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Study on Strength Properties of Concrete Using Stone Dust as A Replacement Material for Fine Aggregate

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A B S T R A C T

Fine aggregate is one of the important material in the preparation of concrete. Concrete is most widely used in construction materials Major components of concrete are aggregates which are usually available in natural form. The demand for river sand in the construction industry has consequently increased due to the extensive use of concrete. The large scale depletion of natural sand creates environmental problems such as soil erosion, failure of river banks, lowering of river bed, saline water intrusion into the land. To avoid these kind of problems and to conserve natural resources fine aggregate used in concrete is replaced by stone dust. Use of stone dust in concrete not only improve the quality of concrete but also act as suitable alternative material for natural river sand for future generations. In the present investigation an experimental programme was carried out to study the strength and properties of conventional concrete using stone dust concrete in M45 grade. Based on the experimental investigations conducted, it is concluded that the stone dust is best alternative for the fine aggregate because fine aggregate and stone dust has similar physical and mechanical properties. It is found that 40% replacement of fine aggregate with stone dust gives prominent strength than conventional concrete.

Keywords: Stone Dust, Conplast SP430, Compressive Strength & Split Tensile Strength.

1. 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 factor besides increasing developmental activities. This results in huge demand of construction materials. 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 demand for river sand in the construction industry has consequently increased due to the extensive use of concrete resulting in the reduction of sand sources and increase in price.Going for alternative and supplementary material which can be used as partial or full replacement of conventional material can play a vital role in conservation of natural resources. 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.Thus an investigation is carried out to identify suitable substitute that is eco-friendly, inexpensive and better for strength performance.

2. Materials

a) Fine Aggregate:

Locally available river sand passing completely through 4.75mm aperture size sieve and conforming to zone-II as per IS:383-1970 specification is utilized in this study . The preliminary test was carried out and the test results are tabulated in Table 1.

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Table.1 Properties of Sand

Properties	Values
D_{60},mm	1.80
D_{30},mm	1.30
D_{10},mm	0.66
Cc	1.42
Cu	2.72
Classification	S.P

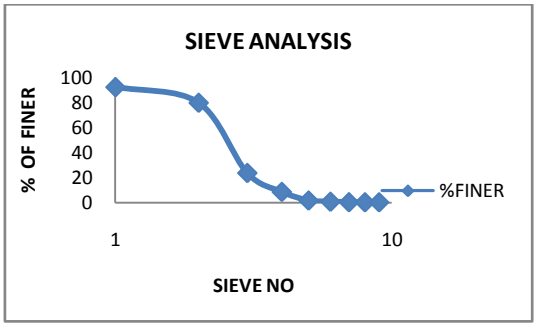

Fig:1 Grain size distribution of soil

b) Coarse Aggregate:

Locally available coarse aggregate having two fraction 20mm and 10mm sizes individually sieved and used in the present study. Only one fraction completely passed through 20mm and aggregate which retained on 10mm sieve is taken for mix proportion. The preliminary test was carried out and the results are tabulated in Table.2

Table.2 Properties of Coarse aggregate

Properties	Values
Specific Gravity	2.7
Impact Value %	27.3
Crushing Value %	17.5
Water absorption %	0.10
Abrasion value %	14.2
Bulk Density	
Loose condition	1219
Dense condition	1425

c) Cement

In this study Ordinary Portland Cement (OPC) 43 grade of single batch was used conforming to IS 8112:1989 specifications. Properties of OPC are listed below in Table.3

Table.3 Properties of Cement

Properties	Values
Finess%	8
Normal consistency%	33
Initial setting time	30 min
Final setting time	187 min
Specific gravity	3.15

d) Stone Dust:

Stone dust obtained from the crushing plant at kasbapuram regional area of kanchipuram District in Tamilnadu.It was grey in colour, dry in condition,used as a thoroughlyretained on 150 micron sieve for entire investigation.The properties of the material are tabulated in Table.4

Table.4 Properties of Stone Dust

Properties	Values
Bulk Density (Kg/cm^3)	18.1
Specific gravity	2.6
Bulking of sand %	4.9
Finess modulus	2.4
Water Absorption %	6.2

e) Conplast SP430

In this study conplast SP430 is used to provide excellent acceleration of strength gain at early ages and major increases in strength at all ages by significantly reducing water demand in a concrete mix and also to makes possible major reductions in water: cement ratio which allow the production of high strength concrete without excessive cement contents. As per IS: 9103-1999 specification. It is in liquid form which is brown in color which has a good combining property with water. The properties of Sp430 are tabulated in Table.6

Table.6 Properties of Conplast (SP430)

Properties	Values
Appearance	Brown in liquid
Specific gravity	1.2
Chloride content	Nil

3. Methodology

a) Fresh concrete workability

To determine consistency of concrete, Slump test was conducted. Workability as slump test for consistency of each batch of concrete mix conforms to IS:1199-1959 specifications was carried out. Slump measured was recorded in terms of millimeter of subsidence of the specimen during test.The results of slump value are tabulated in Table.7

Table.7 Slump Test Values

Mix	Type	Slump value, mm
Mix-1	Conventional Concrete	90
Mix-2	40% of Stone dust with SP	39
Mix-3	40% of stone dust without SP	70
Mix-4	100% of Stone dust with SP	37
Mix-5	100% of Stone dust without SP	48

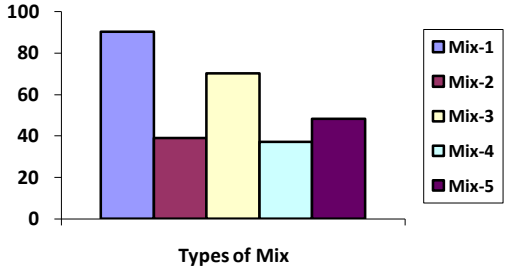

Fig.1 Graphical representation of Slump Value

b) Compressive Test

The cube specimens(150*150mm) were tested for compressive strength at the end of 7 days and 28 days. The specimens were tested after surface of the specimen dried. The load was applied on the smooth sides without shock and increased continuously until the failure of the specimen. The maximum load withstand by the specimens is noted, mean compressive strength is determined and presented in Table.8 & Table.9

Table.8 Compressive strength test results @ 7 days

Mix	Type	Compressive strength,N/mm^2		
		Trail-1	Trail-2	Trail-3
Mix-1	Conventional Concrete	47.2	48.8	46.3
Mix-2	40% of Stone dust with SP	49.9	49.4	49.0
Mix-3	40% of stone dust without SP	46.3	46.9	46.6
Mix-4	100% of Stone dust with SP	44.3	45.0	44.2
Mix-5	100% of Stone dust without SP	43.8	43.7	44.1

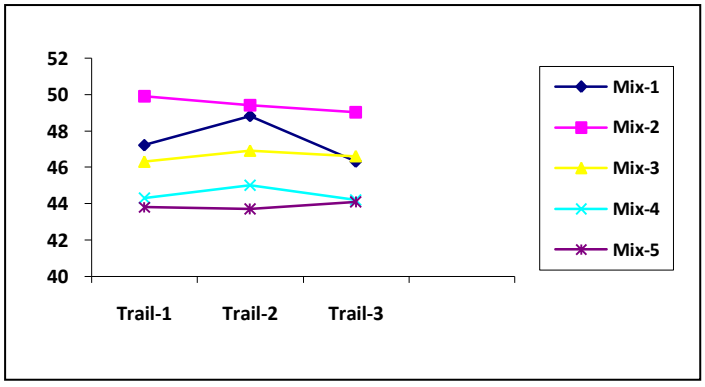

Fig.2 Graphical representation of Compressive Strength @ 7 days

Table.9 Compressive strength test results @ 28 days

Mix	Type	Compressive strength, N/mm^2		
		Trail-1	Trail-2	Trail-3
Mix-1	Conventional Concrete	47.23	48.82	46.33
Mix-2	40% of Stone dust with SP	49.93	49.47	49.09
Mix-3	40% of stone dust without SP	46.34	46.95	46.66
Mix-4	100% of Stone dust with SP	44.34	45.00	44.29
Mix-5	100% of Stone dust without SP	43.84	43.71	44.11

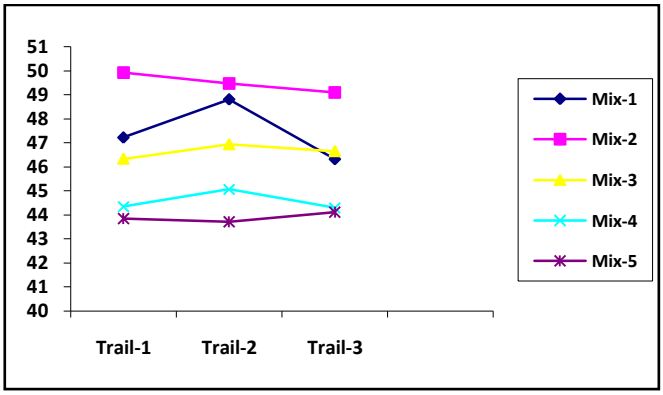

Fig.3 Graphical representation of Compressive Strength @ 28 days

c) Split Tensile Test

A cylinder of specimen 100mm dia and 200mm length were tested for split tensile strength at the end of 7 days and 28 days. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. The results of the split tensile strength are tabulated in Table.10 & Table.11

Table.10 Split Tensile strength test results @ 7 days

Mix	Type	Split Tensile Strength, N/mm^2		
		Trail-1	Trail-2	Trail-3
Mix-1	Conventional Concrete	4.30	4.34	4.13
Mix-2	40% of Stone dust with SP	4.78	4.77	4.73
Mix-3	40% of stone dust without SP	4.54	4.60	4.45
Mix-4	100% of Stone dust with SP	4.11	4.09	4.17
Mix-5	100% of Stone dust without SP	3.92	3.96	4.13

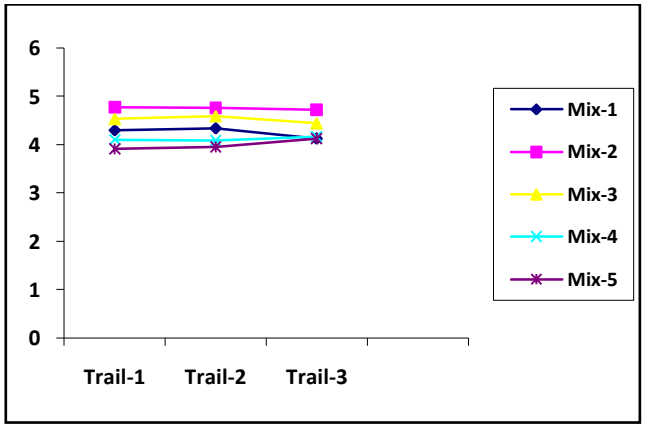

Fig.4 Graphical representation of Split Tensile Strength @ 7days

Table.11 Split Tensile strength test results @ 28 days

Mix	Type	Split Tensile Strength, N/mm^2		
		Trail-1	Trail-2	Trail-3
Mix-1	Conventional Concrete	6.44	6.42	6.45
Mix-2	40% of Stone dust with SP	6.98	7.04	6.95
Mix-3	40% of stone dust without SP	6.31	6.29	6.32
Mix-4	100% of Stone dust with SP	5.81	5.84	5.87
Mix-5	100% of Stone dust without SP	5.68	5.71	5.71

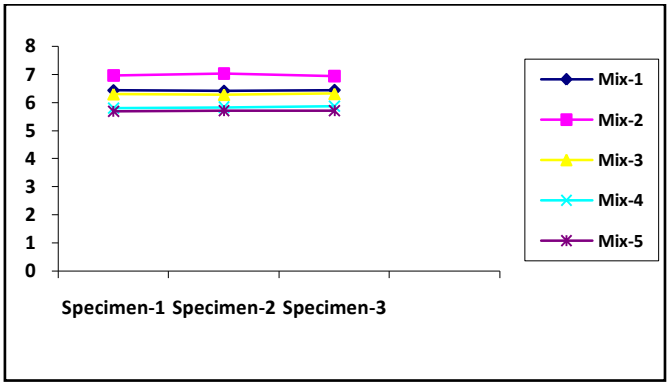

Fig.5 Graphical representation of Split Tensile Strength @ 28 days

4. Results and Discussions

Compressive strength and Split Tensile strength of the concrete cube and Cylinder specimens 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 and Split Tensile strength. In test cube and cylinder specimen was placed in the CTM machine in such manner that the load applied to the opposite sides of the specimens as cast that is not to the top and bottom as per IS;516;1959 specifications.

Table.10 Compressive strength test results @7 & 28 days

Grade	Mix	Type of mix	7 days Avg Compressive Strength, N/mm^2	28 days Avg Compressive Strength, N/mm^2
M_{45}	Mix-1	Conventional Concrete	40.27	47.45
	Mix-2	40% of Stone dust with SP	42.10	49.49
	Mix-3	40% of stone dust without SP	41.74	46.65
	Mix-4	100% of Stone dust with SP	38.24	44.54
	Mix-5	100% of Stone dust without SP	36.35	43.88

A total number of 60 concrete cube and cylinder specimens as a group of 12 cubes (3 cubes & 3 cylinders for 7 days and 3 cubes & 3 cylinders for 28 days test)were cast with 5 different mixes with the addition of superplasticizer.40% & 100 % replacement of natural river sand with stone dust with and without superplasticizer and immersed fully in potable water for curing and tested for 7 days and 28 days compressive and split tensile strength.The average results for compressive and split tensile strength for 7 & 28 days are tabulated in Table.11 & Table.12

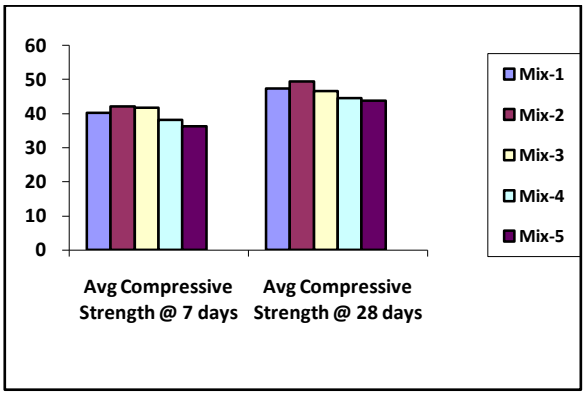

Fig.6 Graphical representation of Compressive Strength @ 7 & 28 days

Table.11 Split Tensile strength test results @7 & 28 days

Grade	Mix	Type of mix	7 days Avg SplitTensile Strength, N/mm^2	28 days Avg Split Tensile Strength , N/mm^2
M_{45}	Mix-1	Conventional Concrete	4.3	6.4
	Mix-2	40% of Stone dust with SP	4.7	6.9
	Mix-3	40% of stone dust without SP	4.5	6.3
	Mix-4	100% of Stone dust with SP	4.1	5.8
	Mix-5	100% of Stone dust without SP	3.9	5.6

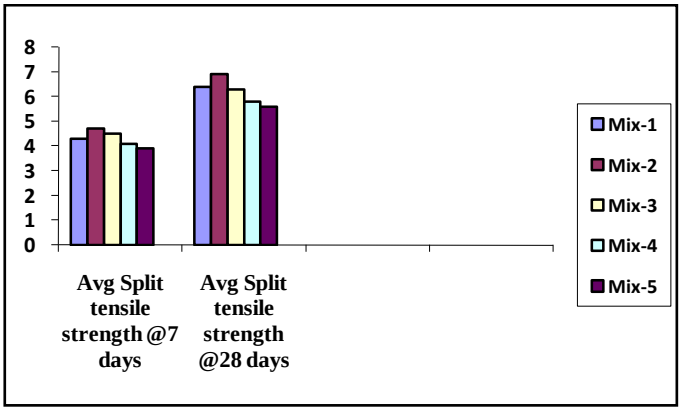

Fig.7 Graphical representation of Split tensile strength @ 7 & 28 days

5. Conclusion

Based on the results and discussions, the following points are concluded,

i. Slump of concrete made using stone dust decreases with increase in replacement level
ii. There is a significant increase in both compressive and split tensile test at 40% replacement of stone dust.
iii. Stone dust can be used as one of the substitute for Fine aggregate in case of non-availability of natural river sand at a reasonable cost.

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