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Stone dust as fine aggregate in concrete: Effects on compressive strength, tensile strength and workability

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Abstract

The use of concrete is increasing day by day; therefore, the demand of natural river sand is also increasing as it is used as fine aggregate in concrete. As a result, excessive sand mining is taking place now a days which results in degradation of rivers, bank erosion, saline-water intrusion from the nearby sea and enlargement of river mouths and moreover this limited resource will not be left for the future generation. So, it is high time that a substitution of river sand should be found. Stone dust can be a good alternative to river sand as it has the capability to increase the compressive and tensile strength of concrete. Stone dust is generally a waste material, so if it can be a good alternative of sand then it will not only preserve the river sand for future but also stone dust disposal problem will be solved. In this research a series of experimental programs has been carried out by replacing the river sand with stone dust in various percentages starting from 10% to 100%. From the experiments and tests, it is observed that with the gradual increase in the percentage of stone dust and decrease of river sand the compressive and tensile strength of concrete increases. Up to 60% stone dust and 40% river sand both strengths gradually increase. But after the mixing percentages of 60% stone dust and 40% river sand the compressive and tensile strengths start to get reduced from the maximum value as the workability of concrete decreases because the water to cement ratio is kept same all through the experiment. In this study the variation of compressive strength, tensile strength and workability is observed for two mix ratios and they are 1:2:4 and 1:1.5:3. The compressive strength test was conducted following ASTM C39 (2014a) and tensile strength tests were conducted following ASTM C496/C 496M (2002) and Slump test were done in accordance with Practice ASTM C 172. So, at an optimum percentage of 60% stone dust and 40% river sand, the concrete can prove to be very suitable for construction.

Keywords: Concrete, stone dust, river sand, compressive strength, tensile strength, workability.

1. Introduction

Concrete is the most used material after water. Concrete is made of cementing material, coarse aggregate, fine aggregate and water. The coarse and fine aggregates make about 70% of concrete. Till present natural river sand was the only material that was used as fine aggregate, but as it is a natural resource, it is limited. Moreover, due to limitless sand mining the environmental balance is also in danger. Therefore, many of the governments have banned sand mining and engineers are looking for the best suitable material to replace sand. Stone dust is a waste material that is produced in stone crushing plants. Normally it is disposed-off as a waste material but for its very fine particle size and light weight it has become very difficult to dispose it properly. Stone dusts fly in the air and pollute it and it is also harmful for the workers as it can cause respiratory problems if inhaled with air. But the positive side is that it can play a useful role as fine aggregate in concrete. The particle side of stone dust is smaller than sand and it also has adhesive properties, so it not only fills up the voids in coarse aggregates but also increases the adhesion among the ingredients of concrete. Because of the increased adhesion the total compressive strength and tensile strength of concrete increase, but at the same time if stone dust is used more than the optimum amount then it can again reduce the strengths (the maximum achieved strength that was obtained using stone dust) and also reduce the workability.

To find out this optimum percentage of stone dust and river sand at a suitable water cement ratio cylindrical concrete specimen were made considering two mix ratios. These are:

- Cement: Fine Aggregate: Coarse Aggregate = 1:2:4
- Cement: Fine Aggregate: Coarse Aggregate = 1:1.5:3

For each mix ratio concrete specimens were made with stone dust as a partial replacement of sand. The percentage ranged from 10% to 100% replacement. For each percentage 3 specimens were made and the average value of the results is taken. In this way detailed tests were carried out to find out the suitability of stone dust as fine aggregate in concrete and the concrete is then tested for its compressive and tensile strength as well as workability.

2. Background of the study

Mohammad et al. (2007) worked with four different concrete mixes prepared with quarry dust as partial replacement of sand and investigated several fresh and hardened concrete properties. It was observed that quarry dust increased the flow of concrete but unit weight and air content properties were unaffected. In hardened concrete dynamic modulus of elasticity and surface absorption were marginally increased but compressive strength decreased. In order to increase compressive strength or maintain the normal concrete compressive strength silica fumes can be used.

The study of Ilangovana et al. (2008) gives attention to physical and chemical properties of quarry dust with respect to requirements of codal provision which are satisfied. The 100% replacement of sand with quarry dust gives better results in terms of compressive strength studies.

Mahzuz et al. (2011) prepared concrete and mortar specimens with stone dust as fine aggregate and compared with normal concrete and mortar made of sand as fine aggregate. Comparisons were made on the basis of compressive strength only. The compressive strength of concrete from stone powder showed 14.76% higher value than that of the concrete made of normal sand. On the other hand, concrete from brick chip and stone powder produce higher compressive value from that of brick chips and normal sand concrete.

Balamurugan and Perumal (2013) replaced the natural river sand in various percentages. The percentages started from 10% replacement then gradually increasing the percentages by 10% each time up to 100% replacement was made on M20 and M25 grade concrete and a constant slump of 60mm was maintained. Compressive strength tests were carried out on specimens at 7^{th} and 28^{th} days. According to him 50% replacement of sand with stone dust at room temperature results in higher compressive strength.

Kujur et al. (2014) carried out compressive and tensile strength tests with stone dust as partial replacement of sand in various percentages. His tests were conducted in India, so the natural river sand and stone dusts were of that area's characteristics. He replaced 30%, 40%, 50%, 60% and 70% of the sand with stone dust and conducted compressive and tensile strength tests on M25 grade concretes. The water cement ratio was 0.46 in his tests. He observed that at 30% replace the strengths decreased but at 40% replacement the strengths increased but after 40% the strengths decreased with increasing percentage of stone dust. At 0% replacement, compressive strength is 26.2 N/mm^2 and 33.7 N/mm^2 at 7^{th} and 28^{th} days respectively and at 40% replacement, the compressive strength of stone dust concrete is 22.1 N/mm^2 and 35.3 N/mm^2 at 7^{th} and 28^{th} days respectively. His results showed that with 40% replacement, compressive strength increased by 4.74% at the age of 28 days compared to referral concrete whereas with 30%, 50%, 60% and 70%, there is reduction in compressive strength by 6.8%, 7.1%, 8.6% and 10.1% at the age of 28 days compared to referral concrete.

Suribabu et al. (2015) found that for the designed mix proportions of M25 and M40 grades of concrete the desired characteristic strengths for cubes are achieved in both conventional concrete and Quarry Stone dust concrete. The strength achieved in concrete made with sand as fine aggregate achieved high strengths when compared with Quarry stone dust concrete. However, in both the cases strengths were falling at a super plasticizer dosage of 1.3% by weight of cement. Similar behaviour was also observed in cubes of M40 grade cubes.

Singh et al. (2015) used stone dust as fine aggregate in M25 grade concrete within replacement percentage range 10%-100% of sand. The concrete specimens were tested for workability and compressive strength. According to their tests the optimum replacement level was 60%. At this percentage the compressive strength of the concrete increased and the workability was also satisfactory. Kumar and Singh (2015) tested the compressive strength, tensile strength and flexural strength of M25 and M30 grade concrete made with stone dust as partial replacement of sand. The increase in compressive strength of concrete with 20% replacement and 50% replacement of fine aggregate with stone dust is found to be 8 to 10%.

Gautam et al. (2017) replaced sand with quarry dust in percentages of 25%, 35%, 45% and 55% and conducted compressive strength, tensile strength and workability tests on M20 grade concrete at 7^{th}, 14^{th} and 28^{th} day. Nylon 66 fibers were also used to increase tensile strength. It was found that 45% replacement gives the best result.

Basavaraj et al. (2017) carried out compressive strength tests on concrete specimens made with partial and full replacement of sand with stone dust. Replacements were made starting from 10% up to 100% with 10% increment in percentage in every step. M20 and M25 grade concrete specimens were tested in various water to cement ratio. Specimens were tested at 7^{th} and 28^{th} days and also effect of temperature (100 degrees Celsius) were also observed. The results showed that at 50% sand and 50% stone dust combination the compressive strength increases 50% compared to normal concrete.

Suraj et al. (2017) suggests that 45% replacement of sand with stone dust is optimum and superplasticizers should be used in order to maintain proper workability. In this way cost of concrete can be minimized and also a huge amount of river sand mining can be avoided. Kumar (2018) experimented with concrete made with stone dust as partial replacement of sand. Sand was replaced with stone dust at a percentage starting from 10% up to 80%.

The concrete specimens were tested for their workability, density and compressive strength. Workability decreases with increased percentage of stone dust. To avoid this problem superpalsticizers can be used. The density of fresh concrete gradually decreases up to 40% stone dust then increases up to 70%. After that density again decreases. The compressive strength of the concrete made with stone dust increased by a percentage of 16.8

Dubewar and Shinde (2018) partially replaced cement with fly ash and sand with stone dust to observe the compressive strength, tensile strength and flexural strength of the modified concrete. It was found that optimum replacement percentage of fly ash is 10% and stone dust is 30%. Beyond these percentages the compressive strength gets reduced.

3. Materials used

3.1 Cement

All types of cement are suitable for this experiment. In this study, Ordinary Portland Cement of Type I (ASTM C 150) manufactured by ‘Crown Cement’ is used. Chemical composition is given in Table 1. Other properties of cement are mentioned in Table 2.

Table 1
Number of chemical constituents in portland cement

Constituents	Percent by weight
Calcium Oxide (CaO)	63.73
Silicon Di Oxide (SiO_2)	22.13
Aluminum Oxide (Al_2O_3)	5.32
Magnesium Oxide (MgO)	1.89
Sulphur Trioxide (SO_3)	2.42
Ferric Oxide (Fe_2O_3)	3.34
Free Lime	1.092
Insoluble Residue (IR)	0.5
Loss of Ignition (LOI)	1.5

Table 2
Other properties of cement

Properties	Result Value
Standard consistency %	25 %
Initial setting time	40 minutes
Final setting time	480 minutes
Soundness (lechatelier expansion)	0.5 mm
Fineness (% retained on 90 µ is seive)	3.5 %
3rd day Compressive strength	14 MPa
7th day Compressive strength	32 MPa
28th day Compressive strength	43 MPa
Specific gravity	2.71

3.2 Fine aggregates

Both of the fine aggregates i.e., stone dust and natural river sand properties are mentioned below.

Natural River Sand: Fine aggregate (FA) used in this investigation was the natural river sand passing completely through 4.75 mm aperture size sieve. Its fineness modulus and specific gravity were 2.75 and 2.3 respectively. Particle size distribution as gradation 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.

Stone Dust: Stone dust which collected was Grey in color, dry in condition, used as thoroughly retained on 150 µm 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 specification with upper and lower permissible limits (UPL & LPL) is shown in Figure 2.

3.3 Coarse aggregates

A Combined grading of the two individual 20 mm and 10 mm Nominal size coarse aggregate (stone chips) (20mm CA & 10mm CA) grading was used with the ratio of these coarse aggregates as 60:40 respectively. They were used in saturated surface dry condition. Properties of the Achieved Combined coarse Aggregate (CCA) of 20 mm Nominal size are shown in Table 3. Grading curve of the combined coarse aggregate is shown in Figure 3.

Table 3
Properties of coarse aggregate

Properties		Result Values
Fineness Modulus	10 mm Aggregate (10mm CA)	5.956
	20 mm Aggregate (20mm CA)	7.012
	Combined Coarse Aggregate (CCA)	6.548
Water absorption (%)		80%

Table 4
Gradation values of the coarse aggregates used

Sieve Size	Cumulative Percentage Passing				
	Upper Permissible Limit (UPL)	Lower Permissible Limit (LPL)	10mm	20mm	Combined Coarse Aggregate (CCA)
0.15	-	-	-	-	-
0.30	-	-	-	-	-
0.60	-	-	-	-	-
1.18	-	-	-	-	-
2.36	-	-	-	-	-
4.75	12	-	19	-	10
10	58	30	95	-	42
20	100	96	100	100	98
25	100	100	100	100	100

4. Experimental methods

In this experiments test were carried out with 2 types of concrete mix ratios. They are:

- Cement: Fine Aggregate: Coarse Aggregate = 1:2:4
- Cement: Fine Aggregate: Coarse Aggregate = 1:1.5:3

For each mix ratio a total of 11 specimens were made. At first 10% sand was replaced with stone dust, then gradually the percentage of stone dust was increased at a percentage of ten percent then at last the specimen was made with 100% stone dust and 0% sand. And also, a normal concrete of 100% sand as fine aggregate was also produced to compare the results. Each type of mix was prepared in 3 molds and then average of the results were taken. Tests were carried out for every type of specimen at 3rd, 7th and 28th days. Mixing was done manually.

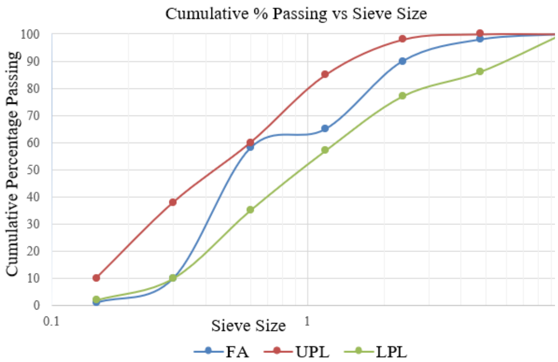

Fig. 1. Grading curve of the fine aggregate (Natural River Sand).

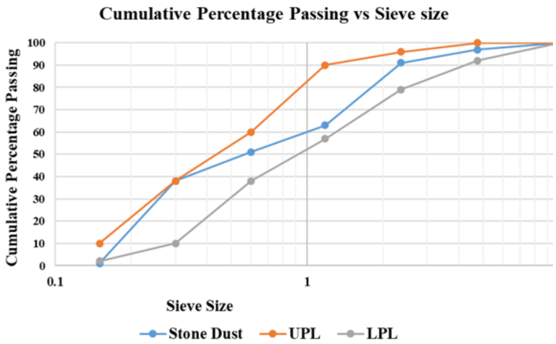

Fig. 2. Grading curve of the stone dust.

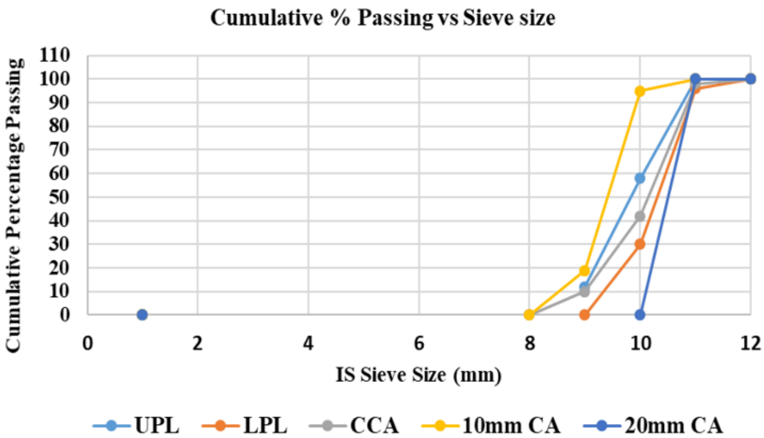

Fig. 3. Grading curve of the combined coarse aggregate.

The molds used were of 4 inches in diameter and 8 inches in height. Curing was done properly in curing ponds. After the molds were prepared and properly cured, compressive strength test and tensile strength tests were conducted. For compressive strength test ASTM C39 (2014a) was followed and for tensile strength test ASTM C496/C 496M (2002) was followed. For Slump test (for workability) Practice C 172 was followed. Compressive and tensile strength tests were conducted using Universal Testing Machine (UTM). For Slump test after producing the concrete mix they were poured in the concrete cone. The cone was placed on a flat leveled place and the cone/mold was filled in three layers, each layer having the volume of approximately 1/3 of total volume of the cone. One third of the volume of the slump mold fills it to a depth of 25/8 in. [70 mm]; two thirds of the volume fill it to a depth of 61/8 in [160 mm]. Each layer was stroked with 25 strokes of tamping rod. The bottom layer was compacted by stroking the tamping rod in inclined position as the slump cone is inclined in shape and then progressed with vertical strokes spirally toward the center. In this way the cone was filled and after filling the surface was made leveled means of a screeding and rolling motion of the tamping rod. After properly filling the mold was raised immediately a distance of 12 in. (300 m) in 5±2 s by a steady upward lift with no lateral or torsional motion. The tests were completed within a time of 2 minutes (standard is to complete within 2.5 minutes). The after lifting the cone the vertical difference between the top of the mold and the displaced original center of the top surface of the specimen was measured.

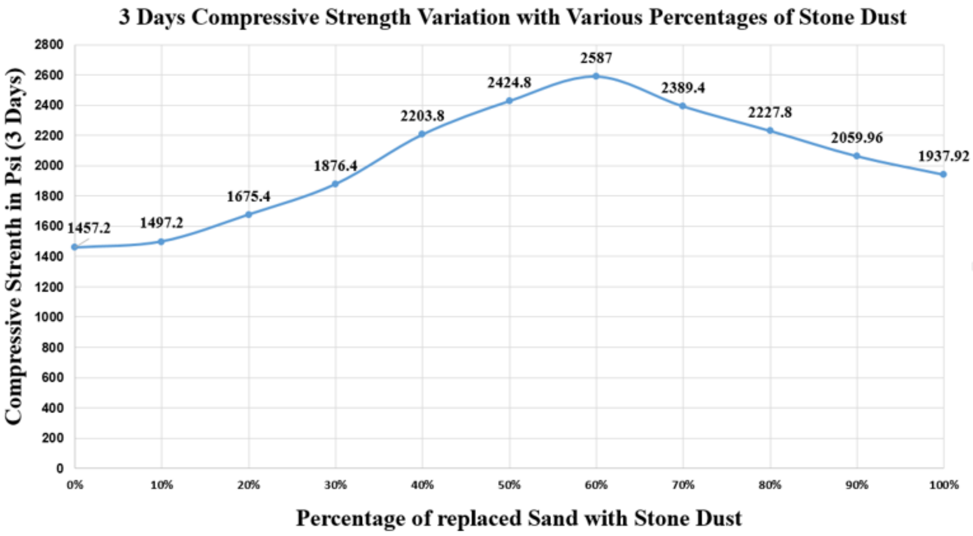

Fig. 4. 3 Days Compressive Strength Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

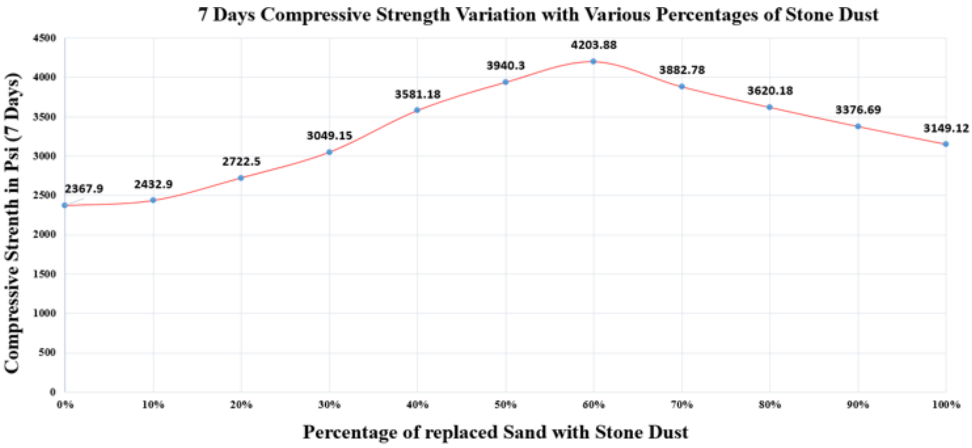

Fig. 5. 7 Days Compressive Strength Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

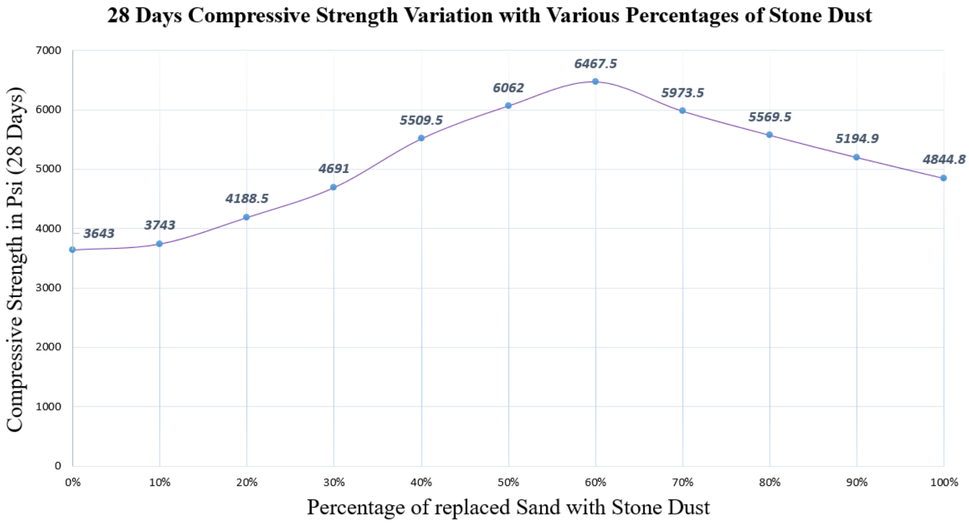

Fig. 6. 28 Days Compressive Strength Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

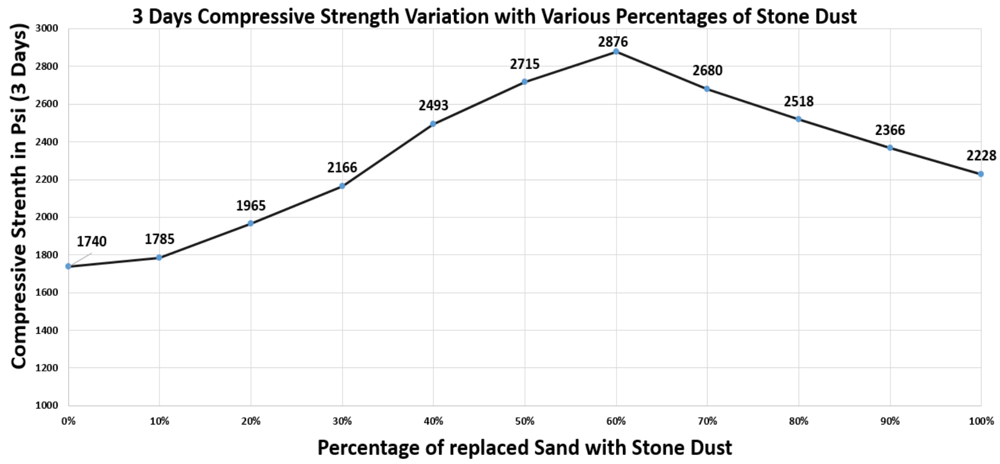

Fig. 7. 3 Days Compressive Strength Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

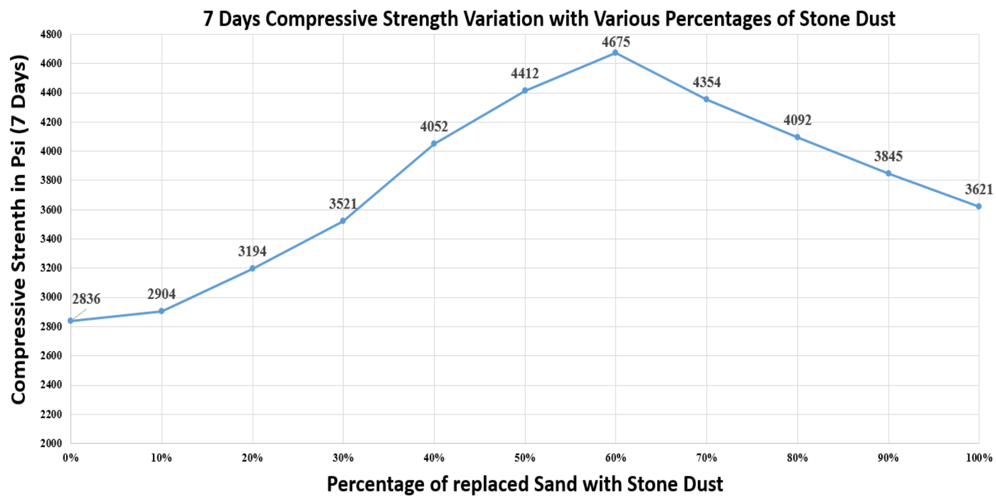

Fig. 8. 7 Days Compressive Strength Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

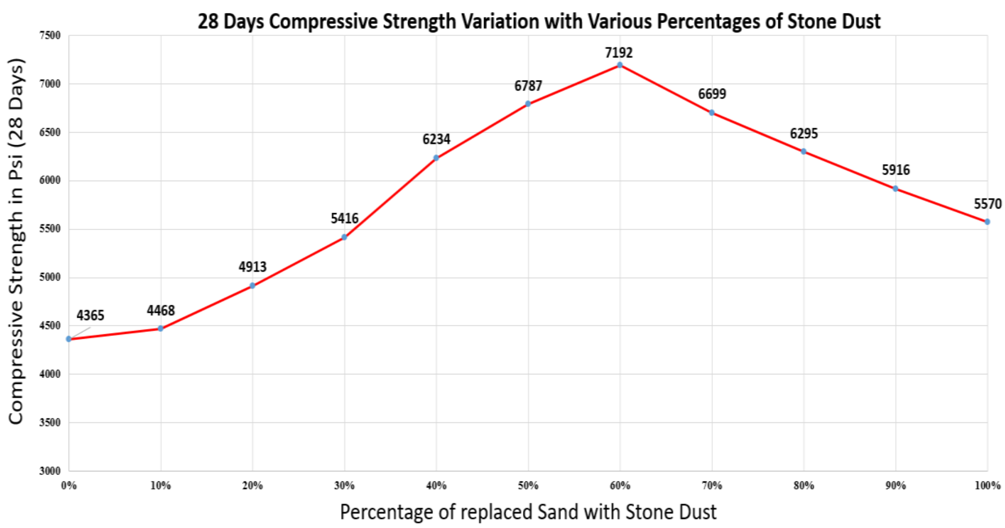

Fig. 9. 28 Days Compressive Strength Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

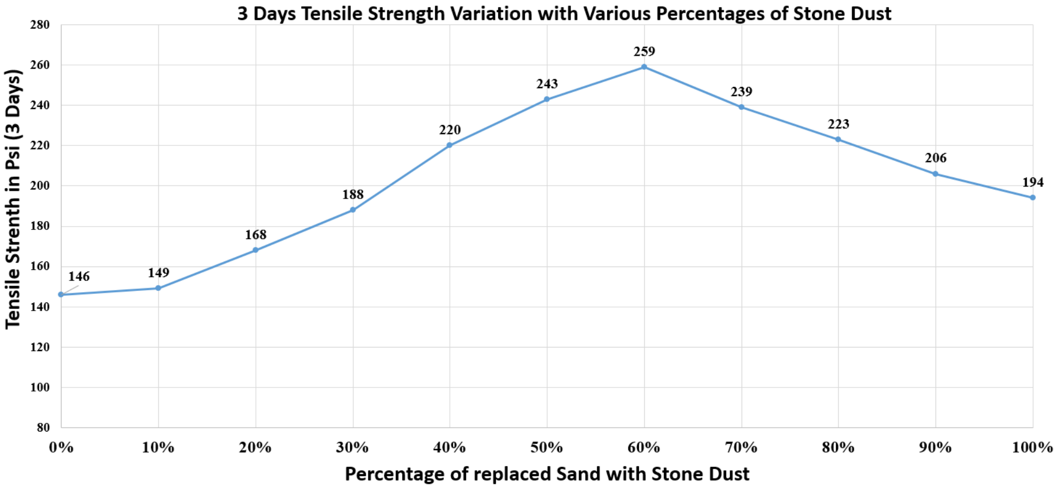

Fig. 10. 3 Days Tensile Strength Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

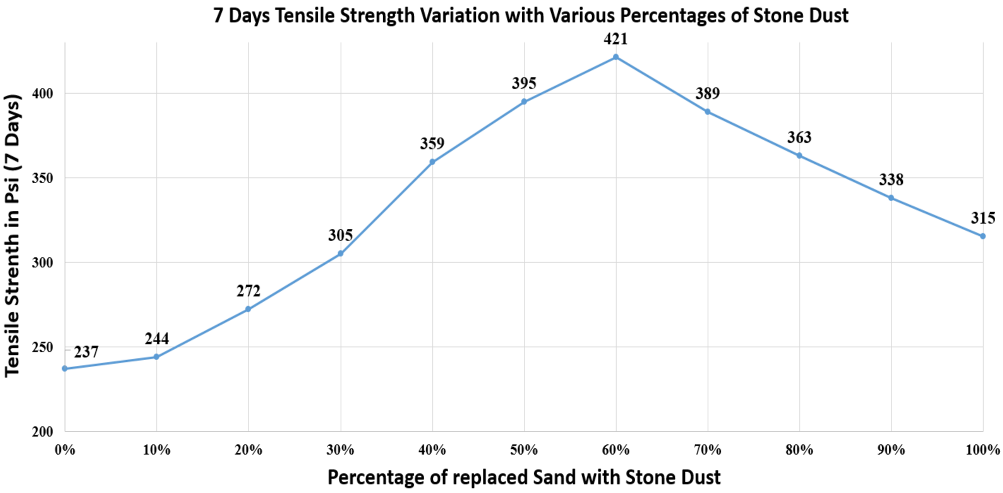

Fig. 11. 7 Days Tensile Strength Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

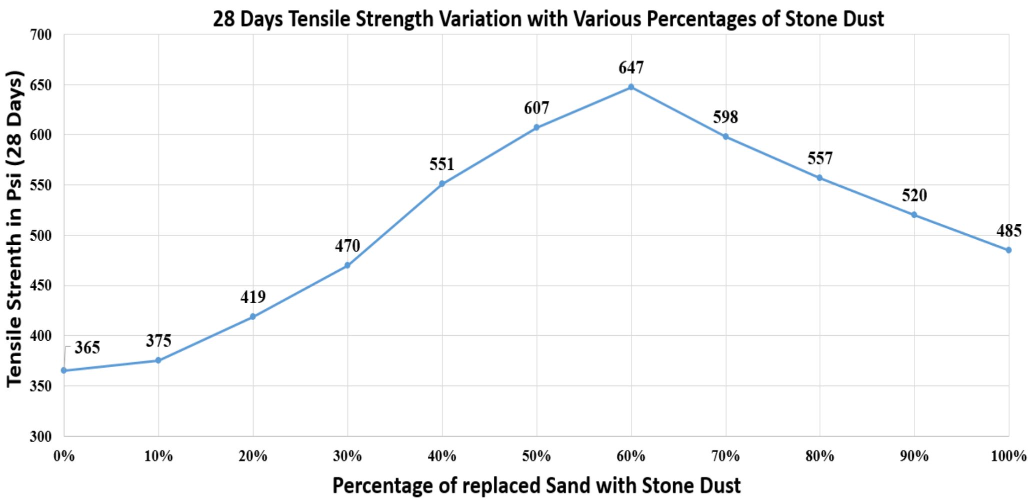

Fig. 12. 28 Days Tensile Strength Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

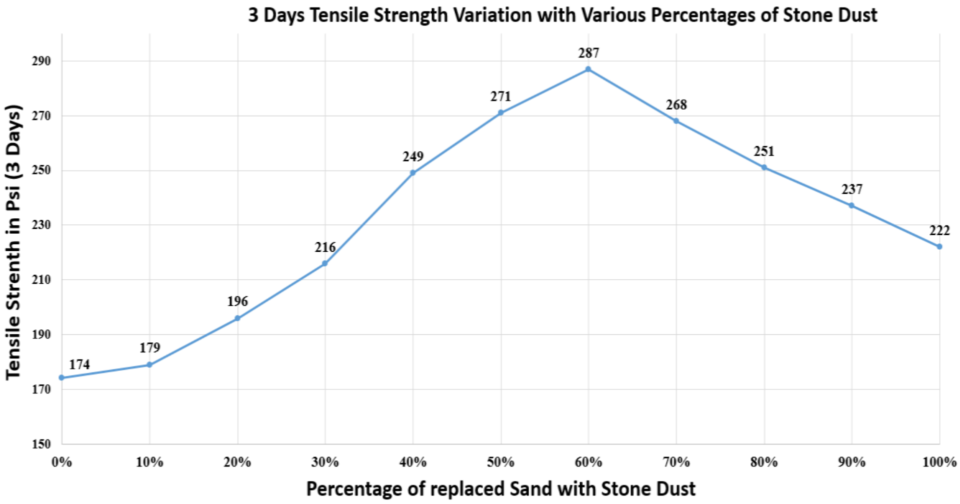

Fig. 13. 3 Days Tensile Strength Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

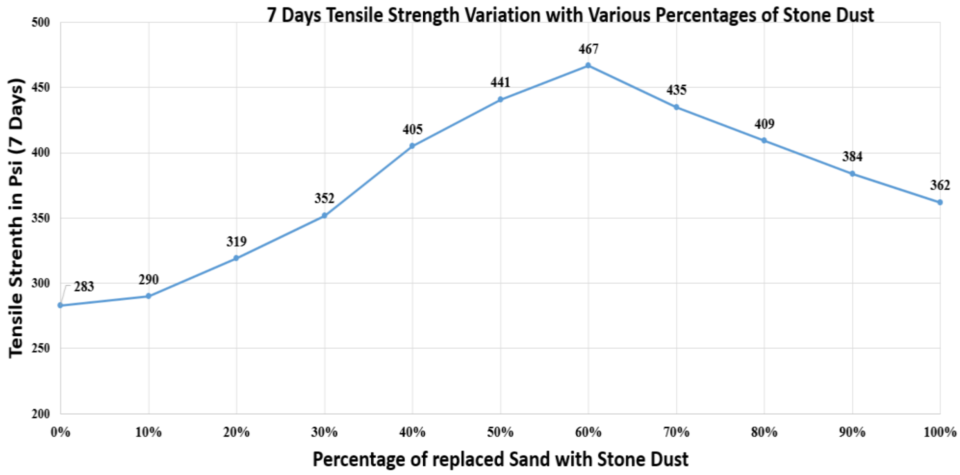

Fig. 14. 7 Days Tensile Strength Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

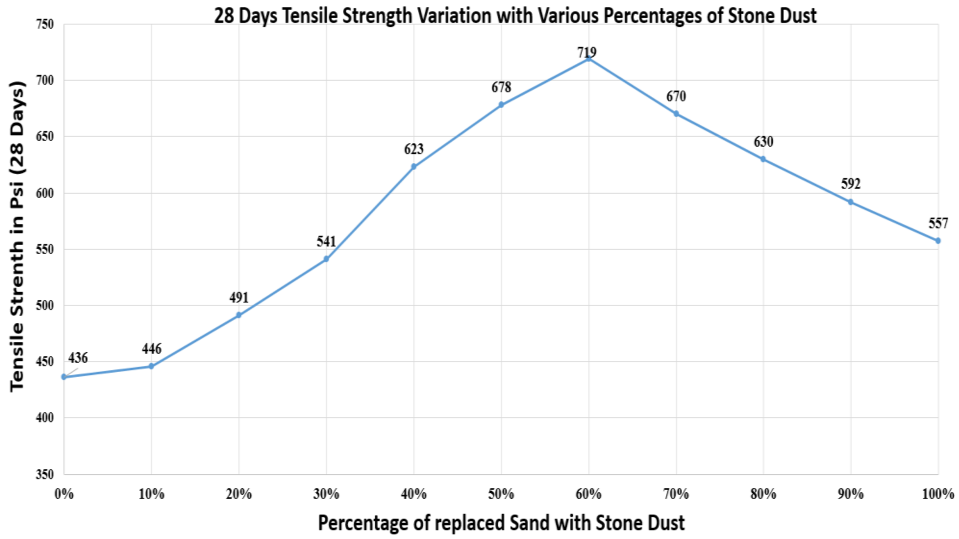

Fig. 15. 28 Days Tensile Strength Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

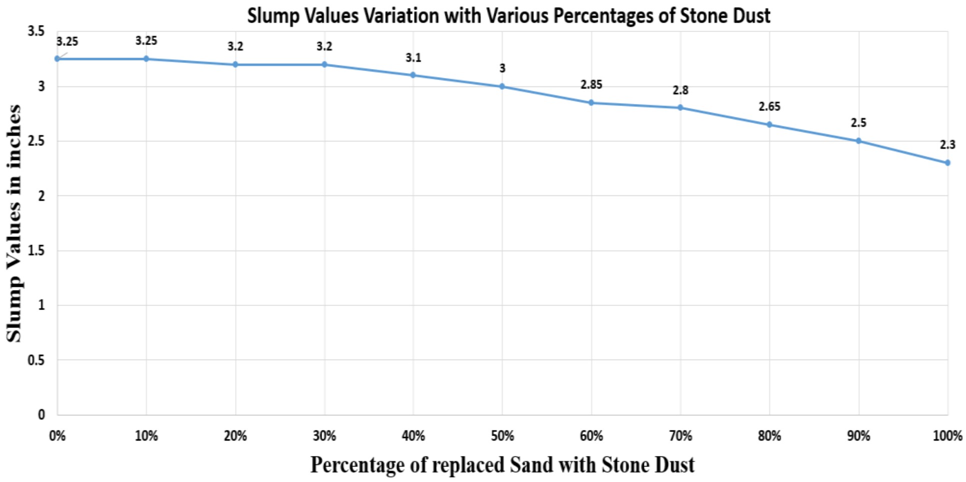

Fig. 16. Slump Values Variation with Various Percentages of Stone Dust for mix ratio 1:2:4

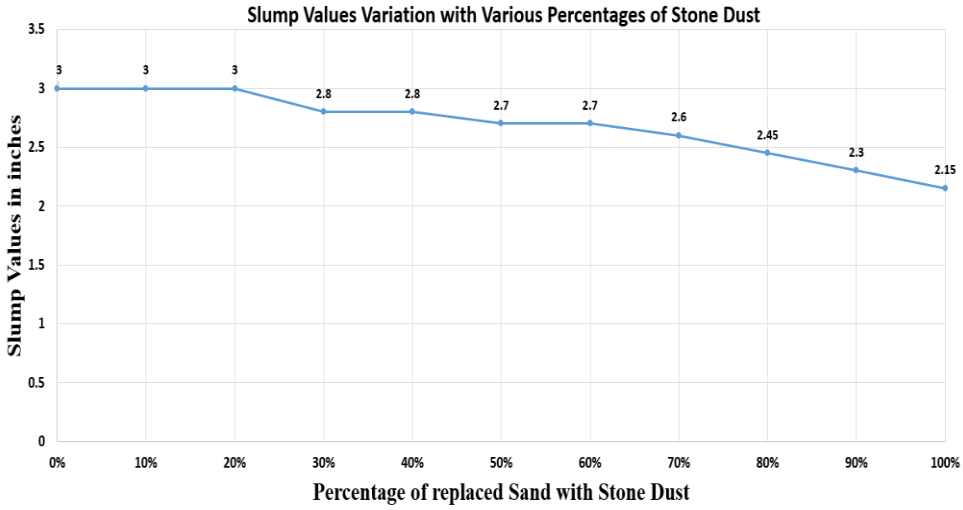

Fig. 17. Slump Values Variation with Various Percentages of Stone Dust for mix ratio 1:1.5:3

5. Test results and discussion

The compressive strength of concrete was obtained by compression test on cylinder samples following ASTM C39.

5.1 Compressive strength for mix ratio 1:2:4

Compressive strength variation with various percentages of stone dust for 3, 7 and 28 days are shown in Table 5. For the mix ratio of 1:2:4 the variation in compressive strength with various percentages of stone dust and sand combination for 3rd, 7th and 28th day are shown in Figures 4, 5 and 6 respectively.

5.2 Compressive strength for mix ratio 1:1.5:3

Compressive strength variation with various percentages of stone dust for 3, 7 and 28 days are shown in Table 6.

For the mix ratio of 1:1.5:3 the variation in compressive strength with various percentages of stone dust and sand combination for 3rd, 7th and 28th day are shown in Figures 7, 8 and 9 respectively.

Table 5
Variation of compressive strength for different percentages of stone dust at 3, 7 and 28 days for mix ratio 1:2:4

Specimen No.	Percentage of Replaced Sand with Stone Dust	3 days Strength (psi)	7 days Strength (psi)	28 days Strength (psi)
1	0% (Normal Concrete)	1457.2	2367.9	3643
2	10%	1497.2	2432.9	3743
3	20%	1675.4	2722.50	4188.50
4	30%	1876.4	3049.15	4691
5	40%	2203.8	3581.18	5509.50
6	50%	2424.8	3940.3	6062
7	60%	2587	4203.88	6467.50
8	70%	2389.4	3882.78	5973.50
9	80%	2227.8	3620.18	5569.50
10	90%	2059.96	3376.69	5194.90
11	100%	1937.92	3149.12	4844.80

Table 6
Variation of compressive strength for different percentages of stone dust \ at 3, 7 and 28 days for mix ratio 1:1.5:3

Specimen No.	Percentage of Replaced Sand with Stone Dust	3 days Strength (psi)	7 days Strength (psi)	28 days Strength (psi)
1	0% (Normal Concrete)	1740	2836	4365
2	10%	1785	2904	4468
3	20%	1965	3194	4913
4	30%	2166	3521	5416
5	40%	2493	4052	6234
6	50%	2715	4412	6787
7	60%	2876	4675	7192
8	70%	2680	4354	6699
9	80%	2518	4092	6295
10	90%	2366	3845	5916
11	100%	2228	3621	5570

5.3 Discussion on the compressive strength results

By observing the compressive strength test results for both the mix ratios it can be said that with the increase in percentage stone dust starting from 10% to 60% the compressive strength also increases. This happens due to the particle shape and size of stone dust. Stone dust particles are “needled shaped” which gives it more binding power and it is smaller than natural river sand which enables it to fill up more space. So due to the “needle shape” and more space filling property the concrete made with stone dust are more compacted in nature which allows it to take on more pressure. As a result, the compressive strength increases with the increase in the percentage of stone dust. Where normal concrete (100% sand) can take 3643 psi of compressive strength at 28 days, concrete made with 60% stone dust can take 6467.50 psi of compressive strength for mix ratio of 1:2:4. That means concrete made with stone dust can take up to 56% more compressive strength than that of normal concrete. So, this a very effective concrete mix. Again, for mix ratio 1:1.5:3 normal concrete shows 4365 psi of compressive strength whereas concrete made with 60% stone dust shows 7192 psi of compressive strength which is 60% more than that of the normal concrete.

The tensile strength of concrete was obtained by split cylinder test as per ASTM C496 (2002). The ultimate tensile load was obtained using Universal testing machine and eventually, tensile strength was found.

5.4 Tensile strength for mix ratio 1:2:4

Tensile strength variation with various percentages of stone dust for 3, 7 and 28 days are shown in Table 7.

Table 7
Variation of tensile strength for different percentages of stone dust at 3, 7 and 28 days for mix ratio 1:2:4

Specimen No.	Percentage of Replaced Sand with Stone Dust	3 days Strength (psi)	7 days Strength (psi)	28 days Strength (psi)
1	0% (Normal Concrete)	146	237	365
2	10%	149	244	375
3	20%	168	272	419
4	30%	188	305	470
5	40%	220	359	551
6	50%	243	395	607
7	60%	259	421	647
8	70%	239	389	598
9	80%	223	363	557
10	90%	206	338	520
11	100%	194	315	485

For the mix ratio of 1:2:4 the variation in tensile strength with various percentages of stone dust and sand combination for 3rd, 7th and 28th day are shown using Figures 10, 11 and 12 respectively.

5.5 Tensile strength for mix ratio 1:1.5:3

Tensile strength variation with various percentages of stone dust for 3, 7 and 28 days are shown in Table 8.

Table 8
Variation of tensile strength for different percentages of stone dust at 3, 7 and 28 days for mix ratio 1:1.5:3

Specimen No.	Percentage of Replaced Sand with Stone Dust	3 days Strength (psi)	7 days Strength (psi)	28 days Strength (psi)
1	0% (Normal Concrete)	174	283	436
2	10%	179	290	446
3	20%	196	319	491
4	30%	216	352	541
5	40%	249	405	623
6	50%	271	441	678
7	60%	287	467	719
8	70%	268	435	670
9	80%	251	409	630
10	90%	237	384	592
11	100%	222	362	557

For the mix ratio of 1:1.5:3 the variation in tensile strength with various percentages of stone dust and sand combination for 3rd, 7th and 28th day are shown in Figures 13, 14 and 15 respectively.

The reason behind the variations observed in Figure 10 to Figure 15 is similar to the reason of the variation of compressive strength. With the increase of stone dust, the tensile strength gradually increases as they have good binding property because of their needled shaped particle size. The increment goes up to 60% of stone dust. But after that the tensile strength seems to decrease, this is because in all specimens the water-cement ratio is kept same but with the increased portion of stone dust amount of water has to be increased for proper mixing and binding. As the specimens lacks the amount of water required that is why the specimens gradually loose their tensile strength. So, this is similar to the compressive strength test results variation.

5.6 Slump test results

Slump test results obtained for each type of specimen for both the mix ratios 1:2:4 and 1:1.5:3 is presented in Table 9 and the variation of slum values with the increase in percentage of stone dust are shown in Figures 16 and 17.

Table 9
Slum values for mix ratios 1:2:4 and 1:1.5:3

Specimen No.	Percentage of Replaced Sand with Stone Dust	Slump values for mix ratio 1:2:4 in inches (mm)	Slump values for mix ratio 1:1.5:3 in inches (mm)
1	0% (Normal Concrete)	3.25 (82.55)	3 (76.20)
2	10%	3.25 (82.55)	3 (76.20)
3	20%	3.20 (81.28)	3 (76.20)
4	30%	3.20 (81.28)	2.80 (71.12)
5	40%	3.10 (78.74)	2.80 (71.12)
6	50%	3.00 (76.20)	2.70 (68.58)
7	60%	2.85 (72.39)	2.70 (68.58)
8	70%	2.80 (71.12)	2.60 (66.04)
9	80%	2.65 (67.31)	2.45 (62.23)
10	90%	2.50 (63.5)	2.30 (58.42)
11	100%	2.30 (58.42)	2.15 (54.61)

Slump Values Variation with Various Percentages of Stone Dust for mix ratio 1:2:4 is shown in Figure 16 and for mix ratio 1:1.5:3 is shown in Figure 17. By observing Figures 16 and 17 it is seen that for both the mix ratios slump value decreases with the increase in the percentage of stone dust. As previously mentioned, stone dust particles have sticky nature which shows adhesion towards the other components of concrete. And because of this adhesion all the components stick with one another and for this reason in the slump test the concrete makes less drop when the slump cone is lifted.

Table 10
Recommended value of slump for various types of construction as per ACI 211. 1-91

Types of construction	Range of slump values in mm
Reinforced foundation walls and footings	20-80
Plain footings and substructure walls	20-80
Beams and reinforced walls	20-100
Building columns	20-100
Pavement and slabs	20-80
Mass concrete	20-80

By observing Table 10 it is seen that if concrete slump value falls between 20mm to 80mm then it can be used in various types of normal construction works. And from test results it is seen that the minimum slum value for mix ratio 1:2:4 is 58.42 mm (100% stone dust) and the maximum is 82.55 mm (0% stone dust, normal concrete) and the slump value of concrete using 60% stone dust is 72.39 mm. When 100% stone dust is used the concrete becomes least workable that means it becomes very much hard to mix. But still at 100% stone dust the slump value for mix ratio 1:2:4 is 54.42, which is in the range. That means for the common construction works we can use 40% to 100% stone dusts as the slump values are in the range of 20mm to 80mm. For mix ratio 1:2:3 the maximum slump value is 76.20mm and the minimum slum value is 54.61mm and for 60% stone dust the value is 68.58 mm. Similarly for 100% stone dust the slump value is 64.61 mm, that is in range. So that means all of the slump values of the specimens are in normal using range. So, in the sense of slump values any kind of specimen can be used.

6. Conclusion

As it is seen that at the mixture of 60% stone dust and 40% river sand maximum compressive and tensile strength can be achieved for any of the two mix ratios. But the workability would be reduced compared to normal concrete workability. Where the workability of normal concrete is 3 or more than 3 inches, the workability of concrete made with 60% stone dust and 40% natural sand is about 2.85 inches. Although the workability decreases but it is still not that low if mechanical mixture is used, but for hand mixing this will be very difficult to mix properly. So, if mechanical mixing equipment is used then 60% stone dust can be taken as optimum percentage but if hand-mixing or manual mixing is considered then the optimum percentage should be 40% or otherwise it would take a lot of extra time and energy for proper mixing. In cases where high workability is required such as in the case of self-compacting concrete, plasticizers or superplasticizers have to be used. At last, in conclusion, it can be said that stone dust is a very good alternative to natural river sand in our country.

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