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Study On Concrete with GGBS and Brick Powder as Partial Replacement of Cement

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Abstract - Concrete production consumes large quantities of cement, which contributes significantly to environmental pollution. To reduce cement consumption, supplementary cementitious materials such as Ground Granulated Blast Furnace Slag (GGBS) and brick powder can be used as partial replacements. This study investigates the mechanical properties of concrete when cement is partially replaced with GGBS and brick powder in different proportions. Concrete mixes were prepared with replacement levels of 10% GGBS + 5% brick powder, 20% GGBS + 10% brick powder, and 30% GGBS + 15% brick powder. Tests such as slump test, compaction factor test, compressive strength test, and split tensile strength test were conducted. The results indicate that partial replacement improves workability and provides satisfactory strength compared to conventional concrete. This study demonstrates that GGBS and brick powder can be effectively utilized in sustainable concrete production.

Keywords - Concrete, GGBS, Brick Powder, Partial Replacement, Compressive Strength, Sustainable Construction

I. INTRODUCTION

Concrete is one of the most widely used construction materials in the world due to its strength and durability. Cement is the primary binding material in concrete; however, its production leads to high carbon dioxide emissions and environmental impact. Therefore, researchers are focusing on alternative materials that can partially replace cement in concrete.

Ground Granulated Blast Furnace Slag (GGBS) is an industrial by-product obtained from the steel manufacturing process. It has good cementitious properties and can improve durability and long-term strength of concrete.

Brick powder is obtained from crushed waste bricks and can also act as a pozzolanic material in concrete. The use of brick powder helps in waste management and reduces environmental pollution.

This study aims to evaluate the performance of concrete when cement is partially replaced with GGBS and brick powder in different proportions.

II. MATERIALS USED

A. Cement

Ordinary Portland Cement (OPC) was used as the main binding material in the concrete mix.

B. Fine Aggregate

Natural river sand passing through 4.75 mm sieve was used as fine aggregate.

C. Coarse Aggregate

Crushed stone aggregates of size 20 mm were used as coarse aggregate.

D. Ground Granulated Blast Furnace Slag (GGBS)

GGBS is a by-product obtained during the production of iron in blast furnaces. It has good cementitious properties and improves the durability of concrete.

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E. Brick Powder

Brick powder was obtained by crushing waste bricks into fine powder. It acts as a supplementary cementitious material and helps in reducing cement consumption.

F. Water

Clean potable water was used for mixing and curing of concrete.

III. METHODOLOGY

Concrete specimens of M25 grade concrete were prepared with different percentages of GGBS and brick powder as partial replacement of cement.

TABLE 1: Different Mix Proportions Prepared

MIX DESIGNATION	GGBS	BRICK POWDER
NORMAL CONCRETE	0	0
MIX 1	10%	5%
MIX 2	20%	10%
MIX 3	30%	15%

Concrete cubes of size 150 × 150 × 150 mm and cylinders of size 150 × 300 mm were cast.

The specimens were cured in water for 28 days before testing.

The following tests were conducted:

- Slump Test
- Compaction Factor Test
- Compressive Strength Test
- Split Tensile Strength Test
- Durability tests like water absorption test
- Temperature Comparison

IV. WORKABILITY TESTS

I. SLUMP TEST

The slump test was conducted to determine the workability of fresh concrete.

TABLE 2: SLUMP TEST

MIX	SLUMP VALUE (mm)
NORMAL CONCRETE	60
MIX 1	110
MIX 2	122
MIX 3	150

The results show that workability increased (medium to high workability) with the increase in GGBS and brick powder content.

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II. COMPACTION FACTOR TEST

TABLE 3: COMPACTION FACTOR TEST

MIX	COMPACTION FACTOR
NORMAL CONCRETE	0.95
MIX 1	0.94
MIX 2	0.96
MIX 3	0.97

Higher compaction factor values indicate better workability of concrete, meaning the concrete can be easily compacted and placed.

III. COMPRESSIVE STRENGTH TEST

TABLE 4: COMPRESSIVE STRENGTH TEST RESULTS

MIX	CUBE LOAD (kN)	STRENGTH (MPa)
NORMAL CONCRETE	524.48	23.31
MIX 1	596.25	26.50
MIX 2	670.50	29.80
MIX 3	576.0	25.60

The results show that partial replacement of cement with GGBS and brick powder provides satisfactory compressive strength.

IV. SPLIT TENSILE STRENGTH TEST

MIX	LOAD (kN)
MIX 1	112
MIX 2	122
MIX 3	110

Split tensile strength tests were conducted on cylindrical specimens.

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TABLE 5: SPLIT TENSILE STRENGTH RESULTS

The results indicate that tensile strength slightly increases with optimum replacement levels.

V. DURABILITY TEST (WATER ABSORPTION TEST)

TABLE 6: WATER ABSORPTION RESULTS

TYPE OF CUBE	DRY WEIGHT OF CUBE (kg)	WET WEIGHT OF CUBE (kg)	WATER ABSORPTION %
NORMAL CEMENT CONCRETE CUBE	1) 7.298 2) 7.342	1) 7.820 2) 7.994	1) 7.15 2) 8.88
20% GGBS+ 10% BP CONCRETE CUBE	1) 7.294 2) 7.398	1) 7.406 2) 7.766	1) 1.53 2) 4.97

Water absorption test is used to measure the amount of water absorbed by concrete. It helps to evaluate the durability and permeability of concrete. Here, normal concrete showed an average water absorption of 8.01% while Mix 2 GGBS+BP concrete shows an average water absorption of 3.25%. showing mix 2 has better durability and lower porosity.

VI. TEMPERATURE COMPARISON

TABLE 7: TEMPERATURE COMPARISON RESULTS

MIX TYPE	COMPOSITION	TEMPERATURE (^{0} C)
NORMAL CONCRETE	100% Cement	35^{0}C
MIX 2	20% GGBS+ 10% BP	30^{0}C

The GGBS BRICK POWDER concrete showed a reduction in temperature (30^{0}C) compared to normal concrete (35^{0}C), indicating lower heat generation during the hydration process.

VII. RESULTS AND DISCUSSION

From the experimental results, it was observed that:

- Workability increased with the addition of GGBS and brick powder.
- Compressive strength was satisfactory for all mixes.
- Mix 2 showed better performance compared to other mixes and it is considered as the “optimum mix”.

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- The use of GGBS and brick powder reduces cement consumption and environmental impact.

VIII. CONCLUSION

The study concludes that GGBS and brick powder can be effectively used as partial replacements for cement in concrete. The experimental results indicate that the workability and strength properties of concrete improve with optimum replacement levels. Among the tested mixes, the combination of 20% GGBS and 10% brick powder showed the best performance. The use of these materials contributes to sustainable construction and reduces environmental pollution.

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