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Utilization of Waste Materials (GGBS+FLY ASH) In Concrete

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ABSTRACT

Concrete is an extensively used material in the construction industry. Normally the concrete is made up of cement, sand and coarse aggregate at the appropriate ratio as per the requirements. The cement used in the preparation of concrete has its own detrimental effect on health and the environment. Sand is a natural building material that depletes fast due to excessive usage. Sand mining done for construction purposes has its own impact on the environment. As a result, a concentrated effort has been made to use alternative technologies to replace cement and sand. As such, the main goal of this research is to suggest alternative approaches to address the issues of excessive sand utilization by agricultural wastes and industrial wastes and by-products.

Keywords : Fly Ash, GGBS, Fresh and Hardened Test on Concrete, Reducing Emissions.

I. INTRODUCTION

Among the most significant contributors to a nation's social and economic development today is the construction sector. The majority of infrastructure, including residential homes, tall buildings, dams, bridges, and retaining walls, has been built using concrete by the construction industry. The most predominately used binder in concrete is blended cement. Today, public and private organizations have been giving considerable importance to different construction materials on account of their environmental behavior. The increasing use of cement-based concrete in construction projects, along with the ensuing release of toxic chemicals into the atmosphere, results in a notable increase in global temperature. The amount of carbon dioxide (CO_2) produced by a thousand kg of cement is almost equal. According to an estimate, around 6–8% of the total CO_2 globally emitted comes from ordinary cement production. The concrete has been investigated currently in favor of depleting carbon dioxide emissions and enhancing the performance eventually reducing in the cost of construction.

Ground Granulated Blast Furnace Slag (GGBS)

The by-product of producing iron and steel in a blast furnace that is turned into granular form is called granulated blast furnace slag. The term "blast-furnace slag" refers to a non-metallic product that is formed of calcium silicates and aluminosilicates, along with other bases, that can be formed in a blast furnace when iron or steel is molten. When used as an aggregate in concrete, blast furnace slag has both financial and environmental advantages. As an alternative to sand, GGBS is supplied by numerous steel mills in India.

Fly Ash

Coal power plants generate electricity by burning pulverized coal, which creates a hazardous byproduct known as fly ash. On its own, fly ash doesn't have any real benefits. In the past, it was released into the atmosphere, but this had a negative effect on the air quality, so regulations were put in place to control how it is disposed. It's now collected and stored at coal power plants or sent to landfills.

However, the danger to humans, wildlife, and the environment presented by fly ash production can be mitigated by using fly ash to improve the composition of concrete.

Fig 1 Fly Ash

SCOPE AND OBJECTIVE

The purpose of this study is to investigate the unique characteristics of concrete by using fly ash (FA) and granulated blast furnace slag (GBFS) as restricted alternatives to natural coarse aggregate and cement, respectively.

Objectives behind the Research

- The examination of concrete's strength characteristics, such as split tensile strength, flexural strength, and compressive strength
- To ascertain the ideal proportion of fly ash and GGBS to be used in concrete as a partial substitute for cement, hence reducing the fly ash disposal issue when using concrete.
- To propose an alternative building martial that could reach requirements of good building material. And also to arrive at a solution for the problem of imbalance between the availability and the demand of conventional building materials.

II. LITERATURE REVIEW

Sonar (2023), objective of the research paper was to investigate the behavior of Self Compacting Concrete uses GBFS cubes, cylinders, and beams under compressive, flexural and tensile loading Conventional concrete cubes, beams and cylinders are cast for the comparison with Self Compacting Concrete using GBFS. Observations were concentrated on Filling Ability and Passing Ability of concrete, tensile strength, compressive, flexural strength. The mix proportion was prepared by replacing fine aggregate by 5%, 10%, 15%, 20% and 25% with GBFS and Fly Ash respectively.

Observation results concluded that SCC helps to improve the environment of the construction locations by reducing noise produced in the plants and construction fields and reducing the requirement of skilled labourers. where concrete is being casted and also reduced the time period of the project construction. The SCC is an ideal type of concrete that can be used for narrow spaces of reinforcement and architecturally demanding sections, or for all structural applications where higher efforts in order to gain sufficient compaction. and also reduced time period of the project construction. Reduction in the cost of construction with the usage of GBFS, which is cheap and easily available.

Wani and Goel (2022) The usefulness of copper slag as fine aggregate in high strength concrete flexural members (beams) was investigated experimentally and reported in the study article. Copper slag replacement to natural sand at 25%, 50%, 75%, and 100% in M40, M60, and M80 grades were the factors taken into consideration. For Rigid pavement (concrete samples of rectangular cross section were cast five boxes in each grade with similar reinforcement and of same sizes, tested under uniformly increasing static applied load at 1/3rd points. The load– deflection curve at mid-span and Moment–Curvature based on deflection under the loads and at mid-span were analysed.

According to the results, the compressive strength of the CFL and CFC mixes increases with the fly ash % up to the optimal fly ash concentration, beyond which it declines. For CFL and CFC blends, the ideal fly ash percentage was determined to be 20% and 30%, respectively. Fly ash that is added in excess of the ideal amount just acts as a weak filler, decreasing the mix's strength and stiffness. The variation of indirect tensile strength as well as resilient modulus follows the same trend as that of UCS for the variation in fly ash content. UCS values increase continuously with increase in binder (lime and cement) content.

III. MATERIAL AND PROPERTIES

CEMENT

Cement in general can be defined as a material which possesses very good adhesive and cohesive properties which make it possible to bond with other materials to form compact mass.

Table 1. Physical properties of OPC

Physical Properties	Results
Fineness (Sp. Surface)	303 m2 /Kg
Specific Gravity	3.1
Soundness (Le-Chatlier Exp.)	10mm
Comp. Strength -7 days	51.6 MPa
Comp. Strength -28 days	71.3 MPa
Initial Setting Time	50 min

FINE AGGREGATE

Locally available river sand which is free from organic impurities is used. Sand passing through sieve is 4.75mm and retaining on IS sieve 150μ is used in the investigation. Care shall be taken to ensure that the sieves are clean before use.

Table 2 Physical Properties of Fine Aggregate

Physical Properties	Results
Fineness Modulus	3.1
Specific Gravity	2.76
Bulk Density	
i) Loose	14.67kN/m3
ii) Compacted	16.50kN/m3
Grading	Zone-II

COARSE AGGREGATE

The coarse aggregate used here with having maximum size is 20mm. The IS 383:1970 code was used to find out the proportion of mix of coarse aggregate, with 60% 10mm size and 40% 20mm.

Table 3 Physical Properties of Coarse Aggregate

Physical Properties	Results
Specific Gravity	2.62
Fineness Modulus	4.01
Bulk Density	
i) Loose	13.43kn/M3
ii) Compacted	16.45kn/M3
Water Absorption	0.73%
Flakiness Index	15.23
Elongation Index	20.85
Crushing Value	2.36
Impact Value	14.2

FLY ASH

it is most commonly used as a pozzolan in PCC applications. Pozzolans are siliceous or siliceous and aluminous material, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementitious compounds. Particle size of fly ash varies from 1μm to 100μm in diameter with more than 50% under 20μm.

Table 4. Physical Properties of FLYASH

Physical Properties	Results
Physical Form	Off White Powder
Specific Gravity	2.78
Specific Surface area	400-600 m2/Kg
Bulk Density(Loose	1000-1100 Kg/m3
Bulk Density (vibrate)	1200-1300 Kg/m4

GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Molten iron slag, a byproduct of producing steel and iron, is quenched in water or steam in a blastfurnace to create glassy, granular material that is subsequently dried and ground into a fine powder.

Table 5 Physical Properties of Ground Granulated Blast Furnace Slag (GGBS)

Physical Properties	Results
Physical Form	Off White Powder
Specific Gravity	2.78
Specific Surface area	400-600 m2/Kg
Bulk Density(Loose)	1000-1100 Kg/m3
Bulk Density (vibrate)	1200-1300 Kg/m4

WATER

Cleanliness and the absence of harmful levels of oils, acids, alkalis, salts, sugar, organic compounds, and other contaminants that could harm concrete characterize the water used for mixing and curing. According to IS: 456-2000 code, concrete is mixed using potable water.

ADMIXTURE

Conplast SP430 is used as a super plasticizer. It is a chloride free, super plasticizing admixture. It is supplied as a brown solution which instantly disperses in water.

MIX PROPORTION

Three cubes measuring 150 x 150 x 150 mm, three cylinders measuring 150 mm in diameter and 300 mm in height, and three prisms measuring 100 x 100 x 500 mm were made using steel molds for every mixture. The caste specimens spent a whole day at room temperature. They were taken out of the mold and left in water to cure for a full day. For seven and twenty-eight days, cubes are used to measure the compressive strength of concrete. For a period of 28 days, the split tensile strength of concrete was measured using three cylinders. A universal testing equipment with a 1000kN capability was utilized to measure the flexural strength of concrete over a 28-day period utilizing three prisms and a two-point bending test with a supporting span.

EXPERIMENTAL INVESTIGATION

- Compressive strength test

The fundamental attribute of concrete that is most important in determining the durability and structural integrity of concrete constructions is its compressive strength.

The load applied to the cross-section area of the face on which the load was applied at the point of failure is the formula for compressive strength for any given material.

Compressive Strength = Load / Cross-sectional Area

Fig 2 Compression Testing Machine

- Flexural Strength of Concrete

The flexural strength of concrete is affected when wheel loads are applied to a road slab that lacks sufficient sub-grade support and/or when temperature or shrinkage causes volume changes. According to IS: 516-1959, it is calculated

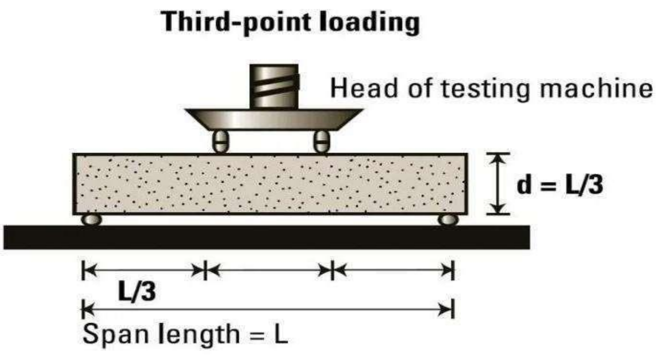

Fig 3 Flexural Strength Test Arrangement

- Tensile Strength Test

Tensile strength is a crucial attribute of concrete because it protects against tensile cracking understructural loads. Because concrete's tensile strength is significantly less than its compressive strength, steel is utilized to support the tension stresses in concrete.

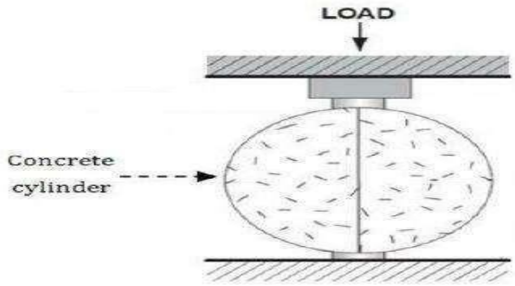

Fig 4. Splitting Tensile Strength Test

RESULTS AND DISCUSSION

FRESH CONCRETE TEST

SLUMP CONE TEST

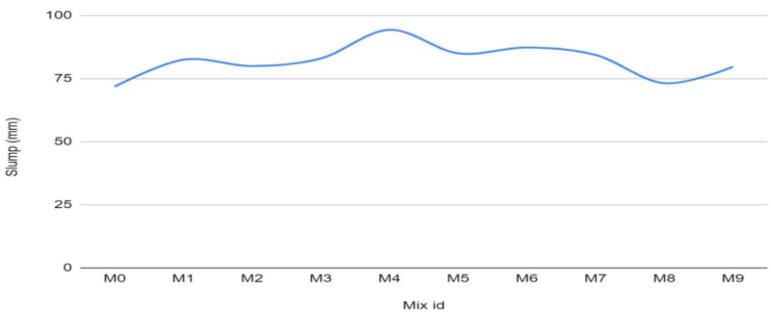

Fig 5 Slump Cone Test in mm

- **Compaction Factor Test**

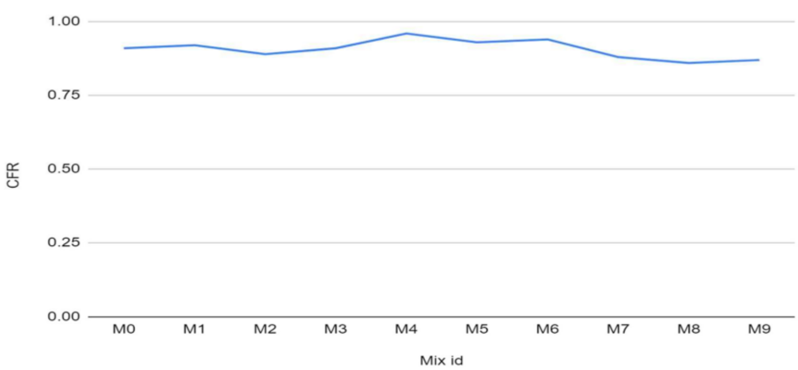

Fig 6 Compaction Factor of Different Mix Proportion of GGBS and Fly Ash

- **Vee- Bee**

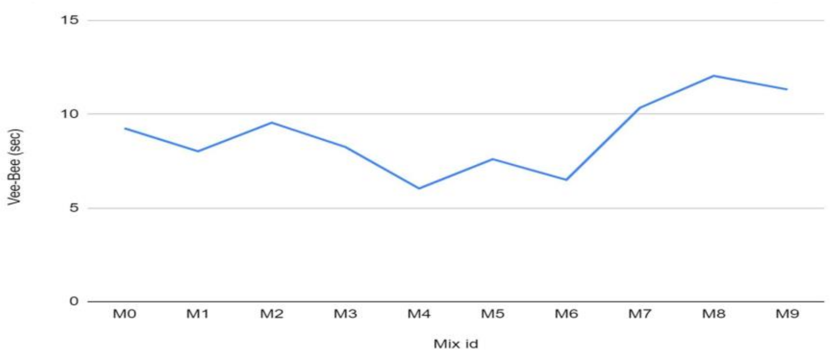

Fig 7 Vee-bee of different mix proportion of GGBS and Fly Ash

STRENGTH TEST

- **COMPRESSIVE STRENGTH TEST**

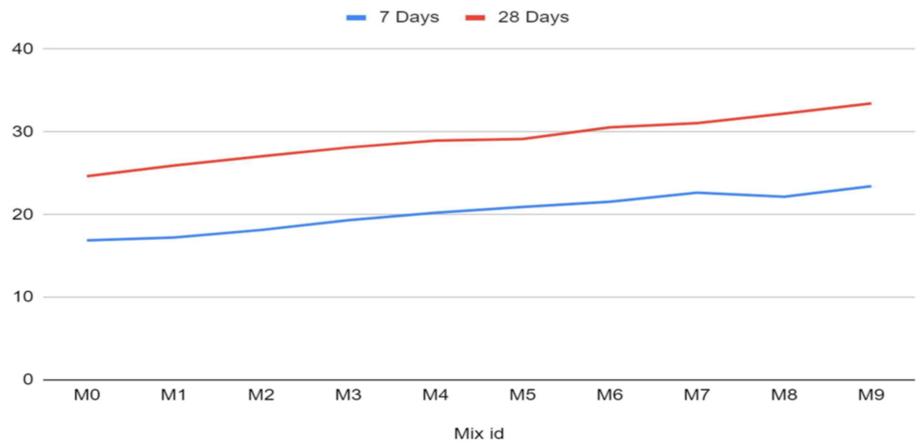

Fig 8 Compressive strength test results for M25grade in N/mm2

- **SPLIT TENSILE STRENGTH**

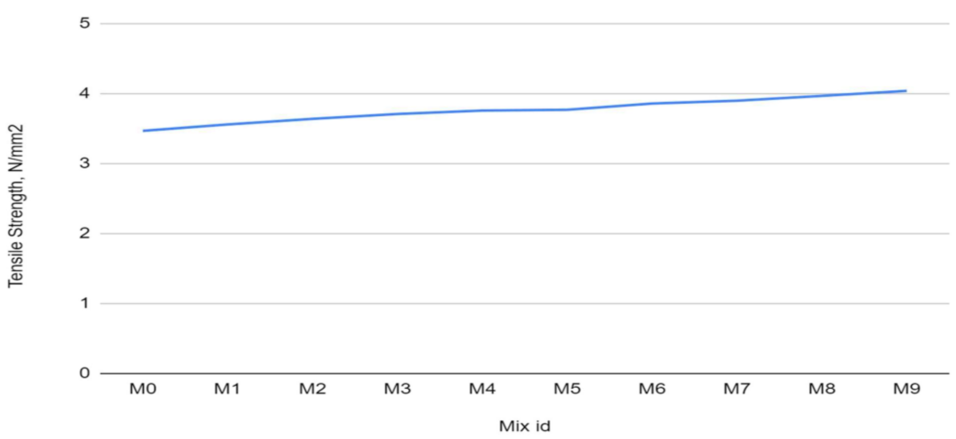

Fig 9 Split Tensile Strength test results for M25 grade in N/mm2

- **FLEXURAL STRENGTH**

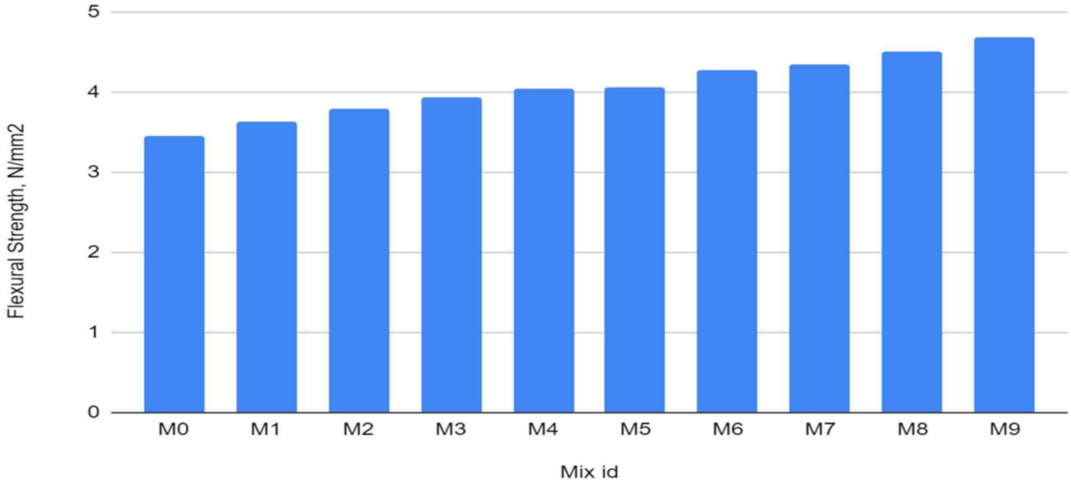

Fig 10 Flexural Strength test results forM25 grade in N/mm2

COST ANALYSIS

Table 6 Cost Analysis

Description	Plain Cement Concrete (M25)			GGBS Concrete (M25)		
	Quantity (kg/m3)	(Rs. perkg)	Amount (Rupees)	Quantity (kg/m3	(Rs. Perkg)	Amount (Rupees)
Coarse Aggregates	1173.78	0.7	821.647	1173.78	0.7	821.647
Sand	653.38	0.46	300.55	653.38	0.46	300.55
OPC 53	435.41	6	2612.46	304.79	6	1828.74
GGBS	-	-	-	87.08	2.8	243.824
		Total	3734.657		Total	3194.491

IV. CONCLUSION

- This research analyzes the compressive strength qualities of concrete by partially replacing cement in concrete with Ground Granular Blast Furnace Slag (GGBS) and Fly Ash.
- The rising demand for cement in the building sector is generating environmental deterioration; as a result, waste materials such as GGBS and Fly Ash are being utilized to substitute cement.
- The main purpose of this work is to evaluate the fresh and hardened characteristics of M-25 grade control concrete and concrete prepared with partial substitution of fly ash and GGBS with variedpercentages.

- To evaluate hardened characteristics compressive strength testing is conducted and comparative research was done.
- Green concrete with economical construction and lower CO2 emissions can be produced with these ratios.
- The Compressive strength increased with addition of fly ash up and the most favorable results were visible for the sample M9 and further additions of GGBS and fly ash will tend to reduce the strength of concrete.
- The Split Tensile strength of Cylinders are increased with addition of fly ash up to 10% and GGBS up to 20% replace by weight of cement and further any addition of FA and GGBS the Split Tensile strength decreases.
- The flexural strength of prisms are increased with addition of fly ash up to 10% and GGBS up to 20% replaced by weight of cement and further any addition of FA and GGBS the flexural strength decreases.

V. FUTURE SCOPE

- This work can further be extended by replacing cement and sand completely from concrete by making use of appropriate admixtures or chemicals.
- The study is to be extended to investigate the effect of reinforced concrete beams and columns under flexure, shear, torsion and fatigue loadings.
- Shrinkage and creep characteristics are important and needs to be investigated.
- To study the structural properties of fly ash and GGBS based geopolymer concrete.

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