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# Experimental Studies on Ternary Blended Concrete using GGBS and Calcined Clay

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***Abstract:** Concrete is the most widely used and versatile building material in all kinds of civil engineering structures.A little more than 5% of global CO2 emissions are attributable to cement, the primary component of concrete.Concrete is strengthened using suitable alternative materials to make it more environmentally friendly.Making the concrete industry sustainable is essential in the current climate in order to reduce its detrimental environmental effects.When choosing raw materials for construction, environmentally friendly products must be employed.The concrete industry is constantly looking for supplemental cementitious materials (SCMs) to address the problem of solid waste disposal.Cement can be substituted with ground granulated blast furnace slag (GGBS), a solid waste made by the iron and steel industry. Cement alternatives can also be made from other resources, such as calcined clay, which is commonly found in oil sand tailings.This study's objective is to experimentally investigate the effects of GGBS in structural concrete by partially substituting calcined clay for cement (5, 10, and 15 percent) and cement for the remaining cement volume.Numerous tests, such as compressive,tensile,and flexural tests,will be used.*
***Keywords:** Calcined Clay, Cement,Flexural Strength,Ground Granulated Blast Furnace Slag(GGBS), Ternary Blended Concrete(TBC).*

## I. INTRODUCTION

In civil engineering, building materials are primarily used in construction.One of the most traditional modern building materials is concrete, which generates more waste than any other material. Much research has been done to attempt and reduce the impact of the cement.The industry can cut its emissions of greenhouse gases by improving the efficiency of the cement manufacturing process or by introducing supplemental cementitious materials (SCMs), which partially replace conventional cement.Concrete comes in a variety of various varieties based on the binder employed.Asphalt, epoxy, and concrete built with normal Portland cement are a few examples.Ordinary Portland Cement (OPC) concrete is the most popular type of concrete used in construction.4.5 billion metric tonnes of it worldwide each year. It has several advantages, including a moderately high compressive strength, independence from shape and form restrictions, low cost, widespread availability of raw materials, adaptability, low energy requirements, and application in a range of environmental settings. Every step in the production of Portland cement has the potential to have an impact on the environment. These include the excessive use of fuel during production, the CO2 emissions from the raw materials during production, and the harm that quarrying causes to the environment.Using machinery and blasting in quarries can also generate airborne contaminants like dust, fumes, noise, and vibration. Equipment to reduce dust emissions during quarrying and cement manufacturing, as well as equipment to trap and separate exhaust gases, are both being used more frequently.It is responsible for around 5% of the total yearly CO2 emissions caused by humans, of which 50% are due to chemical industrial processes and 40% are due to fuel burning.

## II. LITERATURE REVIEW

Aneeta Anna Raju, Lekshmi Priya R, and Shahas S (2017)This study demonstrates that GGBS and bagasse ash can be used in place of cement in concrete without affecting the strength of the final product.The percentage of the mix made up of GGBS and bagasse ash is given by substituting OPC of 43 grade with 0%, 10%, 20%, and 30% of the maximum pozzolanic action.When a blend with high pozzolanic activity substitutes 10% of the cement, the compressive strength increases by 5.64 percent.[1]

Athira Babu and Dr. M. Nazeer(2016) examined the results of experiments on the ternary blended concrete's strength and durability. Different mixes comprising different percentages of silica fume, such as 5%, 10%, and 50%, were used.We produced a binary combination with 50% GGBS.

The GGBS content has kept steady throughout the remaining mixes.The findings indicate that when silica fume content rises, workability tends to decrease.[2]

Narender Reddy and T. Meena (2020)This study advises using Alccofine (an ultra-fine form of slag) as an alternative to cement, which has a substantial negative impact on the environment.After that, Alcofine was used to replace the cement, with the replacement percentage varying between 8 and 14 percent while preserving this ideal ratio of GGBS.[3]
Poornachand Pamu and Kasi Rekha (2018)The results of this investigation showed that ternary blended concrete is more heat resistant than traditional concrete.[5]
P. R. Sreehadevan Pillai and Akhil S. Nair (2018)This study demonstrates how readily available waste materials, such as copper slag and ground granulated blast furnace slag (GGBFS), have shown improved strength when utilised in place of cement and fine aggregate.[7]
Kaushal Prajapati and Abbas Jamani (2017)This study discusses the use of metakaolin and ground granulated blast furnace slag to modify the strength, workability, and durability qualities of concrete.The results showed that adding metakaolin and GGBS to concrete improved its workability, strength, and durability.[9]
S. Sahith Reddy and M. Achyutha Kumar Reddy (2021)According to this study, incorporating pozzolanic components in concrete will be a more secure way to address this problem.The use of fly ash, Ground Granular Blast Furnace Slag (GGBS), Metakaolin, and silica fume as pozzolanic ingredients in concrete has been the subject of numerous studies.[11]
Carlos H. Aramburo, Cesar Pedrajas, and Rafael Talero (2020)According to this journal, calcined clay has surpassed other cementitious materials as having the highest potential to reduce clinker/cement.This study focused on the calcined clay content of the pozzolanic additions when calcined clay was substituted at a level greater than 40%.[12]

## III. METHODOLOGY

Following a thorough analysis of the literature review, which resulted in the acquisition of knowledge about fabrication and a profound comprehension of the fabrication processes, the technique was framed in the following manner.According to the approach that has been described, the procedure has been completed and the experimental results have been evaluated.

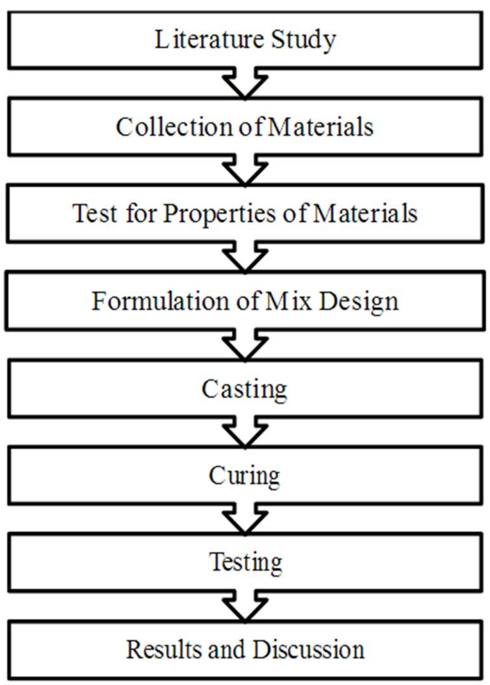


Fig 1 Flow Chart of Methodology

## IV. TEST AND RESULTS OF CONVENTIONAL MIX

The following are the results and discussion of M-50 conventional concrete mix

### *A. Specimen Sizes*

1) Cubes size- 150 X 150mm and Cylinders of 150 X 300mm.
2) Beam of size 1000 X 230 X 300mm is used.

### B. Tests Performed

Tests as Compressive strength, Split tensile Strength, Flexural Strength for corresponding Cube,Cylinder and Beams Are Performed.

### C. Mix Design Criteria

1) Grade Designation - M50
2) Type of cement - OPC53 Grade
3) Maximum nominal size of aggregate – 20mm
4) Minimum cement content & maximum water cement ratio to be adopted,
5) Exposure condition - Severe (From IS 456:2000, Table 3)
6) Maximum water cement ratio – 0.45 (From IS 456:2000, Table 5)
7) Minimum cement content – 320 kg/m³ (From IS 456:2000, Table 5)
8) Workability – 100mm (Slump value)
9) Chemical Admixture – Super Plasticizer

### D. Mix Proportion

1) Cement = 446.50 kg/m³
2) Water = 151.81 kg/m³
3) Fine Aggregate = 742.27 kg/m³
4) Coarse Aggregate = 1100.76 kg/m³
5) Super Plasticizer = 4.47 kg/m³

(Chemical admixture)

### E. Mix Ratio

| Cement | :FA:CA | :Super Plasticizer | :Water |
|---|---|---|---|
| 1:1.66 | :2.47 | :0.01 | :0.34 |

Fig 2 Mix Proportion of Materials

Fig 3 Dry Mixing

Fig 4 Mixing with Admixture

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### *F. Conventional Concrete Results*

The M-50 grade concrete is used. The compressive, Split and Flexural strength tests for 7days and 28days are done and results are obtained.

TABLE I
COMPRESSIVE STRENGTH RESULTS OF CONVENTIONAL CONCRETE CUBE

| Nominal Mix | At 7 Days | At 28Days |
|---|---|---|
| Cube | 34.67 $N/mm^2$ | 52 $N/mm^2$ |

TABLE II
SPLIT TENSILE STRENGTH RESULTS OF CONVENTIONAL CONCRETE CYLINDER

| Nominal Mix | At 7 Days | At 28Days |
|---|---|---|
| Cylinder | 3.67 $N/mm^2$ | 5.68 $N/mm^2$ |

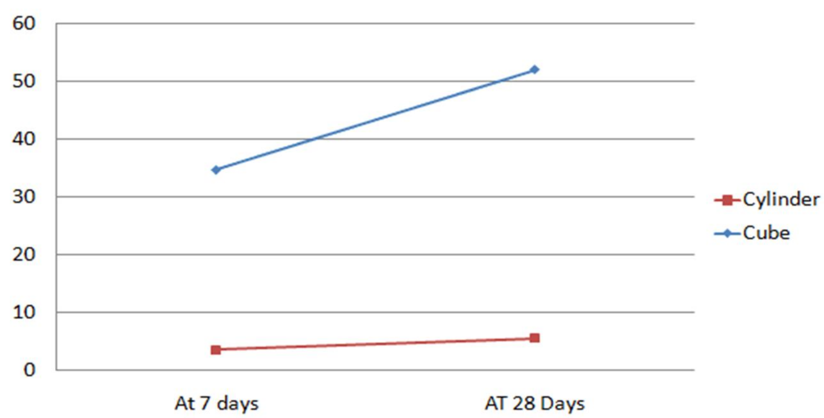


Fig. 5 Chart of Compressive, Split Tensile strength of Conventional Concrete

## V. TEST RESULTS AND DISCUSSION OF GC DESIGN MIX

Cement is partially replaced with GGBS as 40% constant and Calcined clay in 10,20 and 30%.In order to that GGBS and Calcined clay can reduce the cement content thereby not causing any changes in strength criterias.

### *A. Mix Design For Cube*

TABLE III

MIX DESIGN OF CUBE

| Mix Ratio | Cement (kg) | Calcined clay (kg) | GGBS (kg) (40%) |
|---|---|---|---|
| Mix Ratio 1 (CC 10%) | 0.755 | 0.151 | 0.604 |
| Mix Ratio 2 (CC 20%) | 0.604 | 0.302 | 0.604 |
| Mix Ratio 3 (CC 30%) | 0.453 | 0.453 | 0.604 |

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Fig 6 Mix Proportion of Materials

Fig 7 Cube Specimen

Fig 8 Experimental Setup

*B. Test Results-Cube*

TABLE IV
TEST RESULTS OF CUBE

| Mix Ratio | 7 Days | 28Days |
|---|---|---|
| Mix Ratio 1 (CC 10%) | 34.52N/mm$^2$ | 53.50N/mm$^2$ |
| Mix Ratio 2 (CC 20%) | 35N/mm$^2$ | 56.82N/mm$^2$ |
| Mix Ratio 3 (CC 30%) | 34.61N/mm$^2$ | 51.34 N/mm$^2$ |

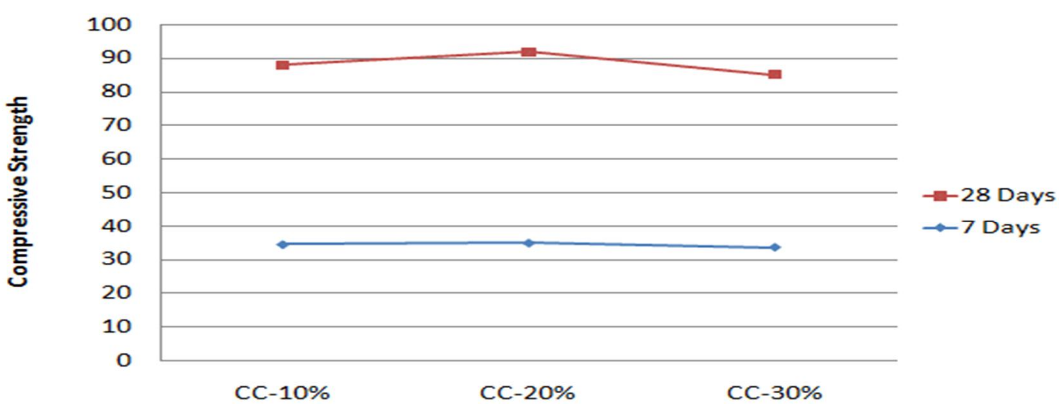


Fig 9 Compressive Strength of Cube

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### *C. Mix Design For Cylinder*

TABLE V
MIX DESIGN FOR CYLINDER

| Mix Ratio | Cement (kg) | Calcined clay (kg) | GGBS (kg) (40%) |
|---|---|---|---|
| Mix Ratio 1 (CC 10%) | 1.185 | 0.234 | 0.948 |
| Mix Ratio 2 (CC 20%) | 0.948 | 0.474 | 0.948 |
| Mix Ratio 3 (CC 30%) | 0.711 | 0.711 | 0.948 |

Fig 10 Greasing of Mould

Fig 11 Cylinder Specimen

Fig 12 Curing of Specimen

### *D. Test Results-Cylinder*

TABLE VI
TEST RESULTS OF CYLINDER

| Mix Ratio | 7 Days | 28Days |
|---|---|---|
| Mix Ratio 1 (CC 10%) | 3.65N/mm$^2$ | 5.62N/mm$^2$ |
| Mix Ratio 2 (CC 20%) | 4.14N/mm$^2$ | 6.38N/mm$^2$ |
| Mix Ratio 3 (CC 30%) | 3.52N/mm$^2$ | 5.43 N/mm$^2$ |

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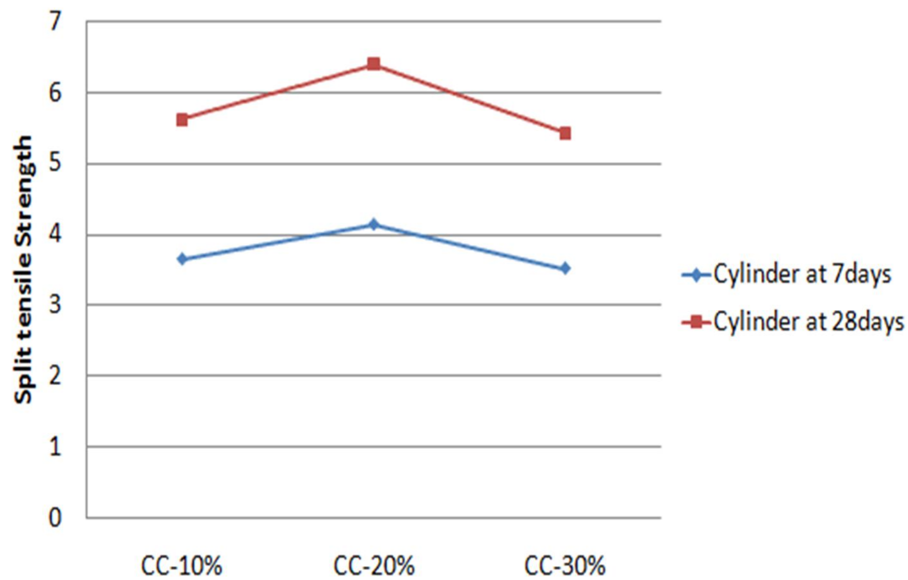


Fig 13 Split tensile Strength Of Cylinder

### *E. Mix Proportion Of Beam*

TABLE VII
MIX PROPORTION OF BEAM

| Mix Ratio | Cement (kg) | Calcined clay (kg) | GGBS (kg) (40%) |
|---|---|---|---|
| Mix Ratio-2 (CC 20%) | 9.44 | 4.72 | 9.44 |

Fig 14 Mix Proportion of Beam

Fig 15 Curing of Beam

### *F. Test Results Of Beam*

TABLE VIII
TEST RESULTS OF BEAM

| Flexural Strength Of Beam | |
|---|---|
| Conventional Mix | Nominal Mix |
| 6.42N/mm$^2$ | 7.58N/mm$^2$ |

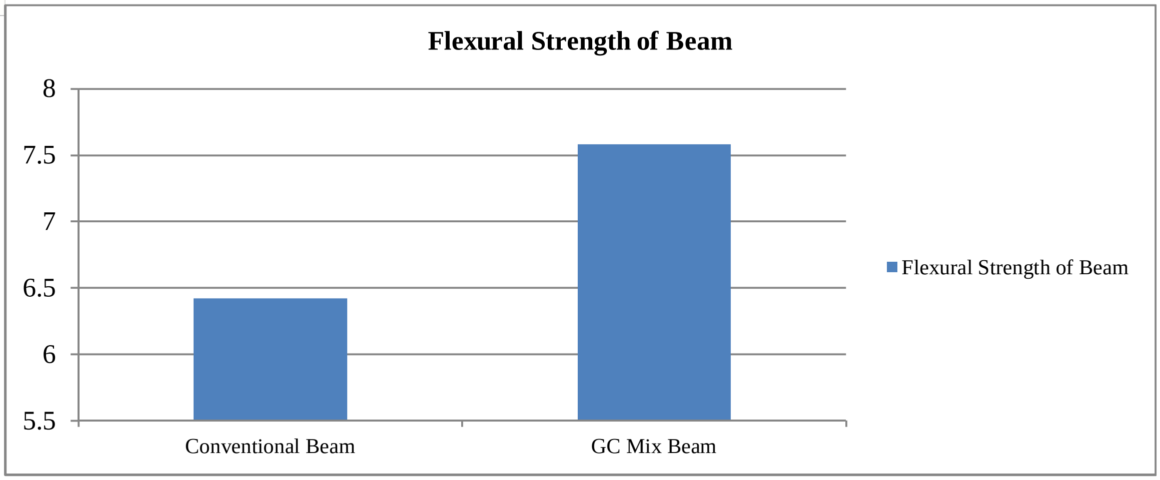


Fig 16 Chart for Flexural strength of Conventional and GC Mix Beam

## VI. CONCLUSION

Cement can be successfully replaced by GGBS and Calcined Clay.Different cement proportions can be utilised to partially replace GGBS and calcined clay in order to determine the appropriate replacement percentage.Concrete will be replaced with hene, GGBS, an industrial byproduct, and calcined clay, a natural pozzolan.Due of environmental challenges and CO2 emissions, the main goal is to use them in concrete-related projects.Both materials have the capacity to cement, which increases their strength and capacity to produce an environment that is benevolent to the environment. As a result, superplasticizers will also be added to concrete in order to give it the increased properties required.The best replacement rate for calcined clay is 20%, which also lowers the risk of pollution.Therefore, cement can replace 20% of CC and 40% of GGBS.Satisfactory findings were obtained for compressive strength, split tensile strength, and flexural strength.Therefore, moving to cement aids in lowering dangerous material emissions.Additionally, it contributes to a pollution-free and environmentally beneficial atmosphere.

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