



PARTIAL REPLACEMENT OF COARSE AGGREGATE BY WASTE CERAMIC TILES AND BAMBOO FIBER AS REINFORCEMENT IN CONCRETE

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Abstract : This study explores the partial replacement of coarse aggregate in concrete with waste ceramic tiles and the incorporation of bamboo fiber as reinforcement. Waste ceramic tiles, an abundant byproduct of the construction industry, are proposed as a sustainable alternative to conventional aggregates, addressing both waste management and resource conservation. Bamboo fiber, known for its high tensile strength and eco-friendliness, is introduced as a reinforcing material to enhance the mechanical properties of concrete. The research aims to evaluate the impact of these replacements on the compressive strength, flexural strength, and durability of concrete. This approach promotes sustainable construction practices, reducing reliance on natural aggregates and offering a potential solution to waste management challenges in the construction sector.

Keywords – *Partial replacement of coarse aggregate, Cement, Ecofriendly concrete, Bamboo fiber reinforcement*

INTRODUCTION

The construction industry is a significant contributor to environmental degradation, primarily due to the extensive use of non-renewable resources and the generation of substantial waste. Concrete, as one of the most widely used materials in construction, presents an opportunity to address these challenges through innovative approaches.

This study investigates the potential of partially replacing coarse aggregate with waste ceramic tiles while incorporating bamboo fiber reinforcement in concrete. Waste ceramic tiles, which are often discarded in landfills, can serve as an effective alternative aggregate, thereby reducing waste and promoting resource efficiency.

Simultaneously, bamboo, known for its rapid growth and high tensile strength, offers an eco-friendly option for reinforcing concrete, enhancing its mechanical properties while minimizing the environmental impact associated with traditional steel reinforcement. By exploring the combined effects of these materials on concrete's performance, this study aims to contribute to the development of more sustainable construction practices. The objectives include evaluating the mechanical properties of concrete with varying percentages of ceramic tile replacement and bamboo fiber inclusion, as well as assessing the overall feasibility and benefits of using these innovative materials. Ultimately, this study aspires to pave the way for a more sustainable approach to concrete production, aligning with the growing demand for environmentally responsible building solutions.

SCOPE AND PURPOSE

The purpose of this study is to evaluate the feasibility of using ceramic tile waste as a partial replacement for coarse aggregate and bamboo fiber as a natural reinforcement in concrete, aiming to enhance its mechanical properties and sustainability. The scope includes developing optimized mix proportions, conducting tests on compressive, tensile, and flexural strength, as well as assessing water absorption and durability. This research also compares the cost-effectiveness and environmental impact of modified mixes with conventional concrete, supporting a sustainable approach to construction using industrial and agricultural waste materials.

CONSTITUENT COMPONENT

A – Cement

A cement is a binder, a substance that sets and hardens and can bind other materials together. Ordinary Portland Cement is a substance used for construction purposes. Cement is seldom used on its own, but rather to bind sand and gravel together.

For this research, Ordinary Portland Cement (OPC) of 53 grade was used, conforming to IS 8112: 1989, which specifies the requirements for OPC with a minimum compressive strength of 53 MPa after 28 days of curing.

B – Sand And Gravel

For this study sand (fine aggregate) and gravel (coarse aggregate) were procured at the native marketplace devoid of organic pollutants and meet the requirements of IS:383-1970[7].

Table 1:
Cement Characteristics.

Test	Results
Specific gravity	3.15
Consistency	34%
Fineness	8%
Initial setting time	76min
Final setting time	248min

Table 2:
Properties of fine and coarse aggregates

Test	Sand	Coarse aggregate
Specific gravity	2.71	2.84
Fineness modulus	3.861	3.71
Water absorption	0.6%	0.29%

Table 3:
Properties of Waste Ceramic Tiles

Test	Results
Specific gravity	2.96
Fineness modulus	3.53
Water absorption	0.15%

C – Water

In this work, potable water was utilized for the process of mixing and curing in accordance with IS:456-2000. Lower water to concrete ratio will yield stronger, more durable concrete, while more water will give a free-flowing concrete with a higher slump. Impure water is not taken to make concrete can cause problems when setting over in causing premature failure of the structure. The Ph value of water used was estimated to be 7.

D – Waste Ceramic Tiles

Waste ceramic tiles can be effectively used as a partial replacement for coarse aggregate in concrete, offering several beneficial properties. Incorporating ceramic tiles enhances the mechanical strength of concrete due to their rigidity and durability. The rough texture of crushed tiles improves the bond between the aggregate and the cement matrix, potentially increasing the overall strength

and stability of the concrete. Additionally, using ceramic tiles promotes sustainability by reducing landfill waste and the demand for natural aggregates. This substitution can also result in a lighter concrete mix, which can be advantageous in certain applications.

E – Bamboo Fiber

Bamboo fiber is increasingly recognized for its potential as a reinforcement material in concrete, offering several advantageous properties. First, bamboo fibers possess high tensile strength and flexibility, which can enhance the overall ductility and toughness of concrete, making it more resistant to cracking. Additionally, bamboo is lightweight, which can reduce the overall weight of the concrete mix, making it easier to handle and transport. Bamboo fiber can be used as a cost effective and sustainable reinforcement in concrete. Bamboo fiber is emerging as a sustainable and potentially cost-effective alternative to steel fiber in construction.

F - Admixture

Armix Ellecrete PC 5 is a Plasticizing, water reducing PCE based concrete admixture for regular grade of concrete. In this admixture is to produce high workability concrete requiring little vibration during placing. And also increased strength, higher cohesion, and chloride free. For normal grades of concrete a dosage from 0.4% to 1.0% by weight of cement is recommended. The dosage may increase to 1.5% to achieve specific slump requirement.

METHODOLOGY

1 – Mix design and preparation of concrete specimen

The mix design phase entails developing concrete mixtures that incorporate waste materials while meeting performance standards. A control mix will be established with no replacement of coarse aggregate and no bamboo fiber. Subsequently, various mixes will be prepared with different percentages of coarse aggregate replaced by crushed ceramic tiles (e.g., 0%, 10%, 20%, 30%) and varying amounts of bamboo fiber as reinforcement (e.g., 0%, 0.5%, 1%, 1.5%). The quantities of each material will be calculated based on the designed proportions for a standard batch size, usually 1 m³, following guidelines from IS: 10262-2009. This careful planning will ensure the mixtures are both workable and meet the desired strength criteria.

The mix proportions were calculated by weight and were mixed manually for each trial mix. After thorough mixing, concrete was poured into moulds to form cubes (150mm x 150mm x 150mm) and beams (500mm x 100mm x 100mm) for testing. The specimens were demoulded after 24 hours and were cured in a water tank for 7th and 28th days to achieve the required strength for testing.

2 – Testing of concrete specimen

To evaluate the performance of the different concrete mixes, a series of tests were conducted. Workability will be assessed through a slump test, compaction and vee bee test to determine the consistency of the concrete mix. Compressive strength will be tested on cube specimens at 7, 14, and 28 days, utilizing a compression testing machine to ascertain the maximum load-bearing capacity and calculate strength values in N/mm². Flexural strength tests will be performed on beam specimens for 28 days using a three-point loading method to determine the modulus of rupture. Durability assessments will include water absorption tests to evaluate porosity and water penetration resistance. After the curing period, the concrete specimens were tested for various strength and durability practices.

RESULT AND DISCUSSION

After following the testing phase, the collected data will be systematically analyzed to interpret the impact of the partial replacement of coarse aggregates and the addition of bamboo fibers on the properties of concrete. The results will be compiled and compared against those of the control mix. Graphs and tables will be prepared to visually represent the relationships between the percentage of ceramic tile replacement, bamboo fiber content, and the resulting mechanical properties of the concrete.

Table 4: Slump Test Result

Aggregate replacement (%)	Slump Value(mm)
0	15
10	42
20	56
30	78

Table 5: Compaction Factor Test Result

Aggregate replacement (%)	Compaction Factor Value
0	0.77
10	0.84
20	0.91
30	0.93

Table 6: Vee Bee Test Result

Aggregate replacement (%)	Vee Bee Seconds (s)
0	25
10	17
20	10
30	4

Table 7: Compressive Strength Test Result

Aggregate replacement (%)	Compressive Strength (7 days) (N/mm ²)	Compressive Strength (28 days) (N/mm ²)
0	22.41	33.62
10	26.82	36.33
20	26.10	35.21
30	23.12	31.60

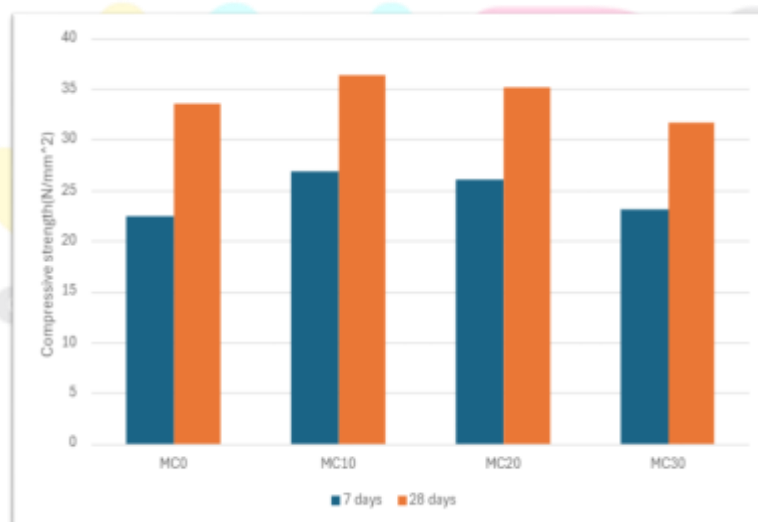
Fig 1: Compressive Strength at 7 days and 28 days in N/mm²

Table 8: Flexural Strength Test Result

Aggregate replacement(%)	Flexural Strength(7 days)(N/mm ²)	Flexural Strength(28days)(N/mm ²)
0	6.41	7.20
10	6.83	7.72
20	6.11	6.93
30	5.84	6.51

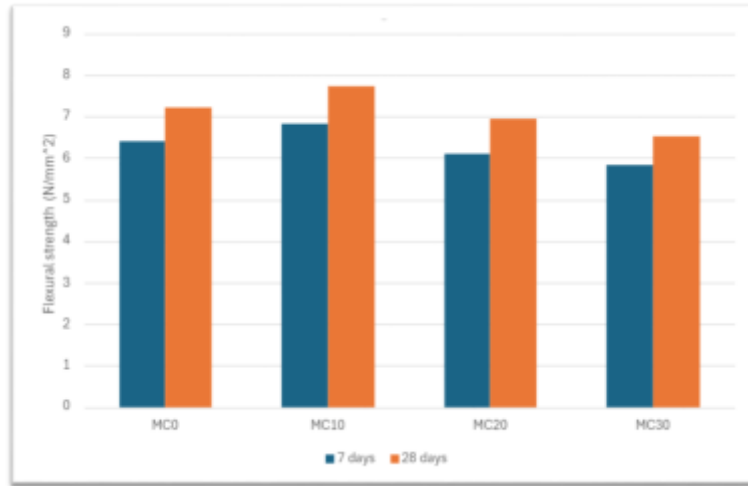


Fig 2:Flexural Strength at 7 days and 28 days in N/mm²

Table 9:Compressive Strength Result after addition of Bamboo Fiber

Addition of bamboo fiber(%)	Compressive Strength(7 days)(N/mm ²)	Compressive Strength(28days)(N/mm ²)
0	26.82	36.33
0.5	27.10	36.60
1	27.31	36.82
1.5	26.63	36.02

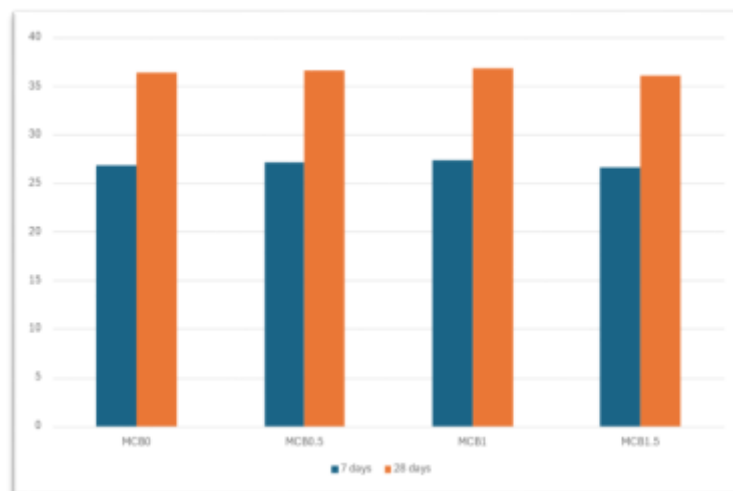


Fig 3:Compressive Strength after addition of Bamboo Fiber at 7 days and 28 days in N/mm²

Table 10: Flexural Strength Result after addition of Bamboo Fiber

Addition of bamboo fiber(%)	Flexural Strength(7 days)(N/mm ²)	Flexural Strength(28 days)(N/mm ²)
0	6.82	7.73
0.5	6.90	7.81
1	7.13	7.93
1.5	6.74	7.52

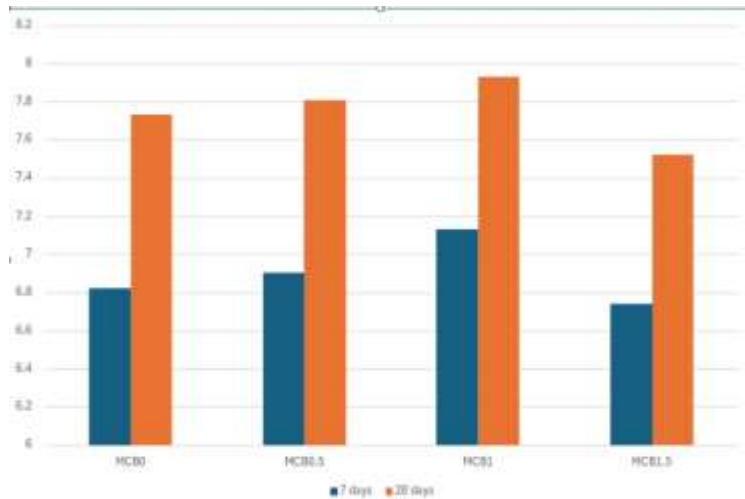


Fig 4: Flexural Strength after addition of Bamboo Fiber at 7 days and 28 days in N/mm²

Table 11 : Split Tensile Strength Result after addition of Bamboo Fiber

Addition of bamboo fiber(%)	Split tensile Strength(7 days)(N/mm ²)	Split tensile Strength(28 days)(N/mm ²)
0	1.72	2.83
1	1.96	3.24

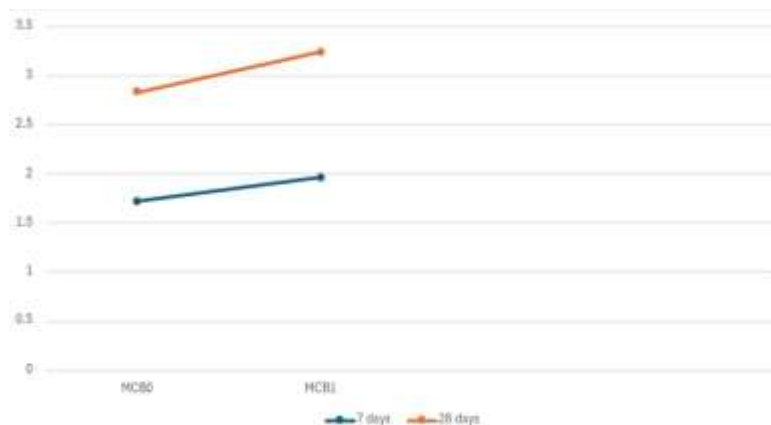


Fig 5 : Split Tensile Strength after addition of Bamboo Fiber at 7 days and 28 days in N/mm²

Table 12 : Water Absorption test Result

Ceramic tile replacement(%)	Bamboo fiber added(%)	Water absorption (%)
0	0	1.85
10	1	2.1

Discussion

The mechanical performance of concrete improved with the inclusion of ceramic tile waste and bamboo fiber, as reflected in compressive, flexural, and tensile strength results. Compressive strength increased over time for all mixes, with MC20 (20% ceramic tile replacement) achieving the highest strength at 28 days. Flexural strength followed a similar trend, with MC10 (10% replacement) showing the greatest improvement, indicating that partial ceramic tile replacement (10–20%) effectively enhances strength without compromising durability.

For Fiber-reinforced concrete, the addition of 1% bamboo fiber (MCB1) yielded the highest compressive (36.82 N/mm²), flexural (7.93 N/mm²), and split tensile (3.24 N/mm²) strengths at 28 days. However, increasing fiber content to 1.5% slightly reduced strength, likely due to poor bonding or increased voids. Water absorption was also marginally higher in mixes with ceramic tile and bamboo fiber (2.1%), potentially increasing drying shrinkage. Therefore, incorporating a water-reducing admixture or adjusting the water-to-cement ratio is recommended to ensure consistent performance while supporting sustainable construction practices.

CONCLUSION

The workability of concrete improves with the increase in the replacement of coarse aggregate with ceramic tile aggregate. Initially, both the compressive and flexural strength of concrete show an increase when the coarse aggregate is replaced with ceramic tile aggregate, up to a replacement level of 10%. However, beyond this 10% replacement, there is a noticeable decrease in both the compressive and flexural strength of the concrete. This suggests that while the inclusion of ceramic tile aggregate can enhance concrete's properties up to a certain limit, excessive replacement may lead to a decline in its strength. The compressive strength, split tensile strength and flexural strength of bamboo fiber reinforced concrete have been tested for the various proportion of bamboo fiber concrete.

The outcomes obtained specifies the strength of bamboo fiber reinforced concrete that increases with an addition of fiber up to 1% and slightly decreases after that. The test result obtained from the flexural strength shows that the bending strength increases with addition of bamboo fiber in the concrete up to 1% and slightly decreases after that. From the results it's concluded that bamboo fiber reinforced concrete provides added strength than conventional concrete

The cost analysis demonstrates that using ceramic tiles as a partial replacement in concrete reduces the overall cost of construction. The total cost for partially replaced concrete (₹43.28) is lower compared to normal concrete (₹45.11) due to the free availability of ceramic waste and a slight reduction in coarse aggregate cost. This approach not only minimizes construction expenses but also promotes sustainability by utilizing waste materials, thereby contributing to environmental benefits and efficient waste management. Hence, incorporating ceramic tile waste in concrete can be a cost-effective and eco-friendly alternative for the construction industry.

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