# Experimental study on strengthening of concrete by partial replacement of coarse aggregate by construction and demolition waste by using Ansys software

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***Abstract:*** **The increasing generation of construction and demolition (C&D) waste has posed significant environmental challenges, necessitating sustainable solutions in the construction industry. This study investigates the potential of partially replacing coarse aggregate with construction and demolition waste in concrete to enhance its strength and sustainability. Experimental analysis was conducted to evaluate the mechanical properties of concrete, such as compressive strength, tensile strength, and flexural strength, at varying replacement ratios. In this study, different mixes of concrete were prepared by placing coarse aggregate with in Broken Tiles , Recycled Coarse aggregate , percentages of 5%, 10%, 15%, and 20% . To complement the experimental findings, advanced simulations were performed using ANSYS software to analyze stress distribution and deformation under load. The results demonstrate that partial replacement of coarse aggregate with construction and demolition waste can achieve comparable or improved structural performance while reducing the environmental footprint of concrete production. The ANSYS simulations validated the experimental data, providing insights into the material behavior and optimizing the replacement ratio. This study contributes to the development of sustainable construction practices and emphasizes the feasibility of integrating construction and demolition waste into concrete as a step toward circular economy principles.**

**Keywords: Demolished Concrete, Compressive Strength, Split Tensile Strength**

## I. INTRODUCTION

Concrete is the premier civil engineering construction material. Concrete is considered as brittle material, primarily because of its low tensile capacity and poor fracture toughness. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water and admixtures(s). Among all the ingredients, aggregates form the major part. Inert granular materials such as sand, crushed stone or gravel form the major part of the aggregates. Traditionally aggregates have been readily available at economic prices and of qualities to suit all purposes. But, the continued extraction of aggregates from nature has caused its depletion at an alarming rate. Many of the non-decaying waste materials will remaining the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. Use of this materials in such a rate leads to preservation of natural aggregates sources. In light of this in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete a sustainable and environmentally friendly construction material. Volume of demolished concrete is increasing because of the following factors:

i.Demolishing of structure for construction of new ones.

ii.Destruction of structures due to natural calamities.

These are some factors due to which billion tons of waste got produced every year. So the investigation we have conducted is about to evaluate the compatibility of productive waste (Demolished Concrete) in concrete production. These lead to the use of recycled aggregate in new concrete production, which is deemed to be a more effective utilization of concrete waste. However, information on concrete using recycled aggregate is still insufficient, and it will be advisable to get more detailed information about the characteristics of concrete using recycled aggregates.

## II. OBJECTIVE

The study explores the use of construction and demolition (C&D) waste as a partial replacement for coarse aggregates in concrete, aiming to promote sustainable construction practices. It assesses the material's physical and mechanical properties, and designs an optimized concrete mix with varying C&D waste proportions. The study uses ANSYS software to simulate and model the concrete's behavior under different loading conditions, comparing it to conventional concrete.The scope of work including knowing the strength parameters of concrete such as compressive strength, split tensile strength and flexural strength in which Recycled aggregate concrete(RAC) waste and Broken tiles(BT) waste replace with coarse aggregate by (5%+5%) , (10%+10%) , (15%+15%) and (20%+20%) using M25 grade of concrete

## III.. MATERIALS USED

### CEMENT :

Ordinary Portland cement is composed of calcium silicate, calcium aluminate and alumina ferrite. It is obtained by blending predetermined proportions lime stone clay and other minerals in small quantities which is pulverized and heated at high temperature-around 1500 degree centigrade to produce clinker. The clinker is then ground with small quantities of gypsum to produce a fine powder called Ordinary Portland cement (OPC).

Table 1 Properties of Cement

| Properties | Results |
|---|---|
| Specific Gravity | 3.15 |
| Fineness | 7.2% |
| Initial Setting time | 40 min |
| Final Setting time | 10 hours |

### AGGREGATE:

Normally Sand is used as fine aggregate for preparing concrete. An individual particle in this range is termed as Sand grain. These sand grains are between coarse aggregate (2mm to 64mm) and silt (0.004mm to 0.0625mm). Aggregate most of which passes through 4.75mm sieve is used. The Coarse aggregate for the work should be river gravel or crushed stone. Angular Shape aggregate of size is 20mm and below. The aggregate which passes through 75mm sieve and retain on 4.75mm are known as coarse aggregate.

Table 2 Properties of Fine Aggregate

| Properties | Results |
|---|---|
| Specific Gravity | 2.40 |
| Water Absorption | 0.8% |
| Fineness | 29.52% |

Table 3 Properties of Coarse Aggregate

| Properties | Results |
|---|---|
| Specific Gravity | 2.36 |
| Water Absorption | 0.5% |
| Fineness | 21.5% |

### BROKEN TILES

Broken ceramic tiles can be crushed into appropriately sized pieces and used as a partial or complete replacement for natural coarse aggregates in concrete. Due to their lower density compared to natural aggregates, broken tiles can produce lightweight concrete.making it suitable for mass concreting, while promoting eco-friendly and sustainable construction practices.

Fig.1 Broken Tiles

Table 4 Properties of Broken Tiles

| Properties | Results |
|---|---|
| Specific Gravity | 2.56 |
| Water absorption | 0.4% |

### RECYCLED CONCRETE AGGREGATE:

Recycled Concrete Aggregate(RCA) is a sustainable, cost-effective and environmentally friendly material for concrete production.By addressing challenges such as water absorption and quality variability, RCA can be successfully integrated into various concrete application reducing the environmental impact of construction while conserving natural resources.

Fig.2 Recycled Concrete aggregate

Table 5 Properties of Recycled Concrete aggregate

| Properties | Results |
|---|---|
| Specific Gravity | 2.66 |
| Water Absorption | 0.3% |

| Cement kg/m$^3$ | Fine Aggregate kg/m$^3$ | Coarse Aggregate kg/m$^3$ | Water kg/m$^3$ |
|---|---|---|---|
| 425.733 | 593.184 | 1119.184 | 191.58 |
| 1 | 1.39 | 2.4 | 0.45 |

## IV.EXPERIMENTAL METHODS

### 1.Concrete Mix Design

The mix design is done by the various proportions of materials for M25 grade concrete which is used in the present study. Then the mix design is designed as per IS 10262-2009 standards

Table 6 Mix Design Proportions

### 2. Casting of Specimen

Cubes of Size 150mm x150mm x150mm, Cylinder of size 200mm x 300mm , Beam of size 700mm x 150mm x 150mm were casted. The materials which are mixed by coarse aggregate, fine aggregate, cement, broken tiles, recycled concrete aggregate and water. After the moulds were casted and compacted. Demoulding was done after 24 hours of casting and specimens were allowed to cured in a water tank.

## V.CONCRETE TESTS AND RESULTS

### FRESH CONCRETE TESTS

SLUMP CONE TEST in M25 Grade Concrete

Table 7 Slump Cone Test

| S.NO | % Replacement | Slump (mm) |
|---|---|---|
| 1 | 0%BT + 0% RCA | 0 |
| 2 | 5%BT + 5%RCA | 60 |
| 3 | 10% BT + 10% RCA | 68 |
| 4 | 15% BT + 15% RCA | 75 |
| 5 | 20% BT + 20% RCA | 80 |

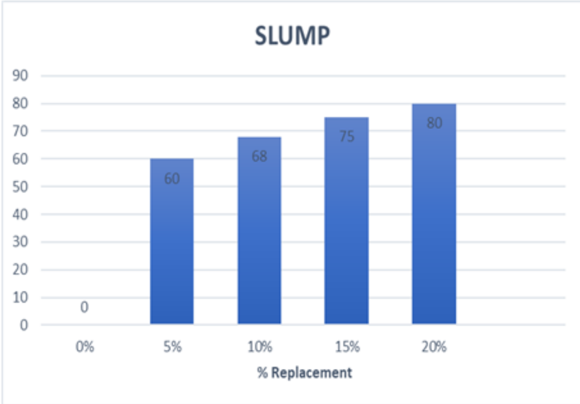


Fig.3 Slump Cone Test

COMPACTION FACTOR TEST in M25 Grade

Table 8 Compaction Factor Test

| S.NO | % Replacement | Compaction factor |
|---|---|---|
| 1 | 0% BT + 0% RCA | 0.89 |
| 2 | 5%BT + 5%RCA | 0.89 |
| 3 | 10% BT + 10% RCA | 0.88 |
| 4 | 15%BT + 15%RCA | 0.86 |
| 5 | 20%BT + 20%RCA | 0.84 |

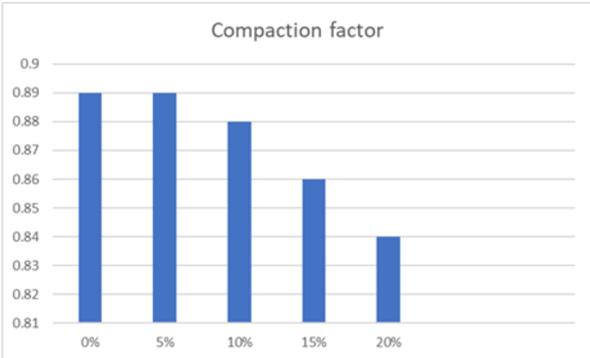


Fig.4 Compaction Factor

### HARDENED CONCRETE TEST

The individual variations of specimen was not more than ± 15 percent of the average. The specimen stored in water was tested immediately on the removal from the tank. The specimen were wiped off and the dimensions of the specimen and their weight were recorded before testing. The bearing surface of the testing machine were wiped clean the other materials, which may come in contact with the compression plates.

### COMPRESSIVE STRENGTH OF CONCRETE

Table 9 Compressive Strength Test

| S.NO | % Replacement | Compressive Strength | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0% BT+ 0% RCA | 18.5 | 24.25 | 32.61 |
| 2 | 5%BT+5%RCA | 18.9 | 24.8 | 32.91 |
| 3 | 10%BT+10%RCA | 19.2 | 25.3 | 33.5 |
| 4 | 15%BT+15%RCA | 18.21 | 25 | 32.71 |
| 5 | 20%BT+20%RCA | 17.78 | 24.51 | 32.43 |

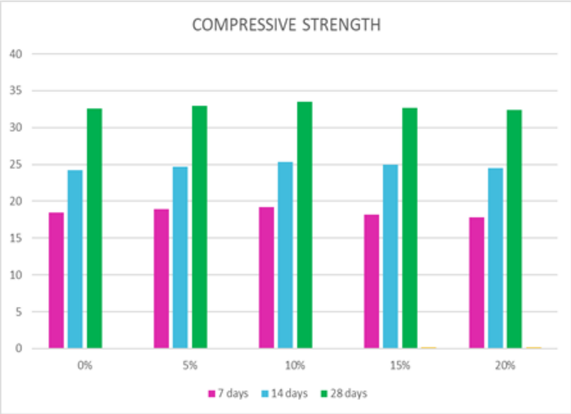


Fig.5 Compressive strength

SPLIT TENSILE STRENGTH TEST

Table 10 Split Tensile strength test

| S.NO | % Replacement | Tensile Strength | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0% BT + 0% RCA | 1.85 | 2.56 | 3.14 |
| 2 | 5%BT+5%RCA | 1.87 | 2.57 | 3.18 |
| **3** | **10%BT+10%RCA** | **1.95** | **2.59** | **3.26** |
| 4 | 15%BT+15%RCA | 1.92 | 2.45 | 3.19 |
| 5 | 20%BT+20%RCA | 1.90 | 2.48 | 3.15 |

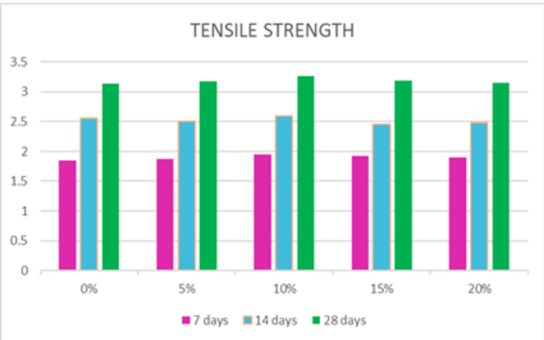


Fig.6 Tensile Strength Test

FLEXURAL STRENGTH TEST

Table 11 Flexural strength test

| S.NO | % Replacement | Compressive Strength | | |
|---|---|---|---|---|
| | | 7 days | 14 days | 28 days |
| 1 | 0%BT+ 0% RCA | 3.12 | 4.24 | 5.04 |
| 2 | 5%BT+5%RCA | 3.01 | 4.17 | 4.92 |
| 3 | 10%BT+10%RCA | 2.98 | 4.12 | 4.88 |
| 4 | 15%BT+15%RCA | 3.1 | 4.16 | 4.96 |
| 5 | 20%BT+20%RCA | 3.15 | 4.19 | 5.05 |

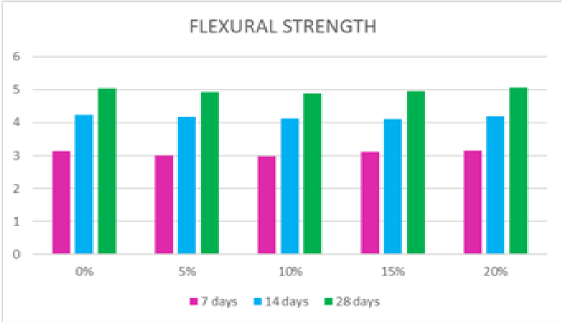


Fig.7 Flexural Strength Test

FLEXURAL STRENGTH RESULT BY USING ANSYS SOFTWARE

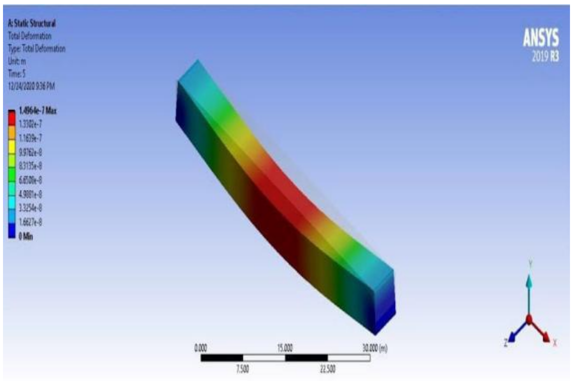


Fig.8 Flexural strength of Beam

## VI.CONCLUSION

This study investigated the effects of partially replacing coarse aggregate with construction and demolition (C&D) waste at 5%, 10%, 15% and 20% on the mechanical properties of concrete. Experimental tests conducted for compressive strength, flexural strength, and split tensile strength revealed that 10% replacement consistently achieved the highest strength in all three categories As the percentage of C&D waste increased beyond 10%, a gradual reduction in strength was observed, especially beyond 20%. However, up to 20%, the concrete still retained acceptable performance levels compared to conventional mixes.Finite Element Analysis using ANSYS software validated the experimental findings, showing similar stress distribution and failure patterns, confirming the structural integrity of the optimized mix.In conclusion, the study demonstrates that 10% C&D waste replacement is the most effective for enhancing concrete strength, while also promoting sustainability by reducing reliance on natural aggregates and minimizing construction waste.

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