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PARTIAL REPLACEMENT OF FINE AGGREGATE WITH WASTE CERAMIC TILE IN CONCRETE

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ABSTRACT

The construction industry continues to make advances in innovation and improvement, which has led to a substantial increase in the usage of natural aggregates in construction projects. Concurrently though the amount of solid trash generated by the demolition of structures has reached an all-time high. This is a never-before-seen phenomenon. Reusing demolished building materials such as ceramic tile and granite powder has been proposed as a way to reduce solid waste and mitigate the shortage of natural aggregates necessary to manufacture concrete as a result of these causes. This was done to reduce the amount of solid waste and the amount of solid garbage. In addition to building demolition, the manufacturing facility also contributes to the production of waste ceramic tile. Several studies indicate that between 20 and 30 percent of the raw materials handled in tile production facilities are lost as waste. This waste material should be forced to be recycled so that we may use the limited natural aggregate resource more efficiently and reduce the amount of waste generated by the construction industry. In lieu of coarse and fine aggregates, numerous types of waste ceramic tile are used, including crushed waste ceramic tile, powder made from crushed waste ceramic tile, and other waste ceramic tile. To the extent of 35 %, coarse aggregates were partially substituted with ceramic waste-based tiles. These tiles were included into the production of aggregates. In place of fine aggregate, 25 %, 30 %, and 35 % of ceramic tile powder and ceramic coarse tile were utilised, accordingly. The construction industry one of the largest consumers of natural resources leading to significant environmental challenges. the sustainable practices are being explored. including the use of waste materials as partial replacements for conventional aggregates in concrete production. This study investigates the feasibility of using waste ceramic tiles as a partial replacement for fine aggregates in concrete aiming to reduce environmental impacts and enhance resource efficiency.

Keywords: Ceramic tile, fine aggregate, solid garbage

INTRODUCTION

Construction sector consistently looks for affordable and sustainable materials to tackle issues related to resource shortages and environmental challenges. One innovative method involves partially substituting fine aggregate in concrete with discarded ceramic tiles. Ceramic waste, an output from manufacturing and demolition activities, is plentiful and frequently disposed of as landfill material. Its incorrect disposal leads to environmental harm, such as soil contamination and the depletion of important resources. Ceramic waste has physical and chemical characteristics comparable to those of natural fine aggregates, rendering it a feasible substitute in concrete manufacturing. Employing ceramic waste decreases the need for natural aggregates while also encouraging recycling and waste management. This method is in harmony with the tenets of sustainable building, providing possible advantages like cost efficiency, minimized ecological impact, and enhanced material performance. The replacement of fine aggregate with ceramic tile waste in concrete has been shown to influence the mechanical and durability properties of the material. Researchers aim to optimize the percentage replacement to ensure that the resulting concrete meets the required standards for strength and performance. This study about feasibility, environmental impact and economic benefits of waste ceramic tiles in concrete as a partial replacement for fine aggregate. Concrete is the construction material that is used in the construction projects. A large increase in the amount of concrete that is being used is being driven by the growth of infrastructure and the expansion of building activities across the world. The information shown in demonstrates that waste ceramic tile is produced not only during the demolition of buildings but also during the manufacturing process. The use of crushed tile and tile powder as a replacement for the fine and coarse aggregates is described in. Broken tiles and powdered ceramic debris were gathered after the surrounding area was thoroughly searched and examined. In a similar vein, the attention of certain researchers is currently being directed on credible evidence. Powder is used in place of the coarse aggregate, and crushed tiles are used in place of the fine aggregate . These crushed tiles and tile powder were used to replace the fine and coarse aggregates separately, as well as in combinations, such as the replacement of coarse and fine aggregates at the same time in a single mix. Moreover, these crushed tiles and tile powder were also employed in conjunction with one another. Tile waste that has been crushed is utilised at a rate of 35 % as a partial replacement for coarse aggregate. In addition, a percentage of crushed ceramic powder equal to 25 %, 30 %, or 35 % of fine aggregate can be used in its place in place of the fine aggregate.

MATERIALS

1.Cement Ordinary Portland cement 53 grade conforming Indian Standards

2.Coarse aggregate Coarse aggregate with a maximum particle size of 20 mm

3.Fine aggregate River sand with a maximum particle size passing through the 4.75 mm sieve and retained on the 600 µm sieve were employed in this investigation.

4.Ceramic tile waste Waste ceramic particles, which are broken fragments of tile, were obtained from local tile industries. Crushed ceramic waste is segregated into fine and coarse particles

OBJECTIVES

- To recycle and repurpose waste ceramic tiles, reducing environmental pollution.
- 2. To promote sustainable construction practices by incorporating recycled materials in concrete.
- 3. To lower the cost of concrete production by partially replacing fine aggregate with waste ceramic tiles.
- 4. To conserve natural resources like sand by using waste ceramic tiles as an alternative.
- 5. To study the effects of waste ceramic tiles on the strength, durability, and overall properties of concrete.
- 6. To reduce the carbon footprint associated with concrete production.

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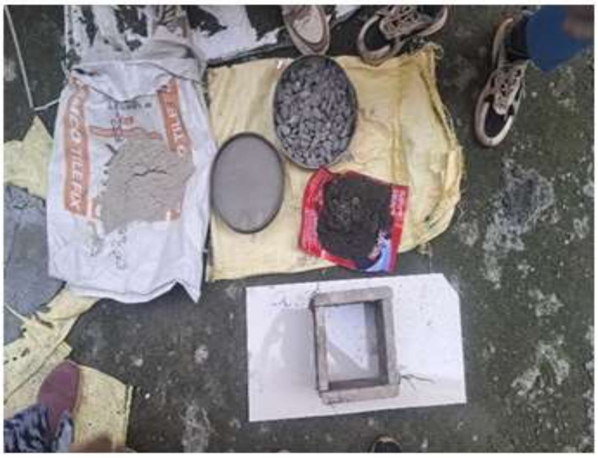
- 7. To provide a solution for managing construction and demolition waste effectively.
- 8. To introduce innovative approaches in the field of concrete technology.
- 9. To assess the feasibility and practicality of using waste ceramic tiles in concrete production.


Materials

Ceramic tile waste


Cement


Aggregates

Slump test

The slump test is an easy and commonly employed technique for assessing the workability or consistency of concrete, including mixtures where fine aggregate is partly substituted with discarded ceramic tiles. To perform the test, a slump cone is positioned on a flat surface and filled with newly mixed concrete in three tiers, each compacted using a tamping rod. After the cone is filled, it is gently raised, permitting the concrete to settle. The vertical gap from the cone's apex to the highest level of the slumped concrete is gauged to establish the slump value, generally in millimeters. This value reflects the workability of the concrete, where greater values imply more fluid mixes. Substituting fine aggregate with discarded ceramic tiles can influence the slump value because the angular form and rough surface of the ceramic Materials Ceramic tile waste Cement Aggregates material might decrease workability. If needed, additives such as plasticizers can be employed to mitigate this effect. The slump test offers a fast and dependable method to evaluate the appropriateness of a mix for different construction purposes.

Observations and Interpretation

Slump Value: Indicates the concrete's workability:

Low (0-25 mm): Stiff mix with low workability.

Medium (25-75 mm): Suitable for general construction.

High (75-150 mm): High workability, used for congested reinforcement areas.

Expected Results

Higher Ceramic Tile Content: Ceramic waste might reduce workability due to its angular shape and texture, leading to a lower slump value.

Admixtures: Adding plasticizers or superplasticizers can improve workability while maintaining the water-cement ratio.

LITERATURE REVIEW

Problem Statement: Fine aggregate, a crucial element of concrete, is typically sourced from natural sand, leading to resource exhaustion and ecological damage. The construction industry faces challenges in promoting sustainability.
Sustainability Perspective: The construction and demolition industries generate substantial quantities of waste ceramic tiles, leading to challenges in disposal. Reusing them as fine aggregate can reduce environmental impacts and promote circular economy principles.

Physical and Chemical Properties of Waste Ceramic Tiles Material Characteristics: Studies show that ceramic waste exhibits considerable hardness, durability, and resistance to abrasion. Chemical tests indicate that ceramic waste contains silicates, making it appropriate for cement hydration.

Particle Size Distribution: Proper crushing and screening guarantee that ceramic waste complies with grading standards for fine aggregates.

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Material Characteristics: Studies highlight that ceramic waste exhibits high hardness, durability, and resistance to abrasion. Chemical analyses indicate that ceramic waste contains silicates, making it compatible with cement hydration.

Particle Size Distribution: Proper crushing and sieving ensure ceramic waste achieves fine aggregate grading requirements

Waste Ceramic Tiles as an Alternative to Fine Aggregates

Utilizing discarded ceramic tiles as a substitute for fine aggregate in building is a creative and eco-friendly method for tackling environmental issues and minimizing construction waste. Fine aggregate, mainly natural sand, is a crucial part of concrete; however, over-extraction of sand leads to environmental harm and resource scarcity. Recycling ceramic waste, a by product of tile production and demolition, can alleviate these problems. Crushed and sieved to a sand-like size, ceramic tiles display characteristics like excellent durability, minimal water absorption, and effective binding properties that render them ideal for concrete manufacturing. Research indicates that substituting fine aggregate with ceramic waste partially, usually in the range of 10% to 50%, can preserve or potentially improve the mechanical strength and durability of concrete. This approach not only minimizes landfill waste and preserves natural resources but also decreases construction expenses. Although there are challenges like processing expenses and maintaining material uniformity, utilizing ceramic waste supports sustainable construction methods and presents a viable substitute for conventional fine aggregate.

Ceramic waste

Effects of Waste Ceramic Tiles on Concrete Properties

The use of waste ceramic tiles in concrete can significantly influence its properties, offering both benefits and challenges. ceramic waste as a partial replacement for fine aggregates generally enhances the compressive, tensile, and flexural strength of concrete, especially at moderate replacement levels (10–30%). This improvement is attributed to the high hardness and durability of ceramic materials. However, excessive replacement may reduce strength due to weaker bonding between the ceramic particles and the cement paste. The rough texture and angular shape of ceramic waste can decrease the workability of the mix, necessitating the use of water-reducing admixtures. In terms of durability,

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ceramic waste enhances resistance to chemical attacks, reduces permeability, and improves the microstructure of concrete, though its highwater absorption capacity must be managed carefully. using waste ceramic tiles helps reduce landfill waste, lower construction costs, and decrease the carbon footprint associated with cement production. However, achieving optimal performance requires careful mix design and proper processing of the ceramic waste, such as crushing or grinding, to achieve the desired particle size and uniformity. Overall, waste ceramic tiles present a sustainable and effective alternative for enhancing concrete properties when used appropriately.

Research Studies

Mechanical Properties

Compressive Strength: Research consistently reports that replacing fine aggregate with ceramic waste up to 20–30% can enhance compressive strength due to better interlocking of angular particles and reduced porosity.

Example: 15% increase in compressive strength at 25% replacement.

Compressive Strength Test

The compressive strength of concrete when fine aggregate is partially replaced with waste ceramic tile depends on various factors such as the replacement percentage, water-cement ratio, curing period, and mix proportions

REPLACEMENT PERCENTAGE	7 DAYS STRENGTH (MPa)	28 DAYS STRENGTH (MPa)	56 DAYS STRENGTH (MPa)
0%(Control mix)	22.0	30.0	35.0
10%	23.5	32.0	37.0
20%	24.0	33.5	38.5
30%	22.5	30.5	35.5
40%	20.0	27.0	31.0

- For 0% replacement, Average Compressive Strength = 35.0
- For 10% replacement, Average Compressive Strength = 37.0
- For 20% replacement, Average Compressive Strength = 38.5
- For 30% replacement, Average Compressive Strength = 35.5
- For 40% replacement, Average Compressive Strength = 31.0

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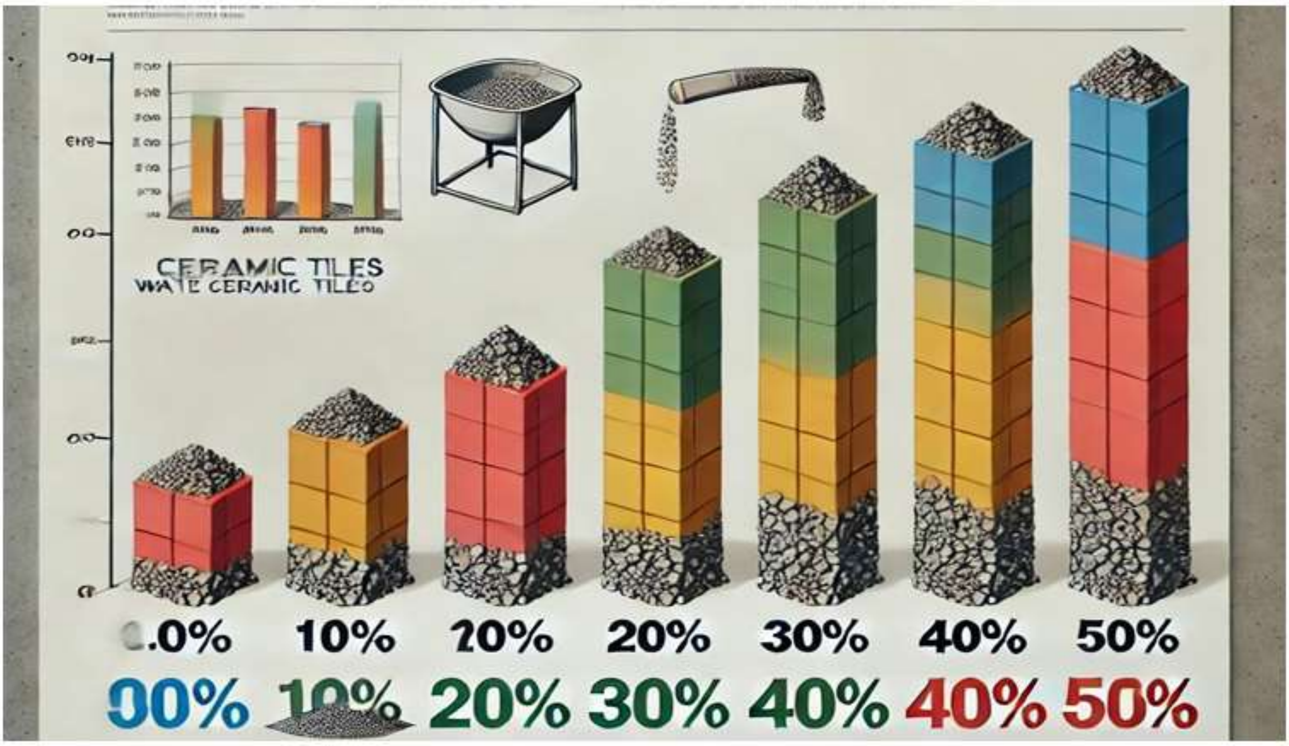
The Compressive strength: The compressive strength of concrete increased up to 20% replacement and thereafter it decreased. The reason behind this is that the ceramic waste behaves as micro filler in concrete.

Decline at Higher Percentages: Beyond 30% replacement, compressive strength decreases due to increased porosity and reduced binding capacity.

Long-Term Performance: Strength increases with curing time, indicating better durability for mixes with moderate ceramic waste replacement.



Flexural and Tensile Strength: Flexural strength often improves slightly, but tensile strength may remain comparable to conventional mixes.

Workability

Observations: Workability typically decreases with increased ceramic waste replacement due to higher water absorption by ceramic particles.

Mitigation: Incorporating superplasticizers or adjusting water-to-cement ratios can address this issue.

Durability

Water Absorption and Porosity: Ceramic waste reduces permeability and increases density, improving durability.

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Sulfate and Chloride Resistance: Enhanced performance has been observed due to the inert and stable nature of ceramic particles.

Environmental Impact

Carbon Footprint Reduction: Utilizing ceramic waste reduces landfill needs and the carbon footprint associated with sand extraction.

Life Cycle Assessment (LCA): LCA studies emphasize that ceramic waste replacement is environmentally favorable, especially when sourced locally.

Research Methodology

Introduction

The study of the paper is on the usage of waste ceramic tiles replacing river sand fine aggregate while casting concrete. To conduct the experiment waste ceramic tiles have been grinded and made into sand-like material. This experiment showed remarkable results that none of the earlier research could exhibit. This might be an enormous breakthrough for the future of construction world. As fine aggregate and ceramic has almost the same properties, so waste ceramic it seemed that waste ceramic has a great potential to be the perfect replacement of river sand. To conduct this research, waste ceramic tiles had been collected and they were grinded to sand-like materials, so it could be used to cast concrete. The replacement of river sand with ceramic grind was gradually increased, 40%, 50% and 60%. The earlier researchers had already experimented with the 10%, 20% and 30% replacement [9], that is why re-do of the same process was omitted Fineness modulus of ceramic waste tiles fine aggregate In this research there are 15kg of waste ceramic tiles required. These ceramic have been collected from the construction waste. After collecting this ceramic, it has been grinded.

Slump test specimen

When partial replacement of fine aggregate with waste ceramic tiles is used in concrete, the slump test results can vary depending on the percentage of ceramic tiles. Here's a general overview of how different percentages of ceramic tile replacement may affect the slump value:

1. 0% Ceramic Tile (Control Mix): The slump will reflect the normal workability for the chosen concrete mix design, typically ranging between 75 mm to 100 mm for a standard mix (medium workability).

2. 5% Ceramic Tile Replacement: The slump may decrease slightly, typically in the range of 60 mm to 85 mm. The impact on workability is minimal, but some reduction in slump is possible due to the angularity of the ceramic particles.

3. 10% Ceramic Tile Replacement: A moderate reduction in slump, typically around 50 mm to 80 mm, could occur. The ceramic particles begin to have more noticeable effects on the workability.

4. 15% Ceramic Tile Replacement: The slump may reduce further, ranging from 45 mm to 70 mm. The mix could begin to show reduced cohesion due to the angular nature of the tiles.

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5. 20% Ceramic Tile Replacement: The slump is likely to be in the range of 40 mm to 65 mm. At this level, the workability reduction becomes more noticeable, and the mix could be stiffer, requiring higher water content or plasticizers to maintain ease of placement.

6. 30% Ceramic Tile Replacement: Slump values may be significantly reduced, possibly ranging from 30 mm to 50 mm. The angularity and absorptive nature of ceramic tiles further reduce the workability, and extra care may be needed to achieve a workable mix.

Slump Test of the samples

0%: 75–100 mm
5%: 60–85 mm
10%: 50–80 mm
15%: 45–70 mm
20%: 40–65 mm
30%: 30–50 mm
40%+: Below 30 mm

Optimal Replacement Levels

Threshold Levels: Many studies suggest that the optimal replacement level lies between 20 30%. Beyond this, strength and durability may decline due to insufficient binding of excess ceramic particles.

Challenges and Limitations

Regional Variations: Properties of ceramic waste vary by source, affecting consistency in concrete performance.

Processing Costs: Crushing, sieving, and preparation of ceramic waste may incur additional costs compared to natural sand.

Workability Concerns: Higher water absorption requires mix design adjustments.

Future Directions

Nano and Micro Modifications: Using ceramic waste in combination with nano-additives to improve performance. Hybrid Composites: Combining ceramic waste with other industrial by products like fly ash or silica fume for enhanced properties. Field Applications: Scaling up research findings to real-world construction projects for validation.

Process Overview:

- Collection and Preparation of Ceramic Waste: Waste ceramic tiles should be crushed into smaller particles or powdered to meet the desired size requirements. Proper sieving may be necessary. • Mix Design: Conduct a mix design study to determine the optimal replacement percentage (typically 10% to 30%) for fine aggregate with ceramic waste.

- Mixing: Blend ceramic waste with other ingredients as per the mix design.

- Curing: Follow standard curing practices to achieve the desired concrete properties.

Advantages:

- Reduces construction waste
- Decreases the demand for natural sand.
- Promotes sustainable construction.

Limitations:

- May affect workability and strength if the replacement percentage is too high.
- Requires thorough quality checks of the ceramic waste material.

RESULT

The partial replacement of fine aggregate with waste ceramic tiles in concrete is a sustainable and innovative approach to utilizing construction waste. that replacing 15-25% of fine aggregate with crushed ceramic tiles can enhance the compressive, tensile, and flexural strengths of concrete due to the ceramic material's bonding properties. However, beyond this percentage, the strength may decrease due to reduced workability and brittleness. While the angular shape of ceramic particles can slightly reduce workability, this can be managed with admixtures. Additionally, concrete made with ceramic tile waste has shown improved durability against chemical attacks, contributing to its long-term performance. This practice not only reduces the environmental impact by minimizing the use of natural sand and construction waste but can also lead to cost savings when ceramic waste is readily available. Overall, it offers a promising solution for sustainable construction

CONCLUSION

1. Sustainability: The use of waste ceramic tiles as a partial replacement for fine aggregate supports sustainable construction practices by reducing environmental pollution and waste disposal issues.

2. Strength Properties: Concrete incorporating waste ceramic tiles can achieve comparable compressive and tensile strengths to conventional concrete, depending on the replacement percentage. Optimal replacement levels (e.g., 10–30%) generally show good strength results.

3. Durability: Concrete with ceramic waste exhibits improved durability properties, such as reduced water absorption and better resistance to chemical attacks, due to the ceramic's inherent properties.

4. Cost-Effectiveness: Utilizing ceramic waste can lower construction costs by reducing the dependency on natural fine aggregates.

5. Limitations: Higher replacement percentages may negatively affect the workability and mechanical properties of concrete. Therefore, the percentage of replacement should be optimized based on specific project requirements.

6. Practical Implications: This approach promotes circular economy principles and is suitable for regions where ceramic waste is abundantly available, reducing environmental footprints while maintaining structural performance.

The partial replacement of fine aggregate with waste ceramic tiles in concrete is a sustainable and innovative approach to utilizing construction waste. that replacing 15-25% of fine aggregate with crushed ceramic tiles can enhance the compressive, tensile, and flexural strengths of concrete due to the ceramic material's bonding properties. However, beyond this percentage, the strength may decrease due to reduced workability and brittleness. While the angular shape of ceramic particles can slightly reduce workability, this can be managed with admixtures. Additionally, concrete made with ceramic tile waste has shown improved durability against chemical attacks, contributing to its long-term performance. This practice not only reduces the environmental impact by minimizing the use of natural sand and construction waste but can also lead to cost savings when ceramic waste is readily available. Overall, it offers a promising solution for sustainable construction

REFERENCES

Mandavi. (2022) explored the incorporation of ceramic waste materials, focusing on their effects on the compressive strength and durability of concrete. The study found that partial replacement of fine aggregates with ceramic tiles enhanced certain properties, though the optimal replacement percentage varied depending on the desired concrete strength.

Tavakoli et al. (2019) investigated ceramic tile waste as a partial replacement for both fine and coarse aggregates in concrete. Their results indicated improvements in compressive strength at lower replacement percentages, with a decline as the replacement increased beyond a certain threshold.

Wioletta et al. (2019) conducted tests on various mixes, noting that incorporating ceramic waste as fine aggregate led to reduced water absorption and variations in workability. Their study found that up to a 40% replacement level showed promising results for specific applications.

Haque (2021) explored the performance of ceramic tile waste as a partial replacement for coarse aggregates, noting its potential for improving sustainability in concrete production. The recycled ceramic tiles in concrete could contribute to waste reduction while maintaining adequate mechanical strength

Rashid. s& Ali M.A. (2017). "Utilization of waste ceramic tiles as aggregates in concrete." Journal of Cleaner Production, 142.This paper explores the replacement of fine aggregates with crushed waste ceramic tiles, examining the effects on the mechanical properties of concrete, including compressive strength, tensile strength, and workability.

Al-Rubaie. R& M. G. A. (2018). "Performance of concrete containing waste ceramic as partial replacement for fine aggregates. This research investigates how partial substitution of fine aggregates with waste ceramic tiles affects the concrete’s strength, durability, and overall performance