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To Study the Effect of M25 Concrete by Partial Replacement of Sand with Glass Powder and Cement by Fly Ash

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Abstract - This Concrete is the most widely used construction material, and the demand for sustainable and eco-friendly concrete has increased significantly in recent years. This study investigates the effect of partial replacement of natural sand with waste glass powder and cement with fly ash on the mechanical properties of M25 grade concrete. The utilization of industrial and waste materials not only helps in reducing environmental pollution but also conserves natural resources. In this experimental investigation, cement was partially replaced by fly ash at different percentages, and fine aggregate was partially replaced by glass powder by weight. Various concrete mixes were prepared and tested for compressive strength, split tensile strength, and workability at curing periods of 7, 14, and 28 days. The results obtained were compared with those of conventional M25 concrete. The test results indicated that the inclusion of glass powder and fly ash improved the workability of concrete and showed comparable or improved strength characteristics up to an optimum replacement level. Beyond this optimum percentage, a reduction in strength was observed. The study concludes that partial replacement of cement with fly ash and sand with glass powder can produce durable and economical M25 concrete while contributing to sustainable construction practices.

***Keywords* - -** *Glass Powder, Fly Ash, Partial Replacement, Fine Aggregate, Cement Replacement, Compressive Strength, Sustainable Concrete, Waste Materials, Eco- friendly Construction.*

I. INTRODUCTION

Concrete is the most extensively used construction material in the world due to its versatility, strength, and durability. Conventional concrete is produced using cement, fine aggregate, coarse aggregate, and water. However, the rapid growth of the construction industry has resulted in excessive consumption of natural resources such as river sand and limestone, leading to environmental degradation and scarcity of raw materials. Therefore, the development of sustainable and eco-friendly concrete has become a major area of research in civil engineering

II. LITERATURE REVIEW

1) *Kishan Jain et.al [2016][1]:*

This study focuses on evaluating the performance of M25 grade concrete when natural sand is partially replaced with glass powder and cement is partially replaced with fly ash, aiming to enhance sustainability and reduce environmental impact. With the rising demand for concrete and the depletion of natural resources like river sand, incorporating waste glass and industrial by-products such as fly ash serves as an effective alternative to minimize landfill disposal lower carbon emissions, and promote eco- friendly construction practices. The research seeks to analyze improvements in workability, compressive strength, flexural strength, and durability parameters by using specified proportions of glass powder and fly ash, while determining their optimal percentage replacement for maximum strength development. The scope of this investigation includes material characterization, mix design, preparation of specimens, and comparative testing of mechanical properties with conventional concrete to establish the feasibility of using these materials in practical construction applications.

2) *Sachin Sirenia et.al [2017][2]:*

The study investigates the use of fly ash (FA) and glass powder (GP) as partial replacements for cement in M25 grade concrete to improve sustainability and reduce waste. Cement was replaced by a fixed 75%portion, with the remaining 25% substituted using different proportions of FA and GP. Tests conducted at 7, 14, and 28 days showed that using 25% fly ash alone (Mix 2) produced the highest compressive and flexural

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strength compared to all other mixes and the control concrete, while increasing glass powder content gradually reduced strength. Over all, the results indicate that fly ash is an effective cement substitute, whereas glass powder lowers performance, and the optimum combination for strength is 75% cement with25% fly ash.

3) Sofia Garefa et.al [2022][3]:

The study investigates the performance of M25 concrete when cement is partially replaced with waste glass powder, aiming to reduce environmental waste and construction costs. Waste glass, rich in silica and possessing pozzolanic properties, was ground to micron level and added to concrete mixes in varying proportions (5–25%). Experimental tests on workability, compressive strength, and split tensile strength showed that concrete with 15% glass powder replacement (GFC3) achieved the highest strength values at both 7 and 28 days, outperforming normal concrete. Higher or lower replacement percentages reduced strength. The results indicate that finely ground waste glass can effectively replace up to 15% of cement without compromising mechanical performance, making it a sustainable and economical alternative in concrete production.

saket rusia et.al [2025][4]:

The study investigates the sustainable use of waste glass as a partial replacement for fine aggregates in concrete paver blocks, aiming to enhance mechanical performance while reducing environmental impact. Using Response Surface Methodology (RSM) and statistical tools such as ANOVA, the research optimizes mix proportions and evaluates key properties including compressive strength, water absorption, and ultrasonic pulse velocity (UPV). Results show that incorporating finely crushed waste glass up to an optimal range of 20–30% significantly improves strength, density, and durability due to better particle packing and pozzolanic activity, while excessive replacement beyond 40% leads to reduced cohesiveness, brittleness, and poor workability. RSM models exhibited strong predictive capability with high R^2 values, confirming reliable optimization of mix variables. Overall, the study demonstrates that recycled glass can be effectively used in paver block production

III. MATERIAL USEDMETHOLOGY

1) Cement

Ordinary Portland Cement (OPC) of 43 grade conforming to IS: 8112 – 2013 was used in this study. Cement acts as the primary binding material in concrete. It provides strength and durability to the concrete through the process of hydration.

2) Fine Aggregate (Sand)

Natural river sand conforming to IS: 383 – 2016 was used as fine aggregate. The sand was clean, free from organic impurities, and well-graded. In this study, fine aggregate was partially replaced by waste glass powder in varying proportions.

3) Coarse Aggregate

Crushed angular coarse aggregates of nominal maximum size **2**0 mm, conforming to IS: 383 – 2016, were used. The aggregates were clean, hard, and free from deleterious materials. Coarse aggregate provides bulk, strength, and stability to concrete.

4) Fly Ash

Fly ash obtained from a thermal power plant was used as a partial replacement of cement. The fly ash used in this study conformed to IS: 3812 (Part 1) – 2013. Fly ash is a pozzolanic material that improves workability and enhances the long-term strength and durability of concrete.

5) Glass Powder

Waste glass powder was used as a partial replacement of fine aggregate. The glass was collected from discarded glass materials, cleaned, crushed, and ground to a fine powder passing through a 75-micron.

IV. METHODOLOGY

4.1.Selection of material

All materials such as cement, fine aggregate, coarse aggregate, fly ash, glass powder, and water were selected in accordance with relevant Indian Standard specifications. Preliminary tests were conducted to determine the physical properties of the materials.

4.2mix design of M25 concrete

The concrete mix was designed as per IS: 10262 – 2019 for M25 grade concrete. A control mix was prepared using conventional materials without any replacement Additional mixes were prepared by partially replacing cement with fly ash and fine aggregate with glass powder in varying percentages by weight.

Table 1.

Physical Properties of cement

Property	Test value	IS code(Is 1489 part 1)
Standard Consistency	31.75 %	30 % – 35 % typical
Fineness (Blaine’s)	357 m²/kg	≥ 300 m²/kg
Soundness (Le Chatelier)	0.5 mm	≤ 10 mm
Initial Setting Time	170 min	≥ 30 min

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Final Setting Time	450 min	≤ 600 min

Table 2

Physical Properties of Sand

Property	Test value	IS code Requirement
Specific Gravity	2.64	2.5 – 2.8 (IS 2386 Part 3)
Water Absorption	1.112 %	≤ 2 % (IS 2386 Part 3)
Fineness Modulus	3.57	2.6 – 3.6 typical (IS 383:2016)

Table 3

Physical Properties of Course Aggregate

Property	Test value	IS code Requirement
Specific Gravity	2.68	2.6 – 2.9 (IS 2386 Part 3)
Water Absorption	0.5 %	≤ 2 % (IS 2386 Part 3)
Aggregate Impact Value	13 %	≤ 30 % (IS 2386 Part 4)

proportion of this study.

4.3 Curing process

After a 24-hour period, the paver blocks were demoulded and left to cure in room temperature water for 28 days. The chosen curing period was meant to encourage appropriate development of strength and hydration. They are let to cure when they have fit the moulds. The first cure may take 24–48 h. After being taken out of moulds, the pavers are cured for seven to twenty-eight days in controlled environments (like curing chambers or water spraying) to reach their best strength.

4.4. Response surface methodology (RSM) modeling and analysis

Using Response Surface Methodology (RSM), the study maximized the mix design and looked at how waste glass volume affected the paver block qualities. Using a central composite design (CCD), input variables (glass percentage, curing duration, and water-to-cement ratio) were investigated for effects on response variables (compressive strength, water absorption, and abrasion resistance). Data analysis was conducted with Design-Expert software, and regression models were created to forecast performance criteria.

4.5 Statistical analysis and optimization

The significance of the variables influencing paver block qualities was determined by means of analysis of variance (ANOVA). The relationship between input and output variables was shown using three dimensional surface plots and contour graphs. Maximum strength and
durability were obtained by determining the appropriate waste glass
percentage using an optimising technique.

4.6 Testing method

4.6.1 Water absorption

Executed in accordance with ASTM C642 to assess the porosity and durability of the paver block. The specimens were subjected to oven drying, weighed, dipped in water, and subsequently re-weighed to ascertain water absorption. The porosity and durability of paver block are assessed by the quantity of water absorbed, as measured by the water absorption test. It indicates the permeability of the paver block, which affects its resistance to weathering, frost, and chemical assault. A sample, typically in the form of a cube or cylinder, is dried in an oven at 105◦C and weighed until a steady weight is attained. The item is thereafter allowed to cool to room temperature, and its dry weight is recorded. The specimen is thereafter immersed in water for a predetermined duration, often 24 h. The surface water is removed, and the saturated weight is recorded following the extraction of the specimen after immersion. Water absorption is quantified as the percentage increase in weight upon the consumption of water relative to dry weight. The smaller the absorption rate of the water, the higher will be the
quality of concrete and the durability

4.7 Compressive strength

Compressive strength is defined as the maximum compressive stress that a material such as concrete can withstand under a gradually applied load without failure. It represents the material's capacity to resist forces that tend to reduce its size by compression. In concrete, this property is one of the most important parameters used to evaluate its quality, performance, and suitability for structural applications.
Compressive strength is determined by applying load on a standard specimen (usually a cube or cylinder) in a compression testing machine until it fails. The value is calculated as the ratio of the applied load at failure to the cross-sectional area of the specimen. It is generally expressed in N/mm^2 or MPa and is commonly measured at different curing ages such as 7, 14, and 28 days.
The compressive strength of concrete depends on various factors, including the water-cement ratio, type and quality of

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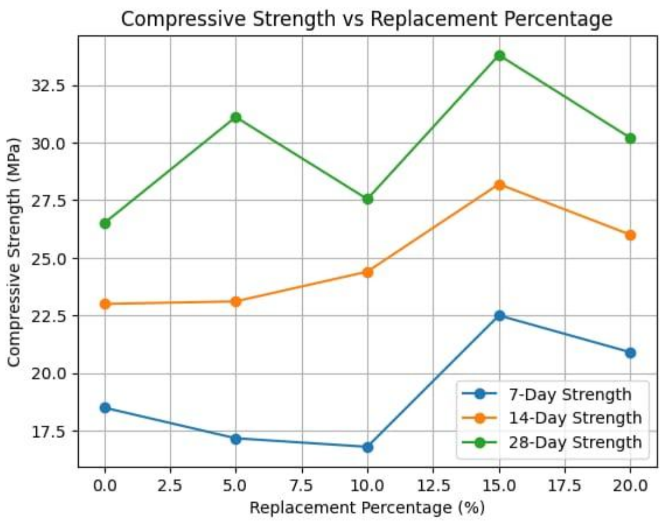
materials, curing conditions, and mix proportions. Higher compressive strength indicates better load-carrying capacity, durability, and resistance to cracking or deformation.

4.8 Compressive Strength Result

Replacement %	7-Day (MPa)	14-Day (MPa)	28-Day (MPa)
0%	18.5	23.0	26.5
5%	17.17	23.11	31.11
10%	16.8	24.4	27.55
15%	22.5	28.2	33.8
20%	20.9	26.0	30.2



V. CONCLUSION

From the above graphs and previous discussion, following conclusion is drawn:

The replacement of cement at an optimum percentage by FA (25%), improved compressive and flexural strengths as compared to traditional concrete.

2. On decreasing percentage replacement of FA (25% 0%) by increasing percentage replacement of GP(0% to 25%), a decreased strength is determined, i.e. WhenGP is used as a replacement material, strength of concrete

3. Overall MIX 2 have a great efficiency of flexural and compressive strengths.

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