Flexural Behaviour of Recycled Aggregate Concrete using Silica Fume

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Abstract— **The use of recycled aggregate concrete in structural concrete is a successful solution to reduce the demand of natural aggregate and the detrimental impacts of waste concrete to the environment. The presence study aimed to find the compressive strength, split tensile strength and flexural behaviour of recycled aggregate concrete using Silica Fume .The experimental research explained in this paper is performed to investigate the Flexural behaviour of recycled aggregate concrete beams when compared with the behaviour of natural aggregate concrete beam and consequently the possibility of using recycled aggregate in structural concrete element. The percentage of replacement is 25%, 50% and 75% of Recycled aggregate concrete with natural aggregate and Silica Fume is used as a cement replacement material at 8% weight of cement. The result obtained from the compressive strength and split tensile strength shows the using 25% of recycled aggregate using Silica Fume gives optimum strength.**

Keywords- RAC, Silica Fume.

I. INTRODUCTION

Recycled aggregate concrete (RAC) is the concrete made of Portland cement and recycled aggregates collected from demolished concrete structures. RAC has become one of the sustainable materials in concrete industry with a great application potential [9]. The shortage of space for construction and demolition waste disposal and high renting costs of landfills is becoming a common problem in urban areas [20]. One of the solutions to the problems related to disposal of construction and demolition waste and depletion of natural resources of aggregates is recycling of deposited building materials, primarily concrete. It can be processed so as to obtain the recycled concrete aggregate (RCA) for various applications, from using it in the pavement base to producing the structural concrete. Of course, recycling of waste concrete is not the aim in itself; it represents a technology of waste processing that has potentially environmental and economic advantages [3]. The major difference between RAC and regular concrete made of natural aggregate is that there exists a layer of residual cement paste on the surface of RAC, which results in poor mechanical properties of RAC. As a result, RAC has only been used sporadically as the main structural material. The residual cement paste has high water absorption capacity, high porosity, and weaker bond of interfacial transition zone (ITZ) between the residual cement paste and new cement paste. To use RAC as a structural material, various combinations of mixing approaches and surface pre treatment methods with different pre treatment materials were developed and optimized to improve the compressive strength of RAC [6]. To improve the strength of RAC, several methods have been developed. Tam et al. (2005) proposed a two-stage mixing approach (TSMA) for improving the strength of RAC made of up to 30% recycled aggregate (RA). In this method, a certain portion of water, cement, and additive (such as silica fume) were mixed with recycled aggregates first, which allowed the cementations slurry to coat the surface of recycled aggregates. After a certain curing period, the coated aggregates were mixed with the rest of the water, cement, sand, and additives. This method showed very encouraging results [4]. More over adding Silica Fume as a supplementary binder material can also improve the mechanical and physical properties of concrete prepared with recycled aggregate concrete. Many researchers have recently focused on the mechanical properties of RAC mixed with recycled aggregate was found that the flexural strength and elastic modulus of Recycled aggregate concrete become inferior to natural concrete with an increasing replacement rate of recycled aggregate , which mainly attribute to high water absorption and low strength of recycled aggregate. It has been reported that at recycled aggregate utilization levels of 25% has no negative impact was observed for the strength and workability [5].

II. EXPERIMENTAL PROGRAM

A. Materials Used

- Cement
- Fine aggregate
- Coarse aggregate
- Recycled aggregate
- Silica Fume
- Water
- Supper Plasticizers

B. Cement

Cement is a binder, it is a substance used for construction that sets, hardens and adheres to other materials, binding them together. In this study, Ordinary Portland Cement 53 grade is used conforming to Indian Standard IS 12269-1987.

C. Fine Aggregate

M-Sand is a substitute of river sand for concrete construction. Due to the depletion of good quality river sand for the use of construction, the manufactured sand has been used. These, Manufactured sand is produced from hard granite stone by crushing. The size of such manufactured sand is in between 4.75mm to 150 micron.

D. Coarse Aggregate

The natural coarse aggregate is mined from rock quarries or dredged from river beds. The maximum size of such 12.5mm aggregates and satisfying the grading requirements of BIS (IS 383-1970) were used.

E. Recycled Aggregate

Recycling of concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality. The quality of concrete with RCA is very dependent on the quality of the recycled material used. The size of recycled aggregate used is 12.5mm.

Figure 1 Recycled aggregate

F. Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. The PH value of water lies between 6 and 8 that indicate the water is free from organic matters. The Portable water from the college was used for mixing and curing throughout the project.

2.2 Tests on Materials

Table: 2.1 Physical properties of cement and aggregates

SI. NO.	**PROPERTY NAME**	
1.	Specific gravity of cement	3.15
2.	Specific gravity of fine aggregate	2.64
3.	Specific gravity of coarse aggregate	2.60
4.	Fineness of cement	6.5%
5.	Fineness modulus of fine aggregate	3.53
6.	Fineness modulus of coarse aggregate	3.92
7.	Water absorption of fine aggregate	2%
8	Water absorption of coarse aggregate	0.3%

Table: 2.2 Physical properties of Recycled aggregate

SL. NO.	**PROPERTY NAME**	
1.	Specific gravity of Recycled aggregate	2.21
2.	Water absorption of Recycled aggregate	0.8%
3.	Fineness modulus of Recycled aggregate	4.9

III. RESULT AND DISCUSSION

2.2.1 Testing of specimen

2.2.1.1 Compressive strength test

Compressive strength was evaluated by using Compression testing machine by casting 36 cubes of 15cm size mix for M50 grade of concrete. The test was carried out by initially clean the bearing surface of the testing machine. Then, Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. After aligning, apply the load gradually till the specimen fails. Finally, record the maximum load. The compressive strength was calculated based on the formula,

$$\text{Compressive strength} = P/A \quad N/mm^2$$

Where,

P - Load in N

A - Area of cube in mm^2

Fig 2.2 Compression testing machine for testing Cube

Table: 2.3 Compressive Strength for 14 days and 28 days

Compressive strength(N/mm^2)		
Percentage of RAC	14 days	28 days
0%	39.25	50.90
25 %	40.14	52.03
50 %	31.92	38.66
75 %	25.19	29.58

The Table: 2.3 shows about average strength of concrete at 14 and 28 days with the replacement of RA at various percentages. In this study, it is observed that about 25% replacement of RA for coarse aggregate provides maximum compressive strength with the constant 8% replacement of Silica Fume in Cement. Also, it shows that the strength of concrete will gets gradually decrease while increasing the percentage of RA in concrete. .

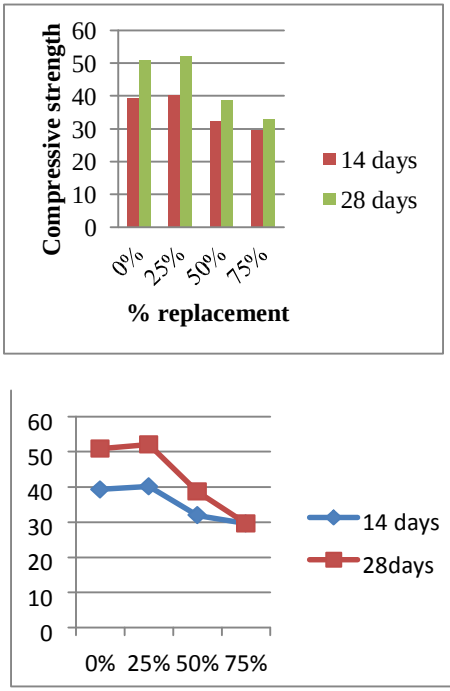

Fig.2.3 Variation of Compressive Strength with Percentage of RA Replacement

2.2.1.2 Split Tensile Strength Test

Split tensile strength was carried out by using Compression testing machine by casting 36 cylinders of 15cm x 30cm size mix for M25 grade of concrete. To evaluate the splitting strength initially, Clean the bearing surface of the testing machine. Then, the cylindrical specimen is placed in a manner that the longitudinal axis is perpendicular to the load. Apply the load gradually till the specimen fails. Finally, Record the maximum load. The Calculation of Splitting Tensile Strength of the Specimen is made by using the formula,

Split tensile strength, $f_t = (2P/\pi DL)$

Where,

P - Compressive load at failure in N
D - Diameter of cylinder in mm
L - Length of cylinder in mm

Fig.2.4 Compression testing machine for testing cylinder

Table: 2.4 Split Tensile Strength for 28 Days

Split Tensile Strength(N/mm^2)	
Percentage of RAC	28 days
0%	4.33
25 %	4.49
50 %	3.44
75 %	2.35

The table: 2.4 shows about average strength of concrete at 28 days with the replacement of RA at various percentages. In this study, it is observed that about 25% replacement of RA for coarse aggregate provides maximum tensile strength with the constant 8% replacement of silica Fume in cement.

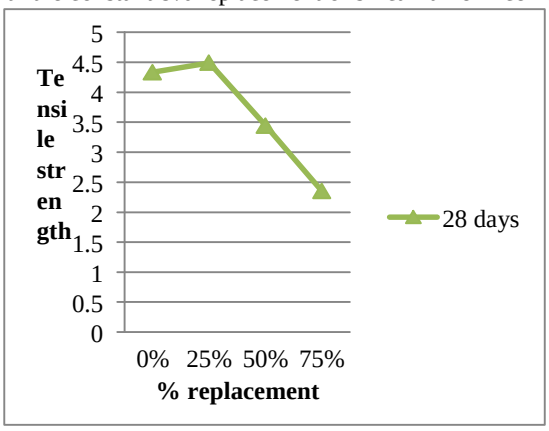

Fig.2.4 Variation of splitting tensile strength with percentage of RA replacement

2.2.1.3 Flexural strength test of concrete beams

For this test, the beams of dimension (150mm x 150mm x 1000mm) were casted. Modulus of rupture, Bending strength, or Fracture strength is also known as Flexural strength. A mechanical parameter for hard but liable to break easily (brittle material), is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The beam tests are found to be dependable to measure flexural strength.

The flexural strength of the beam = PL/BD^2 was deduced from the simple bending theory equation,

$$M/I = \sigma/y = E/R$$

Where,

P = Ultimate load in kN

L = Span length of the beam in m

B = Breadth of the beam in cross section in m

D = Overall depth of the cross section of beam in m.

IV. CONCLUSION

The literature review was studied and the methodology for the project was identified. This project help in reduction of the waste recycled aggregate produced on a day to day life. This waste is better utilized in the production of concrete. Reusing RA as a construction material is a promising way to lessen the amount of waste disposed in landfills across the globe also; it reduces the consumption of natural aggregate and minimizes the impact of the construction industry in the environment. Various tests on concrete materials and recycled aggregate are done and their properties were studied. The preliminary test results are within the range to be obtained. The compression strength of M25 grade of concrete cubes reached its maximum value of strength as per IS code 10262 – 2009. ix design is calculated for M50 grade concrete. From this test results, it is found that 25% of RA and 8% of Silica Fume with cement has more strength .And the strength has drastically reduced when adding 50% RA with Coarse aggregate.

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