Stone Dust and Recycled Aggregate in Concrete – Effect on Compressive Strength

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***Abstract* - The present work presents the results of experimental investigations carried out to evaluate the effect of partial replacement of fine aggregate by stone dust and coarse aggregate by recycled aggregate on strength of concrete. For the study, design mix concrete of grade M_{25} (Referral concrete) was prepared using IS: 10262-2009. Thereafter, the replacement of different constituents of concrete, one at a time was carried out by replacing these with the different sieved fractions of crushed demolition waste. The compressive strength at 7 and 28 days was measured. The compressive strength of these mixes was measured on 100mm cubes. Test results show that the compressive strength of concrete made using 10% of recycled coarse aggregate and 30% stone dust as partial replacement of fine aggregate is comparable to referral concrete.**

Key word: Demolition waste aggregate, Demolition waste fine aggregate, Demolition waste powder, Concrete.

I. INTRODUCTION

Over the years there has been a change in the use of building materials. Cheep and locally available materials such as moulded earth bricks, stones, thatch, timber, steel, aluminium, plastics and fibres of various types and forms have replaced the traditional and costly materials. However, all these materials have been developed to meet specific requirements of climate, availability of skilled labour and specific raw materials to effect the desired economy.

Demolition wastes obtained from a structure predominantly consists of concrete, foreign matter such as various type of finishes, claddy materials, lumber, dirt, steel, hardwares, woods, plastics etc. The strict environmental laws and lack of dumping sites in urban areas on one hand are making disposal problems of demolition waste problematic. The proportion of concrete rubbles is maximum in the demolition waste. 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. The process of removal of impurities and crushing of rubble into suitable and desired aggregate particle size can be carried out in a continuous and sequential manner using appropriate mechanical devices such as jaw crushers, impact crushers, swing hammer crushers etc. The three processes used for processing of demolition waste are (i) Dry, (ii) Wet, and (iii) Thermal - which are used either individually or in combination. The most marked difference in physical properties of recycled concrete aggregate compared with conventional aggregate lies in its higher water absorption. The recycled concrete produced with coarse recycled aggregate and natural sand requirs approximately 5% more free water than the control concrete produced with corresponding natural aggregate, in order to achive the same slump. Hansen and Narud(1983) reported little or no difference in compressive strength of recycled aggregate concrete produced with the aggregate in air-dry or saturated surface dry condition, when the free water cement ratio of fresh concretes were same. Karaa(1986) found that concrete produced with dry recycled aggregate looses its workability and sets faster than the concrete produced with wet recycled aggregates. However, for the same free water cement ratio, there was no effect on compressive strength or modulus of elasticity of the hardened concrete. Hansen and Marga(1992) reported that the water requirement of recycled aggregate concrete made using both coarse and fine recycled aggregate was 14% higher than that of control concretes made using natural sand and gravel. The concrete produced using coarse recycled aggregate and natural sand requires 6% more water. Concrete can be successfully produced using recycled aggregates, produced from the demolition and construction wastes. The concrete produced using these aggregates do not perform as good as concretes produced using natural aggregates in terms of strength. However, the concrete still has a strength that the would make it suitable for some applications, with the added benefit that density values are much lower, making it suitable in situations where self-weight is a problem and very good fire resistance is required [Khalaf and DeVenny(2004)].

The present work presents the results of experimental investigations carried out to evaluate the effect of partial replacement of fine aggregate by stone dust and coarse aggregate by recycled aggregate on strength of concrete. For the study, design mix concrete of grade M_{25} (Referral concrete) was prepared using IS: 10262-2009. Thereafter, the replacement of different constituents of concrete, one at a time was carried out by replacing these with the different sieved fractions of crushed demolition waste. The compressive strength at 7 and 28 days was measured. The compressive strength of these mixes was measured on 100mm cubes. Test results show that the compressive strength of concrete made using 10% of recycled coarse aggregate and 30% stone dust as partial replacement of fine aggregate is comparable to referral concrete.

II. MATERIAL AND METHODS

The present work is an attempt to explore the possibility of using recycling the wastes of different sizes obtained from demolished concrete and stone dust obtained from quarry for future uses. To accomplish this comprehensive experimental program was designed to asses the possibility of partial replacement of regular concrete materials by cheaper and easily available substitute i.e. recycled aggregate and stone dust. The demolished concrete was crushed and sieved on IS sieve to segregate the coarse, fine and powder fractions. The IS sieves used were – 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ and 150µ. The fractions passing 20mm and retained on 4.75mm IS sieve were used as coarse aggregate for replacement. The stone dust obtained from quarry was also sieved and the fractions passing 4.75mm and retained on 600µ IS sieve were used as fine aggregate for replacement. The important properties of different size fractions obtained from demolition waste concrete were: Recycled Coarse Aggregate- Fineness Modulus - 6.51 and Specific gravity – 2.64; Stone Dust - Fineness Modulus – 2.32 and Specific gravity – 2.52. The above materials were used for partial replacement of coarse aggregate, fine aggregate used for making the referral concrete. The replacement levels of fine aggregate were selected as 30 and 40% by weight, however, replacement level of coarse aggregate was 10% by weight. The properties of raw materials used for making the referral concrete are as under. For the referral, M_{25} grade concrete mix was designed as per the method given in IS: 10262 – 2009. The proportion of cement: fine aggregate: coarse aggregate on weight basis was obtained as 1:1.65:3 for water/ cement ratio 0.48. The target strength was 31.6 MPa. The cubes of 100 mm size were used for this investigation and were tested at 7 and 28 days after curing in tap water (Potable) for the periods of specified in IS.

Cement: Portland Pozzolana cement(PPC) obtained from a single batch was used trough out this investigation. The physical properties of this PPC as determined are shown in Table 1. The cement satisfies the requirement of IS: 1489-1991.

TABLE I : PROPERTIES OF CEMENT

S.No.	Properties	Requirements (IS:8112-1989)	Observed values
1	Normal consistency		31.5%
2	Initial setting time	30 minutes (min)	165 Minutes
3	Final setting time	600minutes (max)	215 Minutes
4	7 days compressive strength	22 N/mm^2	33 N/mm^2
5	28 days compressive strength	33N/mm^2	43.2 N/mm^2
6	Soundness test	Not more than10 mm	1 mm
7	Fineness test (90µ sieve)	< 10%	0.98%

Fine Aggregate: It was locally available river sand, which was passed through 4.75 mm sieve. The fineness modulus of fine aggregate was 2.87 and specific gravity was 2.20.

Coarse aggregate: It was locally available crushed stone aggregate of 12.5 mm single size maximum. The fineness modulus of coarse aggregate was 6.40 and the specific gravity of the coarse aggregate was 2.66.

Water: Potable water was used for mixing and curing.

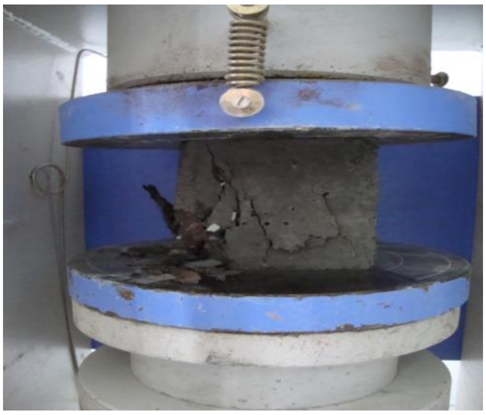

Fig. 1: Test Set up for Compressive Strength Test

III. RESULTS AND DISCUSSION

The results of the present investigation are included in Table 2 and are also plotted in Fig. 2. Fig show the effect of replacement levels of fine aggregate on the strength of concrete mixes at both 7 and 28 days.

Compressive Strength

Table 2 shows the values of cube compressive strength for different replacement levels of cement, fine aggregate and coarse aggregate, alongwith the strength of the referral mix. The variation of compressive strength is shown in Fig. 2.

It is observed that recycled concrete made using 10% replacement of coarse aggregate and 30% fine aggregate gives the strength comparable to the strength of referral concrete, and beyond this replacement level the strength decreases significantly.

TABLE II AVERAGE COMPRESSIVE STRENGTH OF CONCRETE CUBES

Cube Designation	Replacement Level of Coarse Aggregate (%)	Replacement Level of Fine Aggregate (%)	Average Compressive strength N/mm^2	
			7 Days	28Days
A1	0	0	25.9	33.1
A2	10	0	19.1	28.1
A3	10	30	20.5	30.1
A4	10	40	20.1	27.2

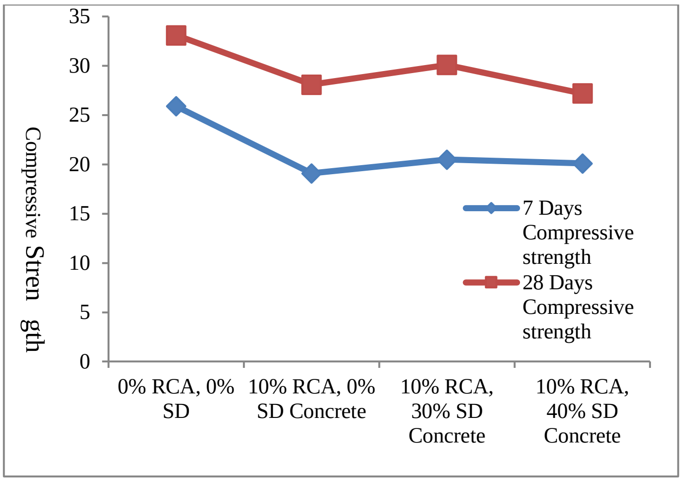

Figure 2 Compressive strength of recycled and referral concrete for different fine aggregate replacement levels.

IV. CONCLUSION

The following conclusions are drawn from this study.

1. The strength of concrete made using recycled aggregate (10%) as partial replacement of coarse aggregate is lower than that of referral concrete.
2. Replacement of regular fine aggregate by stone dust at 30% is possible without much compromising of strength.
3. The strength of concrete made using recycled aggregate (10%) as partial replacement of coarse aggregate and 30% stone dust as partial replacement of fine aggregate is comparable to referral concrete.
4. The replacement of coarse and fine aggregates by recycled aggregate and stone dust respectively is more suitable in respect of strength.

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