Study on Performance of High-Volume Recycled Aggregate on Durability Studies of Industrial Waste Based Concrete

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Abstract- *Due to rapid growth in infrastructure and construction practices the demand of consumption of raw material is getting increases day by day which are to be used in concrete. the possibility of replacement of natural aggregates by recycled aggregates is not utilized sufficiently due to insecurities over the properties possessed by these. The research focuses on replacement of natural coarse aggregates in concrete with manually crushed recycled aggregates. Properties of recycled aggregates were studied and the average mortar content adhered to their surface was determined experimentally. The study presents the mix design for M50 grade concrete. Optimum value for recycled aggregate calculated. The results of strength test (compressive) conducted on Natural coarse aggregate concrete and recycled coarse aggregate concrete of M50 grade for normal water curing. This Project presents the effect of recycled aggregate curing on mechanical properties (compressive strength) of recycled coarse aggregate concrete of M50 grade. The experimental investigation also presents the durability studies like sulphate attack of recycled coarse aggregate concrete of grade M50.*

Keywords- Recycled coarse aggregate, compressive strength, split tensile strength test and flexural test.

I. INTRODUCTION

IIn a developing country like India, old and dilapidated structures are demolished for the purpose of building new and high rise structure to meet the population demand. As a result, considerably large amounts of debris and rubble get accumulated in cities. This waste generated during demolition is mainly in the form of aggregate and dust which are dumped into nearly empty pits or on lands, river beds, pasture lands and agriculture fields leading to wide spread environmental pollution. Development of infrastructure also increases the demand for production of concrete, which in turn increases the demand for supply of aggregates.

Lack of availability of good quality aggregates within reasonable distance brings out the need to identify sources of new aggregate. The waste generated in the region has the potential to meet the aggregate demands for construction activities. The twin objectives of conservation of natural resources and pollution free environment may be achieved if demolished concrete is effectively utilized. The new construction using the demolish waste as aggregate both fine and coarse in making new concrete will provide a solution to the present problem.

Waste arising from construction and demolition (C & D) constitutes one of the largest waste streams developed in many countries, of this a large proportion of potentially useful material disposed as landfill. The environmental and economic implications of this are no longer considered sustainable and as a result, the construction industry is experiencing more pressure than ever before to overcome this practice. On the other hand, in recent years the wisdom of continued wholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection.

The applications of recycled aggregate in construction have done by using demolished concrete pavement as recycled aggregate in stabilizing the base course for road construction. The use of recycle aggregate concrete in construction industry is advantageous and economical. The waste from construction and demolition work is of large volume and increasing in time.

To overcome this issue, sustainable concrete construction is one of the strategies to be considered by the construction industry. One way of achieving these is to introduce recycled aggregates from these wastes of construction and demolition works into the production of concrete. In some countries the government encourage the use of recycled and reuse materials for construction industry. The reuse of recycled aggregate (RA) is not a common practice in

construction industry. Nowadays there is depletion of natural aggregates and time will come where the sources of natural aggregate will soon decrease and will encounter a reduction in its supply.

There is a severe shortage of infrastructural facilities like houses, hospitals, roads etc. in India and large quantities of construction materials for creating those facilities are needed. The planning Commission allocated approximately 50% of capital outlay for infrastructure development in five year plans.

The research on finding out alternate materials in the concrete mainly coarse aggregate was recently started but production of these type of concretes for use in structural work would require careful and systematic processing, grading and testing of aggregate, essential for ensuring its acceptability in structural concrete. At the same time, considerable attention must be given to the control of quality. Due to a shortage in natural aggregate resources a change towards more sustainable production and consumption is urgently required. Utilization of alternative aggregate materials is one of the solutions.

The present work is aimed at assessing the suitability of percentage of recycled coarse aggregate as coarse aggregate in making of M50 grade concrete and evaluating its resistance to marine environment and durability.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength and impact resistance of concrete with different percentages replacement of coarse aggregate with recycled coarse aggregate.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

1. Workability
2. Compressive strength
3. Flexure strength
4. Tensile strength

II. REVIEW OF LITERATURE

Aggregate composed of recycled concrete generally has a lower specific gravity and a higher absorption than conventional gravel aggregate. New concrete made with recycled concrete aggregate typically has good workability, durability and resistance to saturated freeze-thaw action. Lack of widespread reliable data on aggregate substitutes can hinder its use. To design consistent, durable recycled aggregate concrete, more testing is required to account for variations in the aggregate properties. Also, recycled aggregate generally has a higher absorption and a lower specific gravity than conventional aggregate. Research has revealed that the 7-day and 28-day strengths of recycled aggregate concrete are generally lower than values for conventional concrete. Mandal et al. (2002) have found that there will be no affect on the concrete strength with the replacement of 30% of recycled aggregate. But the compressive strength was gradually decreasing when the amount of replacement of recycled aggregate increased. Hansen and Narad (1983) found that the compressive strength of recycled concrete is strongly correlated with the water-cement ratio of the original concrete if other factors are kept the same. When the water-cement ratio of the original concrete is the same or lower than that of the recycled concrete, the new strength will be as good as or better than the original strength, and vice versa. Aggregate composed of recycled concrete was reported to have a lower specific gravity and a higher absorption than conventional gravel aggregate.

A.N.Dabhade et al (2012) have conducted studies on performance evaluation of recycled aggregate used in concrete. From the outcome of experiments it was found that the replacement of 100% NA by RCA can be possible. The replacement of aggregate was carried out by 0, 20,40,60,80 and 100%. The different ratios of the water-cement ratio were used. The workability of concrete had come down with the increase in %of RCA.

Ashraf M. Wagih et al (2012) have performed study on Recycled Construction and Demolition Concrete Waste as aggregate for Structural Concrete. It is reported that the results showed concrete rubble could be transformed into useful recycled aggregate and used in concrete production with properties suitable for most structural concrete applications in Egypt. A significant reduction in the properties of recycled aggregate concrete (RAC) made of 100% RCA was seen when compared to natural aggregate concrete (NAC), while the properties of RAC made of a blend of 75% NA and 25% RCA showed no significant change in concrete properties.

Prof. Chetna M Vyas et al (2012) made studies on recycled aggregate concrete .Split strength had increased when natural aggregates were replaced by recycled coarse aggregates by 40% but modulus of elasticity decreases with replacement of natural aggregates.

R. Kumutha et al (2010) performed studies on Strength of Concrete Incorporating Aggregates Recycled from

Demolition Waste. It is observed that there is a possibility to use 100% crushed concrete coarse aggregates and 60% crushed brick fine aggregate in compression elements like concrete blocks and concrete pavements since the target strength can be achieved.

Ismail Abdul Rahman et al (2009) presented a case study on Assessment of Recycled Aggregate Concrete. It was reported that 100% of RA used in concrete mix to replace the natural coarse aggregate in concrete with 100 x 100 x 100 cube mm were cast with target compressive strength is 25 MPa. The 28-day compressive strength was assess at 3, 14, 28 days reported. It was found that the usage size of 10mm and 14 mm of RA in RAC is quite similar performance with 10mm and 14mm size of natural aggregate (NA) in natural aggregate concrete (NAC).

T. Pauline et al (2015) have done Experimental Studies on Concrete by Replacing Coarse Aggregates with Recycled Aggregates. Concrete mixes with a target compressive strength of 25MPa were prepared by varying normal coarse aggregate and recycled aggregates in percentages of 10% to 100% from the total aggregate. From the experimental studies, it was found that the compressive strength and tensile strength of concrete made with RA increased upto 60% replacement. The concrete of 50% to 60% replacement by RA showed an equivalent strength and with increase in percentage of RA above 60% the strength decreased.

Suchithra et al (2015) Performed Study on Replacement of Coarse Aggregate By E- Waste in Concrete. The replacement of coarse aggregate with E-waste in the range of 0%, 5%, 10%, 15%, and 20%, the mechanical properties and durability of the concrete mix specimens obtained from the addition of these materials is compared with control concrete mix. The test results showed that a significant improvement in compressive strength was achieved in the E-waste concrete compared to conventional concrete and can be used effectively in concrete, the reuse of E-waste results in waste reduction and resources conservation.

Prof. RoshanLal et al (2015) has done An Investigation on Strength Characteristic of Concrete Containing Recycled Aggregates of Marble Waste. The compressive strength, split tensile strength and flexural strength of specimens were tested for mixes containing marble waste recycled aggregates increased for replacement upto 30%. However for the 40%replacement of marble waste aggregate with natural aggregate a marginal decrease in compressive, split and flexural strength is recorded. Therefore it can be concluded that the production of concrete of normal strength is feasible and viable by replacing the natural aggregates by the marble waste aggregates without compromising the strength characteristics.

D.V. PrasadaRao et al (2014) have done Experimental Investigations of Coarse Aggregate Recycled Concrete. It was concluded that recycled aggregate concrete (RCA) has compressive strength comparable to the natural coarse aggregate concrete compressive strength for all grades of concrete at 3, 7, 28 and 90 days. This can be attributed to the cement mortar coat of RCA participates in hydration process and contribute additional strength. The durability property of concrete is determined using RCPT on the concrete specimens prepared with natural coarse aggregate and recycled coarse aggregate ,observed that as per ASTM C1202, the chloride penetrating rate is “high” for RCA concrete and “moderate” for NCA concrete for all grades of concrete.

Jitender Sharma et al (2014) presented a case study on Influence of Recycled Concrete Aggregates on Strength Parameters of Concrete. The tests were conducted by replacing the recycled concrete aggregates by 0,25,50,75 and 100 % replacement of natural aggregates. It was found that the compressive strength, split tensile strength and hardened density of concrete made with RCA decreases with increase in the percentage of recycled concrete aggregates.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Nano silica
5. Metakaolin

Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through

4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

Recycled coarse aggregate

It is now widely accepted that there is a significant potential for reclaiming and recycling demolished debris for use in value added applications to maximize economic and environmental benefits. Recycling industries in many part of the world, at present converts low-value waste into secondary construction materials such as a variety of aggregate grades, road materials and aggregate fines. Often these materials are used in as road construction, backfill for retaining walls, low-grade concrete production, drainage and brickwork and block work for low-cost housing.

While accepting the need to promote the use of RCA in wider applications, it must be remembered that the aggregate for concrete applications must meet the requirements set in relevant specifications for its particular use. The gap between these interests has to be reduced in steps that are manageable and the use of RCA in structural concrete has to be promoted gradually. Similarly considerable attention is required to the control of waste processing and subsequent sorting, crushing, separating and grading the aggregate for use of the concrete construction industry. In some developed countries C & D waste is now regularly recycled and reused, albeit mainly as fill, drainage and sub-base materials, and there is considerable scope for increasing this market and the use of these materials.

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M50.

V. RESULTS AND DISCUSSIONS

This session provides an outline of the experimental results and endeavors to draw some conclusions. The take a look at result covers the workability, mechanical properties and sturdiness properties of concrete with and while not admixtures.

5.1 REPLACEMENT DETAILS

The replacement details of nano silica and metakaolin has been given in the below table. The replacement of cement percentages by 0, 10, 20, 30, 40% with recycled coarse aggregate.

5.2 COMPRESSIVE STRENGTH

Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516:1959. The compressive strength is usually obtained experimentally by means of a compressive test.

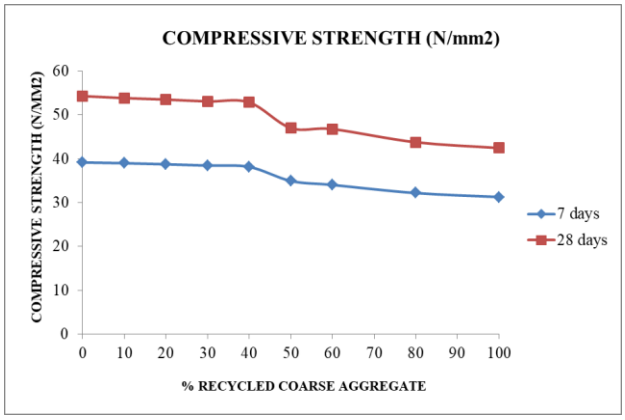

Fig 5.1 Compressive strength of specimens for recycled coarse aggregates

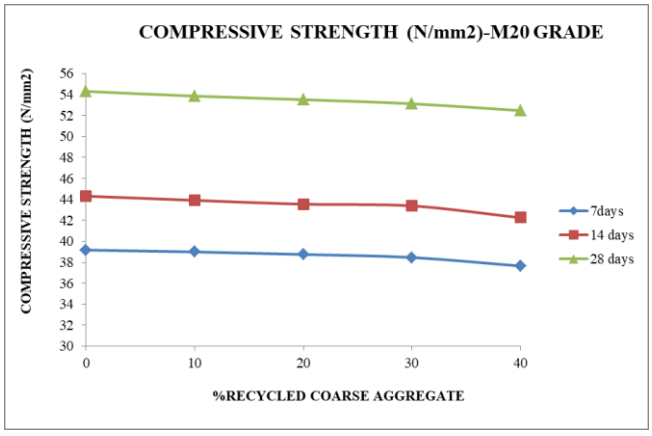

Fig 5.2 Compressive strength of specimens for recycled coarse aggregates for different curing periods

The figures shows that the test results of compressive strength of specimens for normal water curing, it is concluded that the loss of strength increases from 0% to 40% of replacement of RCA to compare with NCA but the maximum percentage of loss of strength was less than 3.4% and the test values was more than theoretical values.

5.2 SPLITTING TENSILE STRENGTH

The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per as per IS 516 (1959) and IS 5816 (1999).

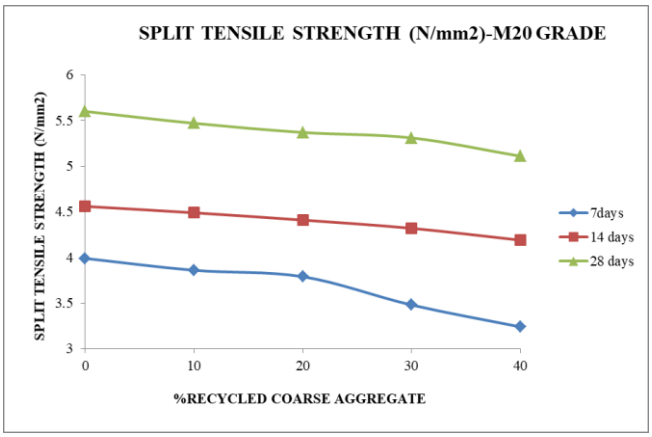

Fig 5.3 Split tensile strength of specimens for recycled coarse aggregates for different curing periods

The figure shows that the test results of splitting tensile strength of specimens for normal water curing, it is concluded that the loss of strength increases from 0% to 40% of replacement of RCA to compare with NCA but the maximum percentage of loss of strength was less than 8.5% and the test values was more than theoretical values.

5.4 FLEXURAL STRENGTH

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in normal water. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per as per IS 516 (1959). After 7 and 28 days curing, prismatic specimens are placed on flexural testing machine having a maximum of 100 KN and a constant rate of loading of 40 kg/m2 per minute is applied on the test specimen by placing the specimen in such a way that the two point loading should be placed at a distance of 13.3 cm from both the ends. Ultimate load at which the prismatic specimen fails is noted down from dial gauge reading.

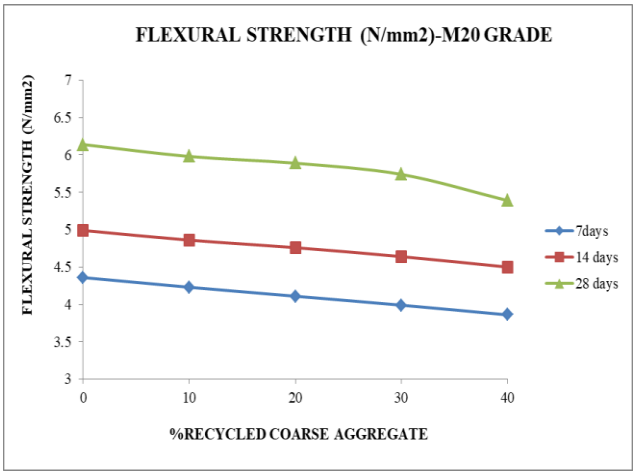

Fig 5.4 Flexural strength of specimens for recycled coarse aggregates for different curing periods

The figures shows that the test results of flexural strength of specimens for normal water curing, it is concluded that the loss of strength increases from 0% to 40% of replacement of RCA to compare with NCA but the maximum percentage of loss of strength was less than 12% and the test values was more than theoretical values.

5.5 DURABILITY TESTS AND RESULTS

In the present study, resistance to the acid attack of recycled aggregate concrete mixes was studied by immersing concrete cubes of size 100mm × 100mm × 100mm with 5% in a diluted Sulfuric acid (H2SO4 solution and maintaining constant pH throughout the curing period. After soaking cubes, in the aforementioned solutions for about 7, 14 and 28 days, the changes in mass, shape and strength were measured.

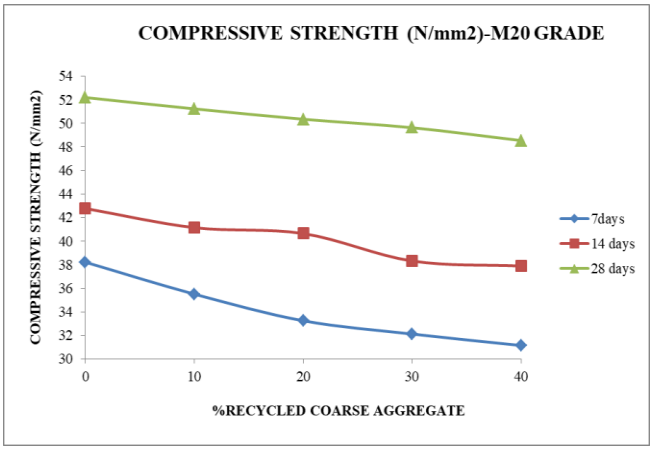

Fig 5.5 Compressive strength of recycled coarse Aggregate concrete immersed in Sulfuric acid

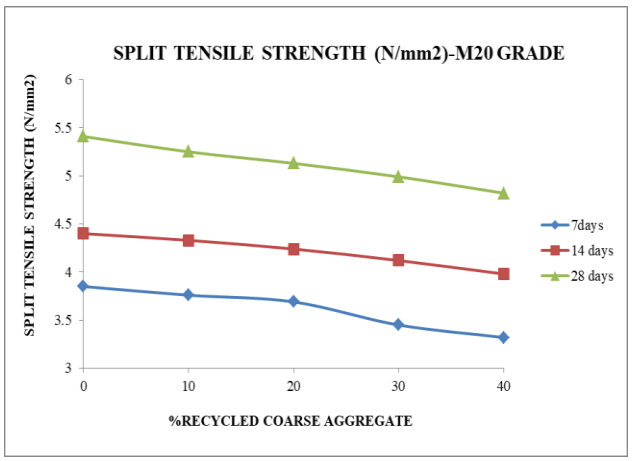

Fig 5.6 Split tensile strength of recycled coarse Aggregate concrete immersed in Sulfuric acid

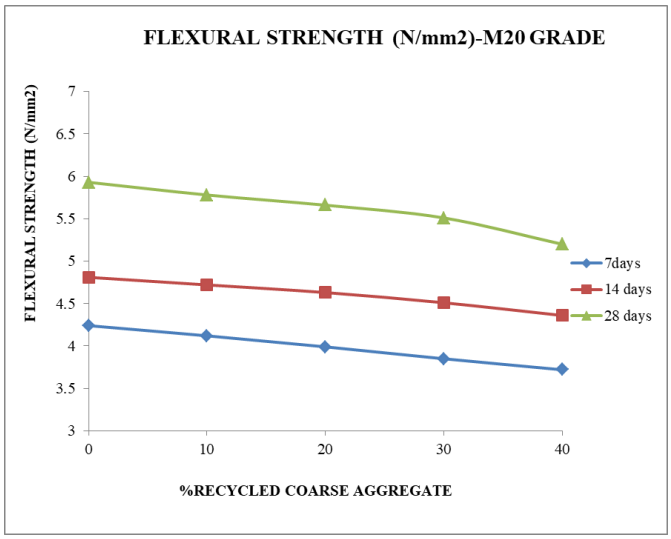

Fig 5.7 Flexural strength of recycled coarse Aggregate concrete immersed in Sulfuric acid

It is noted from the above graphs that when compared to conventional concrete, the recycle aggregate based concrete when immersed in Sulfuric acid. The above Figures from 5.9 to 5.11 show the Strength loss factor for all grades at 5% H2SO4 at 28 days. The strength loss factor is higher with increasing the percentage replacement of recycled aggregate with conventional concrete. The following Figures from 5.9 to 5.11 show the percentage of strength loss factor is increasing with the age of concrete.

VI. CONCLUSIONS

- Based on the results of the experimental studies on M50 grade concretes with recycled and natural coarse aggregates and river sand as fine aggregate and taking the effect of curing with normal water and Sulfuric acid the following conclusions are drawn.
- The Recycled aggregate satisfied the strength requirements for use as alternative to natural coarse aggregate in concrete making like concrete pavements.
- A significant reduction (i.e 10% to 27%) in the strength of recycled aggregate concrete (RAC) made of 50% to 100% RCA was found when compared to Natural Aggregate Concrete (NAC), while the strength of replacement of RCA from 10% to 40% showed no significant change in concrete strength.
- As optimum value of 40 % replacement of normal coarse aggregate with recycled coarse aggregate from 0% to 40% is suggested.
- Recycled aggregate is suitable for use as coarse aggregate in M50 grade concrete as it satisfied required workability and strength criteria upto 40% replacement.
- The loss of compressive strength increases for 0% to 40% of replacement of RCA concrete when to compare with NCA concrete but the maximum percentage of loss of strength was less than 3.4% in normal water curing.
- The loss of split tensile strength increases from 0% to 40% of replacement of RCA concrete when compare with NCA concrete but the maximum percentage of loss of strength was less than 8.5% in normal water curing.
- The loss of flexural strength increases from 0% to 40% of replacement of RCA concrete to compare with NCA concrete but the maximum percentage of loss of strength was less than 12% in normal water curing.
- The percentage weight loss and compressive strength loss of concrete in sulphate attack increases corresponding to the time and it is low value to compare with alkaline and acid attack.
- The percentage weight loss and compressive strength loss of concrete in alkaline attack increases corresponding to the time and it is high value to compare with sulphate attack.

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