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Mechanical Properties of Field Demolished Aggregate Concrete

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Abstract:

This paper studied about the mechanical properties of field demolished aggregate concrete. The demolished concrete from previous construction, after surface treatment is used as aggregate known as recycled aggregate. The present work is studied by replacing the recycled aggregate with natural coarse aggregate from 0% to 50% at every increment of 10% in M 30 grade of concrete. The recycled material obtained is used in the construction of pavements, gutters, curbs, retaining wall backfill, landscaping rock and erosion control. From the study, it is observed that the compressive strength and split tensile strength of natural aggregate with respect to recycled aggregate have a less variation from 0% to 50% replacement. Thus the recycled aggregate can be used effectively as a coarse material in new concrete.

Keywords — ***compressive strength, natural aggregate, recycled aggregate, split tensile strength.***

I. INTRODUCTION

Globally, the concrete industry consumes large quantities of natural resources, which are becoming insufficient to meet the increasing demands. Composting is the waste disposal technique mostly unsustainable for treating huge and bulky demolished waste. The rate of demolishing waste is increasing day by day and the cost of dumping is increasing due to non-availability of appropriate site nearby. Scientists, engineers and technologists are continuously on the lookout for materials, which act as substitutes for conventional materials which possess such properties and enable new designs and innovations resulting in to economy. Apart from these substitute materials, the field demolished concrete is washed, treated and used for the further application in place of natural aggregate. The most important strategy for managing such demolished waste is Recycling or Re-utilization of recycled material. The recycled aggregate can be obtained from concrete and masonry waste by the following sequence of operations like sorting, crushing and sieving. The recycled aggregate thus obtained is used as concrete material in road construction, pavements, construction gutters and retaining wall back fill. This method is useful for environmental protection and economical terms.

II. REVIEW OF LITERATURE

This presents a review of the work of various researchers on the mechanical properties on concrete with partial replacement of field demolished coarse aggregate. Literature is cited, restricted only to those references that are relevant to the theme of the paper.

Sagoe-Crentsil*et al.* [16] compared the fresh and hardened properties of recycled aggregate with natural aggregates. The results obtained in compressive strength observed a reduction up to 10 % when virgin aggregate was substituted with recycled aggregate.

Limbachiya*et al.* [10] studied and discussed about natural aggregate replaced with recycled aggregate in concrete. The compressive strength tested for 50 % to 100 % replacement of virgin aggregate with recycled aggregate decrease the compressive strength by 5 % to 25 %. However, it was observed that up to 30% virgin aggregate can be substituted with recycled coarse aggregate (RCA) without any effects on concrete strength.

Yasuhir*et al.* [20] studied about the development of a sustainable concrete waste recycling system. The recycled coarse aggregate using the aggregate replacing method can acquire sufficient quality as structural concrete. This developed recycling system is applicable to scrap and build of general buildings.

Zaidi *et al.* [21] reported on the results of mechanical properties of recycled aggregate concrete (RAC). The compressive strength for 100% replacement with 20 mm recycled aggregate reported a decrease up to 22.86% at 28 days age concrete. The compressive strength for recycled concrete is within the same range when compared to natural concrete.

Mirjana *et al.* [11] studied about the concrete made with natural aggregate concrete (NAC) as a control concrete and two types of concrete made with natural fine and recycled coarse aggregate. The compressive strength will be same, regardless of the replacement ratio of natural coarse aggregate (NCA) with recycled coarse aggregate (RCA). The same conclusion is valid for concrete tensile strength (splitting and flexural). Compressive stresses in concrete depend on the

quantity of recycled coarse aggregate replaced for all load phases. Increasing the quantity of recycled coarse aggregate up to 100% replacement increases the concrete compressive stress up to 25%.

Murali*et al.* [13] studied on mechanical properties of recycled aggregate concrete replaced with natural aggregate concrete. The test results showed that the compressive and split tensile strength of the recycled aggregate is observed to be lower than the natural aggregate. For 100% replacement, the compressive strength of recycled concrete was decreased by 18.76% when compared to natural concrete. The split tensile strength and flexural strength were also decreased by 9.55% and 17.39% respectively for 100% replacement with recycled aggregate.

Muneera*et al.* [12] investigated on properties of recycled coarse aggregates. Control concrete with water to cement ratio 0.5 were tested at 28 days curing. The test result is 27.6 MPa. For 100% replacement at an age of 28 days the compressive strength and split tensile strength were observed to be 19.1 MPa and 1.94 MPa respectively.

SudhirPatil*et al.* [18] reported the compressive strength of recycled aggregate concrete (RAC) is observed to be higher than the compressive strength of normal concrete when used up to 50 percentage. The compressive strength of concrete obtained by replacing with 50% of recycled concrete aggregate is almost same as that of normal concrete. Results of split tensile strength show that concrete has good tensile strength when replaced up to 25 % to 50 %.

Ryou*et al.* [15] studied about the characterization of recycled coarse aggregate using surface coating method. For all replacements of recycled coarse aggregate except 100%, the compressive strength will be same or higher than the control concrete strength. The same is the case with split tensile strength.

Sherif*et al.* [17] studied and discussed about the suitability of producing concrete with 100% recycled aggregate to meet strength requirements. The results are compared to that of a control mix. Compressive strength of concrete at 3, 7 and 28 days produced with the recycled aggregate was in the range of 41 MPa to 52 MPa.

Preeti*et al.* [14] studied the mechanical properties of RCA. The compressive strength of recycled aggregate concrete is lower than that of the natural aggregate concrete. The compressive strength decreases with an increase in recycled aggregate proportions of 25%, 50% and 100% at an age of 28 days.

Tushar*et al.* [19] reported about the properties of recycled coarse aggregates. The properties of recycled aggregate concrete for different combinations with natural aggregate concrete are compared. The compressive strength of RAC is slightly lower than the control concrete made from similar mix proportions. As per the test results, the use of recycled aggregate up to 30% do not affect the functional requirements of the structure.

The use of natural aggregate is very high in the present scenario. So, to reduce the consumption and scarcity of natural resources this recycled aggregate material is used. This is environment friendly and economical.

III. PROPERTIES OF MATERIALS

Concrete was prepared by mixing various constituents like cement, aggregate and water which are economically available.

A. Cement

Cement is a binder material, a substance used for the construction that sets, hardened and adheres to the other materials, binding them together. Ordinary Portland cement of 53 grades conforming to IS 12269 (1987)[1] was used throughout the work. Its properties are given in Table.1 and Table.2

B. Fine Aggregate

The fine aggregate used in this investigation was clean river sand, whose maximum size was 4.75 mm conforming to grading zone II of IS 383(1970)[2]. The purpose of the fine aggregate is to fill the voids which lead to increase in strength of concrete. Fineness modulus and specific gravity of sand were 2.92 and 2.67 respectively.

C. Coarse aggregate

In the present study, the coarse aggregate was used after soaking in water for 24 hours and then completely air dried. Locally available hard blue granite aggregate of maximum size 20 mm was used. The fineness modulus and specific gravity of coarse aggregate were 7.87 and 2.72 respectively.

D. Recycled aggregate

Recycled aggregate is obtained from old building construction and demolished waste (C&D) waste. In the present study, the recycled aggregate was used after soaking in water for 24 hours and then completely air dried. Maximum size of aggregate used was 20 mm. The fineness modulus and specific gravity of coarse aggregate were 7.42 and 2.79 respectively.

Table 1
Chemical Properties of cement

S. No.	Particulars	Test Results	Requirements as per IS:4031(1988)[3]
1.	Insoluble material (% by mass)	0.68	28.96 Maximum
2.	Magnesia (% by mass)	1.16	6.00 Maximum
3.	Sulphuric anhydride (% by mass)	1.73	3.00 Maximum
4.	Loss on ignition (% by mass)	1.15	5.00 Maximum

5.	Total chlorides (% by mass)	0.006	0.10 Maximum

Table.2
Physical properties of cement

S. No.	Particulars	Test Results	Requirements as per IS:4031(1988)[3]
1	Fineness as weight retained on IS 90micron sieve	5.5%	10% Maximum
2	Standard consistency (%)	30	
3	Setting time a) Initial (minutes) b) Final (minutes)	 155 225	 30 Minimum 600 Maximum
4	Soundness a) Le-chatlier method (mm) b) Autoclave method (%)	 1.0 0.026	 10.0 Maximum 0.8 Maximum
5	Compressive strength(MPa) (IS12269:1987) at 3 days at 7 days at 28 days	 39.61 50.05 63.60	 27 Minimum 37 Minimum 53 Minimum

E. Water

Water is the most important ingredients in concrete and a part of the mixing water is utilized in the hydration of cement to form the binding matrix and the remaining water acts as lubricant to make the concrete readily in pouring state. The water, which is satisfactory for mixing, can also be used for curing.

IV. Experimental work

A. Casting and Curing Concrete Specimens

The materials were weighed as per the mix proportions shown in Table.3 and the coarse aggregate was soaked in water for 24 hours before the mix, sand was dried under atmospheric condition. The required amount of coarse aggregate, fine aggregate, cement and water are taken aside and first water is poured into the mixer to make it wet then the coarse aggregate was fed into the concrete mixer followed by sand, cement and water were mixed uniformly. Cubes, cylinders are compacted on vibrating table having specification IS: 7246-1974[5] and poured on the wet floor so as to reduce water evaporation. Concrete was poured in 3 layers and compacted each layer to avoid voids. All specimens are retained for a period of 24 hours in moist air then the specimens are demoulded, marked and cured in fresh water for a period of 3, 7 and 28 days.

Table 3: Mix proportions

S. No	Ingredient	Standard concrete M 30 as per IS: 10262-2009[4]
1	Cement (OPC 53 grade)	400 kg/m^3
2	Fine aggregate	680 kg/m^3
3	Coarse aggregate	1211 kg/m^3
4	Water	186 *l*/m^3
5	Workability	45 mm slump

B. Testing of specimens

For cubes, compressive strength is found out and for cylinders split tensile strength is determined.

1. Compressive strength:

The specimen is placed in the compressive testing machine of capacity 2000 KN in such a manner that the load is applied to the adjacent side to the direction in which the cube is cast that is, not to the top or bottom side of the casting direction. The specification of the compressive testing machine is as per IS: 14858-2000[6]. The axis of the specimen is carefully aligned with the center of thrust of the spherically seated block which is brought to bear on the specimens for M 30 grade concrete. The load is applied without shock and increased continuously at rate of approximately 140 kg/sq.cm/min as specified in IS: 516-1959[7] until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied on the specimen is recorded and appearance of the concrete and any unusual features in the type of failure is noted

After the curing, specimens of 100 mm size cubes are tested, after ensuring surface dried condition for M 30 grade of concrete. The measured compressive strength of the specimen is calculated by dividing the maximum load applied to the specimen during the test by cross sectional area, calculated from the mean dimensions of the section as per IS: 1199-1959[8]. Average of three specimens is taken as compressive strength provided variation is not more than 15 % on the average. A total number of 54 cubes were cast and tested for M 30 grade concrete were tested as per IS: 516-1959[7].

Compressive strength = P/A

where P is ultimate compressive load and

A is area of cross section.

2. Split tensile strength:

Concrete tensile strength is one of the basic and important properties. The specimen used in splitting tensile strength is cylinder of 150 mm diameter and 300 mm in length. Generally, the concrete is very weak in tension due to its

brittle nature. Cracks are developed when subjected to tensile force. A total number of 54 cylinders for M 30 grade were casted, weighed and tested as per IS: 5816-1999[9].

Split tensile strength $= 2P/\pi dl$

where is diameter of the cylinder and

l is length of the specimen.

V.RESULTS AND DISCUSSIONS

A. GENERAL

The variation of compressive strength and split tensile strength were discussed in detail in the following sections**.**

Fig.1 represents the variation of compressive strength with percentage replacement of recycled aggregate. The compressive strength decreases with increase in % replacement of recycled aggregate. This decrease in compressive strength at 3, 7 and 28 days from 0% to 50% replacement of recycled aggregate was observed to be 13.9%, 16.1% and 15.5 %. Fig.2 represents the variation of compressive strength with age of concrete. At all replacement levels, the compressive strength increases with increase in age of concrete. At 0% replacement, the rate of increase in compressive strength observed from 3 to 7 days is 55.5% and from 7 to 28 days is 50%.At 50% replacement, the rate of increase in compressive strength observed from 3 to 7 days is 51.6% and from 7 to 28 days is 51.06%. Fig.3 represents the variation of split tensile strength with percentage replacement of recycled aggregate. The split tensile strength decreases with increase in % replacement of recycled aggregate. This decrease in split tensile strength at 3, 7 and 28days from 0% to 50% replacement is observed to be 18.19%, 17.24% and 15%. Fig.4 represents the variation of split tensile strength with age of concrete. At all replacement levels, the split tensile strength increases with increase in age of concrete. At 0% replacement, the rate of increase in split tensile strength observed from 3 to 7 days is 46.46% and from 7 to 28 days is 46.2%.At 50% replacement, the rate of increase in split tensile strength observed from 3 to 7 days is 48.14% and from 7 to 28 days is 50%.

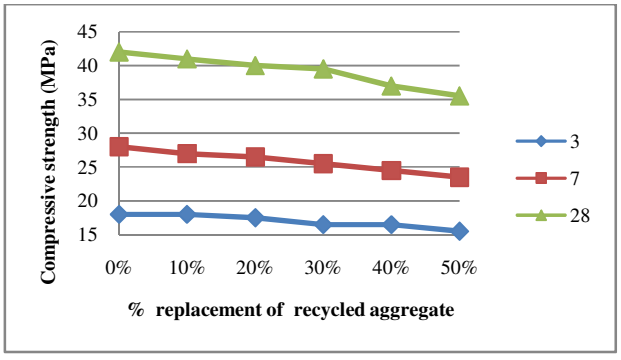

Fig.1 Variation of compressive strength with %replacement of recycled aggregate (RA)

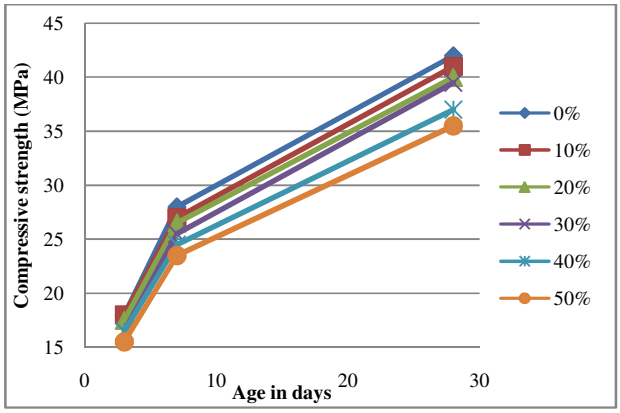

Fig.2 Variation of compressive strength with age of concrete

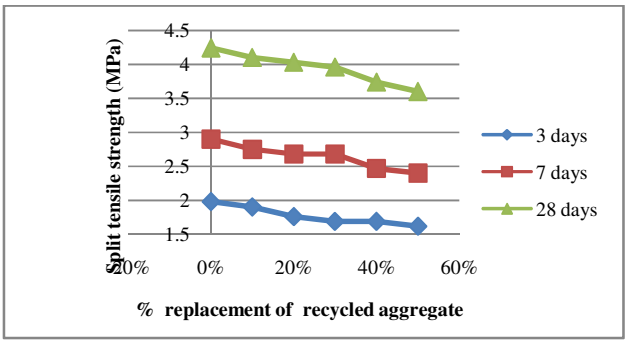

Fig.3 Variation of split tensile strength with %replacement of recycled aggregate (RA)

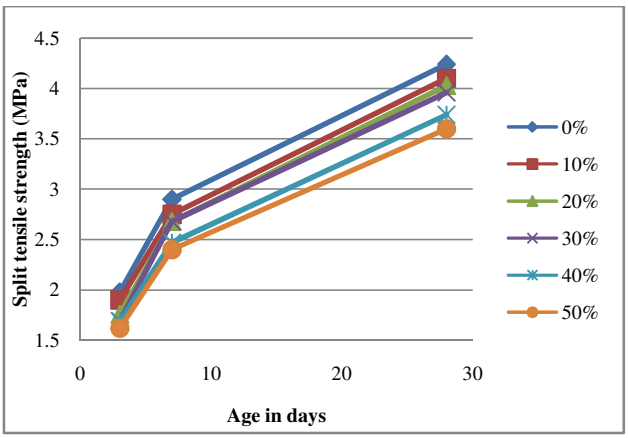

Fig.4 Variation of split tensile strength with age of concrete

VI. CONCLUSIONS

1. The compressive strength of natural aggregate concrete (virgin aggregate concrete) is always higher when compared with recycled aggregate concrete.
2. The compressive strength for all replacements of recycled aggregate from 0% to 50% was

decreased. The decrease was observed to be 15.5%.

3. The split tensile strength for all replacements of recycled aggregate from 0% to 50% was decreased. The decrease was observed to be 15%.
4. With increase in age of concrete, both compressive and split tensile strength also increases.
5. At different ages of concrete (i.e. 3, 7, and 28 days), the rate of increase in compressive strength observed for 3 to 7 days and 7 to 28 days was 51.6% and 51.06% respectively at 50% replacement of recycled aggregate.
6. At 50% replacement, the rate of increase in spilt tensile strength observed for 3 to 7 days is 48.14% and for 7 to 28 days is 50%.
7. Due to these slight variations in strength, the recycled aggregate can be used as concrete material in road constructions, pavements and retaining backfills

REFERENCE

1. *IS: 12269-1989, "Specifications for 53 grade ordinary Portland cement", Bureau of Indian Standards, New Delhi, India.*
2. *IS: 383-1970, "Specifications for coarse and fine aggregates from natural sources for concrete", Bureau of Indian Standards, New Delhi, India.*
3. *IS: 4031-1988, "Methods of physical tests for hydraulic cement", Bureau of Indian Standards, New Delhi, India.*
4. *IS: 10262-2009, "Recommended guidelines for concrete mix design", Bureau of Indian Standards, New Delhi, India*
5. *IS: 7246-1974. "Recommendation for use of table vibrators for consolidation concrete".*
6. *IS: 14858-2000. " Compression testing machine used for testing of concrete and mortar ".*
7. *IS:516-1959, "Method of test for strength of concrete", Bureau of Indian Standards, New Delhi, India.*
8. IS: 1199-1959." Methods of sampling and analysis of concrete".
9. *IS: 5816-1999, "Method of testing for split tensile strength of concrete", Bureau of Indian Standards, New Delhi, India*
10. *Limbachiya (2004), "Performance recycled aggregate concrete aggregate", RILEM International Symposium on Environmental Conscious Material and Systems for Sustainable Development.*
11. *MirjanaMalesev(2010), "Recycled concrete as aggregate for structural concrete production", Sustainability ISSN: 2071-1050, Vol.2 Issue Apr 2010, pp.12204-1225.*
12. *Muneera (2016), "Use of recycled aggregate in concrete", International Journal of science and Research (IJSR) ISSN: 2319-7064, Vol.5 Issue.8, Aug 2016, pp.1253-1255.*
13. *Murali (2012), "Experimental study on recycled aggregate concrete (RAC)", International Journal of Research and Applications (IJERA), Vol.2, Issue2, Mar-Apr2012, pp.407-410.*
14. *Preeti (2015), "A review on recycled concrete aggregates", SSRG International Journal of Civil Engineering (SSRG-IJCE) ISSN: 2348-8352, pp.71-75.*
15. *Ryou (2014), "Characterization of recycled coarse aggregate (RCA) via a surface coating method", International Journal of Concrete Structures and Materials, pp.165-172.*
16. *Sagoe (2001), "Performance of concrete made with commercially produced coarse recycled concrete aggregate", Cement and Concrete Research, 31(5), pp.707-712.*
17. *SherifYehia (2015), "Strength and durability evolution of recycled aggregate concrete", International Journal of Concrete Structures and Material ISSN: 1976-0485, Vol.9 Issue.2, Jun2015, pp.219-239*
18. *SudhirPatil (2013), "Recycled coarse aggregates", International Journal of advanced technology in civil engineering, ISSN: 2231-5721, Vol.2, Issue 2013, pp.27-33.*
19. *TusharSonawane, "Use of recycled aggregate concrete", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN: 2278-1684, pp.52-59*
20. *YasuhirDosho(2007), "Applications of recycled aggregate concrete produced by aggregate replacing method", Journal of advanced concrete technology, Vol.5, Issue Feb 2007, pp.27-42.*
21. *Zaidi(2009), "Assessment of recycled aggregate concrete, "Modern applied science, CCSE, Vol.3, Issue Oct 2009,pp.47- 54.*