# Experimental Examination on Blended Concrete by Incorporating GGBS and Fly ash

**CH. Lokesh Nishanth, Y. Sai Swaroop, Durga Chaitanya Kumar Jagarapu, Arunakanthi Eluru**

***Abstract*: Concrete is the highly used building material around the world. Tons of $CO_2$ is evolved during manufacturing process of cement. This $CO_2$ emission has massive effect on nature and to reduce it blended concrete has been used. Now days, use of cementitious materials are increasing rapidly. Blended concrete is the concrete in which cement is mixed with different proportions of mineral admixtures such as GGBS, silica fume, fly ash etc. In present study, partially replacing of cement with Fly ash and GGBS with three different proportions. Fly ash and GGBS are by-products from coal and iron industries. Here, M40 grade control concrete which is 0% replacement of cement and Blended concrete with 3 different combinations. Both the results will be compared. Cement is substituted by GGBS in 15%, 20% 25% proportion and substituted by Fly ash in 15%, 20% & 25% proportion. These specimens are tested for Split tensile strength, compressive strength and bending strength at the age of 7 and 28 days. Using these industrial wastes not only increases strength but also makes the concrete eco-friendly.***

***Keywords* : Split tensile strength, compressive strength and bending strength, GGBS and Fly Ash.**

## I. INTRODUCTION

Concrete is the combination which consists of Fine aggregates, coarse aggregates, cement and water. Cement is the binding agent which is required for gaining strength. Cement is the main constituent in concrete. One Thousand kilograms production of cement will produce same amount of carbon dioxide [1]. Eventually this will lead to Global warming and several bad effects on environment. According to an estimate, around 6% to 8% of the total global Carbon dioxide comes from cement industries [2]. To reduce this environmental hazard, blended concrete is being used. Blended concrete is the concrete in which cement will be replaced with different mineral admixtures which are pozzolanic in nature.

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Currently lots of research carried out on use of cementitious material such as, metakaolin, GGBS, rice husk ash and silica fume[3]. It was expected that use of Blended concrete lowers the heat produces in cement [4]. Here, cement is partially replaced with fly ash and GGBS in different mix proportions. Replacement levels of cement with GGBS ranges up to 60%. Optimum Strength increased at 20% replacement with GGBS [5]. GGBS is a high quality, with low $Co_2$ emission material. Because GGBS has low Co2 emission, it is used in sustainable concrete construction. The production of GGBS needs fewer than 20% of the energy and generates fewer than 10% of the Carbon dioxide discharge compared to Ordinary Portland cement manufacture. Incorporating GGBS increases the strength and makes the concrete more durable. The problem of land filling the waste byproducts from iron industry will also get reduced by using GGBS as construction material. GGBS is considered as green building material for sustainable constructions. IS 12089:1987(R2008) is the specification for Granulated slag [6]. GGBS also supports to enhance the reflectivity of finished materials and contribute towards the decline of crystalline banks on concrete exteriors. GGBS can be utilized as partial cement substitution in projects like Footings, Structures nearer to Marine, soil stabilization work, paving, Precast construction of Concrete, Concrete frames etc.. Burning of firmer, mature anthracite and coal usually gives Class F fly ash and contains less than 20% of lime (Calcium Oxide). Fly ash class C is obtained from burning of fresher coal and lignite. This consists of more than 20% lime. As per IS 3812:1999, the limit for replacement level is 30% [7]. Here, strength increased at 20% replacement with Fly ash. Incorporation of Fly ash as a partial replacement increases early, late compressive strength and generates low heat. Low amount of $Co_2$ emission during manufacturing of Fly ash makes it more sustainable. Concrete with Fly ash encompass property of resistance to cold weather. Less water is required for Fly ash concrete than the Ordinary Portland cement concrete. Fly ash is being used as Key stuff in various cement-based products. Fly ash incorporated blended concrete produces thick concrete with a smooth surface and sharp detail. Slag and Fly ash formed additional C-S-H gel after reaction with portlandite whose structure is similar type that is accrued by cement hydration. Therefore, GGBS and Fly ash reaction makes a huge contribution to the characteristics and development of concrete [8]. The main objective of this work is to study the strength properties of Blended concrete by incorporating GGBS and Fly ash. Krishna et al., (2017) did research on Fly ash with cement. Rao and Rao (2017) worked on mechanical properties of fly ash with M30 and M60 grade of concrete.

Mounika K., Kumar J., Kameswara Rao (2019) worked on Enhancing the durability and ductility property of concrete incorporated with GGBS and glass fiber .

1 Sowjanya M and Kameswara Rao B (2019) Accelerated curing method for concrete mix proportion by adding GGBS. Sarath Chandra Kumar B and Ramesh K (2016) worked on strength properties of GGBS and metakoalin.

## II. EXPERIMENTAL WORKS

**Materials used:**

53 grade of ordinary Portland cement is used in our work. The chemical and physical properties are mentioned in table 2 and ***GGBS*** : GGBS is a by-product from iron industry. The physical properties and chemical compositions are mentioned in table 1 and 2:

***Fly ash*** : Fly ash of class C is used in this work. The physical properties and chemical compositions are mentioned in table 1 and 2:

GGBS Fly Ash

**Fig:1 Mineral Admixtures**

**Table 1 physical properties of binding materials**

| Properties | Cement | GGBS | Fly Ash |
|---|---|---|---|
| Specific gravity | 3.15 | 2.9 | 2.2 |
| Bulk Density(Kg/m3) | 1865 | 1000-1100 | 540-860 |
| Shape | Spherical | Spherical | Spherical |
| Average particle size | 1.5µ | 4.75mm down | 0.5µm-300µm |

Table 2. Chemical properties of binding materials

**Fine aggregates.** Fine aggregates of zone 2 are used in this work. The physical properties of fine aggregates are mentioned in Table.3.

**Coarse aggregates.** Coarse aggregates of size 20mm are used in this work. The physical properties of coarse aggregates are mentioned in Table.3.

**Table 3: Physical properties of aggregates**

| Physical property | Fine aggregate | Coarse aggregates |
|---|---|---|
| Size | 4.75 | 10-20 |
| Specific gravity | 2.63 | 2.24 |
| Fineness modulus | 2.51 | 6.7 |
| Bu;k density | 1564 | 1800 |
| Water absorption | 0.206 | 0.71 |

**Chemical Admixture:** Conplast SP430 used as a admixture, the physical properties of a Conplast are shown in Table.4.

**Table.4 Physical properties of Conplast SP430**

| Properties | Result |
|---|---|
| Color | Brown |
| PH | 5.6 |
| Density | 1.8 g/cm$^3$ |
| Specific gravity | 1.2 |

**Mix Design:**

After all the material testing the concrete mix is designed as per Indian standards for different mix proportions. All the mix proportions are shown in Table.5.

**Table 5 Mix proportions**

| **Proportions** | **Cement (%)** | **GGBS (%)** | **Fly Ash (%)** |
|---|---|---|---|
| **C** | 100 | 0 | 0 |
| **M1** | 70 | 15 | 15 |
| **M2** | 60 | 20 | 20 |
| **M3** | 50 | 25 | 25 |

The mix quintiles are calculated for one m$^3$. All the quintiles for all mix proportions are presented in Table.6.

**Table.6 Quantities**

| Material | C | M1 | M2 | M3 |
|---|---|---|---|---|
| **Cement** | 394 | 303.38 | 260.04 | 216.7 |
| **Coarse Aggregate** | 1306.62 | 1225.11 | 1225.11 | 1225.11 |
| **Fine Aggregate** | 667.49 | 665.49 | 665.49 | 665.49 |
| **Fly Ash** | -- | 65.01 | 86.68 | 108.35 |
| **GGBS** | -- | 65.01 | 86.68 | 108.35 |
| **Water** | 157.6 | 157.6 | 157.6 | 157.6 |
| **Super Plasticizer** | 2.4 | 2.4 | 2.4 | 2.4 |

## III. RESULTS AND DISCUSSION

***Compression strength*** of cubes which are cured for 7 and 28 days are examined. Compressive test is conducted on cubes of dimensions 15×15×15 cm$^3$.Compression test is done as per the Indian specification IS 516:1959. Optimum strength is attained at 20 % substitution of Cement with GGBS and 20 % with Fly ash. The test results are indicated in Figure .3

**Table 2. Chemical properties of binding materials**

| Binder | CaO | $SiO_2$ | $Al_2O_3$ | MgO | MnO | $TiO_2$ | K2O | $Na_2O$ | $SO_3$ | $Fe_2O_3$ | LOI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cement | 64.2 | 22.7 | 4.6 | 3.4 | 0.9 | 0.2 | 0.8 | 0.1 | 2.5 | 1.4 | 1 |
| GGBS | 34-43 | 27-38 | 13.4 | 0.15-0.76 | <1 | <1 | 0.37 | <1 | <1 | 0.65 | <1 |
| Fly ash | <10 | 25-60 | 10-30 | <1 | 7-15 | <1 | <1 | <1 | <1 | 5-25 | <1 |

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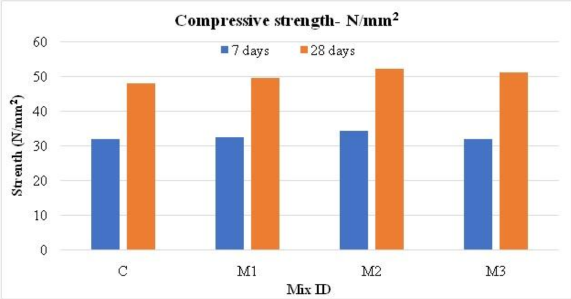


**Fig: 2 Compressive strength**

***Split Tensile strength*** of the cylinders which are cured for 7 days and 28 days and tested. Split Tensile test is executed for cylinders of dimensions 15cm×30cm. Split tensile test is done as per the Indian specification IS 5816:1999. Maximum Split Tensile strength obtained at 20 % substitution with GGBS and 20 % with Fly ash. The test results are indicated in Figure .4

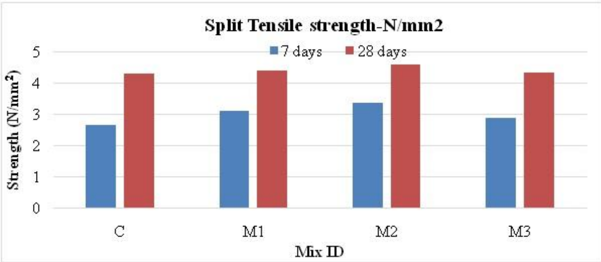


**Fig: 3 Split Tensile strength**

***Bending strength*** of prisms which are cured for 7 days and 28 days is examined. Bending test is conducted for prisms of dimensions 50 cm × 10 cm × 10 cm. Bending test is done as per the Indian specification IS 516:1959. Optimum strength attained at 20 % substitution with GGBS and 20 % with Fly ash. The test results indicated as shown below fig 5 and table 6:

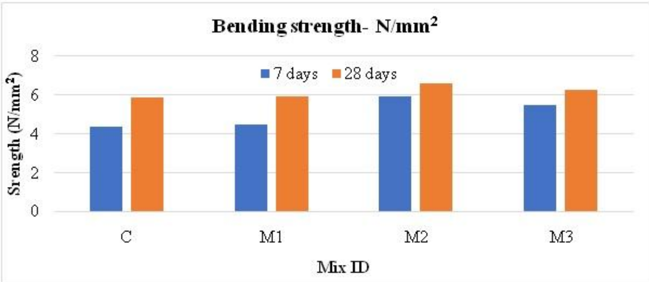


**Fig: 4 Bending Strength**

## IV. CONCLUSION

The experimental results suggest that Blended concrete gave good results than Control Concrete.

- Optimum compressive strength of 52.4N/mm$^2$ attained at 20% of replacement with GGBS and 20% of replacement with fly ash at the age of 7 and 28 days of curing.
- Maximum Split Tensile Strength of 4.61 N/mm$^2$ is acquired at 20% substitution of cement by GGBS and 20% by Fly ash for curing of 7,28 days.
- Maximum Bending Strength of 6.62 N/mm$^2$ is acquired at 20% substitution of cement with GGBS and 20% by Fly ash at 7 and 28 days of curing.
- Incorporation of GGBS along with Fly ash improves the strength of the concrete and makes it sustainable.
- Usage of Blended concrete construction with partial cement substitution in present scenario is economical and eco-friendlier.

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