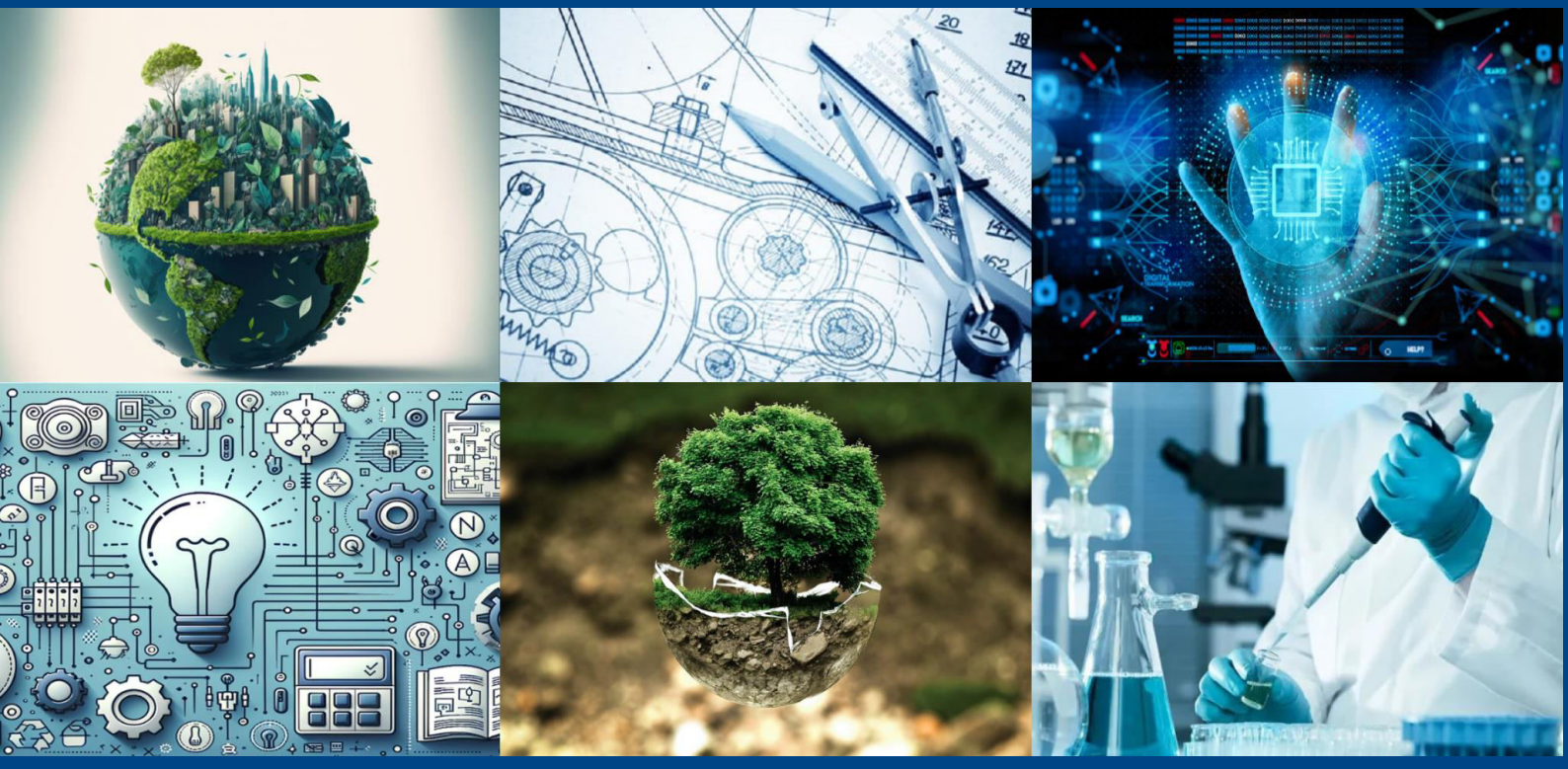
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Experimental Study on the Partial Replacement of Cement with Fly Ash and Fine Aggregate with Crumb Rubber Tyre

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ABSTRACT: This study investigates the use of fly ash and waste tyre rubber as partial replacements in concrete. Fly ash was used to replace cement at 10% and 20%, while crumb rubber was used to replace fine aggregate at 6% and 8%. Concrete mixes were prepared with different combinations of these materials and compared with a conventional control mix. The workability of fresh concrete was studied using the slump cone test, while compressive strength was determined after curing. The results showed that fly ash improved workability, whereas increasing rubber content caused a reduction in compressive strength. The mix containing 10% fly ash and 6% rubber showed satisfactory overall performance.

KEYWORDS: Fly Ash, Rubber Tire Particles, Sustainable Concrete, Slump Cone Test, Compressive Strength Test, Partial Replacement, Waste Utilization, Green Concrete.

I. INTRODUCTION

Concrete is one of the most widely used construction materials because of its strength, durability, versatility, and economical nature. However, the production of cement has a significant environmental impact due to its energy consumption and carbon dioxide emissions. Similarly, the continuous extraction of natural sand for concrete production contributes to the depletion of natural resources and environmental degradation. These concerns have increased the need for sustainable alternatives in concrete production.

Fly ash is an industrial by-product obtained from coal combustion in thermal power plants. Due to its pozzolanic properties, it can be used as a partial replacement for cement. The use of fly ash can improve workability and durability while reducing cement consumption. However, higher replacement levels may affect the early-age strength of concrete.

Waste automobile tyres are another major environmental concern because of their non-biodegradable nature and difficulties associated with disposal. Crumb rubber obtained from waste tyres can be used as a partial replacement for fine aggregate in concrete. The incorporation of rubber can help reduce the consumption of natural sand and provide improved impact resistance and energy absorption. However, excessive rubber content may reduce the compressive strength of concrete due to weaker bonding between rubber particles and cement paste.

The combined use of fly ash and waste tyre rubber can therefore provide a sustainable approach to reducing both industrial and tyre waste while conserving conventional concrete materials. In this study, cement was partially replaced with fly ash at 10% and 20%, while fine aggregate was replaced with crumb rubber at 6% and 8%. A control mix was also prepared for comparison. The workability of fresh concrete was evaluated using the Slump Cone Test, and the compressive strength of hardened concrete was determined after curing.

The main objective of this study is to investigate the effect of fly ash and crumb rubber on concrete properties and to identify a suitable combination that provides satisfactory workability and compressive strength while promoting the sustainable utilization of waste materials.

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1.1 Aim and objectives

To experimentally study the effect of partial replacement of cement with fly ash and fine aggregate with crumb rubber from waste tyres on the workability and compressive strength of concrete, and to identify a suitable replacement combination.

Objectives:

- To study the effect of Fly Ash and Crumb Rubber on the strength and workability.
- To find the optimum replacement percentage of Fly Ash and Crumb Rubber that provides good concrete performance.
- To compare the properties of conventional concrete with modified concrete.
- To check how strong and long-lasting the modified concrete is and support green buildings.

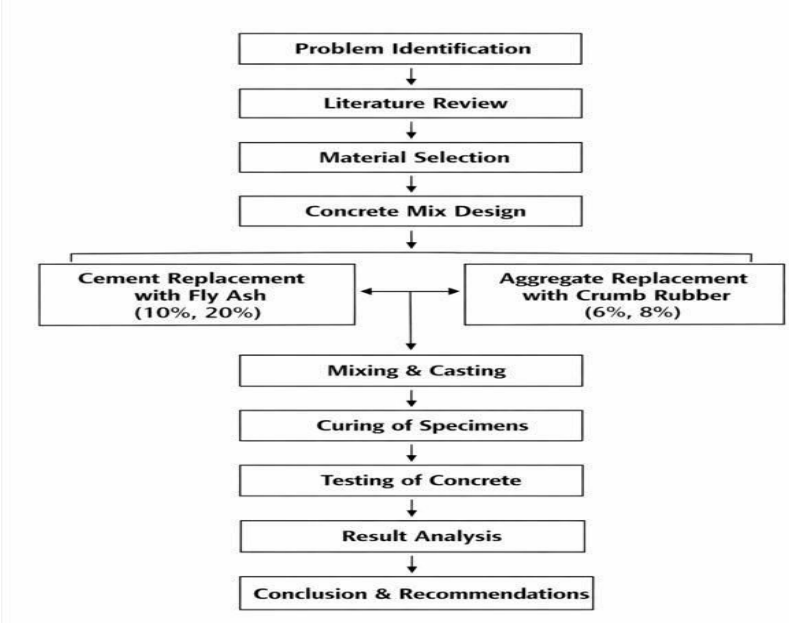
II. LITERATURE REVIEW

Relevant research articles and journal publications were reviewed to evaluate the influence of fly ash and waste rubber tire as partial replacements for cement and fine aggregate, respectively, on the mechanical and durability characteristics of concrete.

III. RESEARCH GAP

Although several studies have investigated the use of waste tyre rubber as a partial replacement for aggregate and fly ash as a supplementary cementitious material, limited experimental studies have focused specifically on their combined use as partial replacements of cement and fine aggregate, respectively. Earlier studies mainly concentrated on rubberized concrete using coarse or fine aggregate replacement, while recent studies have explored more complex combinations involving high-volume fly ash, nano-silica, fibres, recycled aggregates, thermal performance and numerical simulations. Therefore, a research gap exists in developing and experimentally evaluating a simple and economical concrete incorporating fly ash as a partial replacement for cement and crumb rubber tyre as a partial replacement for fine aggregate, particularly with respect to compressive strength at different curing ages. The present study aims to address this gap by evaluating different proportions of fly ash and crumb rubber and identifying a suitable replacement combination for concrete applications.

IV. METHODOLOGY



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Materials Selection

The constituent materials, namely cement, fine aggregate, coarse aggregate, fly ash, rubber tire and water, were selected and tested for their physical and chemical properties as per Indian Standard (IS) specifications.

Mixing of Concrete

The concrete mixing ratio used in this project is 1:1.46:2.51, representing cement, fine aggregate (sand), and coarse aggregate, respectively, by mass. This proportion was used for concrete mixing, with partial replacement of cement by fly ash and sand by crumb rubber tyre.

Casting of Specimens

Cubes were cast for every concrete mix proportion to assess the effects of material replacement on concrete performance.



Fig.1 Casted Specimen

Curing of Specimens

The prepared specimens were cured under water for 3, 7, and 28 days to assess the effect of curing age on concrete performance.

Testing of Concrete

After the designated curing periods, the specimens were subjected to compressive strength tests and other required evaluations to determine their performance characteristics.

V. RESULTS AND DISCUSSION

Tests Conducted:

Compression Test:

The compression test was conducted on concrete specimens prepared with partial replacement of cement and fine aggregate using fly ash and rubber tyre waste. The mix proportions considered were 10% and 20% replacement of cement with fly ash, and 6% and 8% replacement of fine aggregate with rubber tyre particles, respectively. Standard cube specimens of size 150 mm × 150 mm × 150 mm were cast for each mix proportion using a concrete mixer to ensure uniform blending of materials. The specimens were properly compacted using a vibrating machine to eliminate air voids and improve density. After casting, all specimens were cured in water for 3, 7 and 28 days.

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Fig. 2 Compression Testing Machine

Results:

Mix Proportion	3 Days strength	7 Days strength	28 Days strength
FA 10% + CR 6%	12.88	**17.33**	18.66
FA 10% + CR 8%	**15.55**	16.88	**25.77**
FA 20% + CR 6%	12	14.22	21.33
FA 20% + CR 8%	13.77	14.67	21.33

Slump Cone Test:

The slump cone test is a simple test used to determine the workability and consistency of fresh concrete by measuring the vertical settlement (slump) of concrete after removing the cone.

VI. CONCLUSION

The experimental study investigated partial replacement of cement with fly ash and fine aggregate with crumb rubber tyre. Compressive strength was evaluated at 3, 7, and 28 days of curing. Among the tested mixes, FA 10% + CR 8% achieved the highest 28-day compressive strength of 25.77 N/mm2. The results demonstrate that the replacement proportion influence the compressive strength concrete. The suitability of the modified concrete depends on the required strength, workability and intended application.

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