EXPERIMENTAL STUDY ON WASTE GLASS CULLET PARTIAL REPLACEMENT FOR FINE AGGREGATE

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ABSTRACT: The increasing demand for natural sand in concrete production has led to environmental degradation and scarcity of natural resources. To address this issue, the present study investigates the feasibility of using waste glass cullet as a partial replacement for fine aggregate in concrete. Waste glass, being non-biodegradable and abundantly available, poses serious disposal challenges. In this experimental study, fine aggregate is partially replaced with crushed waste glass cullet at varying proportions of 10%, 20%, 30%, and 40% by weight. The concrete mixes were prepared and tested for workability, compressive strength, split tensile strength, and flexural strength at different curing ages. The results indicate that the inclusion of waste glass cullet up to an optimum percentage improves the mechanical strength and durability characteristics of concrete, while also reducing the dependency on natural sand. Beyond the optimum level, however, a reduction in strength was observed due to the smooth surface texture and potential alkali-silica reaction (ASR). The study concludes that waste glass cullet can be effectively utilized as a sustainable alternative material for fine aggregate in concrete production, promoting both cost efficiency and environmental protection.

KEYWORDS: Waste Glass Cullet, Fine Aggregate Replacement, Sustainable Concrete, Compressive Strength, Alkali-Silica Reaction (ASR), Workability, Flexural Strength, Split Tensile Strength, Eco-Friendly Construction.

1.INTRODUCTION: Concrete is the most widely used construction material in the world, composed mainly of cement, fine aggregate, coarse aggregate, and water. Due to rapid urbanization and large-scale infrastructure development, the demand for natural fine aggregate (river sand) has increased significantly. Excessive extraction of river sand has led to severe environmental problems such as riverbed

degradation, groundwater depletion, and loss of biodiversity. Therefore, the search for alternative materials to partially or fully replace natural sand in concrete has become a major focus of research.

Waste glass is a non-biodegradable material that poses disposal and environmental challenges. Every year, tons of glass waste are generated from bottles, windows, and other industrial products. Most of this waste glass ends up in landfills, causing pollution and resource wastage. However, waste glass has good hardness and silica content, making it a potential replacement for fine aggregate in concrete. When properly processed and crushed into small particles (cullet), it can be used to improve certain properties of concrete such as durability and workability.

Using waste glass cullet as a partial replacement for fine aggregate not only helps in effective solid waste management but also contributes to sustainable construction practices. It reduces the consumption of natural sand, lowers the overall cost of concrete, and minimizes environmental impact. The success of approach depends on understanding the mechanical behavior, workability, and long-term performance of concrete containing glass cullet.

Hence, this experimental study focuses on evaluating the performance of concrete in which fine aggregate is partially replaced by waste glass cullet in varying percentages. The study investigates the effects on strength properties, workability, and durability to determine the optimum replacement level for practical application.

2.OBJECTIVES

It decreases the dependency on river sand, there by mitigating the severe ecological and environmental impacts associated with river dredging.

Reduce the overall cost of concrete production.

Reduce water absorption and chloride ion penetrability and highly durable concrete structures suited for harsh or wet environments.

3.EXPERIMENTAL PROGRAM

3.1 MATERIALS AND METHODOLOGY

3.1.1 CEMENT

Ordinary Portland Cement (OPC) of 43 Grade conforming to IS: 8112–2013 was used throughout the investigation.

The cement was fresh and free from lumps, with a uniform color and consistency. It acted as the primary binding material in the concrete

FIG 3.1 CEMENT

3.1.2FINE AGGREGATE

The fine aggregate used was river sand passing through a 4.75 mm IS sieve and conforming to Zone II as per IS: 383–2016. The sand was clean, dry, and free from clay, silt, and organic impurities. It helps to fill voids between coarse aggregates and improves the workability of the mix.

3.1.3 COARSE AGGREGATE

Crushed angular granite coarse aggregates were used, conforming to IS: 383–2016. Aggregates passing through a 20 mm sieve and retained on a 12.5 mm sieve were used for the mix. Coarse aggregates provide strength, stiffness, and dimensional stability to the concrete.

3.1.4 WASTE GLASS CULLET

Waste glass cullet was collected from discarded glass bottles and window glass. The collected glass was cleaned, dried, and crushed into small angular particles passing through a **4.75 mm sieve** and retained on a **150 µm sieve**, making it suitable for use as fine aggregate.

Waste glass cullet mainly consists of **silica (SiO_2)**, which contributes to the pozzolanic activity when used in concrete. It helps in reducing the demand for natural sand and minimizes environmental waste disposal problems.

Properties of Waste Glass Cullet:

- Specific Gravity : 2.50
- Fineness Modulus : 2.60
- Appearance : Transparent to light green
- Shape : Angular and irregular
- Main Chemical Component : Silica (SiO_2)

Replacement Levels Used:

0% (Control Mix)

10% Replacement of Fine Aggregate

20% Replacement of Fine Aggregate

30% Replacement of Fine Aggregate

40% Replacement of Fine Aggregate

Type of concrete	Slump value mm	Compaction factor	Remarks
Conventional concrete	81	0.72	workable
Pumice aggregate (10% replacement of coarse aggregate)	85	0.81	workable
Pumice aggregate (20% replacement of coarse aggregate)	86	0.88	workable
Pumice aggregate (30% replacement of coarse aggregate)	89	0.92	workable

RESULTS

Workability:

The inclusion of waste glass cullet slightly reduced workability due to its **angular shape and smooth surface texture**.

Compressive Strength:

Optimum compressive strength was obtained at **20% replacement** of fine aggregate by glass cullet. Beyond this limit, strength gradually decreased due to poor bonding and the possibility of **Alkali-Silica Reaction (ASR)**.

Split Tensile Strength:

Concrete containing moderate percentages of waste glass cullet showed improved bonding and satisfactory tensile strength compared with conventional concrete.

Flexural Strength:

The flexural behavior followed a similar trend—**moderate replacement (20%) enhanced performance**, while higher replacement levels reduced strength due to weak interfacial bonding.

Durability Observation:

Waste glass cullet contributed to **reduced water absorption** and improved dimensional stability. It also reduced dependency on natural sand, making the concrete more **eco-friendly and sustainable**.

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