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Behaviour of Concrete with Partial Replacement of Coarse Aggregate by Construction Waste

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Abstract - *In an experimental investigation, the impacts of partial replacement of coarse aggregate with waste material at various replacement percentages, including 10, 20, 30, and 40% over M20 grade concrete, were investigated. It was documented how these influences affected flexural strength, split tensile strength, and compressive strength. When compared to ordinary concrete, it was discovered that concrete with waste material in place of coarse aggregate had achieved good strength. Additionally, this was demonstrated to be environmentally benign due to the cost-effective disposal of the leftover stones.*
The building industry requires a lot of raw materials as the world's infrastructure continues to grow. The demand for raw materials rises in tandem with rising raw material usage. Therefore, we must identify a different supplier of raw materials. By replacing some of the coarse aggregate in this project with waste material (10%, 20%, 30%, and 40%, respectively), we are attempting to employ an alternative source for the material.
The waste product is a form of hard cement that has been lost due to environmental factors and is helpful for creating pavement for steps, corridors, and other applications.

Key Words: Waste Material, Concrete, Material, mold

1. INTRODUCTION

Replacing a portion of coarse aggregate in concrete with construction waste materials is a sustainable practice that can help reduce the environmental impact of construction. However, it's essential to ensure the structural integrity and durability of the concrete while using construction waste as a replacement. Here's a methodology and steps to replace a portion of coarse aggregate in concrete with construction waste as below:

(a) Identify Suitable Construction Waste Materials:

Analyze the construction waste materials available on your construction site or from a recycling facility. Common construction waste materials that can be used as aggregates include concrete rubble, bricks, tiles, and ceramic waste.

(b) Characterize Construction Waste Materials:

Conduct tests and analyses to determine the physical and mechanical properties of the construction waste materials. This information is crucial for assessing their suitability as aggregate replacements.

(c) Mix Design:

Develop a concrete mix design that incorporates the construction waste materials as partial replacements for coarse aggregates. The mix design should consider factors such as compressive strength, workability, and durability requirements.

(d) Quality Control and Testing:

Implement a rigorous quality control and testing program to ensure that the concrete meets the desired specifications. Test the fresh concrete for workability and the hardened concrete for compressive strength and durability properties.

(e) Determine Replacement Ratio:

Decide on the percentage of coarse aggregate that will be replaced with construction waste materials. This percentage should be based on the performance requirements of the concrete and the properties of the construction waste.

(f) Pre-processing of Construction Waste:

Depending on the nature of the construction waste materials, some may require pre-processing. For example, concrete rubble may need to be crushed to the desired size before use.

(g) Batching and Mixing:

Precisely weigh and batch the materials, including cement, fine aggregates, water, and the construction waste materials. Ensure thorough mixing to achieve a homogeneous concrete mixture.

(h) Placement and Curing:

Place the concrete in the desired formwork or molds and compact it to remove air voids. Proper curing is essential to maintain hydration and achieve adequate strength.

(I) Testing and Evaluation:

After the concrete has cured, conduct various tests to evaluate its performance, including compressive strength, shrinkage, and durability tests.

(g) Monitor Long-Term Performance:

Monitor the concrete's long-term performance to assess its durability and resistance to environmental factors. This may involve periodic inspections and testing over time.

(k) Documentation and Reporting:

Keep detailed records of the mix design, construction process, and testing results. This documentation can be valuable for future projects and quality assurance.

(l) Regulatory Compliance:

Ensure that the use of construction waste materials complies with local regulations and standards regarding environmental and safety concerns.

It's important to note that the replacement of coarse aggregate with construction waste materials may require adjustments to the mix design and careful consideration of the specific properties of the construction waste. Consulting with a structural engineer or materials expert with experience in sustainable construction practices is advisable to ensure the concrete's performance and longevity.

2. LITRATURE REVIEW

Kalra M. and Mehmood G. (2018) have studied Numerous factors, including cement type, coarse aggregate, and the interface between the aggregate and mortar, affect the strength of a concrete mix. However, the coarse aggregate is typically investigated mainly for its physical characteristics, such as shape, size, water absorption, and specific gravity. However, when we improve the mortar mix's quality, the strength of the coarse aggregate also becomes important. The type of coarse aggregate used has a significant impact on the strength and elasticity modulus of high performance concrete. The strength of mortar and the interfacial bond strength may be comparable for high-strength concrete with compressive strength exceeding 40 MPa, which is often cast with a water-cement ratio less than or equal to 0.4.

This study provides a thorough overview of previous studies on the impact of employing various types of coarse aggregate on the compressive strength, tensile strength, and elasticity modulus of concrete mixes.

Goyal M. & Goyal H. (2018)

The mechanical characteristics, longevity, and structural capabilities of recycled aggregate concrete (RAC) have been the subject of several studies. Both developed Asian and European nations as well as some of the former have used recycled aggregate in construction projects. We are aware that concrete is the primary building material used in all types of civil engineering projects worldwide. Recycling aggregate for construction projects will help to both address environmental issues and make up around 70–80% of the components of concrete. In this essay, a review of previous studies conducted by various researchers and an analysis of their findings have been made.

Kuldeep Dabhekar and Isha Khedikar (2020) carried out their study on the yhe greenery has been replaced by concrete mass due to increased building during the past ten years. We are unable to stop the abrupt population growth since people still need basic homes. We need a lot of coarse aggregate and fine aggregate since we need to build a lot of concrete mass. Sand and aggregates from naturally occurring sources will be exhausted as a result, harming the ecosystem. For improved architectural appearance, cladding material is preferred in futuristic construction methods. This is a heavy usage of granite, marble, and tiles.

These factors led to the repurposing of building waste, such as mosaic tiles, granite powder, and marble chips, in an effort to reduce excessive waste and the scarcity of natural material needed to make concrete.

The garbage from manufacturing factories and building deconstruction both contribute to the waste of mosaic tiles. To manage the scarce natural aggregate and reduce construction waste, this waste material must be recycled. The focus of this article is on determining the optimal ratio of different materials to use in place of both coarse and fine aggregate.

Singh et al. (2020) were studied and He created M25 grade concrete and tested it after 7 and 28 days with various replacement mixes containing 10% recycled coarse particles. The findings of the 28-day test are 28.07 N/mm2, 27.25 N/mm2, and 26.36 N/mm2. The findings showed that as aggregate substitution increases, concrete strength declines. Based on the findings, he came to the conclusion that a 20% aggregate replacement is ideal without compromising strength.

Khadka et al. (2021) performed their studies for the failure of several structures in Nepal before they reach their design life expectancy is attributable to the use of subpar construction materials by the authors, particularly low-quality cement concrete. to examine the impact of coarse aggregate sources on cement concrete's compressive strength. A compressive strength test was carried out using a UTM machine for a total of 48 cubes in order to determine the parameters of coarse aggregates from four chosen river sources. After testing the sources of coarse aggregate for their specific gravity, water absorption, loose bulk density, and aggregate abrasion values, it was discovered that they ranged from (2.56-2.79), (1568.38-1707.06) kg/m3, (1.76-1.94%), and (18.75-26.5) %, respectively.

All 48 samples' compressive strengths, which range from 20.64 N/mm2 to 32.47 N/mm2, were higher than the M20 grade's minimum strength requirement. The mean compressive strength of the sixteen combinations that were tested varied from one another. Chisang coarse aggregates outperformed other sources in terms of average compressive strength. The results of a two-way ANOVA analysis demonstrate that the mean compressive strength of concrete produced using various sources of coarse particles differs significantly. According to the study's findings, all sources of coarse aggregates and the concrete they produce can be used to construct residential buildings and other M20-grade concrete projects.

Geeta B. & Saleem A (2021) have been presented a review of the literature has been done to examine the characteristics, strengths, and properties of concrete using a variety of alternative aggregates for partial replacement of coarse aggregate, including coconut shell aggregates, tire rubber aggregates, glass waste aggregates, plastic aggregates, palm kerenal shell aggregate, recycled brick ballast aggregate, recycled concrete aggregate, and ceramic aggregates.

Here, reviews of research studies by various researchers are examined and collated. According to research, the use of alternate coarse aggregates significantly influences workability, strength, and durability qualities. Therefore, it is clear that using agro-industrial wastes as alternatives to coarse aggregates in concrete will benefit in protecting natural resources and preserving the ecological balance of the environment.

The problem facing the concrete industry in the future is the incorporation of more sustainable and alternative raw materials from appropriate waste streams. While biomass or other types of waste can take the role of regular manufacturing fuels [1].

A sustainable method that can help lessen the negative effects of construction on the environment while utilizing waste materials is to substitute some of the coarse aggregate in concrete with construction trash.

3. PROCESS OF MAKING CONCRETE BY PARTIAL REPLACEMENT OF COARSE AGGREGATE BY CONSTRUCTION WASTE

Collect Construction Waste Materials:

- Identify and collect suitable construction waste materials such as broken concrete, bricks, tiles, or other inert construction waste. Ensure that the collected waste materials are clean and free from contaminants.

Sorting and Preparation:

- Sort the collected waste materials based on their type and size. Remove any non-inert or non-recyclable materials.
- Crush or break down the waste materials into smaller, manageable sizes if necessary. This can be done using crushers or mechanical equipment.

Testing and Quality Control:

- Conduct tests on the construction waste materials to assess their physical and chemical properties. These tests may include particle size distribution, strength, durability, and contamination analysis.
- Ensure that the waste materials meet the required quality standards and are suitable for use in concrete.

Mix Design:

- Develop a concrete mix design that includes the partial replacement of coarse aggregate with construction waste materials. The mix design should consider factors such as the desired concrete strength, workability, and the proportion of waste material to be used.

Batching:

- Accurately weigh and measure the ingredients for the concrete mix, including cement, fine aggregate, water, and the construction waste material.

Mixing:

- Mix the ingredients in a concrete mixer according to the established mix design. Ensure thorough and consistent mixing to achieve a homogenous mixture.

Testing and Quality Assurance:

- Perform quality control tests on the fresh concrete mixture, such as slump tests and temperature monitoring, to ensure it meets the desired specifications.

Placing and Curing:

- Place the concrete mixture into the formwork or molds as per the construction requirements.
- Properly cure the concrete to maintain moisture and temperature conditions for a specified period to ensure good strength development.

Quality Control and Testing (Hardened Concrete):

- After the concrete has hardened, conduct tests on the hardened concrete specimens to evaluate its strength, durability, and other relevant properties.

Monitoring and Evaluation:

- Continuously monitor the performance of the concrete over time to assess its long-term durability and behavior.

Documentation and Reporting:

- Maintain records of the mix design, quality control tests, and performance evaluations for future reference and reporting.

3.1. Process to The Concrete Mix Design

CONCRETE MIX DESIGN

Grade designation = M20
Type of cement = OPC43 grade conforming to IS8112
Maximum nominal size of aggregate = 20mm
Workability= 75 mm (slump)
Water-cement ratio = 0.45

Above given are the mix proportions used in this project for M20 grade concrete:

4. TEST RESULTS AND DISCUSSION

Table-1: **Compression Strength Test values**

No. of Days of Curing		**7**	**14**	**28**
Compressive Test Value (N/mm^2) for different proportions	0%	21.95	29.98	33.85
	10%	20.63	28.74	32.50
	20%	19.98	28.78	30.05
	30%	19.80	27.30	29.86
	40%	18.69	25.02	29.00
	50%	17.75	24.15	26.15
	100%	13.50	18.50	21.20

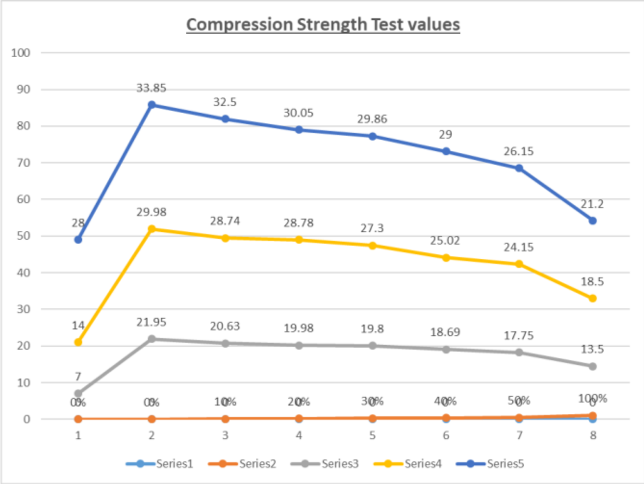

Fig.1. Compression Strength Test values

Table-2: **Flexural strength test values**

Percentage of Demolition Waste	**Flexural Strength for 28 days of curing (N/mm^2)**
0	10.95
10	10.5
20	10
30	9.75
40	9.25
50	9
100	6.75

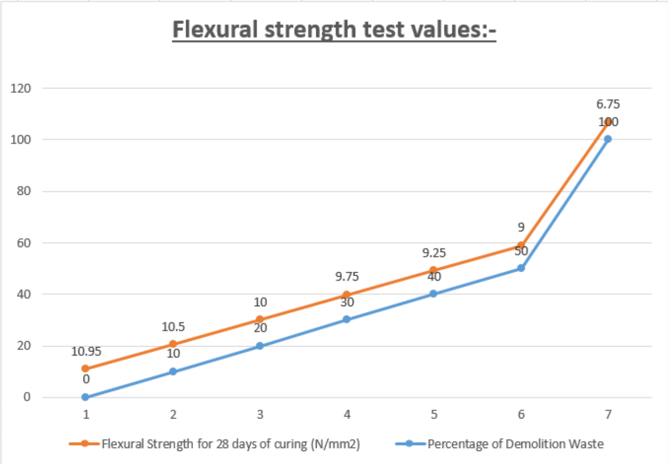

Fig.2. Flexural Strength Test values

Table-3: **Results for the Split Tensile Strength Test**

Percentage of Demolition Waste	Strength (N/mm^2) for 28 days of curing
0	3.42
10	2.98
20	2.78
30	2.65
40	2.39
50	2.15
100	1.75

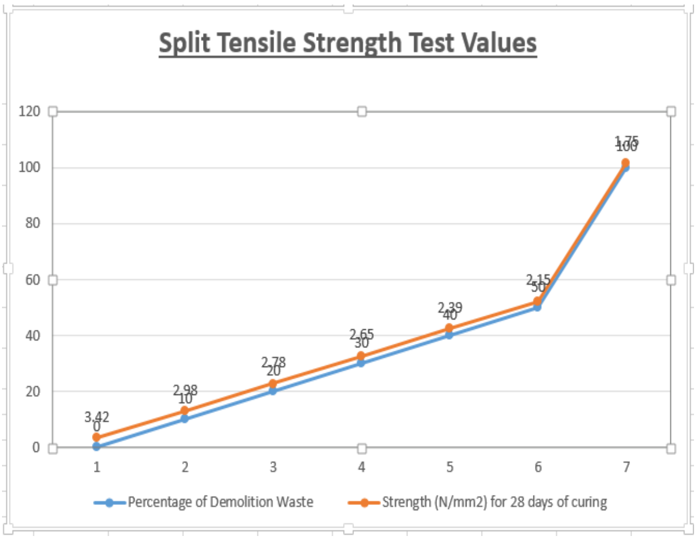

Fig.3. Split Tensile Strength Test values

4.1. Test On Materials

Table-4: **Specific gravity of Materials**

Type of Material	Specific Gravity
Cement	3.07
River Sand	2.57
Coarse Aggregate	2.75
Demolition Waste	2.47

Table-5**: Results for the Split Tensile Strength Test**

Percentage of Demolition Waste	Strength (N/mm^2) for 21 days of curing
0	3.01
10	2.42
20	2.14
30	2.06
40	1.97
50	1.78
100	1.32

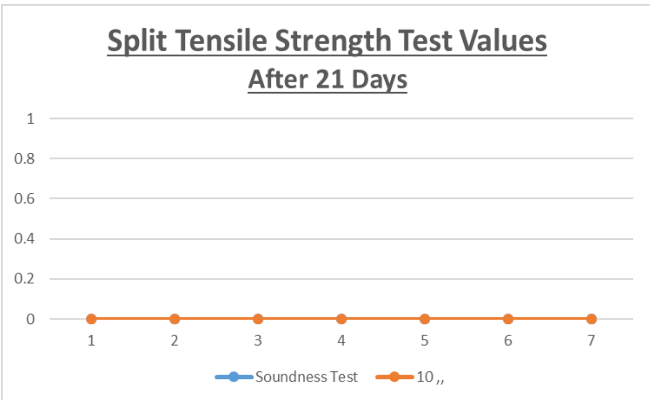

Fig.4. Split Tensile Strength Test values (after 21 days)

Table-6: Impact value on aggregate

Material	Impact value %
Coarse aggregate	15.05
Demolished waste	20.15

Fig-5. Demolished Concrete Waste

Fig-6. Flexural Strength Test

5. CONCLUSION

Based on the present work following conclusions can be drawn

1.Construction waste concrete, also known as recycled concrete aggregate (RCA), is a valuable resource that can have several positive environmental and economic impacts when managed properly. Here are some key conclusions regarding construction waste concrete:

2.Sustainable Resource: Construction waste concrete can be recycled and used as a sustainable alternative to natural aggregates in construction projects. This reduces the depletion of natural resources and the environmental impact associated with quarrying.

3.Waste Reduction: Recycling construction waste concrete helps divert large amounts of waste from landfills, reducing the strain on landfill capacity and decreasing the potential for environmental pollution.

4.Energy and Emissions Reduction: The recycling process typically consumes less energy and emits fewer greenhouse gases compared to the production of virgin aggregates from quarries. This contributes to a lower carbon footprint in construction.

5.Cost Savings: Using recycled concrete can be cost-effective, as it is often less expensive than virgin aggregates, reducing overall construction project costs.

6.Strength and Performance: Recycled concrete can exhibit similar strength and performance characteristics to natural aggregates when properly processed and used in construction. It can be used for various applications, including road base, structural concrete, and more.

7.Regulations and Standards: Many regions have regulations and standards in place to promote the recycling of construction waste, including concrete. Compliance with these regulations is essential for responsible construction practices.

8.Quality Control: To ensure the quality and performance of recycled concrete, proper processing, sorting, and quality control measures are crucial. This includes removing contaminants and ensuring proper gradation.

9.Durability Considerations: While recycled concrete can be a viable option, it's essential to consider its durability in specific applications and environmental conditions. Proper design and engineering are critical to ensure long-term performance.

In conclusion, construction waste concrete has the potential to be a valuable and sustainable resource in the construction industry when managed properly. By reducing waste, conserving resources, and lowering environmental impacts, it can contribute to more responsible and eco-friendly construction practices. However, it is essential to follow regulations, maintain quality control, and consider application-specific factors to maximize its benefits.

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