expressing the gradation of aggregate is one which the consecutive sieve openings are constantly doubled such as 10mm, 20mm, 40mm etc. under such a system, employing a logarithmic scale, lines can be spaced at equal intervals to represent the successive sizes. The aim of this test was to determine the range of particular size of aggregate to obtain the particle size, in each aggregate sieve analysis was carried out according to the specification in the British standard using BS 410 sieves, to know the grading for the various aggregate. The retained material in each sieve was weighed and expressed as a percentage by weight of the sample passing each of the sieves.

2.6. COMPRESSIVE STRENGTH TEST

About twelve cube of 150 by 150mm were subjected to compressive strength test to determine their strengths for 7, 14, 21, and 28 days, three cubes were crushing at the age of each day. The cube was weighed to determine the densities after weighing. The cubes were placed on the lower steel platen of the compression test machine. Compressive load was then applied at a constant rate until the sample failed for the recording according to the gauge reading at its failure point.

2.7. CONCRETE MIX DESIGN

This is the process of selecting suitable ingredient of concrete and determining their relative quantities with the purpose of providing an economical concrete which has certain minimum properties notably workability, strength and durability. The method used in the various mixes was British mix design. The design for the strength of 28 days of 20N/mm^2 and   mm^2 using ordinary Portland cement with fine aggregate and coarse aggregates. 340kg/mm^2 for grade 20 and 360kg/mm^2 for grade 25 was cement content and the ratio of water applied in concrete production remained 0.05.

3.   RESULTS AND DISCUSSION

3.1. SIEVE ANALYSIS

3.1.1. SHARP SAND

Particle size distribution for the sharp sand is in the percentage shown and is presented in Table 1 and figure 1 indicating the weight at 375g:

Fine   -   5%
Medium sand   -   85%

Coarse sand   -   8%
Fine gravel   -   2%

Uniformity coefficient

$$Cu = \frac{D60}{D10} = \frac{480 \times 10^{-3}}{250 \times 10^{-3}} = 1.92$$

Uniform distribution

$$\frac{D60}{D10} < \text{ and the particles are sandy in nature}$$

Table 1: Sieve analysis result for sharp sand total weight = 375g

B.S sieve (mm)	Weight retained (g)	Percentage retained (%)	Percentage cumulative retained (%)	Percentage passing (%)
3.35	-	-	-	100
2.36	5.10	4.27	5.63	98.64
1.18	16.00	4.27	5.53	94.37
0.60	18.50	4.94	10.57	89.43
0.425	150.50	40.17	50.74	49.26
0.300	109.60	29.25	79.99	20.01
0.212	58.96	15.72	95.71	4.29
0.150	9.40	2.51	98.22	1.78
0.075	3.50	0.93	99.15	0.85
Pan	3.20	0.85	100.0	0.00
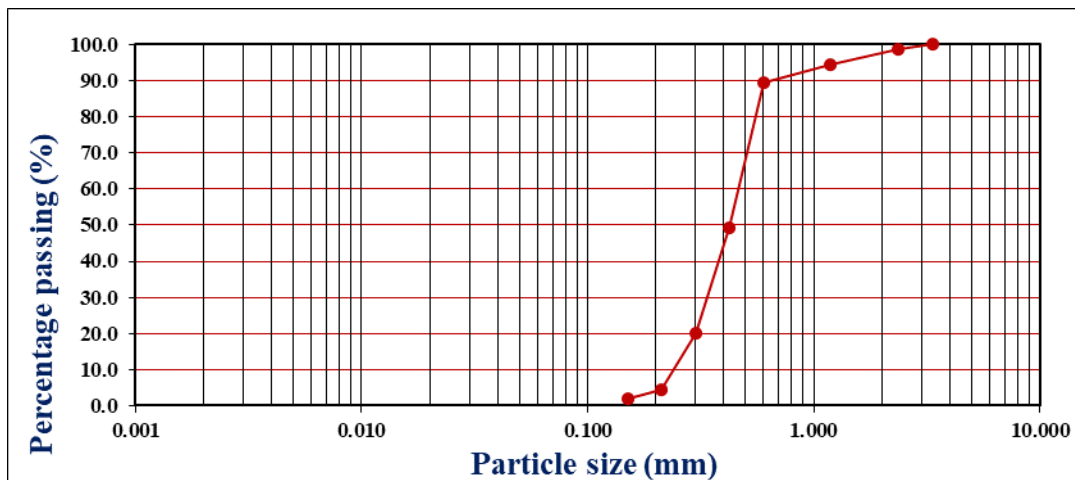
Figure 1: Sieve analysis of sharp sand

3.2. STONE DUST

Particle size distribution for the stone dust in percentage shown in Table 2 and figure 2 with an aggregates of 298g;

Fine   -   510
Medium sand   -   54%
Coarse sand   -   26%
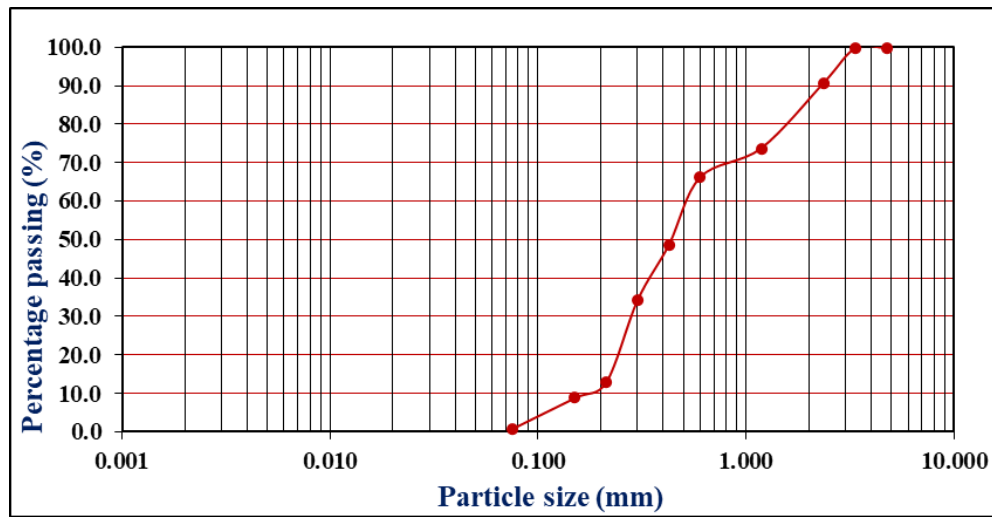Fine gravel   -   10%

Uniformity coefficient

$$Cu = \frac{D60}{D10} = \frac{599 \times 10^{-3}}{175 \times 10^{-3}} = 3.42$$

The particle are well grade sand with small proportion of the gravel.

Table 2: Sieve analysis of stone dust aggregates total weight – 298g

B.S sieve (mm)	Weight retained (g)	Percentage retained (%)	Percentage cumulative retained (%)	Percentage passing (%)
4.76	1.00	0.34	0.34	98.66
2.36	26.70	8.94	9.28	90.72
1.18	50.70	17.06	26.36	73.62
0.60	22.40	7.52	32.88	66.10
0.425	52.00	17.45	51.33	48.67
0.300	43.10	14.46	65.79	32.21
0.212	63.40	21.28	87.07	12.19
0.150	12.20	4.09	91.16	5.82
0.075	24.00	8.05	99.21	0.79
Pan	2.30	0.79	100.00	0.00

Figure 2: Sieve analysis of stone dust

Coarse aggregate
Particle size distribution shown;
|		
Fine	-	8%
Medium sand	-	8%
Coarse sand	-	7%
Fine gravel	-	32%
Medium	-	45%

Uniformity coefficient

$$Cu = \frac{D60}{D10} = \frac{80 \times 10^{-3}}{300 \times 10^{-3}} = 2.83$$

The particle is well grade sand with small proportion of the gravel as indicated in Table 3 and figure 3 with a total coarse aggregate of 1794.2G.

Table 3: Sieve analysis result for coarse aggregate total weight = 1794.2G

B.S Sieves Designation (mm)	Weight retained (g)	Percentage retained (%)	Percentage cumulative retained (%)	Percentage passing (%)
12.70	59.10	3.33	33.33	96.67
9.50	335.10	18.68	22.01	77.99
4.76	972.20	48.61	70.62	29.38
2.36	202.50	11.29	81.91	18.09
1.18	78.90	4.39	86.30	13.70
0.60	22.50	1.25	87.55	12.45
0.425	31.80	1.77	89.32	10.68
0.300	25.50	1.42	90.74	9.26
0.212	32.90	1.83	92.57	7.43
0.150	33.40	1.86	94.43	5.57
0.075	46.30	2.58	7.01	2.99
Pan	53.60	2.99	100.00	0.00
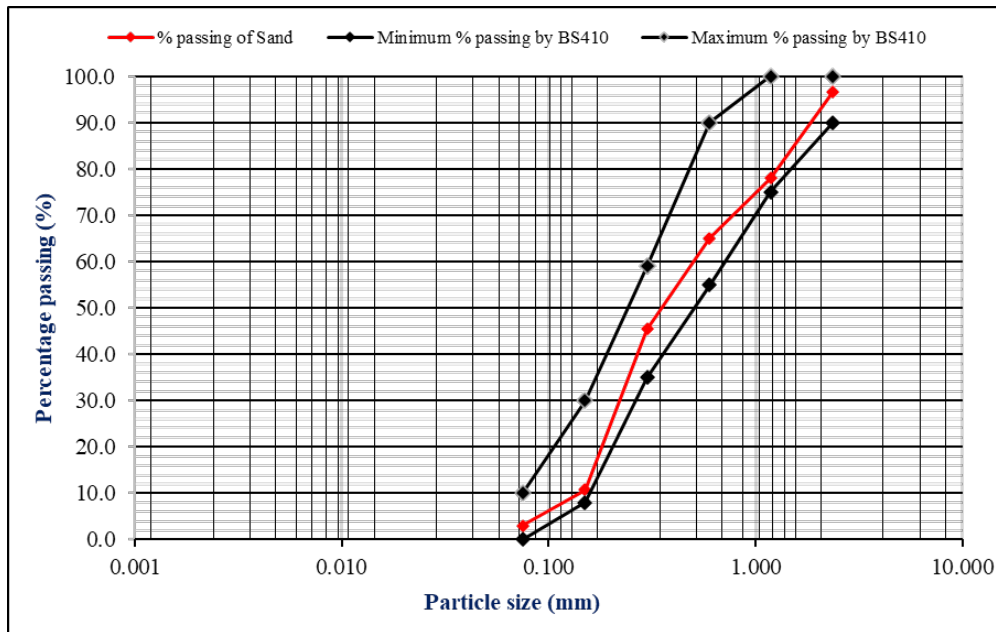
Figure 3: Sieve analysis for coarse aggregate

The British mix design method explicitly recognizes the durability requirement in the mix section. The method is applicable to normal weight of concrete made from Portland cement only. From the results obtained in Table 1-3 and figure 1 to 3 of the sieve analysis test, it is was observed that the cost of producing concrete with sharp and stone dust is almost the same. Though this title is different, can make a great deal of change in the overall cost when very large volume of concrete is required. If the site of quarry dust and if you can get the river sand close to the construction site, the price will be less. Hence, the cost of producing concrete with sharp sand with stone dust together is higher than that of river sand only.

3.3. COMPRESSIVE STRENGTH TEST RESULT

The strength developed by a concrete made with given material and in a given proportion increase for many months under favorable condition, but most specification put the strength at 28 days. The strength development of concrete made with all types of Portland cement depend on temperature and humidity. The strength of river sand (C20) stone dust (SDC20) and replacement of C20 with SDC 20 concrete at 7 days, 14 days, 21 days and 28 days are adequately presented in Table 4-11 respectively.

Table 4: Strength of river sand (c20) stone dust (sdc20) and replacement of C20 with SDC 20 concrete 7 day

C20

Sample No	Date Cast	Date crush	Wt of sample (g)	Size of sample (mm)	Density kg/m³	Crushing load (kg)	Strength n/mm²	Cement Content kg/m³	Free water cement ratio
C20A	30-11-10	7-12-10	7950	150	2355	290	18.88	340	0.5
C20B	30-11-10	7-12-10	80.12	150	2373	300	19.03.	340	0.5
C20C	30-11-10	7-12-10	8200	150	2429	300	19.47	340	0.5
Average density =2385, average strength =19.12									
SDC 20									
SDC20A	30-11-10	7-12-10	8220	150	2435.	310	1,952	340	0.5
SDC20B	30-11-10	7-12-10	8240	150	2442	335	1957	340	0.5
SDC20C	30-11-10	7-12-10	7950	150	2355	320	18.88	340	0,5
Average density - 2410, Average strength = 19.32									
Replacement of C 20 with SDC 20									
C20/SDC20A	30-11-10	7-12-10	7890	150	2337	220	18.74	340	0.5
C20/SDC20B	30-11-10	7-12-10	8820	150	2613	419	20.94	340	0.5
C20/SDC20C	30-11-10	7-12-10	8300	150	2459	360	19.71	340	0.5
Average density = 2469, Average strength = 19.79									

Table 5: Strength of river sand) (C25) stone dust (SDC25) and replacement of c25 with SDC 25 concrete at 7 day

Sample No	Date Cast	Date crush	Wt of sample (g)	Size of sample (mm)	Density kg/m³	Crushing load (kg)	Strength n/mm²	Cement Content kg/m³	Free water cement ratio
C25A	30-11-10	7-12-10	7850	150	2357	280	18.74	360	0.5
C25B	30-11-10	7-12-10	8300	150	2459	270	19.71	360	0.5
C25C	30-11-10	7-12-10	8360	150	2477	280	19.85	360	0.5
Average density = 2424, Average strength =19.43									
SDC 25									
SDC25A	30-11-10	7-12-10	8545	150	2531	330	1952	360	0.5
SDC25B	30-11-10	7-12-10	8250	150	2442	250	1957	360	0.5
SDC25C	30-11-10	7-12-10	8270	150	2450	320	18.88	360	0.5
Average density = 2475, Average strength = 19.84									
Replacement of C 25 with SDC 25									
C25/SDC25A	30-11-10	7-12-10	7530	150	2231	270	18.74	360	0.5
C25/SDC25B	30-11-10	7-12-10	8600	150	2548	300	20.94	360	0.5
C25/SDC25C	30-11-10	7-12-10	8700	150	2577	280	19.71	360	0.5

Average density = 2452, Average strength =19.65

Table 6: Strength of river sand (C20) stone dust (SDC20) and replacement of c20 with SDC concrete 14 day

Sample No	Cast	Date Crushed	Wt of sample (g)	Size of sample (mm3)	Density kg/m3	Crushing load (kg)	Strength n/mm2	Cement content kg/m3	Free water cement ratio
C20A	30-11-10	14-12-10	7915	150	2345	460	18.79	340	0.5
C20B	30-11-10	14-12-10	8030	150	2379	320	19,07	340	0.5
C20C	30-11-10	14-12-10	8040	150	2382	390	19.09	340	0.5
Average density = 2368, average strength =18.98									
SDC 20									
SDC20A	30-11-10	14-12-10	8040	150	2382	470	19.09	340	0.5
SDC20B	30-11-10	14-12-10	7915	150	2345	300	18.79	340	0.5
SDC20C	30-11-10	14-12-10	.8030	150	2379	468	19.07	340	0.5
Average density = 2368, Average strength = 18,98									
Replacement of C 20 with SDC 20									
C20/SDC20A	30-11-10	14-12-10	8213	150	2433	350	19:50	340	0.5
C20/SDC20B	30-11-10	14-12-10	7817	150	2316	380	18.56	340	0.5
C20/SDC20C	30-11-10	14-12-10	8200	150	2429	410	19.47	340	0.5
Average density =2392, average strength = 19.17									

Table 7: Strength of river sand (C25) stone dust (SDC25) and replacement of c25 with SDC 25 concreted at- 14 day

Sample No	Date Cast	Date crush	Wt of sample (g)	Size of sample (mm)	Density kg/m3	Crushing load (kg)	Strength n/mm	Cement Content kg/m3	Free water cement ratio
C25A	30-11-10	14-12-10	8132	150	2409	300	19.31	360	0.5
C25B	30-11-10	14-12-10	.	W	2260	290	18.12	360	0.5
C25C	30-11-10	14-12-10	7850	150	2325	300	18.64	360	0.5
Average density = 2331, Average strength = 18.69									
SDC 25									
SDC25A	30-11-10	14-12-10	8959	150	2651	375	21.25	360	0.5
SDC25B	30-11-10	14-12-10	8850	150	2622	373	21.01	360	0.5
SDC25C	30-11-10	14-12-10	8135	150	2410	362	19,22	360	0,5
Average density = 2561, Average strength = 20.49									
Replacement of C 25 with SDC 25									
C25/SDC25A	30-11-10	14-12-10	7890	150	2364	300	18.95	360	0.5
C25/SDC25B	30-11-10	14-12-10	8880	150	2631	340	21.09	360	0.5

C25/SDC25C	30-11-10	14-12-10	7620	150	2258	300	18.09	360	0.5
Average density = 24 .18, Average strength =19.37									

Table 8: Strength of river sand (C20) stone dust (SDC20) and replacement of C20 with SDC concrete 21 day

Sample No	Date cast	Date crushed	Wt of sample (g)	Size of sample (mm3)	Density kg/m3	Crushing load (kg)	Strength n/mm2	cement content kg/m3	Free water cement ratio
C20A	30-11-10	21-12-10	8025	150	2377	400	19.06	340	0.5
C20B	30-11-10	21-12-10	8887	150	2633	430	21.10	340	0.5
C20C	30-11-10	21-12-10	8539	150	2530	400	20.28	340	0.5
Average density =2313, Average strength = 2014									
SDC 20									
SDC20A	30-11-10	21-12-10	8747	150	2591	450	20.77	340	0.5
SDC20A	30-11-10	21-12-10	8507	150	2520	500	202.0	340	0.5
SDC20A	30-11-10	21-12-10	8992	150	2664	500	21.35	340	0.5
Average density = 2916, average strength = 20.77									
Replacement Of C 20 With SDC 20									
C20/SDC20A	30-11-10	21-12-10	8200	150	2429	490	19.47	340	0.5
C20/SDC20A	30-11-10	21-12-10	8995	150	2665	450	21.36	340	0.5
C20/SDC20A	30-11-10	21-12-10	8600	150	2548	430	20.42	340	0.5
Average density = 2866, Average strength =20.41									

Table 9: Strength of river sand (C25) stone dust (SDC25) and replacement of C25 with SDC 25 concrete at 21 day

Sample No	Date Cast	Date crush	Wt of sample (g)	Size of sample (mm)	Density kg/m^3	Crushing load (kg)	Strength n/mm^2	Cement Content kg/m^3	Free water cement ratio
C25A	30-11-10	21-12-10	7835	150	2321	340	18.60	360	0.5
C25B	30-11-10	21-12-10	8100	150	2400	400	19.23	360	0.5
C25C	30-11-10	21-12-10	7640	150	2263	390	18.14	360	0.5
Average density = 2328, Average strength = 18.65									
SDC 25									
SDC25A	30-11-10	21-12-10	g365^v	150	2378	450	19.86	360	0.5
SDC25B	30-11-10	21-12-10	7890	150	2338	495	18.73	360	0.5
SDC25C	30-11-10	21-12-10		150	2596	500	20.81	360	0.5
Average density = 2440, Average strength =19.08									
Replacement of C 25 with SDC 25									
C25/SDC25A	30-11-10	21-12-10	8539	150	2530	400	20.28	360	0.5

C20/SDC25B	30-11-10	21-12-10	7743	150	2294	360	18.39	360	0.5
C20/SDC2C	30-11-10	21-12-10	8887	150	2633	440	21.10	360	0.5
Average density = 2485, Average strength =19.92									

Table 10: Strength of river sand (C20) stone dust (SDC20) and replacement of C20 with SDC 20 concrete 28 day

Sample No	Date Cast	Date crushed	Wt of sample (g)	Size of sample (mm3)	Density kg/m³	Crushing load (kg)	Strength n/mm	Cement content kg/m³	Free water cement ratio
C20A	30-11-10	28-12-10	8580	150	2542	510	20.39	340	0.5
C20B	30-11-10	28-12-10	8630	150	2557	520	20.40	340	0.5
C2Q.C	30-11-10	28-12-10	8430	150	2497	500	20.02	340	0.5
Average density =2532, Average strength =20.29									
SDC 20									
SDC20A	30-11-10	28-12-10	8600	150	2548	610	20.42		0.5
SDC20A	30-11-10	28-12-10	8730	150	2586	620	20.73	340	0.5
SDC20A	30-11-10	28-12-10	8700	150	2577	610	20.66	340	0.5
Average density =2570, Average strength. = 20.60									
Replacement of C 20 with SDC 20									
C20/SDC20A	30-11-10	28-12-10	8500	150	2518	520	20.18	340	0.5
C20/SDC20B	30-11-10	28-12-10	8635	150	2558	530	20.50	340	0.5
C20/SDC20C	30-11-10	28-12-10	8500	150	2518	520	20.18	340	0.5
Average density = 253l, Average strength = 20.28									

Table 11: Strength of river sand (C25) stone dust (SDC25) and replacement of C25 with SDC 25 concrete at 28day

Sample No	Date Cast	Date crush	Wt of sample (g)	Size of sample (mm)	Density Kg/m³	Crushing load (kg)	Strength n/mm²	Cement Content kg/m³	Free water cement ratio
C25A	30-11-10	28-12-10	8650	150	2563	500	20.54	360	0.5
C25B	30-11-10	28-12-10	8550	150	2533	598	20.30	360	0.5
C25C	30-11-10	28-12-10	8550	150	2533	597	20.30	360	0.5
Average density =2543, Average strength =20.38									
SDC 25									
SDC25A	30-11-10	28-12-10	8580	150	2542	630-	20.37	360	0.5
SDC25B	3041-10	28-12-10	8680	150	2571	590	20.28	360	0.5
SDC25C	3d4i4&	, 284&-W-	g63a.	150	2561	620	20,54	360	0.5
Average density = 2549, Average strength = 20.39									
Replacement of C 25 with SDC 25									

C20/SDC25A	30-11-10	28-12-10	8580	150	2542	598	20.38	360	0.5
C20/SDC25B	30-11-10	284240	8680	150	2571	600	20.71	360	0.5
C20/SDC25C	30-11-10	2842-10	8660	150	2565	598	2.057	360	0.5
Average density = 2551 Average strength =20.55									

3.4. DENSITY OF THE CONCRETE CUBES

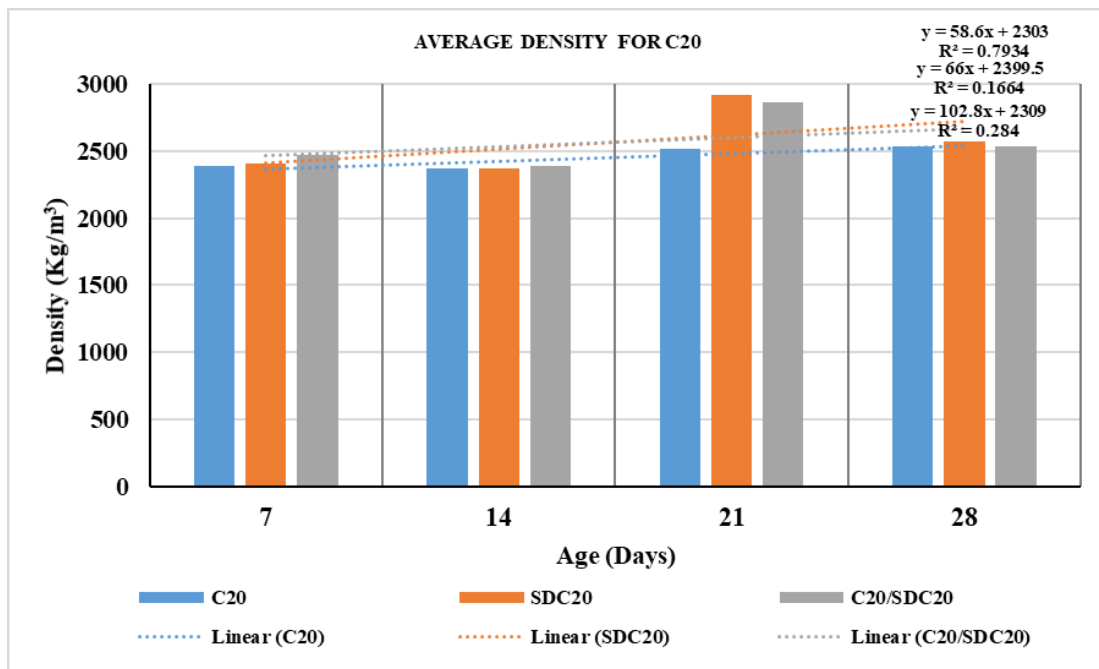This can be expressed as the ration of weight to volume in mathematical form.

$$\text{Density} \quad (D) \quad = \quad \frac{\text{Weight}}{\text{Volume}}$$

This is the factor that affect the strength of concrete. The higher the density the higher the compressive strength, as indicated in Table 12.

Stone dust has normal weight because their densities are comparable to that of sharp sand concrete according to Neville (2003) ranges from 2200 to 260Qkg/m². The result obtained was that density of quarry dust higher than that of sharp sand.
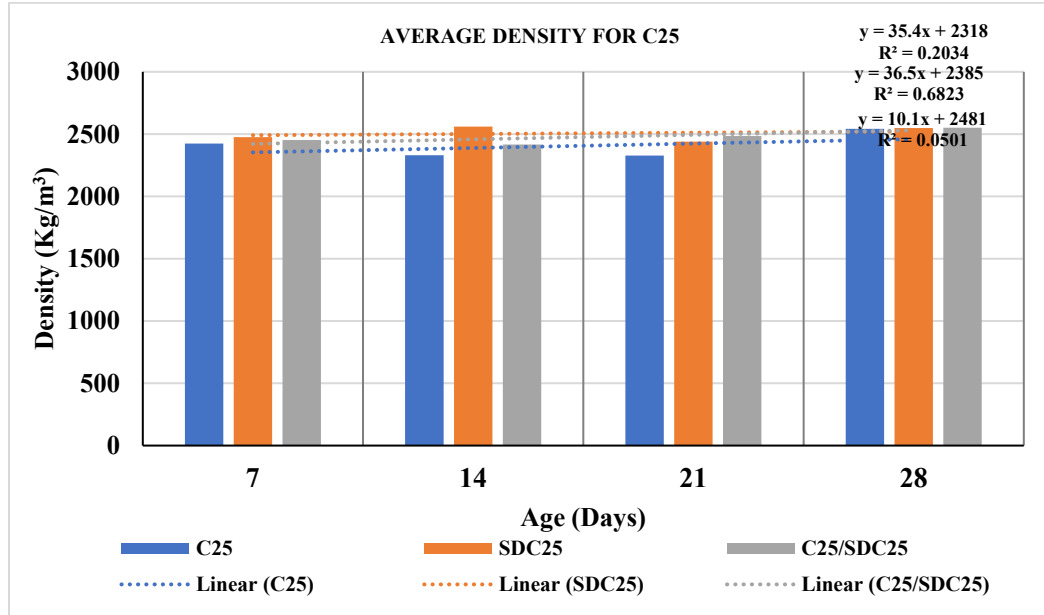
Table 12: The average density and strength for C20

CURING AGE Days	DENSITY C20 (Kg/m³)	DENSITY SDC20 (Kg/m³)	DENSITY C20/SDC20 (Kg/m³)
7	2385	2410	2469
14	2368	2368	2392
21	2513	2916	2866
28	2532	2570	2531

Figure 4: Average density for C20
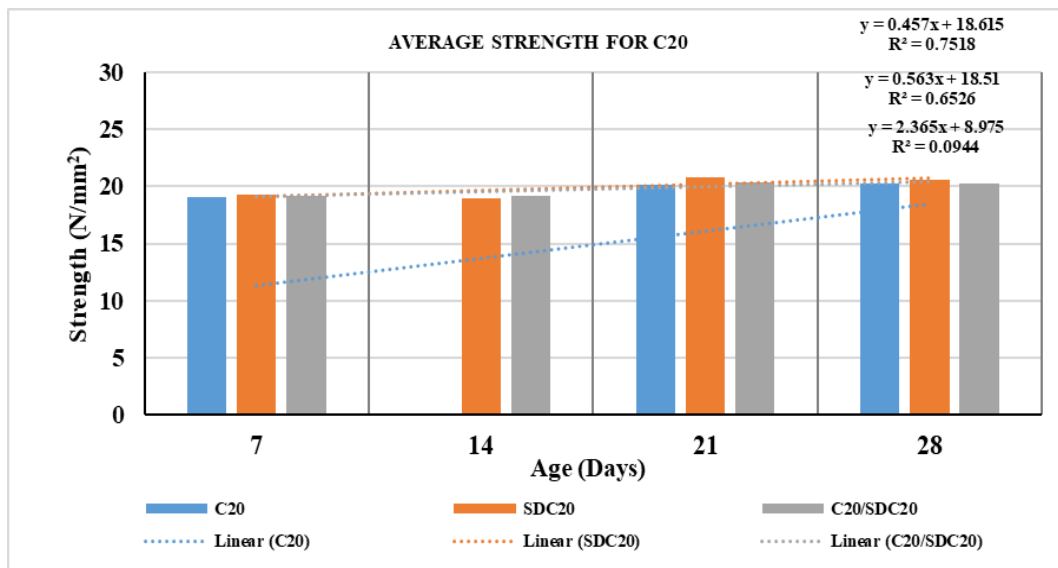
Table 13: The average density and strength for C25

7	2424	2475	2452
14	2331	2561	2417
21	2328	2440	2485
28	2543	2549	2551

Figure 5: Average density for C25

Table 14: The average strength for C20

Curing Age	Strength C20 (N/mm²)	Strength SDC20 (N/mm²)	Strength with SDC20 (N/mm²)
7	19.12	19.32	19.17
14	18,98	18.98	19.17
21	20.14	20.77	20.41
28	20.29	20.60	20.28

Figure 6: Average strength for C20

Table 15: The average strength for C25

7	19.43	19.84	19,65
14	18.69	20.49	19.37
21	18.65	19.08	19.92
28	20.38	20.39	20.55
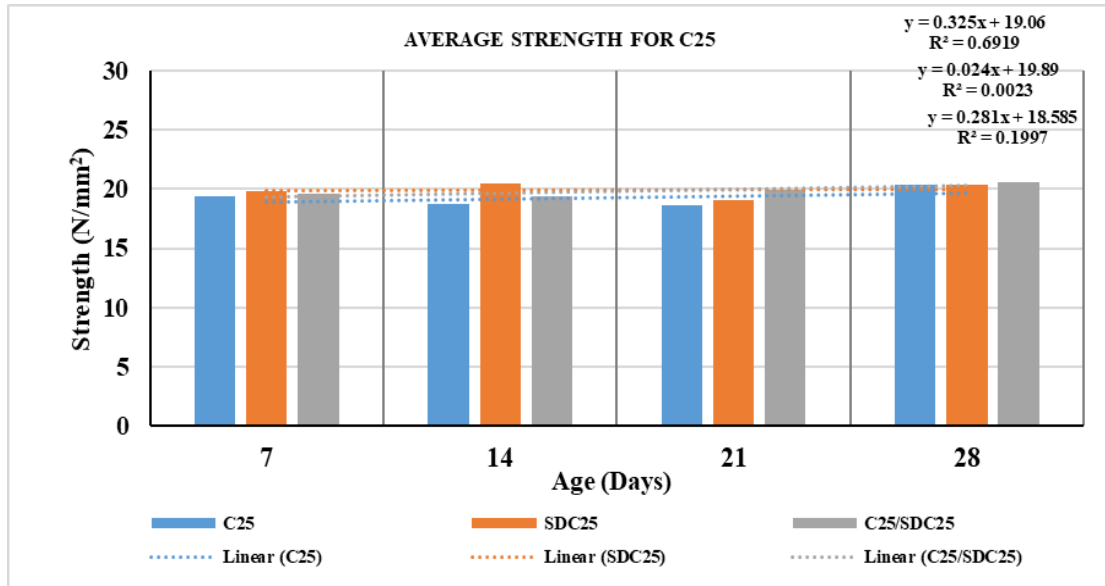
Figure 7: Average strength for C25

3.5. STANDARD DEVIATION

The account of the deviation of every value from the distribution has been taking by using the standard deviation. The value which is higher shown that there was a high level of consistencies during the laboratory work.

Standard deviation (SD) = $\frac{\sqrt{\sum(x-x)2}}{n}$

Where xi = x_1, x_2, x_3, the value of the compressive strength for the cube produced.

x = mean of number of value

n = Total number of value

The standard deviation for the various mixes designed are to be calculated at 7, 14, 21 and 28 days to know the strength.

For C_2O at 7 days curing strength

$$SD = \frac{(18.88 - 19.12)^2 + (19.03 - 19.12)^2 + (19.47 - 19.12)^2}{274^3 N/mm^2}$$

For SDC_2O 7 days strength

$$SD^2 = \frac{(19.52 - 19.32)^2 + (19.59 - 19.32)^2 + (18.88 - 19.32)^2}{3}$$

=$0.105n$/MM

For C_20 at 14 days 1 strength

$$SD^2 = \frac{(18.79 - 18.98)^2 + (18.98)^2 + (19.07 - 18.98)^2 = (19.09 - 18.93)^2}{3}$$

$0.102 N/mm^2$

For C_2O at 14 days 1 strength

$$SD^2 = \frac{(18.79 - 18.98)^2 + (19.07 - 18.98)^2 + (19.09 - 18.98)^2}{3}$$

$2.7 N/mm^2$

For SOCO20 at 14 days strength

$$SD^2 = \frac{(19.09 - 18.98)^2 + (18.79 - 18.98)^2 + (19.07 - 18.98)^2}{3}$$

$2.7 N/mm^2$

For X_20 with SDC_2O at 14 days strength

$SD^2 (19.50 - 19.17)^2 = + (18.56 - 19.17)^2 + (19.47 - 19.17)^2$
$0.19 N/mm^2$

For C_20 at 21 days strength

$$SD^2 = \frac{(19.06 - 20.14)^2 + (21.10 - 20.14)^2 + (20.28 - 20.14)^2}{3}$$

$0.702 N/mm^2$

For SDC_2O 21 days strength

$$SD^2 = \frac{(20.77 - 20.77)^2 + (20.20 - 20.77)^2 + (21.35 - 2.77)^2}{3}$$

$= 0.105 n/MM$

For C_20 at 14 days 1 strength

$$SD^2 = \frac{(18.79 - 18.98)^2 + (18.98)^2 + (19.07 - 18.98)^2 = (19.09 - 18.93)^2}{3}$$

$0.2204 N/mm^2$

For C_2O with SDC_20 21 days strength

$$SD^2 = \frac{(19.47 - 20.41)^2 + (21.36 - 20.41)^2 + (20.42 - 20.41)^2}{3}$$

$= 3.008 N/mm^2$

For C_20 at 28 days strength

$$SD^2 = \frac{(20.37 - 20.29)^2 + (20.49 - 20.29)^2 + (20.02 - 20.29)^2}{3}$$
$$= 02.436 N/mm^2$$

For sdc25 at 7 days strength

$$SD^2 = \frac{(20.29 - 19.84)^2 + (19.59 - 19.84)^2 + (19.64 - 19.84)^2}{3}$$
$$= 0101 N/mm^2$$

For C25 with SOC25 at 27 days strength

$$SD^2 = \frac{(17.88 - 19.56)^2 + (20.42 - 1965)^2 + (20.66 - 19.65)^2}{3}$$
$$1.58.19 N/mm^2$$

For C25 at 14 days strength

$$SD^2 = \frac{(19.31 - 18.69)^2 + (18.12 - 18.69)^2 + (18.64 - 18.69)^2}{3}$$
$$= 1.069 N/mm^2$$

For SDC25 at 14 days strength

$$SD^2 = \frac{(21.25 - 20.49)^2 + (21.01 - 20.49)^2 + (19.22 - 20.49)^2}{3}$$
$$0.8203 N/mm^2$$

For C25 with SDC25 at 14 days strength

$$SD^2 = \frac{(18.95 - 19.37)^2 + (21.09 - 19.37)^2 + (28.09 - 19.37)^2}{3}$$
$$= 1.8548 N/mm^2$$

For C25 at 21 days strength

$$SD^2 = \frac{(18.60 - 18.65)^2 + (19.23 - 18.63)^2 + (18.14 - 18.65)^2}{3}$$
$$= 1.0400 N/mm^2$$

For SDC25 at 21 days strength

$$SD^2 = \frac{(19.86 - 19.08)^2 + (18.73 - 19.08)^2 + (20.81 - 19.08)^2}{3}$$
$$= 0.2412 N/mm^2$$

For C25 with SOC25 at 21 days strength

$$SD^2 = \frac{(20.28 - 19.92)^2 + (18.39 - 19.92)^2}{3}$$
$$1.2876 N/mm^2$$

For x25 at 28 days strength

$$SD^2 = \frac{(20.54 - 20.38)^2 + (20.38 - 20.30)^2 + (20.30 - 20.38)^2}{3}$$
$$= 0.0384 N/mm^2$$

For SDC25 at 28 days strength

$$SD^2 = \frac{(20.37 - 20.39)^2 + (20.28 - 20.39)^2 + (20.54 - 20.39)^2}{3}$$
$$1.3448 N/mm^2$$

For C25 with SDC25 at 14 days strength

$$SD^2 = \frac{(18.95 - 19.37)^2 + (21.09 - 19.37)^2 + (28.09 - 19.37)^2}{3}$$
$$= 1.8548 N/mm^2$$

For C25 with SDC25 at 28 days strength

$$SD^2 = \frac{(20.38 - 20.55)^2 + (20.71 - 20.55)^2 + (20.57 - 20.55)^2}{3}$$

3.6. TARGET MEAN STRENGTH

Variation of concrete in production, is the amount by which the produced concrete strength is greater than the characteristic strength. Margin for design takes care of the variation of concrete, in production, it is the amount by which the produced concrete strength is greater than the characteristic strength. From the results shown in Table 16 and figure 8, comparative analysis of the concrete produced replacing stone dust with sharp sand in each case was examined. The formula used are:

FM =   fe + Ks where
Fm =   the target mean strength
Fe =   specified characteristic strength
Ks =   the margin, which is the product of
S   =   standard deviation and
K   =   a constant

The K is device from the mathematics of the normal distribution and increase as the proportion of detective is decrease thus:
K for = For 10 percentage defective = 1.28
K for 5 percentage defective = 1.64
K for M percentage defective = 2.33.
A value of 5% defective is however, permitted in cp 110, 1985 for instance; the target mean strength of gate 20 concrete is Fm = fe + ks
= 20+ (1.64 x 8) = 33N/mm².

Table 16: Target mean strength

Age day	Strength (N/mm²)	Target mean strength
7	C20:19.12	57%
14	C20:18.98	62%
21	C20;20.14	64%
28	C20:20.29	68
7	SDC20: 19.32	72%
14	SDC20;18.98	66%
21	SDC20:2,14	74%
28	SDC20: 20.60	77%
	Target mean strength	
7	C20/SDC20: 19.79	58%
14	C20/SDC20: 19.17	60%
21	C20/SDC20: 20.41	68%
7	C25:19.43	54%
14	C25: 18.69	60%
21	C25: 18.65	64%
28	C25: 20.38	70%

Target mean, strength

7	C25/SDC25: 19:65	56%
14	C25/SDC 25: 19.37	62%
21	C25/SDC 25 :19.92	68%
28	C25/SDC 25: 20.55	72%
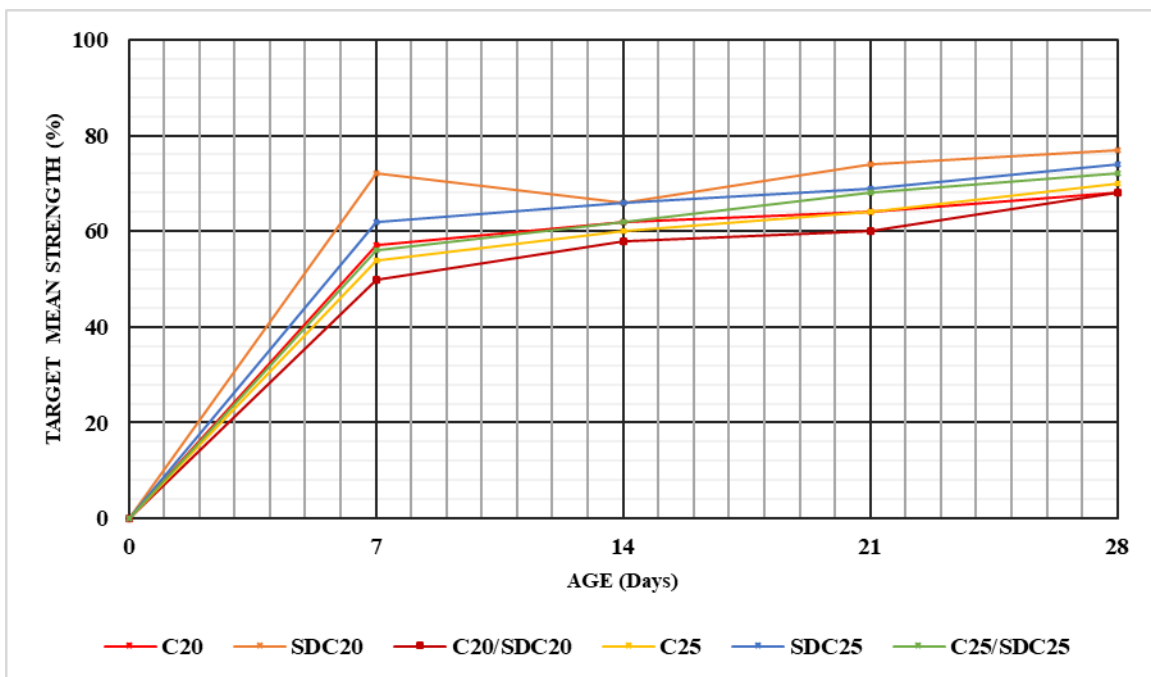
Figure 8: Target mean strength gradient

4. CONCLUSION AND RECOMMENDATION

From the research work carried out on the effect of replacing sharp sand with stone dust in concrete work, many inferences have been deduced from the results of the investigation, some of the conclusion based on this investigation are summarized thus:

1) If the proper design procedures are followed, stones dust as fine aggregate does not have any detrimental effect on the overall properties of concrete, rather it helps to improve on the properties, if sharp sand could be added with stone dust it will help the concrete to be detrimental.

2) Sharp sand with stone dust concrete develop 6 -12% more compressive strength than sharp sand (fine aggregate) while stone dust concrete develops 6 - 14% more compressive strength also than river sand, it attains higher strength at early age than sharp sand concrete.

3) The cost implication replacing stone dust with sharp sand in concrete is within the acceptable margin of price differentials. Economical to consider replacing sharp sand with stone dust for use when a cheaper means of transportation is devised or the construction site is closer to the site were the material can be obtained.

4) Concrete with replacement requires more water than river sand concrete that's why it's develops higher strength. In this case, when replacing sharp sand with stone dust, in concrete, you must know that enough water is supplied to the concrete.

4.1. RECOMMENDATION

In view of the foregoing engineering advantages of replacing sharp sand with stone dust in concrete, the following recommendations are presented to stakeholders:

1) In construction industry professionals should come up with more information regarding the replacing of sharp sand with stone dust in concrete by investing in research into replacing and how it can be used to obtain concrete with must higher strength than that form river sand or that of stone dust

2) Government should make the transportation section more efficient so as to reduce the cost of transporting good and materials for construction and other constitutions of concrete from one place to another.

3) Awareness campaigns should be organized by professional in Civil Engineering way of seminar and workshop to enlighten the general public on the cost and strength consideration for replacing sharp sand with stone dust in concrete work, by so doing more and more people will come to embrace the replacing of sharp sand with stone dust instead of using only sharp sand in the construction site they will use both the sharp sand with stone dust. By so doing stone dust will give more strength together with the strength of river sand and the strength will be higher than that of sharp sand only. For that, many people will like to use both the sharp and with stone dust for the construction of their own structures.

CONFLICT OF INTEREST

The author have declared that no competing interests exist.

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