

Flexural Behaviour of RC Beams with Recycled Aggregates



K. Ramadevi, M. Juhi Hephzibah Shalini

Abstract: Continuous raw material demand was increased in concrete productions which requires good quality and cost efficient alternative materials like Recycled Coarse Aggregate, M Sand and Glass as aggregate. This paper reports the behaviour of concrete using Glass aggregate as Fine Aggregate and Recycled aggregate as Coarse Aggregate replacement in concrete up to 15% and 30% respectively. In this project work, the concrete grade M25 was selected and IS method was used for mix design. The properties of Cement, M-Sand, Natural Coarse Aggregate, Glass as Aggregate and Recycled Aggregate were investigated. The Beam Specimens were casted with and without C&D waste (Coarse Aggregate Replaced with Recycled Aggregate at 30% and Fine Aggregates replaced with Glass Aggregate at 15%). Vibration Analysis were made by using FFT analyser to determine acceleration characteristics. The work is focused on possible conservation of natural resources by substituting with waste material by suggesting a possible reuse option for Construction waste.

Key words: C&D Waste, Recycled Aggregate, Glass Powder, and Vibration Analysis, FFT analyser.

I. INTRODUCTION

Coimbatore city Municipal Corporation says that population of the city is 10.09 lakhs and the quantity of garbage generated is 601 MT/day which includes debris concrete, steel, glass, plastic waste, broken concrete etc. Buildings demand more materials and our energy, but they also produce waste. The waste due to construction and destruction are generated during the construction, repair and disposal phases of a building. This includes waste from wrecked constructions, the renovations and wastes due to repair. Nowadays more attention is dedicated on the environment issues on waste and protection of natural resources like natural aggregates and reusing of wastes materials.

During recent years, consciousness regarding environmental atrocity has increased due to the interest of construction community in utilizing waste or recycled materials in concrete has also aggravated. If we see around us, we can see so many materials we consider waste which rather must be opportunities. When glass waste is crushed it

is like natural river sand since it is made from silica and it shows properties of an aggregate material.

II. OBJECTIVES

- To collect and process aggregates from C&D waste.
- To examine the physical properties of glass aggregate and recycled aggregate, compare the test results with river sand, M-sand and natural aggregates respectively.
- To Study the compression and of cement by utilising waste glass in various percentages (0%,5%, 10%,15%, and 20%) as replacement for fine aggregates.

III. MATERIALS USED

i) Cement

OPC of 53 grade conforming to (IS12269-2013) was used throughout the work. The results of tests done to determine the mechanical properties of the cement indicated its suitability for concrete works. The cement satisfies the requirement of IS: 8112-1989 The physical properties of the cement used in this investigation are shown in Table 1

Table 1 Physical Properties of Cement

Test conducted	Result	Requirements
Fineness	8%	Not exceed 10%
Specific Gravity	3.1475	3.10 to 3.15
Consistency	33%	26% to 33%
Setting time (Initial)	75 minutes	Shall not be less than 30 minutes

ii) fine aggregate

a) Natural Aggregates

River sand and M-sand passing through 4.75 mm IS sieve were obtained from local supplier.

b) Glass Powder

Waste glass were produced while demolition of buildings. Glass waste is found to be a very hard material. Glass waste has to be powdered to required size prior to adding in concrete. In this experiment, glass powder having particle size less than 2.36 mm was used.

Table 2 presents the physical properties of the fine aggregate used in this investigation.

Manuscript published on 30 September 2019.

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Table 2 Result of physical properties of the Fine Aggregate

Test conducted	Sample		Requirement
	M-Sand	Glass Powder	
Fineness modulus	3.11	2.65	2.2 to 3.2
Water absorption	1.9%	0.9%	0.5% to 2.0%
Specific Gravity	2.63	2.63	2.4 to 2.7
Moisture content	Nil	Nil	Less than 1 %

iii) Coarse Aggregates

a) Coarse Aggregate From Natural Resources

Aggregates obtained from crushed granite of size passing through 20mm and retained on 4.75mm I.S sieve as per IS: 383 - 1970 was used as aggregates.

b) Recycled Coarse Aggregate

Recycled aggregate was collected from waste concrete waste (washed in water) passing through 20 mm and retained on 4.75 mm I.S sieve as per grading requirements of IS: 2386 - 1983 were used as recycled coarse aggregate.

Table 3 presents the test results of physical properties of the coarse aggregate used in this investigation. The designations adopted are Sample 1 (Natural Aggregate) and Sample 2 (Recycled Aggregate).

Table 3 Result of Physical Properties of the CA

Test Conducted	Samples		Requirement
	1	2	
Water Absorption	0.8%	0.4%	0.1 % to 2.0%
Moisture Content	Nil	Nil	Less than 1 %
Crushing Strength Test	25.7%	27.6%	Not More than 30%
Aggregate Impact Value	30%	31%	Not More than 45%

IV. CONCRETE MIX DESIGN

Mix design as per IS: 10262 - 2009 for M25 grade concrete was done and the results are presented in Table 4.

Table 4 Concrete Mix Design

Weight	W/c	Cement	FA	CA
Kg/m ³	190	420	692	1143
Ratio	0.45	1	1.64	2.71

V. EXPERIMENTAL INVESTIGATION

Two number of beam specimens were cast and tested for flexure up to failure. These beams were cast for a span of 1.5 m, with simple supports and tested against two-point loading. Loads and corresponding deflections were recorded at the mid span and at 1/3rd of the span using analog dial gauges. Vibration Analysis of the casted RC Beams was done using Fast Fourier Transformer (FFT) analyzer was done.

HYSD steel bars of diameter 10 mm as the longitudinal reinforcement in the flexure zone and 8 mm diameter bars were used in the compression zone of the RC beam specimens. Vertical stirrups, 2 legged of 6 mm diameter at a spacing of 200 mm (at mid span) and 120 mm (at supports) center to center was provided as shear reinforcement.

The test specimen was cast in steel moulds. The raw materials were weighted accurately. The concrete was mixed thoroughly in dry condition in a concrete mixer. The lubricated oil was applied in the cast iron moulds. To ensure uniform mixing, 3 to 5 minutes mixing time was given. Then steel bars were tied and kept in to the mould. Fresh concrete is discharged into the beam mould in three layers, each layer was properly compacted.

After 24 hours, the specimens were removed from moulds and prepared for curing with potable water using gunny bags for 28 days. The test specimen was mounted in a Loading frame of 100T Capacity. The ends of the beam was rested on simple supports. The load was applied at two locations each 500 mm away from center of the beam headed towards the support.

Analog dial gauges with least count of 0.01 mm were used for measuring deflections under 1/3rd points and at mid span. Deflections were noted for corresponding loads until failure occurred. During testing, the performance of the beam was witnessed carefully. The first crack load, ultimate load and deflection at ultimate load were noted for both beams. Figure 1 shows the formation of cracks in the beam under testing.



Fig 1 Crack formation in the RC Beam

VI. VIBRATION ANALYSIS OF RC BEAMS

Beams comprising of both Conventional Concrete and E-Waste were tested under Vibration Analyzer Instrument and Frequency range for the RC beams was determined. Catastrophic failures indicate Cracks in the vibrating components. Hence, it is necessary to know the dynamics of cracked structures. Stiffness degradation of the structure occurs due to damage in a structure, and hence the natural frequencies of the structure also reduces consequently. Fast Fourier Transformer (FFT) Algorithm is used for measurement and indicative of vibration. The FFT Analyzer is a PC based virtual instrument. The location of natural frequency is represented by the peaks in the frequency response spectrum. The frequency curve was obtained using NVGATE software. Figure 1 shows the testing of RC beam using FFT analyzer.



Fig.2. Testing of C&D-Waste Beam using FFT Analyzer

VII. RESULT AND DISCUSSION

a) LOAD DEFLECTION BEHAVIOUR OF RC BEAMS

The RC Beams of Conventional Concrete and 30% replacement of reusable aggregate by coarse aggregate (15% replaced with glass powder as fine aggregate) were tested and Load - Deflection Behaviour of beams is represented in the following Figures 3 and 4.

Table 5 presents the test results of RC Beams with natural aggregates and RC beam with 30% recycled coarse aggregate under flexure.

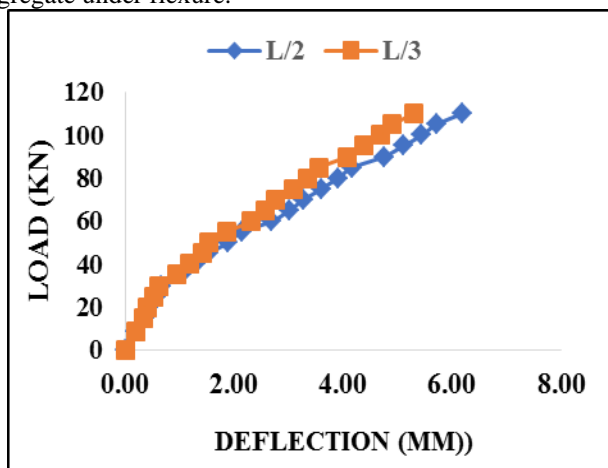


Fig 3. Load deflection behaviour on conventional concrete

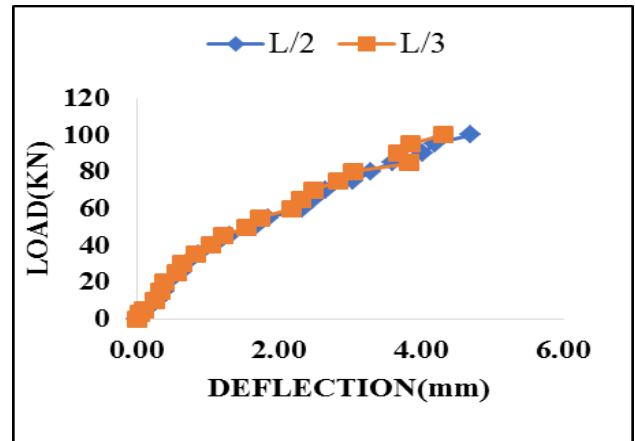


Fig 4. Load deflection behaviour on 30% replacement of C&D waste

Table 5 Test Results of Beams

Beam Test parameters	CM	M-30
First Crack Load (kN)	45	40
Ultimate Load (kN)	130	100
Initial stiffness of the Beam (kN/mm)	47.37	50
Stiffness at Ultimate Load (kN/mm)	15.19	21.28
Stiffness from Graph (kN/mm)	16.33	21.01

b) Vibration Analysis OfRc Beams

The test results of vibration analysis with frequency and acceleration variations is shown in Table 6.

Table 6 Vibration Analysis Results

Specimen ID	Frequency (kNm)	Acceleration ($\mu\text{m/s}^2$)
Control mix	4.087	174.4
M-15- 30	2.55	67.7

VIII. CONCLUSIONS

- For the same load the M-15-30 Beam indicated 5.76 % higher deflection than that of Conventional RC Beam.
- In the RC Beam Tests, the Ultimate Load Carrying Capacity for M-15-30 Beam is 100 kN which is 23.07% less than that of Conventional RC Beam.
- The first crack load for M-15-30 beam is found to be 40kN which is less than 11.11 % of Conventional RC Beam. This is due to the presence of recycled aggregate.
- Moreover, Stiffness of 30% replacement of coarse aggregate with recycled aggregate beam higher than the Conventional RC Beam.
- In the Vibration Analysis Test, the Frequency range of M-15-30 RC Beam is lesser than the Conventional RC beam.

➤ Moreover, the Acceleration of Conventional RC Beam is more than the M-15-30 RC Beam

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