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Comparative Study on the Properties of Concrete using Fresh and Recycled Aggregates

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***Abstract*: Concrete is the most abundant used man-made construction material in the world. It is made by mixing cementing materials, water, aggregate and sometimes admixtures in required proportions. Mixing of such naturally occurring material result in a partial solid mass, which can be moulded into any shape? It hardens like a rock mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for a long period and concrete, becomes stronger with age. Earlier the strength was emphasized without a thought on the durability of structures. The durability of concrete and concrete structures is has become a major concern. These are particularly reliable concrete structures which were constructed since 1970 or thereabout by which time (a) the use of high strength rebar's with surface deformations (HSD) started becoming common, (b) significant changes in the constituents and properties of cement were initiated, and (c) engineers started using supplementary cementations materials and admixtures in concrete, often without adequate consideration. The strength, durability and other characteristic of concrete subservient on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing. According to IS-456-2000, three grades of concrete are reputed: Ordinary concrete (M15-M20), Standard concrete (M35-M65), High strength concrete (M60-M100).**

For recycled aggregates to be used in structural concrete, it is essential to carry out an in-depth study of their material properties and analyze how these properties in turn affect the quality of the second-generation concrete.

1) **In this research the characterization of the properties of recycled aggregates has been studied and the structural behaviour of concrete made with different percentages of recycled coarse aggregates has been analysed through various tests like compressive strength test, Flexural strength test, split tensile test.**
2) **To analyse the structural behaviour of concrete made with different percentages of recycled coarse aggregates.**

The aim of this research is to acquire concrete which does not only concern on the strength of concrete but also to make the utilization of the (C&D) waste. From the experimental work undertaken in the present research it is observed that the construction and demolition waste when appropriately segregated and processed can be effectively used as recycled aggregates in making second generation concrete. A reduction in compressive strength of 4-10 percent at 28 days for M35 grade concrete has been noticed by using recycled aggregates in the proportion of 40 to 60 percent respectively. Recycled aggregates in size of 10 mm when incorporated along with coarse recycled aggregates of size 20 mm in concrete have found to further reduce the compressive strength up to 7.95% percent. The mechanical properties namely compressive strength, flexural and split tensile strength decrease with the increasing percentage of recycled aggregates. However, at 40 percent replacement of recycled aggregate not much significant difference is observed between normal and recycled aggregate concrete. Therefore, up to 40 percent recycled coarse aggregates may be used in the preparation of concrete.

***Keywords*: Construction Demolition(C&D), Recycled Aggregate (RA), Recycled Aggregate Concrete (RAC), Compressive Strength (CS), Waste Concrete Aggregate (WCA)**

1. Introduction

Construction and demolition waste is obtained whenever any (C&D) activity takes place. It is figured that the construction industry in India generates about 10-12 million tons of waste annually. Projections for building material requirement of the housing sector indicate a shortfall of aggregates to the extent of about 55,000 million m3. An additional 750 million aggregates would be required for achieving the targets of the road sector. Recycling of aggregate substantial from construction and demolition waste may reduce the demand-supply gap in both these sectors. Concrete and masonry waste can be recycled by classifying, crushing and sieving into recycled aggregate. This recycled aggregate can be put up to make concrete for road construction and building material. Presently in India this waste is disposed off in the landfill or used as an infill material. The poor management of solid waste has led to pollution of groundwater and surface water through leach ate. Unscientific practices in processing and disposal in reclaimed areas or river banks compound the environmental hazards posed by solid waste. With landfill spaces decrease and environment being destroyed, this inert waste needs a better strategy to manage. Thus with huge demand seen in construction industry and strategies present to fulfil the demand, an integrated and holistic approach involving design and construction engineering is required which respects the construction and economic environment of the country. Recycled aggregates are obtained from the demolished waste crushed concrete. From a quality point of view, these aggregates are heterogeneous in composition being derived from different minerals and adhered

mortar. The properties of these aggregates must be determined if they are to be used in concrete; therefore, the study of aggregates characteristic is important. The objective of this work is to analyze and propose technical guidelines on compressive strength, performance criteria and behavior of concrete made with recycled aggregates.

2. Methodology

The scope of work incorporated a rigorous experimental programme to establish the possible ways in which recycled aggregates could be used to provide a new concrete of M35 grade. The experimental program was conducted with a series of trial tests to ensure adequate strength gain with the new recycled material. The C&D waste was processed for removal of impurities to obtain the recycled aggregates from Rajasthan zones thus identified. Recycled aggregates therein were obtained by crushing of the old concrete produced from demolished sites. The material was first manually crushed and further crushed using a laboratory jaw crusher. The different properties of this recycled aggregate material were studied following to their site specific characteristics, as this influences the properties of concrete prepared. Finally, the material was used in preparation of concrete and the behaviour of such concrete was tested for compressive strength split tensile and flexural test. The sequential steps in which the behaviour of recycled aggregate concrete has been studied in the present work is shown.

A. Dry rolling

This method consists of dry mixing of recycled coarse aggregates in a rotary drum mixer of the capacity 2.5 cu-ft .10 kg of the agglomerated recycled aggregate sample (Rp) in saturated surface dry condition is placed in a rotary drum mixer. The drum mixer is rotated at a speed of 20 revolutions per minute for 20 minutes after which the aggregates are sieved and the loss in weight is measured.

Fig. 1. Rotatory Drum Mixer

1) *Compressive Strength:* The 'concrete cube test' is the most intimate test and is used as the standard method of measuring compressive strength for quality control purposes. The test was performed on cubes of 150 mm size. The cube specimens were cast using standard moulds and compacted by using vibrator. Test was performed as per Indian standard specification IS 516-1959, on the 24 cube specimen to find the compressive strength at an age of 7 and 28d. The compression testing machine used in this study was of maximum capacity 2000 kN. The load was applied without shock and increased continuously at a rate of approximately 14 MPa/min and the maximum load carrying capacity of the cube specimen was observed and considered as ultimate compressive load. The compressive strength test was performed at 7 and 28 days on two companion cylinders for each of the respective curing conditions.
2) *Flexural strength:* Flexural strength test was carried out as per Indian standard specification IS 516-1959 at an age of 28 on concrete beams of size 100 x 100 x 500 mm. The beams were cast by compacting the concrete mix in a detachable steel moulds in 3 equal layers. After 24 h, the beams were remoulded and cured in water. Universal testing machine of 400 kN capacity is used for determining the flexural strength of concrete beams. The load was applied perpendicular to the face of the specimen and applied without eccentricity. The load was increased until failure takes place and the maximum load applied was recorded. In all the specimens tested the failure was occurred at a distance of more than 133 mm from the nearer support.
3) *Split tensile strength:* Split tensile strength for each mix was evaluated by conducting split tensile test in cylindrical concrete specimen as per Indian standard specification IS 5816-1999 at an age of 28 days. Figure 4.3 shows the arrangement of split tension test setup. In this test a concrete cylinder of 150 mm diameter by 300 mm long, was placed with its axis horizontal between the platens of a compression testing machine and the load was applied without shock and increased continuously at a rate of 1.4 MPa/min until failure by splitting along the vertical diameter. The maximum load applied was then recorded.

3. Test results

Table 2
Workability of concrete at different % of RCA using natural aggregate

Replacement (%)	Slump Value
0%	96
40%	93
60%	80
100%	76

Table 1
Final mix proportions obtained per m^3 of concrete

Ingredients	Water	Cement	F.A	10mm	20mm	Admixture
Quantity	189 litres	460 kg	635kg	578.5 kg	619 kg	1.2
Ratio	0.43	1	1.6	1.36	1.54	0.003

Table 3
Compressive, Flexural strength and split tensile test result

S. No.	% Recycled aggregate	28 days Comp. Strength (MPa)	28 days Flexural Strength (MPa)	Split Tensile Strength (MPA)
1	0	45.17	6.17	4.56
2	40	43.02	6.09	4.22
3	60	38.45	5.87	4.17
4	100	35.63	5.33	4.03

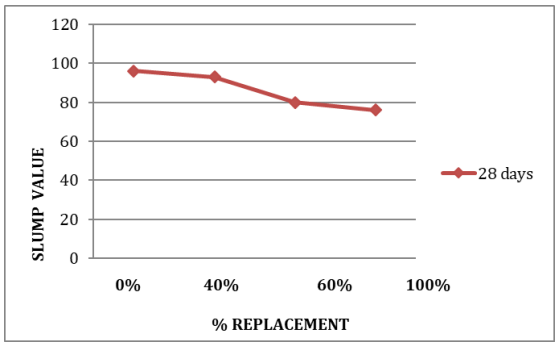

Fig. 2. Workability of recycled aggregate concrete

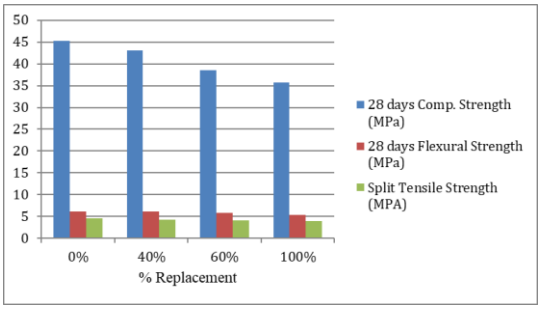

Fig. 3. Bar chart of compressive, flexural strength and split tensile test result

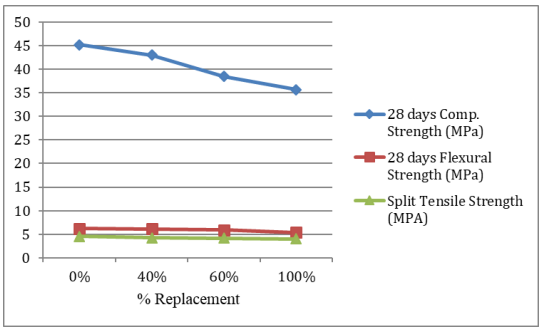

Fig. 4. Graph comparison b/w compressive, flexural strength and split tensile test result at 28 days

4. Summary and conclusion

From the experimental work undertaken in the present research it is observed that the construction and demolition waste when appropriately segregated and processed can be effectively used as recycled aggregates in making second generation concrete. However, replacement of normal aggregates by such recycled aggregates leads to reduction in the compressive strength of concrete. Therefore, up to 40 percent recycled coarse aggregates may be used in the preparation of concrete. Noticeable reduction in compressive strength is observed with increasing percentage of recycled aggregate beyond 40.

In M35 at 40% replacement level of natural coarse aggregate by recycled coarse aggregate following conclusions were obtained from this study:

- If we increase the content of recycle coarse aggregate, the workability tends to increase.
- In grade M35 at 40% replacement level of natural coarse aggregate by recycled coarse aggregate desired strength is achieved and if we increase the percentage of recycled aggregate more than 40% the strength will be decrease.
- The compressive strength of concrete made by using 40% of RCA is gives desired strength respectively, as compared to concrete made using natural aggregate at zero recycled aggregate content.
- The flexural strength of concrete made using 40% RCA is decrease by 22.47% respectively, as compared to concrete made using natural aggregate at zero recycled aggregate content.
- The split tensile strength of concrete made using RCA is lower by 17.42% respectively, as compared to concrete made using natural aggregate at zero recycled aggregate content.
- The compressive strength of concrete made using 40% RCA is 43.02(MPa) respectively.
- The flexural strength of concrete made using 40%RCA is 6.09(MPa) respectively.
- The split tensile strength of concrete made using 40%RCA 4.22(MPa) respectively.
- The slump of recycled aggregate mix concrete with natural aggregate decreases with increase in amount of recycled aggregate content with natural aggregates.

A. Future scope of work

- In future work, the effect of processing techniques and mixing approaches can be studied on other properties of concrete by using Brick Recycled Aggregate/Stone masonry.
- The investigation to establish the effect of quality C&D waste, obtained from different sources can also be made.
- The use of recycled aggregates in higher grade concrete can be studied.

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