# EXPERIMENTAL INVESTIGATION ON HARDEN CONCRETE BY REPLACING CEMENT WITH MICRO SILICA & SAND BY COPPER SLAG IN ADDITION WITH GLASS FIBRE

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*Abstract:* **This project work focuses on investigating the characteristics of M30 grade concrete with partial replacement of cement using ultra-fine micro silica and sand by copper slag. Different series of concrete mixtures were prepared for this experimental study. Cement is replaced with ultra-fine micro silica at proportions involving 0%,5%,10% and 15% and sand is replaced with copper slag at constant proportion 20%, 40% and 60%.Glass fibre is added 1%. All specimens were cured for 7,14 & 28 days to investigate the compressive strength, split tensile strength and flexural strength. It is found that by the partial replacement of cement using ultra fine micro silica and sand by copper slag helped in improving the strength and enhanced mechanical properties of the concrete substantially compared to the normal mix concrete.**

***Keywords:***Glass fibre, M30 mix, micro silica, copper slag

## I INTRODUCTION

Concrete is composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and the finally makes the concrete to fail.

The formation of cracks is the main reason for the failure of the concrete. To increase the tensile strength of concrete many attempts have been made. One of the successful and most commonly used methods is providing steel

reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encountering are bar. Thus need for multidirectional and closely spaced steel reinforcement arises. That cannot be practically possible. Fiber reinforcement gives the solution for this problem.

So to increase the tensile strength of concrete a technique of introduction of fibers in concrete is being used. These fibers act as crack arrestors and prevent the propagation of the cracks. These fibers are uniformly distributed and randomly arranged. This concrete is named as fiber reinforced concrete. The main reasons for adding fibers to concrete matrix is to improve the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large volume of follow up research have led to the development of a wide variety of material formulations that fit the definition of fiber Reinforced Concrete.

## II MATERIALS

***CEMENT: Ordinary*** Portland cement conforming to IS 269-1976 and IS 4031-1968 was adopted in this work. The cement used is 53 grade.

***COARSE AGGREGATE: The*** aggregate used in this project mainly of basalt rock which comes under normal weight category. The aggregate are locally available. The nominal size of coarse aggregate used is 20mm. The coarse aggregate was also tested for various properties like specific gravity, fineness modulus, crushing strength, water absorption to check their suitability for the experiment.

***FINE AGGREGATE: Natural*** sand which is easily available and low in price was used in the work. It has cubical or rounded shape with smooth surface texture. Being cubical, rounded and smooth texture it gives good workability. Particles of this sand have smooth texture. Sieve analysis was done to find out fineness modulus and specific gravity for sand as per IS .383-90

***GLASS FIBRE :*** Glass fibers with an aspect ratio of 857:1 are used.

***Fig: Glass fibre***

***COPPER SLAG: Copper*** slag is a by-product material produced from the process of manufacturing copper. As the copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. The end product is a solid , hard material that goes to the crusher for further processing

*Fig: Copper slag*

***MICRO SILICA: Micro silica*** is one of the artificial pozzolans, commonly used as mineral admixture in FRC. Silica fume is very fine non- crystalline silica, produced in electric arc furnaces, as a byproduct of the production of elemental silicon or alloys containing silicon also known as condensed silica fume or micro silica. It is mainly amorphous silica with high $SiO_2$ content, extremely small particle size and large surface area, highly reactive pozzolano used to improve mortar and concrete. It improves durability primarily by reducing permeability to water and chlorides.

Micro silica is produced during the high temperature reduction of quartz, to give silicon or ferrosilicon metal. As the quartz is heated to 2000°C and an electric arc is fired through the furnace, it releases silicon monoxide gas. This gas rises and reacts with oxygen in the upper parts of the furnace and condenses as it cools, into the pure spherical particles of micro silica.

*Fig: Micro silica*

**III CASTING AND TESTING**

Totally 30 cubes, 30 cylinders were casted for M30 mix design. 1% Glass fibre was used as the additional ingredient of concrete. Compression testing machine is used for testing the Compressive strength of cubes and split tensile strength of cylinder.

***DETAILS OF TEST SPECIMEN***

**Details of moulds**

| Sl. no | SPECIMEN NAME | SIZE OF SPECIMEN |
|---|---|---|
| 1 | CUBE | 150X150X150mm |
| 2 | CYLINDER | Dia-150mm and Height-300mm |

*Fig: Cylindrical & Cubical mould*

***PREPARATION OF SPECIMEN***

***BATCHING: The*** quantity of ingredients was arrived by conducting proper weight batching and stored separately for mixing.

***MIXING: Proper*** mixing of concrete was carried out manually in a good way.

*Fig: Concrete mixing*

***PLACING*** **:**Mixed concrete is placed in the mould in such a way that there is no chance of

segregation. Proper compaction was done by using tamping rod.

*FINISHING AND CURING* :After placing the concrete, the surface of the specimen was finished properly in a smooth manner. After 24 hours the moulds are removed and the specimen was subjected to curing.

## IV EXPERIMENTAL RESULT

### *COMPRESSIVE STRENGTH*

Cubical specimens of size 150mm were casted for conducting compressive strength test for each mix. The compressive stress test was carried out as per IS: 516-1979. This test was carried at 7,14 & 28 days of curing.

**Procedure**

The specimen is removed from water after specified curing time and excess water is wiped out from the surface. Note the weight and dimension of the specimen. Clean the bearing surface of the testing machine. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. Rotate the moveable portion gently by hand so that it touches the top surface of the specimen. Apply the load gradually without shock and continuously at the rate of 140kg/cm²/min till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

$$\text{Compressive strength} = \frac{\text{Load in N}}{\text{Area in Sq.mm}}$$

**Table: Compressive strength (N/mm²)**

| OPTIMUM PERCENTAGE (GLASS FIBRE+MICRO SILICA+COPPER SLAG) | DAYS | COMPRESSIVE STRENGTH |
|---|---|---|
| (0+0+0) | 7 days | 21.5 |
| | 14days | 24 |
| | 28days | 32.8 |
| (1+10+40) | 7 days | 22 |
| | 14days | 26 |
| | 28days | 35.2 |

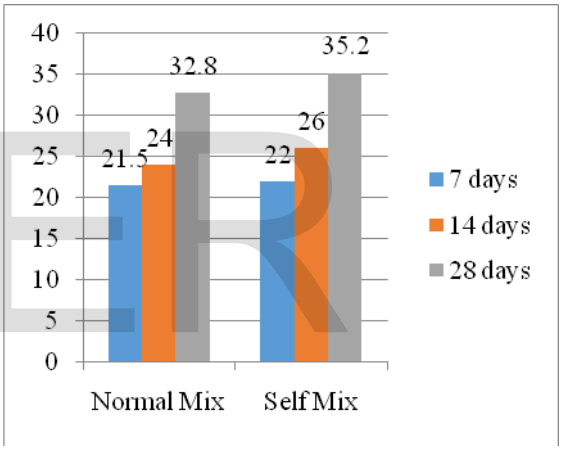


*Fig: Result variation of compressive strength*

### *SPLIT TENSILE STRENGTH*

The split tensile strength is the indirect measurement of the tensile strength by placing a cylindrical specimen horizontally between the loading surfaces. This method consists of applying a diametric compressive force along the length of a cylindrical specimen. This loading includes tensile stress on the plane containing the applied load. Tensile failure occurs rather than compressive failure. Plywood strips are used so that the load is applied uniformly along

the length of the cylinder and the load is applied until failure of the cylinder, along the vertical diameter. The maximum load is divided by appropriate geometrical factors to obtain the splitting tensile strength of concrete.

**Procedure:**

Take the wet specimen from water after 7 days of curing. Wipe out water from the surface of specimen. Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place. Note the weight and dimension of the specimen. Set the compression testing machine for the required range. Keep a plywood strip on the lower plate and place the specimen. Align the specimen so that the lines marked on the ends are vertical and centred over the bottom plate. Place the other plywood strip above the specimen. Bring down the upper plate to touch the plywood strip. Apply the load continuously without shock at a rate of approximately 14-21kg/cm$^2$/min (Which corresponds to a total load of 9900kg/min to 14850kg/min.

**Table: Split tensile strength (N/mm$^2$)**

| OPTIMUM PERCENTAGE (GLASS FIBRE+MICRO SILICA+COPPER SLAG) | DAYS | SPLIT TENSILE STRENGTH |
|---|---|---|
| **(0+0+0)** | 7 days | 2.3 |
| | 14days | 2.8 |
| | 28days | 3 |
| **(1+10+40)** | 7 days | 2.5 |
| | 14days | 2.9 |
| | 28days | 3.2 |

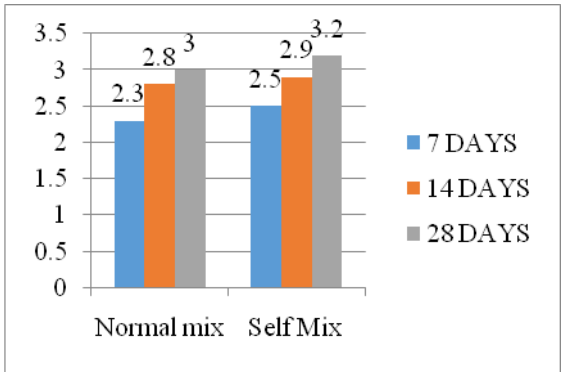


*Fig: Split tensile strength result variation*

## V CONCLUSION

Fine particles of copper slag contributing to improved compressive strength, split tensile strength, flexural strength compared to conventional concrete. The increase in compressive strength can be contributed due to reduced capillary pore size and usage of micro silica as supplementary cementitious material. The bonding strength also increased due to use of micro silica which in turn enhances strength.

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