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COMPARISON OF COMPRESSIVE AND FLEXURE STRENGTH OF FINE AND COARSE AGGREGATE REPLACED CONCRETE WITH REFERRAL CONVENTIONAL CONCRETE

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Abstract

Concrete is prime construction material used in practice. No construction can be dreamed without use of concrete. The main constituents of concrete such as sand, stone and water are naturally available. These resources of natural aggregates (sand, stone) are depleting day by day due to over exploitation for the sake of developmental activities. It is worthwhile to seek alternative for naturally available aggregates. The aim of this study was to investigate the possibility of using stone dust as partial replacement of fine aggregate and recycled aggregate as partial replacement of coarse aggregate. In the present study cubes and beams were cast to determine the compressive and flexural strength of concrete made using stone dust and recycled aggregate as replacement of natural aggregate. Concrete of M25 grade was designed for a W/C ratio of 0.48 for the replacement of 10% coarse aggregate with recycled coarse aggregate and replacement of 30% and 40 % of fine aggregate (sand) with stone dust. The result indicates that the replacement of fine aggregate with stone dust and coarse aggregate with recycled coarse aggregate simultaneously are not reliable for compressive strength. Results shows that with partial replacement of stone dust with 0%, 30% and 40% and 10% recycled coarse aggregate, flexure strength increased by 26.4%, 16.67% and 21.87% at the age of 28 days respectively as compared to referral concrete whereas with 10% replacement of recycled coarse aggregate there is Increase in flexure strength by 26.4% at the age of 28 days compared to referral concrete.

Introduction

Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water and admixture. The economy, efficiency, durability, mold ability and rigidity of reinforced concrete make it an attractive material for a wide range of structural applications. The main constituents of concrete such as sand, stone and water are mainly naturally available. They are not produced in laboratory or in any industry; they are obtained from the nature and processed to make it perfect for aggregate. For example, sand is carried by river water and then collected, and stones are obtained by crushing of bolder using stone crusher. These resources of engineering materials (sand, stone) are limited and day by day the dependency on them must be minimized. So some other materials should be introduced by replacing sand and stone. Stone dust is one of such alternative of sand that can fulfill the demand of fine aggregate. Rao et al. (2006) reported that Construction and Demolition (C&D) waste constitutes a major portion of total solid waste production in the world, and most of it is used in landfills. Research by concrete engineers has clearly suggested the possibility of appropriately treating and reusing such waste as aggregate in new concrete.

Patel et al. (2013) reported that 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 aggregates. Siva Kumar et al. (2014) concluded that the strength of concrete produced is dependent on the properties of aggregates used. Nagpal et al. (2013) reported that the construction industries are in stress to identify alternative materials to replace the demand of natural sand and aggregate. Nagbhusana et al. (2011) reported that crushed stone powder can effectively used to replace natural sand without reduction in the strength of concrete at replacement level up to 40%. Patel and Pitroda (2013) investigated that 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.

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 cylindres of a design mix M25 grade concrete were cast. The 100 mm

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cubes were tested for compressive strength and the beam of size (500 mm × 100 mm × 100 mm) were tested for flexural strength. The M25 mix proportion was (1:1.65:3) at w/c ratio of 0.48.

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 kujur et al. (2014).

Table 1. 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)

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.

Table 2. Sieve analysis for fine aggregate

S. NO.	Sieve Size	Weight Retained (g)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %	Standard % Weight 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

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) and kujur et al. (2014).

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Table 3. 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	2.36 mm	453	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 = 640.83		

Fineness Modulus = 640.83/100=6.40

Table 4. 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

Stone dust

Stone dust was obtained from local stone crushing units of Bharatpur, Rewa Road, and 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 0.5%.

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Table 5. 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	2.36 mm	80	84	8.4	91.6	75-100
3	1.18 mm	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.

Water

Potable water was used for mixing and curing.

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 0.48 were used for M25 grade of concrete and the cement content was 380 kg/m3, satisfying the requirements of minimum cement content (300 kg).

Results and discussion

Compressive Strength

The result of compressive strength with replacement of stone dust and recycled coarse aggregate for 7 and 28 days are noted in table 8 and its graphical representation is shown in fig.1. Decrease in compressive strength has been observed with partial replacement of stone dust with 0%, 30% & 40% and partial replacement of recycled coarse aggregate with 10% for each proportion. At 0% replacement compressive strength is 26.2 N/mm2and 33.7 N/mm2at 7 and 28 days respectively and at 10% replacement the compressive strength of recycled coarse aggregate concrete is 18.7 N/mm2and 28.9 N/mm2 at the age of 7 and 28 days respectively.

Table 6. Compressive Strength of Different Mixes.

Sl. No.	Cube designation	Average Compressive strength (N/mm^2)		%age replacement of stone dust	%age replacement of recycled aggregate
		7 days	28 days		
1	A1	26.3	33.7	0	0
2	A7	18.7	28.9	0	10
3	A8	21.3	30.7	30	10
4	A9	20.1	26.4	40	10

Results shows that with 10% replacement of recycled aggregate compressive strength decreased by 14.24% at the age of 28 days compared to referral concrete whereas with 30% replacement of stone dust and 10% replacement of recycled coarse aggregate there is reduction in compressive strength by 8.9% at the age of 28 days compared to referral concrete. Reduction in compressive strength takes place if the amount of fine dust is more in stone dust due to that w/c ratio increases. The dust particles amount is not enough

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to fill all the voids between cement paste and aggregate particles; they have lower compressive strength values. Angular shape of stone dust particle is also one of the reason to decrease the compressive strength. As we increase the replacement factor of stone dust with same replacement factor of recycled coarse aggregate compressive strength reduces because of low water absorption capacity of recycled aggregate.

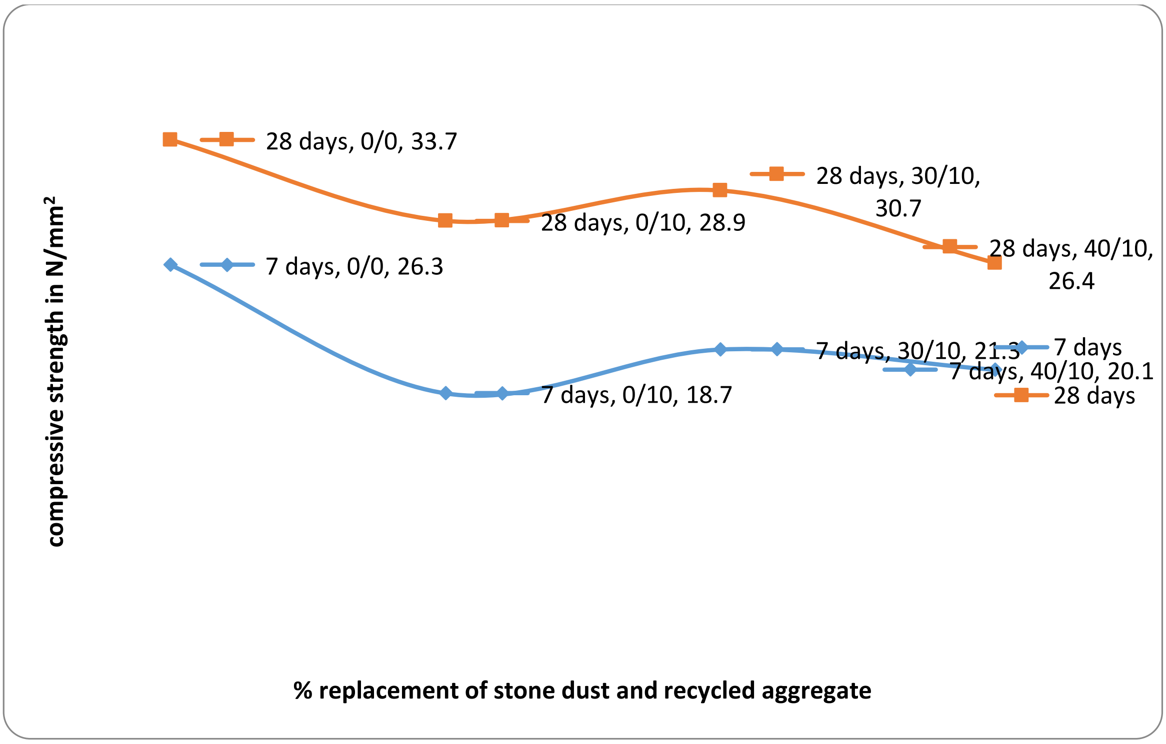

Fig. 1. Variation of Compressive Strength with Replacement Level.

Flexural strength

The result of flexure strength with replacement of stone dust and recycled coarse aggregate for 7 and 28 days are noted in table 7 and its graphical representation is shown in fig.2. Increase in flexure strength has been observed with partial replacement of recycled coarse aggregate with 10% and also slight increase in partial replacement of stone dust with 30% & 40% and recycled coarse aggregate with 10% for each proportion at 28 days. At 0% replacement split tensile strength are 0.46 N/mm2and 0.48 N/mm2at 7 and 28 days respectively and at 10% replacement of recycled coarse aggregate the split tensile strength is 0.36 N/mm2and 0.68 N/mm2 at the age of 7 and 28 days respectively.

Table 7. Flexural Strength of Different Mixes.

Sl. No.	beam designation	Average Flexure strength (N/mm^2)		%age replacement of stone dust	%age replacement of recycled aggregate
		7 days	28 days		
1	C1	0.46	0.50	0	0
2	C7	0.36	0.68	0	10
3	C8	0.40	0.60	30	10
4	C9	0.52	0.64	40	10

Results shows that with 10% replacement of recycled coarse aggregate; split tensile strength increased by 36% at the age of 28 days compared to referral concrete whereas with 30% replacement of stone dust and 10% replacement of recycled coarse aggregate there is reduction in split tensile strength by 20% at the age of 28 days compared to referral concrete. It is makeable that 7 days curing for different ratios strength is decreases but for the same ratio for 28 days strength increases.

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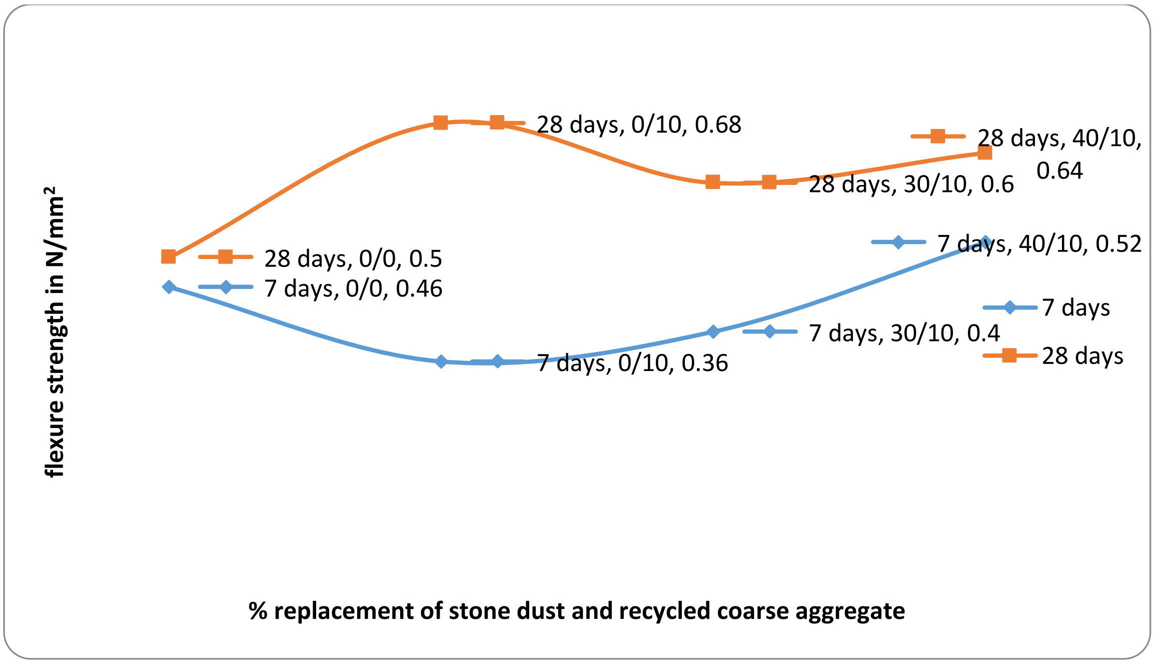

Fig. 2. Variation of flexural strength with replacement level.

Conclusion

From the above study, the following conclusions are obtained:

1. Replacement of fine aggregate with stone dust and coarse aggregate with recycled coarse aggregate simultaneously are not reliable for compressive strength.
2. Replacement of fine aggregate with stone dust and coarse aggregate with recycled coarse aggregate simultaneously increased the flexural strength upto 40% replacement level.
3. Results shows that with partial replacement of stone dust with 0%, 30% and 40% and 10% recycled coarse aggregate, flexure strength increased by 26.4%, 16.67% and 21.87% at the age of 28 days respectively as compared to referral concrete whereas with 10% replacement of recycled coarse aggregate there is Increase in flexure strength by 26.4% at the age of 28 days compared to referral concrete.

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