# Experimental Investigation on Strength Properties of Binary Blended Concrete and Ternary Blended Concrete using Various Mineral Admixtures

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*Abstract*— Basically the need for this project is to determine the most economical and effective with respect to the strength properties of concrete after partially replacement of cement with various mineral admixtures. Therefore, the cement is partially replaced with Fly Ash and G.G.B.F.S as Binary Blended Concrete (BBC) and in addition to that Silica Fume is added to the BBC as Ternary Blended Concrete (TBC) for M20 and M30 grade of concrete as designed by using IS: 10262-2009. The cement is replaced as percentage by weight i.e., 10% 20% 30% for BBC and the maximum strength of compressive strength of concrete at 28 days was found at 20% replacement for both Fly Ash and G.G.B.F.S Blended Concrete and addition of 05% 10% 15% of Silica fume is added to the 20% as TBC. The strength properties of concrete were found by Compressive strength of concrete, Split Tensile strength of concrete and Flexural strength of Concrete.

***Key words:*** Cement, Fly Ash, G.G.B.F.S, Silica Fume, Fine Aggregate, Coarse Aggregate, Binary Blended Concrete, Ternary Blended Concrete, Strength Characteristics, Parial Replacement

## I. INTRODUCTION

Maintainability was a major issue that being concern in making an improvement. This is since economical improvement has turn into a key viewpoint in the public eye, Economics and advancement. At the same the expense of creation of cement is expanding at disturbing rate and characteristic assets giving the crude material for its assembling are draining.

Considering the high costs of Portland cement, a significant requirement for advancing cementitious materials less expensive than normal Portland concrete. Therefore, partially replacement of cement is required by mineral admixtures possessing the pozzolonic materials in it, such as Fly Ash, G.G.B.F.S, Silica Fume, Rice Husk Ash, and Matakoline are recommended as pozzolonic materials.

Therefore, various studies have been conducted individually by partial replacement of cement and thus a conclusion consisting the comparison of this mineral admixture is required. In this way, it is obliged to be familiar with the quality advancement of cement with fly Ash/ G.G.B.F.S and silica fume as an incomplete substitution material for concrete to make concrete. The exploration general intended to look at the changed properties of solidified cement made with diverse bond substitution levels of fly Ash / G.G.B.F.S and silica fume with concrete as Binary / Ternary having immaculate customary Portland concrete.

## II. MATERIAL USED

### A. Cement:

Cement in general can be defined as a material which posses' very good adhesive and cohesive properties which make it possible to bond with other material to form compact mass. Cement used in this project is Ultra-Tech cement 53 Ğrade ordinary Portland cement meeting the requirements of IS12269. Cement content lesser than 380 kg/m3 can also be employed with the addition of finer mineral admixtures such as ggbfs, fly ash, silica fume, RHA etc

### B. Fine Aggregate (FA):

All locally available natural river sand can be used for Concreting. Both rounded and crushed sand can be used. Fine aggregate used in this project is of Tq. Shahpur Dist Yadgir. Common sand fitting in with zone II is utilized at this very moment. The greatest size of the fine aggregate was taken to be 4.75mm.The sieve analysis of fine aggregate was done at this very moment standard determination IS 383-1970. Specific gravity of fine aggregate is considered as 2.65, and Bulk density is considered as 1440 kg/m$^3$.

### C. Coarse Aggregate (CA):

Coarse aggregate used for concreting should be round and well graded diamond shaped. Coarse aggregate used should be clean and free firm dirt. Smaller the size of aggregate higher the workability of concrete. Coarse aggregate should be 20mm and downsize when passed through IS Sieve. Specific gravity of fine aggregate is considered as 2.70, and Bulk density is considered as 1440 kg/m3.

### D. Water:

Water fitting in with the fundamentals of IS: 456-2000 is discovered to be suitable for making concrete. It is by and large expressed that if the water is fit for drinking, it is additionally fit for making cement. In this present examination, Tap water supplied by municipal council was utilized for making concrete and curing.

### E. Properties of Materials Used

| Property | Cement | F.A | C.A |
|---|---|---|---|
| Sp. Gravity | 3.12 | 2.65 | 2.70 |
| Bulk Density(kg/m$^3$) | - | 1640 | 1440 |
| Fineness (%) | 1.2 | 3.25 | 5.12 |

Table 1: Properties of Materials Used

### F. Mineral Admixtures:

#### 1) Fly Ash (FA)

In this study, low calcium FA collected from Raichur Thermal Power Plant (Karnataka, India) was used as partial replacement of cement in concrete. As part of the composite concrete mass, FA acts both as cementatious component and as fine aggregate. Specific gravity of FA is considered as 2.60

*2) Ground Granulated Blast Furnace Slag (G.G.B.F.S)*

G.G.B.F.S is a by-product of the steel industry. G.G.B.F.S is manufactured when molten slag is quenched rapidly by using water jets, which produces a granular glassy aggregate. Specific gravity of G.G.B.F.S is considered as 2.80

*3) Silica Fume (SF)*

In view of its compelling fineness and high silica content, silica fume is an exceptionally successful pozzolanic material. Specific gravity of SF is considered as 2.20

## III. MIX DESIGN

Mix design is carried out by using Indian standard codes i.e, IS 456-2000, & IS 10262-2009. In my dissertation work I am using M20 & M30 grade conventional concrete & the mix details are as follows.

| M20 Grade | Cement (Kg) | Fine aggregate (kg) | Coarse aggregate (kg) | Water (lts) |
|---|---|---|---|---|
| Quantity | 372 | 698.23 | 1165.104 | 186 |
| Proportions | 1 | 1.88 | 3.13 | 0.5 |

| M30 Grade | Cement (Kg) | Fine aggregate (kg) | Coarse aggregate (kg) | Water (lts) |
|---|---|---|---|---|
| Quantity | 425.73 | 655.43 | 1141.37 | 191.58 |
| Proportions | 1 | 1.53 | 2.68 | 0.45 |

Table 2: Mix Designations for M20 & M30 Grade Concrete

### *A. Nomenclature of Mixes for M20 Grade Concrete*

| Mix Designation | Cement content kg/m$^3$ | | FA / G.G.B.F.S content kg/m$^3$ | |
|---|---|---|---|---|
| | % | M20 | % | M30 |
| PCC | 100 | Mix 1 | 0 | Mix 5 |
| BFC - 10 / BGC - 10 | 90 | Mix 2 | 10 | Mix 6 |
| BFC - 20 / BGC - 20 | 80 | Mix 3 | 20 | Mix 7 |
| BFC - 30 / BGC - 30 | 70 | Mix 4 | 30 | Mix 8 |

Table 3: Nomenclature of Mixes for M20 Grade Concrete

### *B. Nomenclature of Mixes for M30 Grade Concrete*

| Mix Designation | Cement content kg/m$^3$ | | FA / G.G.B.F.S content kg/m$^3$ | |
|---|---|---|---|---|
| | % | M20 | % | M30 |
| TFC - 05 / TGC - 05 | 90 | Mix 9 | 10 | Mix 12 |
| TFC - 10 / TGC - 10 | 80 | Mix 10 | 20 | Mix 13 |
| TFC - 15 / TGC - 15 | 70 | Mix 11 | 30 | Mix 14 |

Table 4: Nomenclature of Mixes for M30 Grade Concrete

## IV. EXPERIMENTAL SETUP

| Specimen name | Specimen size | Number of specimens |
|---|---|---|
| Cube | 150 mm x 150 mm x 150 mm | 192 |
| Cylinders | 150 mm diameter and 300 mm height | 96 |
| Prisms | 100 mm x 100 mm x 500 mm | 96 |

Table 5: Experimental Setup

## V. RESULTS AND DISCUSSION

### *A. Hardened Properties of Concrete*

*1) Cubes:*

After Casting and demoulding of cubes the specimen of the concrete is cured and tested for 7 days & 28 days in order to determine the initial strength of concrete for 7 days and final strength for 28 days. The cubes are tested in compressive testing machine, the results are shown below.

*2) Compressive Strength Test Results For FA Based Binary Blended Concrete*

| MIX ID | Average strength in N/mm$^2$ M20 | | MIX ID | Average strength in N/mm$^2$ M30 | |
|---|---|---|---|---|---|
| | 7 days | 28 days | | 7 days | 28 days |
| CC M1 | 17.95 | 25.69 | CC M5 | 26.34 | 37.13 |
| BFC M2 | 16.57 | 25.29 | BFC M6 | 23.14 | 36.55 |
| BFC M3 | 18.38 | 26.12 | BFC M7 | 26.60 | 38.37 |
| BFC M4 | 16.06 | 24.85 | BFC M8 | 22.89 | 35.39 |
| TFC M9 | 17.04 | 24.92 | TFC M12 | 25.22 | 36.12 |
| TFC M10 | 18.09 | 25.98 | TFC M13 | 26.49 | 37.31 |
| TFC M11 | 16.46 | 24.45 | TFC M14 | 25.40 | 35.79 |

Table 6: Compressive Strength Test Results for FA based binary blended concrete

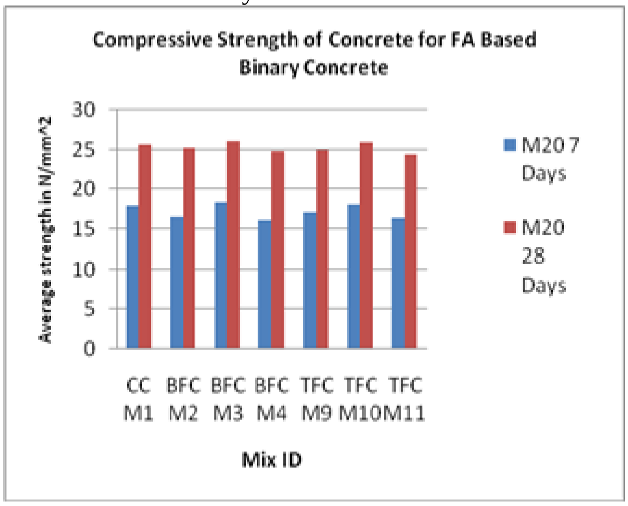


Fig. 1:

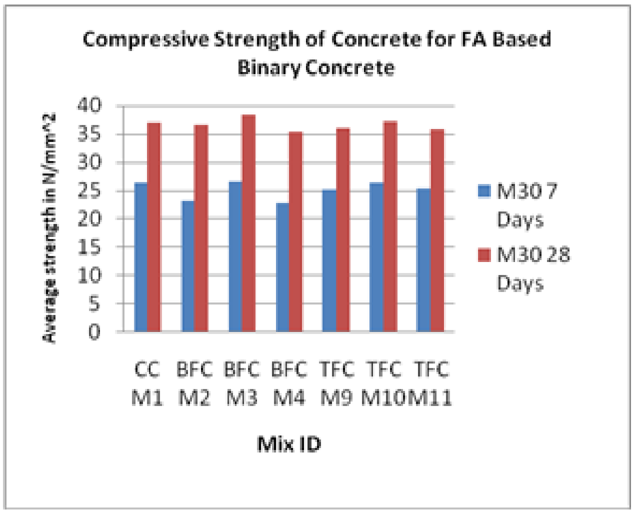


Fig. 2:

*3) Compressive Strength Test Results for G.G.B.F.S Based Binary Blended Concrete*

| MIX ID | Average strength in N/mm² M20 | | MIX ID | Average strength in N/mm² M30 | |
|---|---|---|---|---|---|
| | 7 days | 28 days | | 7 days | 28 days |
| CC M1 | 17.95 | 25.69 | CC M5 | 26.34 | 37.13 |
| BGC M2 | 17.08 | 25.22 | BGC M6 | 25.65 | 36.55 |
| BGC M3 | 18.20 | 26.09 | BGC M7 | 26.63 | 37.57 |
| BGC M4 | 16.46 | 24.85 | BGC M8 | 25.07 | 36.19 |
| TGC M9 | 17.40 | 25.80 | TGC M12 | 26.05 | 36.84 |
| TGC M10 | 18.28 | 26.81 | TGC M13 | 26.71 | 37.86 |
| TGC M11 | 16.93 | 25.14 | TGC M14 | 25.54 | 36.26 |

Table 6: Compressive Strength Test Results for G.G.B.F.S based binary blended concrete

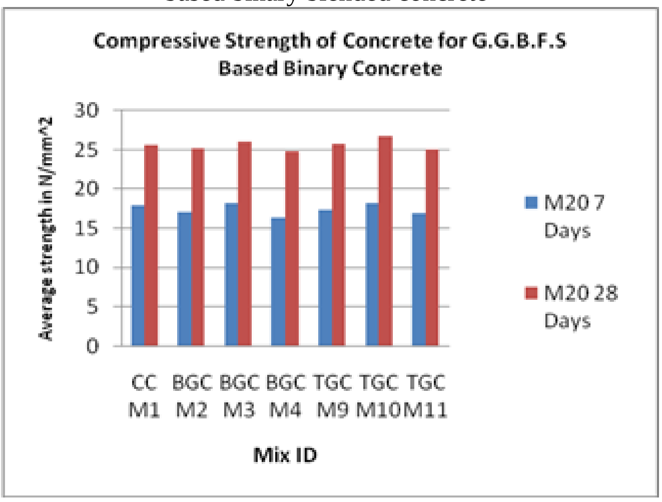


Fig. 3:

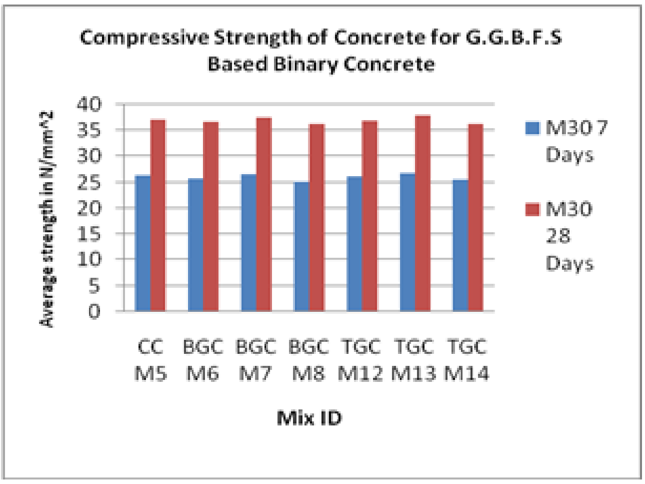


Fig. 4:

## B. Cylinders:

The split tensile strength testing was done for 28 days in order to find the strength of cylinder, the results are shown below.

*1) Split Tensile Strength Test Results For FA Based Binary Blended Concrete*

| MIX ID | Average strength in N/mm² | MIX ID | Average strength in N/mm² |
|---|---|---|---|
| | M20 - 28 days | | M30 - 28 days |
| CC M1 | 2.81 | CC M5 | 3.12 |
| BFC M2 | 2.50 | BFC M6 | 2.83 |
| BFC M3 | 2.90 | BFC M7 | 3.22 |
| BFC M4 | 2.44 | BFC M8 | 2.67 |
| TFC M9 | 2.79 | TFC M12 | 2.94 |
| TFC M10 | 3.03 | TFC M13 | 3.29 |
| TFC M11 | 2.68 | TFC M14 | 2.81 |

Table 7: Split Tensile Strength Test Results for FA based binary blended concrete

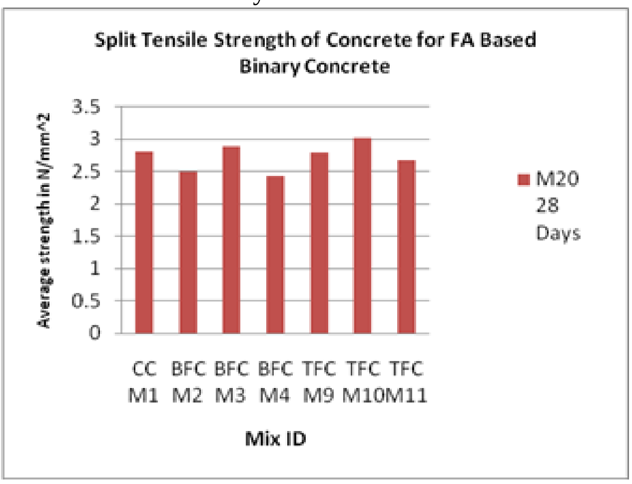


Fig. 5:

 

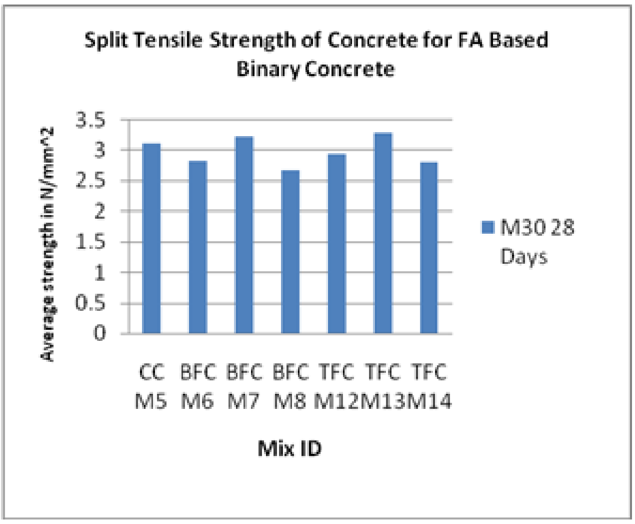


Fig. 6:

*2) Split Tensile Strength Test Results For G.G.B.F.S Based Binary Blended Concrete*

| MIX ID | Average strength in N/mm² | MIX ID | Average strength in N/mm² |
|---|---|---|---|
| | **M20 - 28 days** | | **M30 - 28 days** |
| CC M1 | 2.81 | CC M5 | 3.12 |
| BGC M2 | 2.70 | BGC M6 | 2.99 |
| BGC M3 | 2.85 | BGC M7 | 3.26 |
| BGC M4 | 2.63 | BGC M8 | 2.74 |
| TGC M9 | 2.70 | TGC M12 | 3.03 |
| TGC M10 | 3.01 | TGC M13 | 3.31 |
| TGC M11 | 2.59 | TGC M14 | 2.89 |

Table 8: Split Tensile Strength Test Results for G.G.B.F.S based binary blended concrete

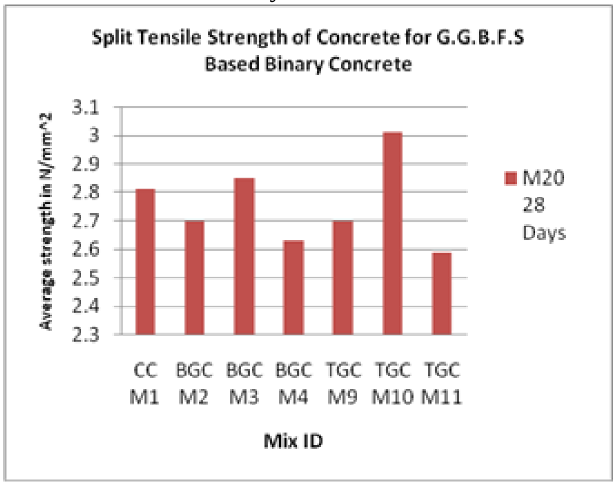


Fig. 7:

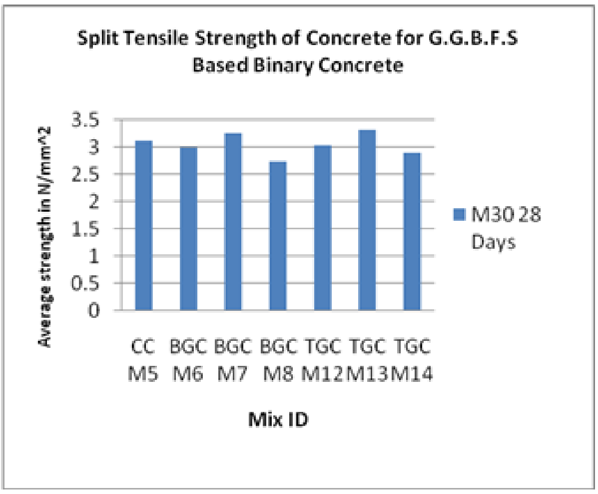


Fig. 8:

*C. Prisms:*

The Flexural strength testing was done for 28 days in order to find the strength of Prisms, the results are shown below

*1) Flexural Strength Test Results for FA Based Binary Blended Concrete*

| MIX ID | Average strength in N/mm² | MIX ID | Average strength in N/mm² |
|---|---|---|---|
| | **M20 - 28 days** | | **M30 - 28 days** |
| CC M1 | 5.43 | CC M5 | 6.34 |
| BFC M2 | 5.21 | BFC M6 | 6.03 |
| BFC M3 | 5.56 | BFC M7 | 6.36 |
| BFC M4 | 5.01 | BFC M8 | 5.85 |
| TFC M9 | 5.21 | TFC M12 | 6.15 |
| TFC M10 | 5.65 | TFC M13 | 6.45 |
| TFC M11 | 5.18 | TFC M14 | 5.99 |

Table 9: Flexural Strength Test Results for FA based binary blended concrete

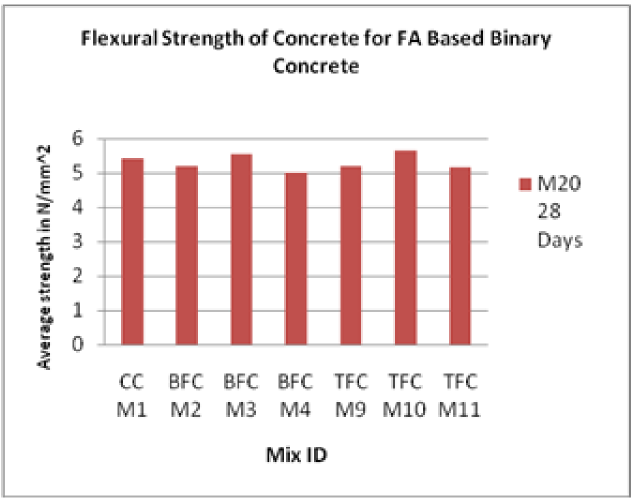


Fig. 9:

 

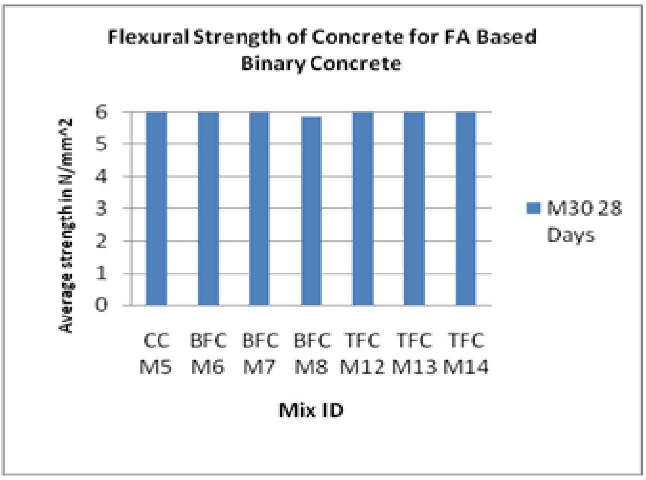


Fig. 10:

*2) Flexural Strength Test Results for G.G.B.F.S based Binary Blended Concrete*

| MIX ID | Average strength in N/mm$^2$ | MIX ID | Average strength in N/mm$^2$ |
|---|---|---|---|
| | **M20 - 28 days** | | **M30 - 28 days** |
| CC M1 | 5.43 | CC M5 | 6.34 |
| BGC M2 | 5.34 | BGC M6 | 6.13 |
| BGC M3 | 5.61 | BGC M7 | 6.38 |
| BGC M4 | 5.18 | BGC M8 | 5.83 |
| TGC M9 | 5.22 | TGC M12 | 6.23 |
| TGC M10 | 5.64 | TGC M13 | 6.47 |
| TGC M11 | 5.15 | TGC M14 | 6.12 |

Table 10: Flexural Strength Test Results for G.G.B.F.S based binary blended concrete

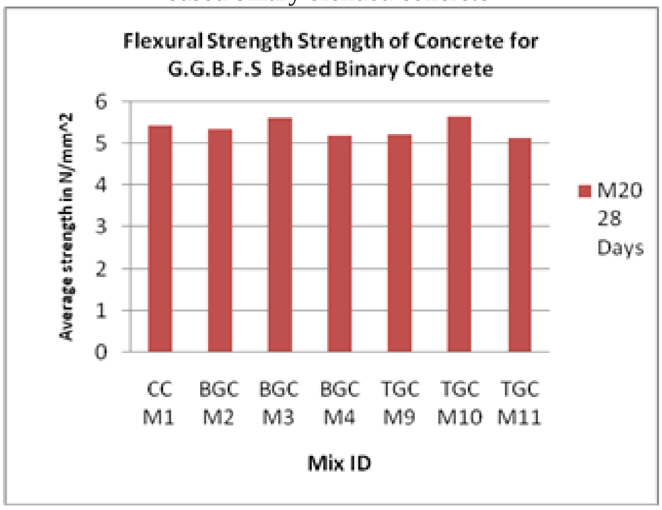


Fig. 11:

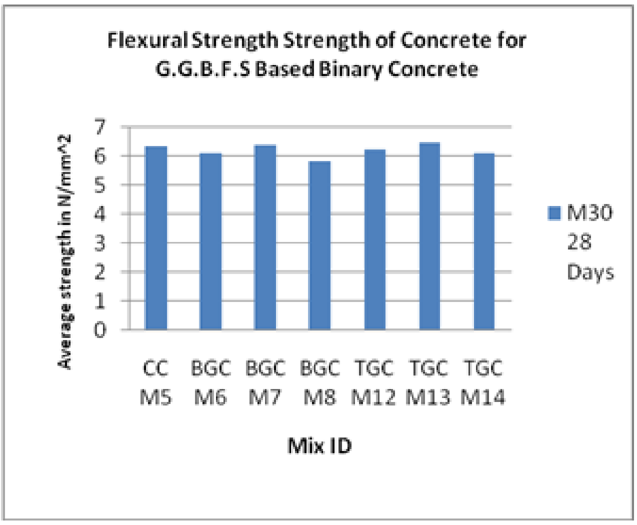


Fig. 12:

## VI. Discussion

- With the addition of Fly Ash and G.G.B.F.S the strength of concrete increases up to optimum replacements than the values goes on decreasing with more addition of mineral admixtures.
- The strength increase with the addition of Fly Ash and G.G.B.F.S is noticed from 10-20% partially replacement of cement.
- M20 Grade concrete Mix designation BFC- M2 & BFC-M3 which is 10%, 20% partially replacement of FA shows higher strength values then Control Concrete M20 M1 and for M30 Grade concrete Mix designation BFC- M6 & BFC – M7 which is 10%, 20% partially replacement of FA shows higher strength values then Control Concrete M30 M5.
- M20 Grade concrete Mix designation BGC- M2 & BGC-M3 which is 10%, 20% partially replacement of G.G.B.F.S shows higher strength values then Control Concrete M20 M1 and for M30 Grade concrete Mix designation BGC- M6 & BGC – M7 which is 10%, 20% partially replacement of G.G.B.F.S shows higher strength values then Control Concrete M30 M5.
- M20 Grade concrete Mix designation TFC- M9 which is 05% partially replacement of FA shows higher strength values then Control Concrete M20 M1 and for M30 Grade concrete Mix designation TFC- M12 which is 05% partially replacement of FA shows higher strength values then Control Concrete M30 M5.
- M20 Grade concrete Mix designation TGC- M9 & TGC-M10 which is 05%, 10% partially replacement of G.G.B.F.S shows higher strength values then Control Concrete M20 M1 and for M30 Grade concrete Mix designation TGC- M12 & TGC – M13 which is 05%, 10% partially replacement of G.G.B.F.S shows higher strength values then Control Concrete M30 M5.

## VII. Conclusion

The following conclusions were made based on experimental study on conventional concrete and SCC of M40 grade using mineral admixtures like fly ash and Ground Granulated Blast Furnace Slag.

- Conventional concrete (CC) of M30 grade is designed as per IS code - 10262:2009 and a compressive strength of 37.13 N/mm2 is attained at 28 days.
- Binary Blended Concrete of M20 and M30 Grade by partially replacement of cement by 20% Fly ash obtained maximum compressive strength, split tensile strength and flexural strength.
- Binary Blended Concrete of M20 and M30 Grade by partially replacement of cement by 20% G.G.B.F.S obtained maximum compressive strength, split tensile strength and flexural strength.
- Ternary Blended Concrete of M20 and M30 Grade by partially replacement of cement by 05% Fly ash obtained maximum compressive strength, split tensile strength and flexural strength.
- Ternary Blended Concrete of M20 and M30 Grade by partially replacement of cement by 10% G.G.B.F.S obtained maximum compressive strength, split tensile strength and flexural strength.

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