ISSN: 2278-5213

RESEARCH ARTICLE

Stone Dust as Partial Replacement of Fine Aggregate in Concrete

Franklin Eric kujur*, Vikas Srivastava, V.C. Agarwal, Anjelo F. Denis and Ehsan Ali
Dept. of Civil Engineering, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed University), Allahabad-211007, India
franklinkujur@gmail.com*; +91 8303028346

Abstract

The resolution for taking up this investigation owing to the fact that nowadays natural aggregate (coarse and fine) confirming to Indian Standards is becoming scarcer and costlier due to its non-availability in time because of law of land, illegal dredging by sand mafia and accessibility to the river source during rainy season. Keeping this in view, this study was undertaken to evaluate the effect of partial replacement of natural sand with stone dust in concrete. Experimental programme was conducted using 30%, 40%, 50%, 60% and 70% partial replacement of fine aggregate with stone dust has been taken for concrete of M25 grade with 0.46 water cement ratio. In this study, set of cubes and beams were cast for compressive and split tensile strength respectively. Concrete specimens were tested after 7 and 28 d moist curing. It has been observed that 40% replacement of fine aggregate with stone dust is adaptable.

Keywords: Concrete, compressive strength, fine aggregate, split tensile strength, stone dust, moist curing.

Introduction

Concrete has been used as a major construction material ever since its inception. World over, last three to four decades have seen construction of numerous concrete structures with compressive strength of concrete in the range of 20-100 MPa. Indian construction industry also prefers use of concrete with compressive strength in the range of 20-85 MPa. The properties of concrete are influenced by the properties of the aggregate and water/cement ratio. Additives are those substances added to concrete that do not come under the binding agents and aggregates. The proper use of additives compromises certain beneficial effects to concrete, including improved quality, enhanced frost and sulphate resistance, control of strength development and improved workability. The possibility of using solid wastes in concrete has received increasing attention in recent years as a promising solution to the rising solid waste problem. There is a double environmental benefit by using industrial by-products (Prakash *et al.,* 2007).

Construction activities are taking place on huge scale all over the world and demand of construction materials are increasing day-by-day. Production of concrete and utilization of concrete has rapidly increased, which results in increased consumption of natural aggregate and sand (Patel *et al.,* 2013). Aggregate is one of the main ingredients in producing concrete which covers 75% of the total for any concrete mix. Strength of concrete produced is dependent on the properties of aggregates used (Sivakumar *et al.,* 2014). Conventionally concrete is mixture of cement, sand and aggregate since all the ingredients of concrete are of geological origin, the construction industries are in stress to identify alternative materials to replace the demand of natural sand and aggregate (Nagpal *et al.,* 2013). The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients (Sathawanea *et al.,* 2013). Every year 250-400 tons of stone wastes are generated on site. The stone cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the stone waste quickly and use in the construction industry (Patel and Pitroda, 2013). The advantages of utilization of by products or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load and waste management cost, reduction of production cost as well as improving the quality of concrete (Jain *et al.,* 1999). Considering the above facts in view, the effect of partial replacement of fine aggregate with stone dust on concrete strength under compression and tension was investigated.

Materials and methods

Cement: In this study, Portland Pozzolana Cement (PPC) of Prism Brand obtained from single batches throughout the investigation was used. Properties of cement are given in Table 1.

Mix design: The design mix proportion of 1:1.65:3 (where 3 is proportion of 20 mm and 10 mm aggregate) and W/C ratio of 0.46 is used for M25 grade of concrete and the quantity of cement is 380 kg/m^3 by using IS-10262-2009 method of mix design.

Table 1. Properties of cement.

Properties	Experimental	Codal requirement[IS 1489 (Pt-1)-1991]
Normal consistency %	31.5%	-
Initial setting time	165 min	(Not less than 30 min)
Final setting time	215 min	(Not more than 600 min)
Soundness of cement (Le chatelier expansion)	0.75 mm	(Not more than 10 mm)
Fineness of cement (% retained on 90 μ IS sieve)	3.77%	10%
Specific gravity of cement	2.67	3.15
Compressive strength		
7 d testing	33.0	22 N/mm^2 (min)
28 d testing	43.2	33 N/mm^2 (min)

Table 2. Sieve analysis for fine aggregate.

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %	Standard % weight passing for zone II
10 mm	-	-	-	100	100
4.75 mm	6	6	1.2	98.8	100
2.36 mm	32	38	7.6	92.4	75-100
1.18 mm	68	106	21.2	78.8	55-90
600 µm	106	212	42.4	57.6	35-59
300 µm	190	402	80.4	19.2	8-30
150 µm	94	496	99.2	0.8	0-10
Pan	04	500	-	-	-
Total = 252			Fineness modulas = 252/100 = 2.52		

Table 3. Sieve analysis for coarse aggregate of 10 mm size (5 kg sample).

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %
20 mm	0.018	0.018	0.36	99.64
10 mm	3.490	3.508	70.16	29.84
4.75 mm	1.456	4.963	99.26	0.74
2.36 mm	0.026	4.989	99.78	0.22
1.18 mm	0.011	5.000	100	-
600 µm	-	-	100	-
300 µm	-	-	100	-
150 µm	-	-	100	-
Fineness modulus = 669.56/100=6.69				

Table 4. Sieve analysis for coarse aggregate of 20 mm size (5 kg sample).

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %
40 mm	-	-	-	100
20 mm	4.444	4.444	44.44	55.55
10 mm	5.531	9.975	99.75	0.25
4.75 mm	0.025	10.00	100	-
2.36 mm	-	-	100	-
1.18 mm	-	-	100	-
600 µm	-	-	100	-
300 µm	-	-	100	-
150 µm	-	-	100	-
Fineness modulus = 744.19/100=7.44				

Table 5. Sieve analysis for stone dust.

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %	Standard % weight passing for zone II
4.75 mm	-	-	-	100	100
2.36 mm	14	14	1.4	98.6	75-100
1.18 mm	164	178	17.8	82.2	55-90
600 µm	196	374	37.4	62.6	35-59
300 µm	400	774	77.4	22.6	8-30
150 µm	196	970	97.0	3.0	0-10
Pan	25	995	100	0	0

Total cumulative % retained = 231, Fineness modulus=231/100=2.31, Specific gravity=2.50, Water absorption=0.5%.

Fine aggregate: The fine aggregate was locally available river sand which is passed through 4.75 mm sieve. The specific gravity of fine aggregate is 2.9 and fineness modulus of fine aggregate is 2.52. Result of sieve analysis is shown in Table 2.

Coarse aggregate: The coarse aggregate was locally available quarry having two different sizes; one fraction is passing through 20 mm sieve and another fraction passing through 10 mm sieve. The specific gravity of coarse aggregate is 2.66 for both fractions. The grading of coarse aggregate of 10 mm and 20 mm size are given in Table 3. Proportion of 20 mm and 10 mm size aggregate was taken as 60% and 40%. Result of sieve analysis of coarse aggregate is given in Table 3 and 4.

Stone dust: Stone dust is collected from local stone crushing units of Bharatpur, Rewa road, Uttar Pradesh. It was initially dry in condition when collected and was sieved by IS: 90 µ sieve before mixing in concrete. Stone dust is of grey colour and shape of particles is irregular. Properties are mentioned in Table 5.

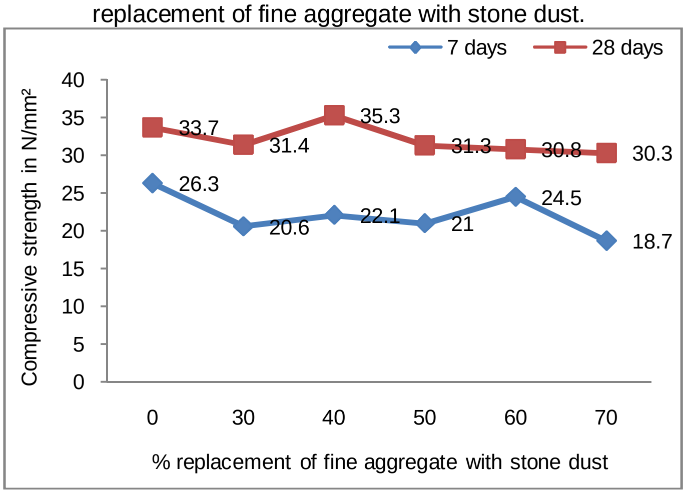
Results and discussion

Compressive strength with replacement of fine aggregate with stone dust: The result of compressive strength with replacement of stone dust for 7 and 28 d are shown in Table 6 and its graphical representation is shown in Fig. 1. It was observed that at 30% replacement, strength was decreased but at 40% replacement, strength increased and then decreased at each replacement. At 0% replacement, compressive strength is 26.2 N/mm^2 and 33.7 N/mm^2 at 7 and 28 d 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 and 28 d respectively. Results shows that with 40% replacement, compressive strength increased by 4.74% at the age of 28 d 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 d compared to referral concrete. Reduction in compressive strength takes place as the amount of fine dust is more in stone dust due to that w/c ratio increases. The dust particles amount is not enough to fill all the voids between cement paste and aggregate particles; they have lower compressive strength values.

Table 6. Compressive strength of specimen with waste LDPE.

Cube designation	Average compressive strength (N/mm^2)		% replacement of fine aggregate
	7 d	28 d	
A1	26.3	33.7	0
A2	20.6	31.4	30
A3	22.1	35.3	40
A4	21	31.3	50
A5	24.5	30.8	60
A6	18.7	30.3	70

Fig. 1. Line chart for compressive strength of specimens with replacement of fine aggregate with stone dust.



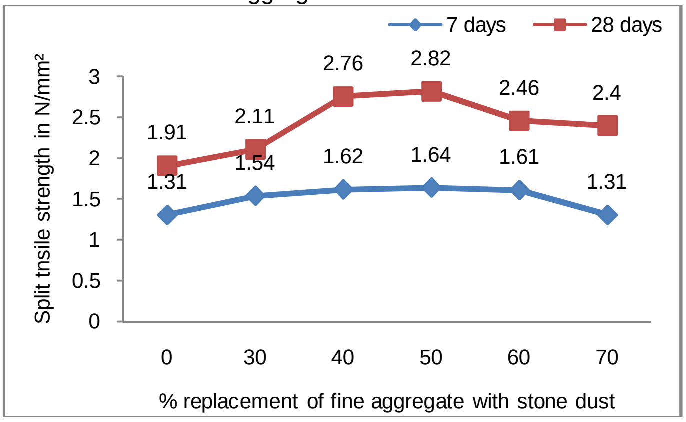
Angular shape of stone dust particle is also one of the reason to decrease the compressive strength.

Split tensile strength with replacement of fine aggregate with stone dust: The result of split tensile strength with replacement of stone dust for 7 and 28 d are noted in Table 7 and its graphical representation is shown in Fig. 2. It was observed that with increases in replacement factor of fine aggregate with stone dust, split tensile strength also increased. At 0% replacement, split tensile strength is 1.31 N/mm^2 and 1.91 N/mm^2 at 7 and 28 d respectively and at 50% replacement the split tensile strength of stone dust concrete is 1.64 N/mm^2 and 2.82 N/mm^2 at 7 and 28 d respectively.

Table 7. Results for split tensile strength with replacement of fine aggregate with stone dust [Refer to IS 5816: 1999].

Cylinder designation	Average compressive strength (N/mm^2)		% of Plastic
	7 d	28 d	
B1	1.31	1.91	0
B2	1.54	2.11	30
B3	1.62	2.76	40
B4	1.64	2.82	50
B5	1.61	2.46	60
B6	1.31	2.40	70

Fig. 2. Line chart for split tensile strength with replacement of fine aggregate with stone dust.



Results shows that with 50% replacement, split tensile strength increased by 25.1% and 47.6% at the age of 7 and 28 d respectively compared to referral concrete whereas with 30%, 40%, 60% and 70% there is increase in split tensile strength by 10.47%, 44.5%, 28.7% and 25.65% at the age of 28 d compared to referral concrete. Stone dust concrete is acceptable as its split tensile strength is increasing with increase in percentage replacement.

Conclusion

The following are the conclusive points derived at the end of the study:

- Fine aggregate can be replaced by stone dust with 40%, at this replacement level compressive strength is more than referral concrete.
- At replacement level, 50% of fine aggregate with stone dust is more than referral concrete; after this level split tensile strength is decreasing however split tensile strength is more than referral concrete.
- Fine aggregate can be effectively replaced by stone dust in concrete.

References

1. Jain, M.E.M., Safiuddin, M. and Yusuf, K.M. 1999. A study on the properties of freshly mixed high performance concrete. *Cement Concr. Res.* 29(9): 1427-1432.
2. Nagpal, L., Dewangan, A., Dhiman, S. and Kumar, S. 2013. Evaluation of strength characteristics of concrete using crushed stone dust as fine aggregate. *Int. J. Innov. Technol. Explor. Engg.* 2(6): 102-104.
3. Patel, A.N. and Pitroda, J. 2013. Stone waste: Effective replacement of cement for establishing green concrete. *Int. J. Innov. Technol. Explor. Engg.* 2(5): Page number.
4. Prakash, V.S., Krishnan, D. and Jeenu, G. 2007. Influence of fine stone dust on high strength concrete. 32nd Conf. on our world in concrete and structures, 28-29 August 2007, Singapore Article Online Id: 100032054, 2007.
5. Sathawane, S.H., Vairagade, V.S. and Kene, K.S. 2013. Combine effect of rice husk ash and fly ash on concrete by 30% cement replacement. *Procedia Engg.* 51: 35-44.
6. Sivakumar, N., Muthukumar, S., Sivakumar, V., Gowtham, D. and Muthuraj, V. 2014. Experimental studies on high strength concrete by using recycled coarse aggregate. *Int. J. Engg. Sci.* 4(1): 27-36.