



# Investigating The Effects Of Flyash And Ggbs As Cement Replacements In Concrete

<sup>1</sup>NakkaVenkataramana,<sup>2</sup>R. Kowshik

<sup>1</sup>P.G. Student,<sup>2</sup>Assistant Professor

<sup>1,2</sup>Department of Civil Engineering,

<sup>1,2</sup>Chaitanya Engineering College, Kommadi, A.P.

**Abstract:** Concrete is most extensively used material in construction. CO<sub>2</sub> is emitted during the manufacture of cement, damaging the environment. By lowering cement usage leads to reduction of CO<sub>2</sub> generated. The increasing demand for cement made researchers to think about the supplementary materials for partial replacement of cement. In the same case if these supplementary materials are naturally occurring or any industrial wastes, then it results in both environment sustainability and economical. The present work focuses on investigating characteristics of M50 grade concrete with partial replacement of cement with GGBS and fly ash. The total replacement of cement with GGBS and Flyash were 40%, 50% and 60%. The cubes, cylinders and prisms are tested for compressive strength, split tensile strength, flexural strength.

**Index Terms** - Compressive strength, Flexural strength, Flyash, GGBS, Split tensile strength, Supplementary materials.

## I. INTRODUCTION

Concrete is the most frequently used construction material in the world, with around 6 billion tones manufactured each year. In terms of per capita usage, it ranks second to water. Cement is a key ingredient in concrete, responsible for binding the other materials together. On the other hand, the manufacture of cement contributes significantly to carbon dioxide emissions, which exacerbates environmental problems including climate change and global warming.

The construction industry seeks alternatives to cement, including binding materials and mineral admixtures. On other hand many industries generate waste, including fly ash (FA), blast furnace slag (GGBS), silica fume, red mud, pond ash, sugarcane bagasse ash, rubber waste, plastic waste, and demolished concrete waste, posing environmental threats and contributing to the waste disposal crisis.

Fly ash, a byproduct of coal combustion in power plants, and GGBS, a byproduct of the iron and steel industry, are both considered industrial wastes. Incorporating these materials into concrete offers a sustainable solution for their disposal, diverting them from landfills and reducing the environmental footprint associated with their disposal. By utilizing fly ash and GGBS as supplementary cementitious materials (SCMs), concrete producers can contribute to resource conservation and mitigate the carbon emissions associated with traditional cement production.

Partial replacement of cement with fly ash and GGBS can lead to improved performance characteristics of concrete. These materials possess pozzolanic or latent hydraulic properties, which react with calcium hydroxide in the presence of water and contribute to the formation of additional hydration products. As a result, concrete containing fly ash and GGBS typically exhibits enhanced durability, reduced permeability, and increased resistance to chemical attacks such as sulfate and chloride ingress. Moreover, the finer

particle size distribution of fly ash and GGBS can improve the workability and cohesiveness of concrete mixes, facilitating easier placement and compaction.

## II. LITERATURE REVIEW

[1] Nguyen, C. V. (2022), "Effect of Locally Sourced Fly Ash and GGBS on the Compressive Strength and Chloride Resistance of Concrete":

The researchers investigated the effect of locally sourced fly ash and ground granulated blast-furnace slag (GGBS) on the compressive strength and chloride resistance of concrete. The mix proportion was cementitious material (total of ordinary Portland cement (OPC), fly ash and GGBS): sand: coarse aggregate: water of 1:2:3:0.6 in which 20% by mass of total cementitious materials was replaced by class F fly ash and GGBS. Compressive strength and rapid chloride penetration tests were conducted at 28, 56 and 120 days. The results shows that fly ash and GGBS reduce slightly the compressive strength but improve significantly the chloride resistance of concrete. Within the range of investigation, 10% of fly ash and 10% of GGBS are recommended to replace OPC as they improve the chloride resistance and maintain the compressive strength of concrete.

[2] Prashant Raj et al; (2022), "An experimental study on partial replacement of cement by GGBS":

In this paper, the authors focused on investigating characteristics of M35 grade concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS) by 30, 40, and 50%. They found that Workability increased with GGBS replacement level. Also, they concluded that optimum GGBS content for strength is 40%.

[3] P. Priya Rachel (2019), "Experimental Investigation on Strength and Durability of Concrete using High Volume Flyash, GGBS and M-Sand":

The study focuses on the partial replacement of concrete with industrial by products such as High volume flyash and Ground granulated blast furnace slag with full replacement of aggregate with M-Sand. Studies have been carried out on the characteristics compressive strength, tensile and flexural strength of concrete, produced using HVFA and GGBFS in the ratio of 0%, 30%, 40% and 50% by the weight of the cement and 100% replacement of M- Sand. The durability property such as Rapid Chloride Penetration Test, Sorptivity Test and Water Penetration Test were studied for a period of 56 days. The optimum compressive strength with 30% HVFA in 56 days is 53.83N/mm<sup>2</sup> and the optimum compressive strength with 50% GGBS in 56 days is 58.17 N/mm<sup>2</sup>. The investigation also showed that the other mechanical property such as flexural strength, split tensile strength gives better results with optimum replacement of High Volume Flyash and Ground Granulated Blast furnace slag.

[4] Virendra Desale, Aarti Kambl, Palash Borwal, Akshay Ingole and Prof. Sudhanshu Pathak (2018), "Experimental Analysis of Partial Replacement of Cement by Ggbs and Fly Ash in Concrete":

The main objective of this thesis is to find an optional material to replace cement if not fully but partially. GGBS (Ground Granulated Blast Furnace Slag) is the waste product from the iron manufacturing industry, which may be used as partial replacement of cement in concrete due to its inherent cementing properties. Fly ash which is a byproduct from burning pulverized coal in electric power generating plants. Hence various proportions are made to replace cement partially by GGBS and Fly Ash. Replacing cement partially by GGBS and Fly Ash gives similar strength after 28 days. Various combinations of concrete gives variable results and maximum quantity of GGBS is 60% that can be replaced by cement and gains the required strength after 28 days. The use of GGBS and Fly Ash is more cheaper than cement and eco-friendly than conventional.

[5] Jagriti Gupta and Nandeshwar Lata (2018), "Effect of Addition and Replacment of GGBS and Flyash with Cement in Concrete":

This study is to work out the effect of mineral admixture GGBS and Fly ash in concrete of grade M-35 & M40 when it is added in & replaced for the fresh state and hardened state i.e. for workability and strength of concrete using OPC (43 grade). As mineral admixture GGBS and Fly ash have been added to OPC which varies from 5% to 30% at interval of 5% by total weight of OPC and the same as partial replacement of OPC (43grade) which varies from 5% to 30% at interval of 5% by total weight of OPC. Various ranges of addition

and replacement of cement by GGBS and Fly Ash in the concrete. All mixes of concrete were examined for workability as slump test of fresh concrete. Hardened concrete was examined for Compressive strength for 7 days and 28 days. Slump was found higher in partial replacement at 30% (GGBS & Fly ash) as compared to that of addition of GGBS & Fly ash. Compressive strength of concrete was increased in both the mixes of M35 at 15% addition and replacement of GGBS & Fly ash, but when further GGBS & Fly ash was added to OPC or partial replacement of OPC by GGBS & Fly ash is done the Compressive Strength goes on decreasing.

[6] P. J. Patel and H. S. Patel (2013), "Effect on Compressive And Flexural Strength of High- Performance Concrete Incorporating GGBS And Fly Ash":

This paper presents the results obtained from laboratory investigation of various trial mixes of concrete mix incorporating fly ash and alccofine for high performance concrete of M60 grade using Indian Standard Recommended method of concrete mix design. In all mix proportions strength gain up to 7 days is excellent, between 7 to 28 days strength gain is comparatively less, but between 28 to 56 days strength gain is high because of fly ash.

### III. MATERIALS USED

#### 3.1 Cement

Cement is a well-known building material that has played an essential role in construction. There are many different types of cement available on the market, and each type is employed under specific conditions due to its unique qualities such as color and composition. The Ordinary Portland cement of 53-grade was utilized in this study in accordance with IS: 12269-1987. The cement tests are carried out in accordance with Indian standards.

#### 3.2 Fine Aggregate

The aggregates that pass through the 4.75mm IS sieve are known as fine aggregates. River sand was employed as the fine aggregate in this construction. Sand passing through sieve is 4.75mm and retaining on IS sieve 150 $\mu$  is used in the investigation. Care shall be taken to ensure that the sieves are clean before use. (IS: 2386 (Part-I) – 1963).

#### 3.3 Coarse Aggregate

The maximum size of aggregate is generally limited to 20mm. Coarse aggregate which passed through 12mm sieve but retained on 6mm sieve is used. Coarse aggregate is obtained by crushing various types of granites, schist, crystalline and lime stone and good quality sand stones. Testing is done as per Indian Standard Specification IS: 383-1970. The size of the aggregate bigger than 4.75 mm is considered as Coarse Aggregate.

#### 3.4 Flyash

Fly ash, also known as a flue- ash, is one of the residual substances that is produced during combustion and consists of the fine particles that are produced by the flue gases. In an industrial context, fly ash usually refers to ash produced during the combustion of coal. Fly ash is pozzolanic in nature, and contains less than 7% lime. is the alumino silicate source material used for synthesis of geopolymeric binder.

#### 3.5 GGBS

Ground Granulated Blast furnace Slag (GGBS), a co-product produced simultaneously with iron, molten blast furnace slag is cooled instantaneously by quenching in large volumes of cold water, known as granulation, to produce Granulated Blast furnace Slag. GGBS is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation.

#### 3.5 Mixing Water

Ordinary potable water of normally pH 7 is used for mixing and curing the concrete specimen. The water utilized in the mortar mix design and curing is potable water supply from water supply system. It is free from organic compounds or suspended solids.

## IV. TESTS ON CONCRETE SPECIMENS

### 4.1 Slump Cone Test

Slump test is to determine the workability or consistency of the concrete mixture prepared in the laboratory or at the construction site during the course of work. A concrete Slump test is performed from batch to batch to check the uniform quality of the concrete during construction. The slump cone test is a widely used method for assessing the workability and consistency of fresh concrete. It provides a quick and simple way to measure the flow of concrete, which is an important indicator to be placed, compacted, and finished during construction. The test is particularly useful for routine quality control on construction sites.

### 4.2 Strength Tests

The various strength tests performed on hardened concrete are Compressive Strength test, Split Tensile Strength test, Flexural Strength test.

#### 4.2.1 Compressive Strength Test

The compressive strength test on concrete is one of the most important tests to assess the quality and performance of concrete. Compressive strength is the ability of concrete to withstand axial loads or forces without undergoing deformation, failure, or collapse. The test is typically conducted on standard cylindrical or cubical specimens.

#### 4.2.2 Split Tensile Strength Test

The split tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. The concrete is not usually expected to resist the direct tension due to its low tensile strength and brittle nature.

#### 4.2.3 Flexural Strength Test

Flexural strength of Concrete, also known as Modulus of rupture, is an indirect measure of the tensile strength of unreinforced concrete. Modulus of rupture can also be defined as the measure of the extreme fibre stresses when a member is subjected to bending. Apart from external loading, tensile stresses can also be caused by warping, corrosion of steel, drying shrinkage and temperature gradient.

## V. RESULTS AND DISCUSSIONS

### 5.1 Workability Test-Slump

Table 1: Slump Cone Test Results

| Mix ID | Slump Value (mm) |
|--------|------------------|
| M1     | 90               |
| M2     | 100              |
| M3     | 150              |
| M4     | 145              |
| M5     | 70               |
| M6     | 130              |
| M7     | 135              |
| M8     | 145              |
| M9     | 120              |
| M10    | 135              |

**Table 2: Compressive Strength Results**

| Mix ID | Compressive Strength (N/mm <sup>2</sup> ) |         |
|--------|-------------------------------------------|---------|
|        | 28 Days                                   | 56 Days |
| M1     | 52.90                                     | 57.98   |
| M2     | 56.87                                     | 65.75   |
| M3     | 59.65                                     | 69.07   |
| M4     | 55.84                                     | 59.81   |
| M5     | 48.79                                     | 54.05   |
| M6     | 51.29                                     | 64.18   |
| M7     | 44.70                                     | 48.54   |
| M8     | 54.69                                     | 64.75   |
| M9     | 40.19                                     | 47.23   |
| M10    | 40.02                                     | 47.20   |

**Table 3: Split Tensile Strength Results**

| Mix ID | Split Tensile Strength (N/mm <sup>2</sup> ) |         |
|--------|---------------------------------------------|---------|
|        | 28 Days                                     | 56 Days |
| M1     | 4.82                                        | 4.94    |
| M2     | 4.84                                        | 4.97    |
| M3     | 4.94                                        | 5.06    |
| M4     | 4.19                                        | 4.31    |
| M5     | 4.56                                        | 4.67    |
| M6     | 4.77                                        | 4.89    |
| M7     | 4.42                                        | 4.54    |
| M8     | 4.84                                        | 4.93    |
| M9     | 4.16                                        | 4.29    |
| M10    | 4.28                                        | 4.41    |

**Table 4: Flexural Strength Results**

| Mix ID | Split Tensile Strength (N/mm <sup>2</sup> ) |         |
|--------|---------------------------------------------|---------|
|        | 28 Days                                     | 56 Days |
| M1     | 6.08                                        | 6.24    |
| M2     | 6.11                                        | 6.28    |
| M3     | 6.20                                        | 6.35    |
| M4     | 5.45                                        | 5.60    |
| M5     | 5.82                                        | 5.98    |
| M6     | 6.03                                        | 6.18    |
| M7     | 5.68                                        | 5.84    |
| M8     | 6.10                                        | 6.27    |
| M9     | 5.42                                        | 5.58    |
| M10    | 5.53                                        | 5.70    |

## V. CONCLUSIONS

The conclusions from the experimental investigations are as follows:

1. Incorporation of Fly ash and GGBS as a partial replacement of cement in concrete gives good results in both fresh and hardened state.
2. In low volume replacement Mix M3 (20%Fly ash +20%GGBS+60%OPC) gives good workability and strength.
3. In high volume replacement Mix M8 (40%Fly ash+20%GGBS+40%OPC) gives good workability and strength.
4. The study reveals that low volume replacement mix M3 (20% Flyash+20% GGBS+60% OPC) is giving good result than high volume replacement Mix M8 (40%Flyash+20% GGBS+40% OPC) at all ages of curing.
5. Making concrete with the combination of Fly ash and GGBS and cement with different percentages gives good results compared to control concrete. So the best way to use these materials is in combination.
6. Due to environmental issues in the production of cement, industrial by products like fly ash and GGBS are used as supplementary materials in concrete and it saves cost of production of concrete, and makes it eco-friendly.

## REFERENCES

- [1] P. Priya Rachel, "Experimental Investigation on Strength and Durability of Concrete using High Volume Flyash, GGBS and M-Sand", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Vol 7, Issue 3 , pp: 396-403, March 2019.
- [2] Virendra Desale, Aarti Kambl , Palash Borwal , Akshay Ingole and Prof. Sudhanshu Pathak, "Experimental Analysis of Partial Replacement of Cement by Ggbs and Fly Ash in Concrete", International Journal of Engineering Research & Technology (IJERT), Vol 7, Issue 5 , pp: 596-598, May 2018.
- [3] Varun BK and Harish BA, "Effect of Addition of Flyash and GGBS on Cement Concrete in Fresh and Hardened State", International Journal of Advance Engineering and Research Development, pp: 91-100, Volume 5, Issue 02, February -2018.
- [4] Jagriti Gupta and Nandeshwar Lata, "Effect of Addition and Replacement of GGBS and Flyash with Cement in Concrete", International Journal of Engineering Research & Technology (IJERT), Special Issue, Volume 6, Issue 11, pp: 1-7, 2018.
- [5] J.Vengadesh Marshall Raman and V.Murali Krishnan, "Partial Replacement of Cement with GGBS in Self Compacting Concrete for Sustainable Construction", SSRG International Journal of Civil Engineering ( SSRG – IJCE ) , Vol 4, Issue 3 , pp: 22-25, March 2017.
- [6] P. J. Patel and H. S. Patel, "Effect On Compressive And Flexural Strength Of High- Performance Concrete Incorporating GGBS And Fly Ash", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development, Vol 3, Issue 2, pp:109-114, 2013.
- [7] Neeraja.D. "Experimental Investigations on Strength Characteristics of Steel Fiber Reinforced Concrete", International Journal of Scientific & Engineering Research Volume 4, Issue 2, February-2013.