An Experimental Investigation on Effect of Recycled Aggregate and Stone Dust on Concrete

Sumit Sachan[1], Vikas Srivastava[2], V.C.Agarwal[3]

[1] *M.TECH(SE) Department of Civil Engineering, Sam Higginbottom Institute of Agriculture Technology & Sciences, (Deemed University), Allahabad-211007, U.P, India*

[2] *Associate.Professor, Department of Civil Engineering, Sam Higginbottom Institute of Agriculture Technology & Sciences, (Deemed University), Allahabad-211007, U.P, India*

[3] *Professor & Head, Department of Civil Engineering, Sam Higginbottom Institute of Agriculture Technology & Sciences, (Deemed University), Allahabad-211007, U.P, India*

sumit1989sachan@gmail.com[1], vikas_mes@rediffmail.com[2], vcagarwalmnnit@gmail.com [3]

Abstract- **In present experiment on PPC concrete is to find the appropriate proportion at which stone dust & recycled aggregate partially replace the fine and course aggregate respectively in PPC concrete gives the hardened concrete properties. The percentage of stone dust partial replacement of fine aggregate in PPC concrete are 0%,10% and recycled aggregate partial replacement of course aggregate in PPC concrete are 0%,50%,60%,70%. M25 grade of concrete is used for conducting different strength test on PCC concrete. The different concrete tests are compressive strength test on 100x100x100mm cube and split tensile test on cylinder of dia. 150mm and height 150mm. From the experimental studies, it is found that 60% of quarry dust and 10% of recycled aggregate are the valuable proportion for the hardened concrete properties. All specimens were tested after curing age 7 days & 28 days. Strength properties of the treated and untreated coarse aggregate were compared. The results indicated that the compressive and split tensile strength of recycle aggregate is found to be less than the natural aggregate.**

Keywords: **Demolition waste, concrete, compressive strength, split tensile strength, stone dust, fine aggregate.**

I. INTRODUCTION

Owing to rapid urbanization, industrialization and developmental activities in construction industry, demand of construction material which are normally naturally available is increasing day by day. Resulting which need of search for alternating material aroused. Concrete is most used construction material in different form of basic ingredients of concrete(cement, coarse aggregate, fine aggregate and water) are naturally available as such need to be conserved from over-exploitation to ensure its availability for generation to come. Total aggregate in concrete constituent about two-third to three-fourth of total mass of concrete.

Replacement of coarse and fine aggregate with suitable alternative materials will result in deduction of unit cost, conservation of natural resources and protection of environment too.

Owing to increased construction activities and demolition of old structures, very large amount of construction & demolition waste are generated which are expected to be increased day by day. The disposal of concrete waste is a challenge for the authority concerned as a large suitable site is required for disposal of these waste & these waste are also major source of land, air and water pollution. Concrete trouble is major proportion of construction & demolition waste, which can be recycled to make recycled aggregate with certain processing and modification. Resulting recycled aggregate can effectively been used in concrete making as partial replacement of natural coarse aggregate.

Stone dust is a waste material obtained from crusher plant during the process of blasting the rocks. Stone dust is fine proportion of resulting material from blasting and of no use commercially. It is kept in abundance near crushing plants, which is a source of environmental pollution. Stone dust can be used as partial replacement of natural sand in concrete, which results in utilization of this waste in one hand and conservation of natural resource on the another hand.

Nagaraj and Zahida (1996) reported that sand and 50% quarry dust combination gives higher strength when compared than the conventional concrete due to the sharp edges of stone providing stronger bond with cement compared to the rounded shape of ordinary sand. Shukla and Sachan (2000) studied environmental hazardous stone dust utilization in building construction. Nagabhusana *et al.* (2011) reported that crushed stone powder can be effectively used to replace natural sand without reduction in the strength of concrete at replacement level up to 40%.Pofale and Quadri (2013) reported that compressive strength of concrete (M25 & M30) made using crusher dust increased at all the replacement level between 30 to 60% at a interval of 10%. However maximum increased in strength is observed at a replacement level of 40%. Sukesh *et al.* (2013) reported that compressive strength of concrete made using quarry dust is slightly higher than that of conventional concrete. Kumar *et al.* (2013) reported that there is increase in strength in concrete containing quarry rock dust is 10- 12%

more than that of similar mix of Conventional Concrete. Reddy (2010) reported that stone dust can be used in place of natural sand in concrete. He concluded that by using stone dust as total replacement of natural sand in concrete higher strength can be achieved. Ilangovana *et al.* (2008) concluded that replacement of natural sand with quarry rock dust as full replacement in concrete is possible. However they advice to carry out trial casting with quarry rock dust proposed to be used. Kujur *et al.* (2014) reported that fine aggregate can be replaced (up to 40%) by stone dust in concrete without compromising the strength. Singh *et al.* (2014) concluded that replacement of fine aggregate with stone dust does not affect the compressive strength up to the replacement level of 40% respective of curing period. Monish *et al.* (2013) reported that recycled aggregate can be used in concrete as partial replacement of coarse aggregate up to 30% with marginally compromise of compressive strength. However up to 30% replacement of coarse aggregate with recycled aggregate compressive strength of same was comparable to conventional concrete. Sandeep *et al.* (2014) concluded that replacement of fine aggregate with stone dust does not affect the compressive strength up to the replacement level of 40%, irrespective of the number of days. Shahbaz *et al*. (2014) concluded that the compressive strength of 60% stone dust and 10% RCA sample is in close proximity of the referral concrete and can be satisfactory used.

II. MATERIALS AND METHODS

METHODOLOGY: An experimental investigation was conducted to get the strength of specimens (cubes and beams) made with the use of stone dust and recycled aggregates as partial replacement of fine aggregates and coarse aggregates respectively. The strength of conventional concrete and other mixes were determined at the end of 7 and 28 days of moist curing. To study the effect of stone dust and recycled aggregates inclusion, cubes and cylinder of a design mix M25 grade concrete were cast. The 100 mm cubes were tested for compressive strength and the cylinder of size (150 mm dia. and 15 mm height) were tested for split tensile strength. The M25 mix proportion was (1:1.65:3) at w/c ratio of 0.50.

A. CEMENT

In the present study, Portland Pozzolana Cement (PPC) of a single batch was used throughout the investigation. The physical and chemical properties of PPC as determined are given in table 1. The cement satisfies the requirement of IS: 1489:1985. However, a more or less similar test result of cement was reported by Sandeep *et al.* (2014), kujur *et al.* (2014) and Shahbaz *et al.* (2014). Similar test results of material properties may be due to the same source of material used in investigation.

TABLE I
Properties of cement (Method of test refers to IS: 1489: 1985)

Properties	**Experimental**	**Codal requirement [IS 1489 (Pt-1)-1985]**
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 micron IS sieve)	3.77%	10%
Specific gravity of cement	2.67	3.15
Compressive strength		
7 days testing	33.0	22 N/mm^2(min)
28 days testing	43.2	33 N/mm^2(min)

B. FINE AGGREGATE

The fine aggregate used was locally available river sand, which passed through 4.75 mm. Result of sieve analysis of fine aggregate is given in table 2. The specific gravity of fine aggregate is 2.43 and fineness modulus is 2.87. However, more or less similar test results of aggregates were reported by Sandeep *et al.* (2014),kujur *et al.* (2014) and Shahbaz *et al.* (2014). Similar test results of material properties may be due to the same source of material used in investigation.

TABLE II
Sieve analysis for fine aggregate

S. NO.	**Sieve Size**	**Wt. Retained (g)**	**Cumulative Weight Retained**	**Cumulative % Weight Retained**	**Passing %**	**Standard % Wt. Passing for Zone II**
1	4.75mm	-	-	-	100	100
2	2.36 mm	50	50	5.0	95	75-100
3	1.18 mm	232	282	28.2	71.8	55-90
4	600µ	348	630	63.0	37	35-59
5	300 µ	296	926	92.6	7.4	8-30
6	150 µ	60	986	98.6	1.4	0-10
7	Pan	12	998	100	0	0
			Total = 287.4			

Fineness Modulus = 287.4/100= 2.87

C. COARSE AGGREGATE

Two aggregate sizes (20 and 10 mm) were used in this investigation. The specific gravity of coarse aggregate was 2.72 for both the fractions. Result of sieve analysis of 10 and 20 mm coarse aggregate are given in table 3 and 4 respectively. The 20 and 10 mm aggregate were mixed in the ratio of 60:40. However, more or less similar test results of aggregates were reported by Sandeep *et al.* (2014),kujur *et al.* (2014) and Shahbaz *et al.* (2014) Similar test results of material properties may be due to the same source of material used in investigation.

TABLE III
Sieve analysis for coarse aggregate of 10mm size

S. No.	Sieve Size	Weight Retained (g)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %
1	20 mm	-	-	-	100
2	10 mm	1680	1680	56	44
3	4.75mm	865	2545	84.83	15.17
4	2.36mm	453	2998	100	-
5	1.18mm	0	2998	100	-
6	600µ	0	2998	100	-
7	300 µ	0	2998	100	-
8	150 µ	0	2998	100	-
				Total = 640.83	

Fineness Modulus = 640.83/100=6.40

TABLE IV
Sieve analysis for coarse aggregate of 20mm size

S. No.	Sieve Size	Weight Retained (g)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %
1	40 mm	-	-	-	100
2	20 mm	290	290	9.66	90.34
3	10mm	2494	2784	92.8	7.2
4	4.75 mm	214	2998	100	-
5	1.18 mm	0	2998	100	-
6	600µ	0	2998	100	-
7	300 µ	0	2998	100	-
8	150 µ	0	2998	100	-
				Total = 602.46	

Fineness Modulus = 602.46/100=6.024

D. STONE DUST

Stone dust was obtained from local stone crushing units of Mirzapur, Vindhyachal Road, Uttar Pradesh. It was initially dry in condition when collected, and was sieved before mixing in concrete. Result of sieve analysis of stone dust is given in table 5. Specific gravity of stone dust was 2.50 and Water absorption was 0.50%. Similar test results of material properties may be due to the same source of material used in investigation.

TABLE V
Sieve analysis of stone dust

S. No.	Sieve Size	Weight Retained (g)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %	Standard % Weight Passing for Zone II
1	4.75mm	4	4	0.4	99.6	100
2	2.36mm	80	84	8.4	91.6	75-100
3	1.18mm	336	420	42.0	58.0	55-90
4	600µ	510	930	93.0	7.0	35-59
5	300 µ	70	1000	100.0	0	8-30
6	150 µ	-	-	-	-	0-10
7	Pan	-	-	-	-	0
			Total Cumulative % Retained = 243.8			

Fineness Modulus = 243.8/100=2.44

E. WATER

Potable water was used for mixing and curing.

F. MIX DESIGN

The mix design was carried out as per the recommendations laid down in IS-10262-2009.

The design mix proportion of 1:1.65:3 at W/C ratio of 0.50 were used for M25 grade of concrete and the cement content was 380 kg/m^3, satisfying the requirements of minimum cement content (300 kg).

III. RESULTS AND DISCUSSION

A. COMPRESSIVE STRENGTH

The result of compressive strength with replacement of stone dust and recycled aggregate for 7 and 28 days are presented in table 6 and its graphical representation is shown in fig.1.From the results, compressive strength of concrete with 60% replacement of stone dust and 10% replacement of recycled coarse aggregate have the highest 7 and 28 days strength which reaches 22.0 N/mm^2 and 36.1 N/mm^2 respectively.

TABLE VI
Compressive Strength Of Different Mixes.

Sl. No.	Cube designation	%age replacement of stone dust	%age replacement of recycled aggregate	Average Compressive strength (MPa)	
				7 d	28 d
1	A1	0	0	25.9	33.1
2	A2	10	50	17.0	30.3
3	A3	10	60	22.0	36.1
4	A4	10	70	20.5	33.0

Results shows that with 60% replacement of fine aggregate with stone dust and 10% replacement of coarse aggregate with recycled coarse aggregate, the compressive strength of concrete increased by 8% at the age of 28 days compared to referral concrete.. It can be seen from table and figure that compressive strength is increased with addition of stone dust but only at 60% further addition of stone dust resulted in decrease of the strength that is similar to the finding of Sandeep *et al.* (2014) and reported similar trend and concluded that optimum replacement level is 40%.

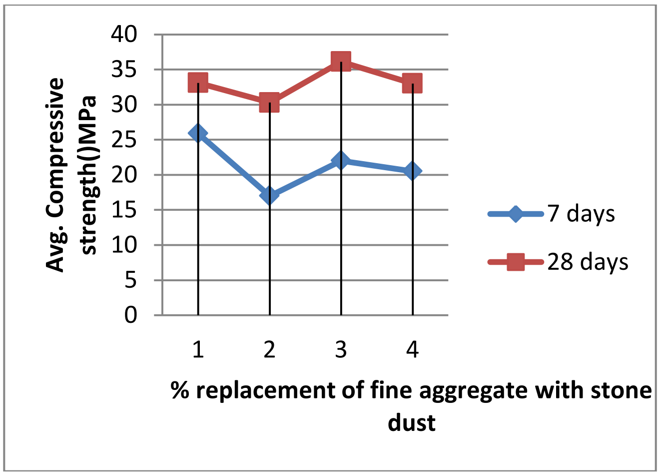

Fig. 1. Variation of Compressive Strength with Replacement Level.

B. Split Tensile Strength

The split tensile strength of specimen were determined at 7 and 28 days and are given in table 7. The variation of split tensile strength with replacement level show in Fig 2. It is observed that the split tensile strength increases marginally at 7 day with replacement level. However at 28 day, the split tensile strength increases significantly with replacement level as compared to the referral concrete.

Sl. No.	Cylinder designation	%age replacement of recycled aggregate	%age replacement of stone dust	Average Flexural strength (MPa)	
				7 d	28 d
1	C1	0	0	1.39	1.89
2	C2	10	50	1.31	2.03
3	C3	10	60	1.78	2.68
4	C4	10	70	1.50	2.32

Result shows that with 60% replacement of stone dust and 10% replacement of recycled aggregate, the split tensile strength of replaced concrete is increased by 40% at the age of 28days as compared to referral concrete. While, at 50% & 70% the values are 2.03 N/mm^2 & 2.32N/mm^2 respectively.

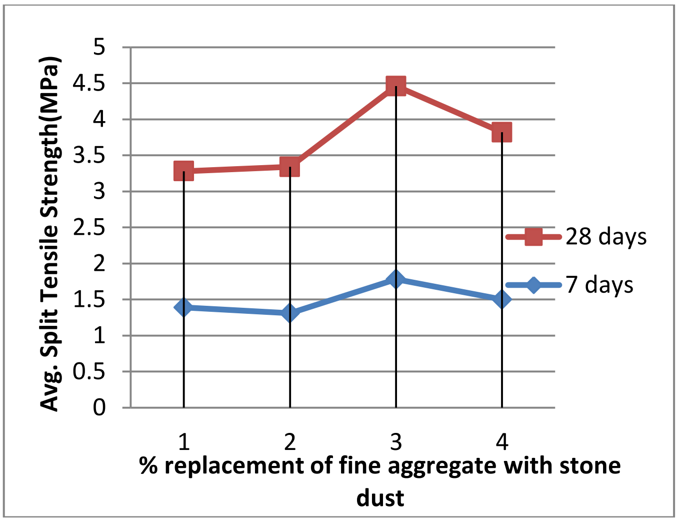

Fig. 2. Variation of split tensile strength with replacement level.

IV. CONCLUSION

From the above study, the following conclusions are obtained:

[A] Compressive strength of concrete made using 10% recycled aggregate and 60% stonedust as replacement of coarse aggregate and fine aggregate respectively, is about 8% more than that of referral concrete at 28 days. However, compressive strength at 10% recycled aggregate and 70% stone dust is marginally than that of conventional concrete.

[B] The compressive strength of 60% stone dust and 10% recycled aggregate sample is close proximity of the referral concrete. Thus it can be concluded that stone dust up to 60% with 10% recycled concrete aggregate is satisfactory to use.

[C] Results shows that with partial replacement of stone dust with 50%, 60% and 70% and 10% recycled coarse aggregate, split tensile strength increased by 7.4%, 41.8% and 22.7% at the age of 28 days respectively as compared to referral concrete whereas with 60% replacement of stone dust and 10% replacement of recycled coarse aggregate there is increase in split tensile strength by 41.8% at the age of 28 days compared to referral concrete.

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