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Experimental Study on Sustainable Concrete Using Bagasse Ash, Crumb Rubber and Waste Ceramic Tiles

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Abstracts - The increasing generation of industrial and agricultural waste has led to serious environmental concerns, particularly in the construction sector. This study presents an experimental investigation on the use of bagasse ash, crumb rubber, and waste ceramic tiles as partial replacements for cement, fine aggregate, and coarse aggregate in concrete. M35 grade concrete was prepared and tested for workability and compressive strength at 7 and 28 days. The results indicate that optimum replacement levels of 15% bagasse ash, 2% crumb rubber, and 15% ceramic tiles provide satisfactory performance. The study demonstrates that sustainable concrete can be produced with acceptable strength, reduced environmental impact, and improved cost efficiency, making it suitable for practical construction applications.

Keywords - Sustainable Concrete, Bagasse Ash, Crumb Rubber, Ceramic Tiles, Waste Materials

1 INTRODUCTION

The rapid growth of construction activities has resulted in excessive consumption of natural resources and the generation of large quantities of waste materials. Disposal of such waste leads to environmental pollution and increased landfill costs. Therefore, there is a need to develop sustainable construction materials that can reduce environmental impact while maintaining structural performance.Concrete, being the most widely used construction material, provides an opportunity to incorporate waste materials as partial replacements. The use of bagasse ash, crumb rubber, and ceramic tile waste not only reduces dependency of natural resources but also help in effective waste management.

The present study aims to evaluate the combined effect of these waste materials on the properties of concrete. Special emphasis is given to identifying optimum replacement levels that can achieve a balance between mechanical performance, cost efficiency, and environmental sustainability, thereby making the concrete suitable for real-world construction applications.

2 METHODOLOGY

M40 grade concrete was designed as per IS 456:2000 and IS 10262:2009. The materials used include cement, fine aggregate, coarse aggregate, bagasse ash, crumb rubber, and crushed ceramic tiles

The replacement levels adopted were

1. 15% bagasse ash as cement replacement
2. 2% crumb rubber as fine aggregate replacement
3. 15% ceramic tiles as coarse aggregate replacement

Concrete cubes of size 150 mm × 150 mm × 150 mm were cast and cured for 7 and 28 days. Workability was measured using the slump test, and compressive strength was determined using CTM.

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Proper mixing, casting, compaction, and curing procedures were followed to ensure consistent, accurate results.

3 RESULT AND DISCUSSION

The experimental results indicate that the use of waste materials has a noticeable influence on both fresh and hardened properties of concrete.

3.1 WORKABILITY ANALYSIS

The slump values showed a slight decrease with the addition of waste materials. This reduction can be attributed to the irregular shape and higher surface area of crumb rubber and bagasse ash. However, the use of a superplasticiser helped maintain the workability required for construction.

3.2 COMPRESSIVE STRENGTH ANALYSIS

The compressive strength results indicate that strength increases up to an optimum replacement level and decreases beyond that. The optimum values were found to be:

1. 15% for bagasse ash
2. 2% for crumb rubber
3. 15% for ceramic tiles

TABLE 1 COMPRESIVE STRENGHTH ANALYSIS

Mix Type	Replacement	7 Days (MPa)	28 Days (MPa)
Normal Concrete	0%	26.8	38.5
Bagasse Ash	15%	26.5	39.5
Crumb Rubber	2%	25.2	36.8
Ceramic Tiles	15%	26.3	37.9

The results show that bagasse ash improves long-term strength due to pozzolanic reactions, while crumb rubber slightly reduces strength but enhances ductility. Ceramic tiles show performance comparable to conventional aggregates.

The percentage variation in compressive strength indicates that the optimized mix achieves nearly similar performance to conventional concrete with only a minor reduction.

3.3 COST EFFICIENCY

The use of waste materials significantly reduces the overall cost of concrete production. Cement is the most expensive component in concrete, and its partial replacement with bagasse ash leads to cost savings.

Similarly, the use of crumb rubber and ceramic tiles reduces the demand for natural aggregates. Since these materials are often locally available, transportation costs are minimized. Additionally, the use of waste materials reduces landfill disposal costs.

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Thus, the proposed concrete mix offers a cost-effective solution for construction, especially in rural and resource-limited areas.Overall, the optimized use of bagasse ash, crumb rubber, and ceramic tiles in concrete results in a cost-effective construction material. This approach is particularly beneficial for affordable housing, rural infrastructure, and large-scale construction projects where cost reduction is a major concern.

4 CONCLUTION

The present investigation highlights the potential of utilizing waste materials such as bagasse ash, crumb rubber, and waste ceramic tiles in the production of sustainable concrete. The experimental results clearly demonstrate that partial replacement of conventional materials with these waste products can be achieved without significant loss of strength, provided that the replacement levels are carefully optimized.

From the strength analysis, it was observed that bagasse ash contributes positively to the long-term compressive strength due to its pozzolanic nature, which enhances the microstructure of concrete. In contrast, crumb rubber introduces flexibility into the concrete matrix, improving its resistance to cracking and impact, although with a slight reduction in compressive strength. Waste ceramic tiles, on the other hand, exhibited performance comparable to natural coarse aggregates, making them a suitable alternative material.

The study also confirms that the optimum replacement levels of 15% bagasse ash, 2% crumb rubber, and 15% ceramic tiles provide a balanced combination of strength, workability, and durability. Beyond these limits, a noticeable reduction in performance is observed, indicating the importance of controlled material substitution.

In addition to mechanical performance, the economic and environmental benefits of using waste materials are significant. The reduction in cement and natural aggregate consumption leads to lower construction costs, while the utilization of locally available waste materials minimizes transportation expenses and landfill burden. This approach contributes to sustainable development by conserving natural resources and reducing environmental pollution.

Furthermore, the findings of this study suggest that waste-based concrete can be effectively used in practical construction applications, particularly in low to medium strength structures, rural infrastructure, and cost-sensitive projects. The adoption of such materials can play a crucial role in promoting eco-friendly construction practices.

Overall, this research establishes that the integration of waste materials in concrete is not only a viable engineering solution but also a necessary step towards achieving sustainable and economical construction in the future.

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