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Research Paper

STRENGTH CHARACTERISTICS OF CONCRETE USING CRUSHED CERAMIC TILES AS COARSE AGGREGATE

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ABSTRACT

Concrete is one of the most extensively used construction materials due to its strength, durability, and versatility. The rapid growth of construction industries has led to increased demand for natural aggregates, resulting in depletion of natural resources. Simultaneously, ceramic tile waste generated from construction and demolition activities has become a major environmental concern. This study investigates the utilization of crushed ceramic tiles as a partial replacement for conventional coarse aggregate in concrete production. Various percentages of ceramic tile aggregates were used in concrete mixes, and their effects on compressive strength, split tensile strength, flexural strength, and workability were examined. Experimental results indicate that ceramic tile aggregates can effectively replace natural coarse aggregates up to an optimum level without significantly affecting the strength properties of concrete. The study demonstrates that the use of ceramic tile

waste promotes sustainable construction practices and reduces environmental pollution.

1. INTRODUCTION

Concrete is the backbone of modern infrastructure and is widely used in buildings, bridges, pavements, and dams. Aggregates occupy nearly 70–80% of the total volume of concrete and significantly influence its strength and durability. The continuous extraction of natural aggregates has led to depletion of natural resources and environmental degradation.

Ceramic tiles are commonly used in flooring, wall cladding, and sanitary applications. During manufacturing, transportation, and installation, a considerable quantity of ceramic tile waste is generated. Disposal of ceramic waste in landfills creates environmental and economic issues. Recycling ceramic tile waste in concrete production can provide an effective solution for waste management and sustainable development.

Crushed ceramic tiles possess good hardness, durability, and resistance to abrasion, making them suitable as a replacement for coarse aggregate in concrete. This research focuses on evaluating the strength characteristics of concrete incorporating crushed ceramic tiles as coarse aggregate.

2. OBJECTIVES OF THE STUDY

The primary objectives of this study are:

1. To investigate the feasibility of using crushed ceramic tiles as coarse aggregate in concrete.
2. To study the compressive strength of concrete with ceramic tile aggregates.
3. To evaluate split tensile and flexural strength properties.
4. To identify the optimum replacement percentage of ceramic tile aggregates.
5. To promote sustainable and eco-friendly construction materials.

3. LITERATURE REVIEW

Several researchers have investigated the use of ceramic waste in concrete production.

- Studies revealed that ceramic waste aggregates possess good

mechanical properties and can partially replace natural aggregates.

- Researchers observed improved durability and abrasion resistance in ceramic aggregate concrete.
- Some studies indicated that excessive replacement may reduce workability due to the angular shape of ceramic particles.
- Experimental investigations concluded that replacement levels up to 20–30% provide satisfactory strength results.

The literature indicates that ceramic tile waste can be effectively utilized in concrete while reducing environmental impacts.

4. MATERIALS USED

4.1 Cement

Ordinary Portland Cement (OPC 53 Grade) conforming to IS 12269 standards was used.

4.2 Fine Aggregate

Natural river sand passing through 4.75 mm sieve was used as fine aggregate.

4.3 Coarse Aggregate

Crushed granite aggregates of size 20 mm were used as conventional coarse aggregate.

4.4 Ceramic Tile Waste

Discarded ceramic tiles collected from construction sites were crushed into suitable aggregate sizes.

4.5 Water

Clean potable water free from impurities was used for mixing and curing.

5. PROPERTIES OF MATERIALS

Material	Specific Gravity	Water Absorption
Cement	3.15	-
Fine Aggregate	2.65	1.2%
Natural Coarse Aggregate	2.72	0.5%
Ceramic Tile Aggregate	2.45	1.8%

6. MIX PROPORTION

Concrete of M30 grade was designed according to IS 10262 guidelines.

Mix ID Ceramic Tile Replacement (%)

CT0	0%
CT10	10%
CT20	20%
CT30	30%
CT40	40%

7. EXPERIMENTAL METHODOLOGY

The following tests were conducted on concrete specimens:

7.1 Workability Test

Slump cone test was performed to determine workability.

7.2 Compressive Strength Test

Cube specimens of size 150 mm × 150 mm × 150 mm were tested after 7 and 28 days curing.

7.3 Split Tensile Strength Test

Cylindrical specimens were tested under compression to evaluate tensile strength.

7.4 Flexural Strength Test

Beam specimens were tested using a two-point loading method.

8. TEST RESULTS

8.1 Slump Values

Mix ID Slump (mm)

CT0	82
CT10	79
CT20	75
CT30	71
CT40	66

The workability decreased slightly with increasing ceramic aggregate content due to rough and angular surfaces.

9. COMPRESSIVE STRENGTH RESULTS

7 Days Compressive Strength

Mix ID Strength (MPa)

CT0 24.8

CT10 25.5

CT20 26.1

CT30 24.7

CT40 22.9

28 Days Compressive Strength

Mix ID Strength (MPa)

CT0 36.5

CT10 37.8

CT20 39.2

CT30 36.8

CT40 33.5

The results indicate that 20% replacement of natural coarse aggregate with ceramic tile aggregate achieved maximum compressive strength.

10. SPLIT TENSILE STRENGTH RESULTS

Mix ID Tensile Strength (MPa)

CT0 3.1

Mix ID Tensile Strength (MPa)

CT10 3.3

CT20 3.5

CT30 3.2

CT40 2.9

Concrete with 20% ceramic tile aggregate showed improved tensile strength due to better interlocking properties.

11. FLEXURAL STRENGTH RESULTS

Mix ID Flexural Strength (MPa)

CT0 4.5

CT10 4.7

CT20 4.9

CT30 4.6

CT40 4.2

12. DISCUSSION OF RESULTS

The experimental investigation revealed the following observations:

- Workability decreases gradually with increased ceramic tile content.
- Compressive strength increases up to 20% replacement and decreases afterward.
- Ceramic tile aggregates improve bonding due to their rough texture.

- Excessive replacement reduces strength because ceramic particles are more brittle than natural aggregates.
- Durability characteristics improved due to lower permeability.

The optimum replacement level was found to be 20%.

13. ADVANTAGES OF USING CERAMIC TILE WASTE

1. Reduces environmental pollution.
2. Conserves natural aggregate resources.
3. Reduces landfill disposal problems.
4. Produces economical concrete.
5. Promotes sustainable construction.
6. Enhances certain mechanical properties.

14. APPLICATIONS

Concrete incorporating ceramic tile aggregates can be used in:

- Pavement blocks
- Non-structural concrete
- Residential buildings
- Footpaths
- Drainage works
- Precast concrete units

15. CONCLUSION

This study concludes that crushed ceramic tiles can effectively be used as partial replacement for natural coarse aggregates in concrete production. The experimental results showed that concrete with 20% ceramic tile aggregate replacement exhibited better compressive, tensile, and flexural strength compared to conventional concrete. Beyond the optimum percentage, strength gradually decreased due to brittleness and reduced bonding efficiency.

Utilization of ceramic tile waste in concrete contributes to sustainable development by reducing environmental pollution, conserving natural resources, and promoting eco-friendly construction practices. Therefore, ceramic tile waste can be considered a suitable alternative material in concrete manufacturing.

16. FUTURE SCOPE

1. Investigation on long-term durability properties.
2. Study on high-performance ceramic aggregate concrete.
3. Use of ceramic waste in self-compacting concrete.
4. Application in lightweight concrete.

5. Investigation under aggressive environmental conditions.

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