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# Experimental Behaviour of High Performance Concrete Using GGBS and M-Sand

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**Abstract:** Concrete is a composite material composed of fine and coarse aggregate bonded together with fluid cement which hardens over time. Manufacturing sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the world. The research aim is to study the effect of using GGBS and M-sand in high performance concrete. To conduct the experimental program and to determine the ultimate Compressive Strength, Split Tensile and Flexural Strength of HPC of these grades M60 and M80 comparing these with that of M25 Mix proportion
**Keywords:** GGBS, M Sand, Glenium B 233

## General

Most use of the term "Concrete" refers to Portland cement concrete or to concretes made with other hydraulic cements, such as cement foundation. However, road surfaces are also a type of concrete, "Asphaltic concrete", where the cement material is bitumen.[1]

A range of materials can be used as the cement in concrete. One of the most familiar of these alternative cements is asphalt concrete. Other cementitious materials such as fly ash and slag cement, are sometimes added as mineral admixtures (see below) - either pre-blended with the cement or directly as a concrete component - and become a part of the binder for the aggregate.[3]

The most conspicuous of these are fly ash, a by-product of coal-fired power plants, ground granulated blast furnace slag, and silica fume, a by-product of industrial electric arc furnaces**.**[2] The use of these materials in concrete reduces the amount of resources required, as the mineral admixtures act as a partial cement replacement.

## High strength concrete

High strength concrete has a compressive strength greater than 40MPa (5800 psi). In the UK, BS EN 206-1 defines High strength concrete as concrete with a compressive strength class higher than C50/60. High strength concrete is made by lowering the water-cement (W/C) ratio to 0.35 or lower.[8]

### M-Sand

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Another reason for use of M-Sand is its availability and transportation cost.[5]Since this sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off river sand bed. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

### Ground granulated blast-furnace slag (GGBS)

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.[3]

### Fly ash

Fly ash, also known as "Pulverized Fuel Ash" in the United Kingdom, is one of the residues generated by coal combustion, and is composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash[10]. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the boiler is known as coal ash.

**Micro silica**

Silica fume, also known as micro silica, (CAS number 69012-64-2, EINECS number 273-761-1) is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as Pozzolonic material for high performance concrete.

**Chemical admixtures**

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate that is added to the mix immediately before or during mixing.

**Fosroc Admixtures**

Chemical admixtures are the ingredients in concrete other than Portland cement, water, and aggregate that is added to the mix immediately before or during mixing.[12]Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing; and to overcome certain emergencies during concrete operations.

**Super Plasticizer Admixtures**

**Glenium B-233**

Glenium B233 is an admixture of a new generation, based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. Glenium B233 is free of chloride & low alkali. It is compatible with all types of cements.

**Properties of Glenium B233**

| Properties | Limits |
|---|---|
| Color | Light brown liquid |
| Relative density | 1.09 ± 0.09 |
| Ph | >6 |
| Chloride ion content | <0.2% |

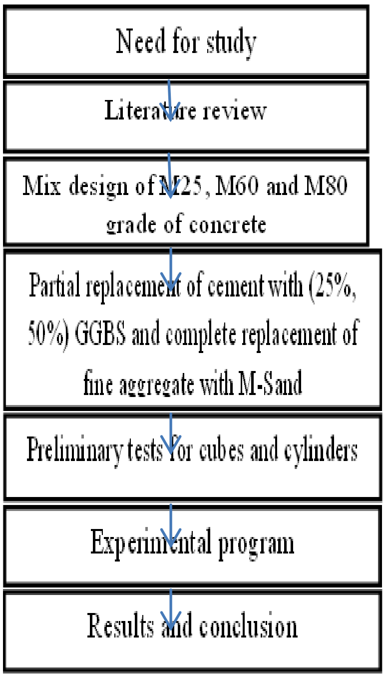
Glenium B233 dosage ranges from 500ml to 1500ml per 100kg of cementitious material is normally recommended. Optimum dosage of chemical admixture is 1.5 to 2%, dosage below 1.5% affects the workability and over dosage affects the setting time.

**Need For Study**

Due to the depletion of good quality of river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of M-sand is its availability and transportation cost. Since this sand can be crushed from hard granite rocks, it can be readily available at the nearby places, reducing the cost of transportation from far-off river sand bed.

The chemical composition of GGBS contributes to the production of superior cement. Over the period of time, its load-bearing properties continue to increase as it absorbs surplus lime released during hydration to form more calcium silicate hydrates.[7]These hydrates add to the strength of cement. Hence it is economical to use in the construction. It is excellent binder to produce high performance cement and concrete.

**Methodology**




Initially we decide the project and examine the need for the study, later we underwent many literature review based on that we choose how to work on this and then we estimated the cost of the materials and it is effective in cost so we decided to execute it. Then we collected the samples and its physical property tests were carried out. Next we choose the various proportions (0%, 25%, and 50%) for the replacement material for M25, M60, and M80 grade concrete. We casted cubes, cylinders and reinforced beams and the curing period are 14, 28 and 56 days. We done preliminary test for cubes and cylinders and experimental work mainly on reinforced beams..By comparing all the test results of the specimens, suggestion for the efficient amount of replacement of GGBS in the cement was concluded.

**Compressive Strength Test**

It is the capacity of a material or structure to withstand loads. The size for the specimen of the cube is 15ommx150mmx150mm, we have done the casting and he curing period was taken is 14, 28 and 56 days for M25, M60, and M80 grades of concrete. Totally 27 samples are taken for each grade and for one ratio three samples are taken. So for three grades we have taken three different ratios hence totally 54 cubes are casted. The test results for the compression strength are listed below in the table

| Grade | % of proportion | Comp strength in N/mm$^2$ | | |
|---|---|---|---|---|
| | | **14 days** | **28 days** | **56 days** |
| M25 | Nominal mix | 23.3 | 27.35 | 29.95 |
| | 25% | 26.56 | 31.59 | 33.38 |
| | 50% | 25.12 | 29.19 | 31.45 |
| M60 | Nominal mix | 53.37 | 63.82 | 76.51 |
| | 25% | 59.69 | 68.82 | 83.17 |
| | 50% | 57.13 | 67.57 | 80.72 |
| M80 | Nominal mix | 69.51 | 81.44 | 97.31 |
| | 25% | 71.31 | 84.22 | 100.19 |
| | 50% | 70.46 | 80.89 | 95.75 |

**Split Tensile test**

The tensile strength of the concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle in nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concede member may crack. The size of the cylinder is 300mmx150mm where it is also casted and cured for 14 and 28 days. Similarly for split tensile test we have casted two cylinders for each grade with three different ratios, so totally three grades 24 specimens are casted. The test results for the split tensile are given below in the table

| Grade | % of proportion | Tensile strength in N/mm$^2$ | | |
|---|---|---|---|---|
| | | 14 days | 28 days | 56 days |
| M25 | Nominal mix | 2.70 | 3.12 | 3.48 |
| | 25% | 2.76 | 3.26 | 3.66 |
| | 50% | 2.71 | 3.14 | 3.42 |
| M60 | Nominal mix | 3.92 | 4.79 | 5.81 |
| | 25% | 4.15 | 4.88 | 5.92 |
| | 50% | 3.98 | 4.71 | 5.67 |
| M80 | Nominal mix | 4.79 | 5.63 | 6.87 |
| | 25% | 5.38 | 5.59 | 6.84 |
| | 50% | 4.72 | 5.52 | 6.73 |

**Flexural Strength Test**

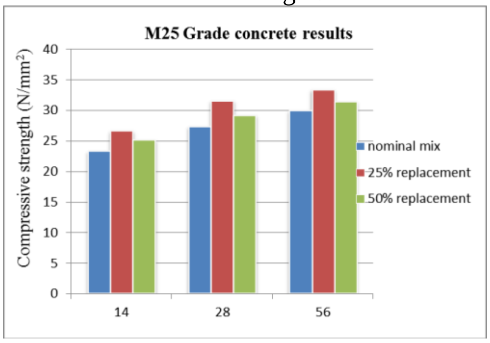
Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6x6 inch concrete beams with a span length of atleast three times the depth.

Hence the size of the beam we used is 750x150x150mm since beam isalso casted and cured for 14 28 and56 days for the M25, M60 and M80 grades of concrete.

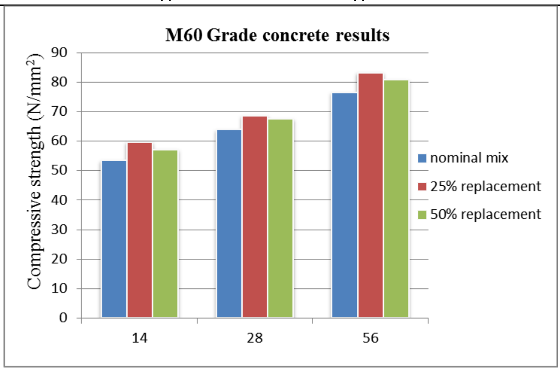
Similarly for flexural strength we have taken two beams for each grade so totally for three different ratios for 14 and 28 days, we have casted 24 beams for the three different grades. The test result for the flexural strength is listed below in the Table

| Grade | % of proportion | Flexural strength in N/mm$^2$ | | |
|---|---|---|---|---|
| | | 14 days | 28 days | 56 days |
| M25 | Nominal mix | 3.19 | 3.79 | 4.23 |
| | 25% | 3.41 | 4.01 | 4.46 |
| | 50% | 3.35 | 3.90 | 4.35 |
| M60 | Nominal mix | 4.97 | 5.78 | 7.02 |
| | 25% | 5.02 | 5.91 | 7.19 |
| | 50% | 4.99 | 5.88 | 7.12 |
| M80 | Nominal mix | 5.47 | 6.39 | 7.87 |
| | 25% | 5.51 | 6.53 | 8.00 |
| | 50% | 4.74 | 8.00 | 7.71 |

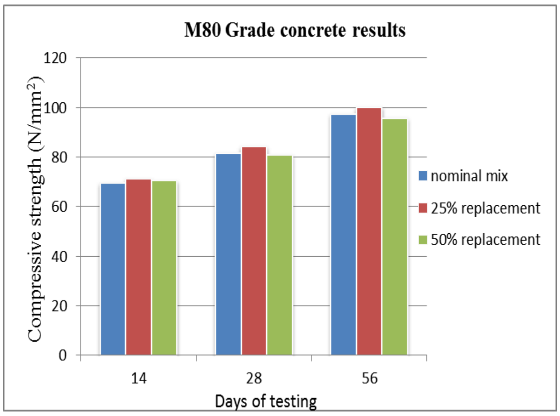
The flexural strength for the reinforced beams are arrived by providing point loads on it specific distance. By comparing the flexural strength of various grades of various percentage of replacement shows that the 25% of replacement of GGBS in cement gives the high flexural strength value, if the percentage of replacement of GGBS increases it decrease its flexural strength.



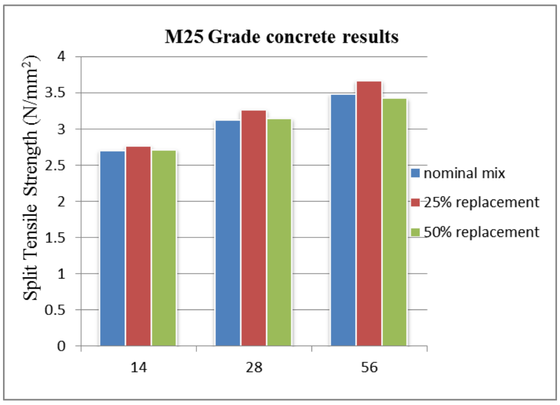

COMPRESSIVE STRENGTH TEST OF M25 GRADE CONCRETE



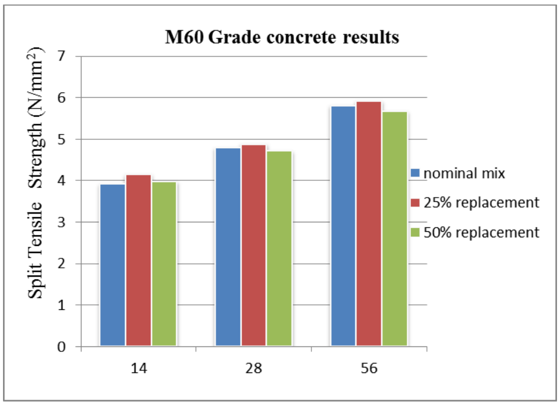

COMPRESSIVE STRENGTH TEST OF M 60GRADE CONCRETE



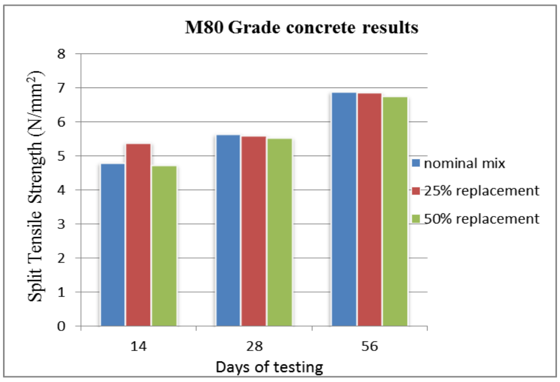

COMPRESSIVE STRENGTH TEST OF M 80GRADE CONCRETE



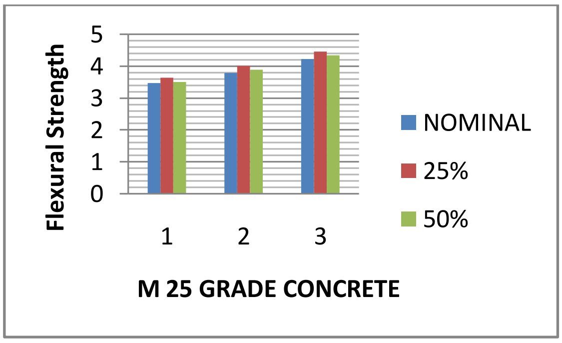

SPLIT STRENGTH TEST OF M25 GRADE CONCRETE



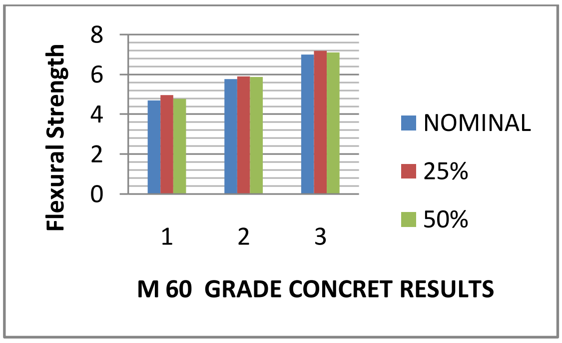

SPLIT STRENGTH TEST OF M 60 GRADE CONCRETE



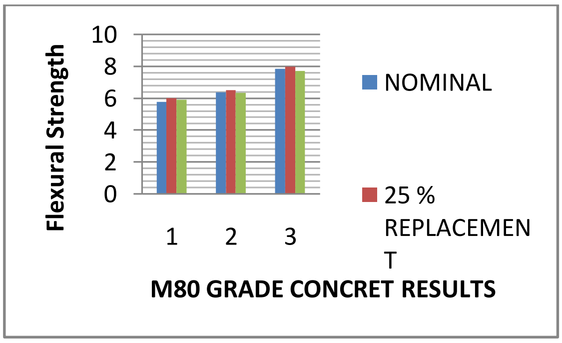

SPLIT STRENGTH TEST OF M80 GRADE CONCRETE




FLEXURAL STRENGTH TEST OF
M 25 GRADE CONCRETE




FLEXURAL STRENGTH TEST OF
M 60 GRADE CONCRETE




FLEXURAL STRENGTH TEST OF
M 80 GRADE CONCRETE

## Conclusions

Based on the experimental studies conducted the following conclusions are drawn.

- The optimum replacement level of GGBS in cement is 25%, because 25% replacement gives higher strength whereas the strength gradually reduces for the 50% of replacement proportion.
- In high performance concrete also 25% of replacement gives efficient strength.
- The chemical admixture Fosroc increases the strength in nominal mix. Whereas Glenium B233 increase the 2% of strength in high performance.
- Hence fly ash is used in high performance concrete because when it binds with GGBS it strength improves gradually whereas the fly ash will give an optimum result in 22-30%.
- Compressive strength of concrete had shown an increasing trend with the increase of curing period.

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