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# STUDY ON PARTIAL REPLACEMENT OF CEMENT BY GROUND GRANULATED BLAST FURNACE SLAG (GGBS) AND ADDITION OF CARBON FIBER

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**Abstract -** Concrete is a composite material consisting of a hard inert particulate substance known as aggregates and bonded together by cement and water. Brittleness and crack formation are weaknesses of concrete related to its durability. The present research trend in concrete technology is towards increasing the strength and durability of concrete to meet the demands of the modern construction. The manufacturing process of cement emits considerable amount of carbon dioxide (CO2). Therefore, is an urgent need to reduce the usage of cement. Ground Granulated Blast Furnace Slag (GGBS) is a byproduct from steel industry. It has good structural and durable properties with less environmental effects. The concrete in which the cement is replaced 35-40% by GGBS have advanced durability properties such as increased resistance to sulphate attack, increased resistance to alkali silica reaction, reduced chloride ion ingress which enhances corrosion resistance. Carbon fibers also offer an economical benefit as they are readily available as a waste product from the aerospace industry and offers 2 to 5 times more rigidity than the other fibers. Carbon fibers possess many potential benefits over other fibers, including a higher strength, higher modulus, and increased durability. It has higher strength than steel with quarter of its weight. The main objective of this research is to design M30 grade concrete and perform strength tests and durability studies by adding 0%, 0.50%, 1.00% and 1.50% of carbon fibers by volume of concrete and constant adding percentage of GGBS is 40%. The strength and durability characteristics are studied. The mechanical properties studied are compressive, split tensile and flexural strengths. The test specimens were also subjected to acid and sulphate attacks and tested for their durability. The results show that there is an increase in compressive, split tensile and flexural strengths of carbon fiber reinforced concrete.

***Key Words***: Carbon fiber, GGBS, High Strength, Increased Durability.

## 1. INTRODUCTION

### 1.1 General

Concrete is the most commonly used constructional material in the world, which can be attributed largely to the fact that its characteristics can be altered to meet the needs of a wide variety of applications. However concrete has some deficiencies such as low tensile strength, low post cracking capacity, brittleness and low ductility, limited fatigue life, not capable of accommodating large deformations, low impact strength. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suited for a wide range of applications.

### 1.2 OBJECTIVES

The main objective of this study is to determine the high strength and increased durability by partial replacement of cement by GGBS and addition of Carbon fiber to the mixes and also to compare the results of mixes.

### 1.3 SCOPE

To determine the properties of the materials. To examine the mechanical properties of hardened concrete. To determine the permeability range.

## 2. LITERATURE REVIEW

**2.1 Dr. Deborah D.L Chung –** The use of short pitch-based carbon fibers (0.05% of weight of cement, 0.189 vol.% concrete), together with a dispersant, chemical agents and silica fume, in concrete with fine and coarse aggregates resulted in a flexural strength increase of 85%, and a flexural toughness increase of 205%, a compressive strength increase of 22%, and a material price increase of 39%. The slump was 4 in at a water/cement ratio of 0/50. The air content was 6%, so the freeze-thaw durability was increased, even in the absence of an air entrainer. The aggregate size had little effect on the above properties. The minimum carbon fiber content was 0.1 vol. %. The optimum fiber length was such that the mean fiber length decreased from 12 mm before mixing to 7 mm after mixing, which used a Hobart mixer. The drying shrinkage was decreased by up to 90%. The electrical resistivity was decreased by up to 83%.

**2.2 Manikanta, Bimalendu Dash, G.Mohan Sai -** Concrete is a major part to construct a engineering structure. To construct a building, we have to take a good grade and strong concrete. In now a day, all the structures are constructed by the normal concrete. Normal concrete is

a good concrete for the construction but to overcome the disadvantages of the normal concrete we must do the research on a special concrete. That type of concrete has the better properties than the normal concrete. Suppose, we can choose the carbon fibre reinforced concrete. This concrete is made up with the adding of carbon fibre reinforced polymer. We must add the sea sand and sea water to gain the binding strength between the aggregates and the cement and the sand. To know the activity of these property we must test the concrete made from the carbon. The properties of both the concrete are compared by the results of the laboratory tests and the site tests. The tests are done to know which concrete is doing better job in the construction. The other components we must add are resins, some chemicals like NaCl. Mechanical properties like compressive strength, modulus of rupture, toughness have high influence on the concrete.

**2.3 Shanmuganathan.N, Akbar Basha. S, Sheik Ibrahim.K, Mohammed Fahad.A.S** - Cement is the most important material of the concrete which produced by natural raw material like silica and lime over consumption of lime may lead to the condition there will be no lime production of cement for concrete. The effect of cementitious waste material (GGBS) as cement in concrete give more compressive strength and flexural strength 0-80% replacement of GGBS in different grade of concrete. The GGBS give more strength in 40% of replacement and attains more than 9% strength in 7 days and increasing of 6% strength with 30% replacement attains in 28 days. The large replacement of GGBS cause reduction in flexural & compressive strength in adding 30% of GGBS compressive strength lower than the plain cement concrete addition. Concrete achieve adequate strength in GGBS. The compressive & flexural strength will be high in adding 15%-45%.it will identical to achieve mechanical Properties.

**2.4 P. Saranya, Praveen Nagarajan, A P Shashikala** - Concrete is the most commonly used material in the construction industry in which cement is its vital ingredient. Although the advantages of concrete are many, there are side effects leading to environmental issues. The manufacturing process of cement emits considerable amount of carbon dioxide (CO2). Therefore is an urgent need to reduce the usage of cement. Ground Granulated Blast furnace Slag (GGBS) is a by-product from steel industry. It has good structural and durable properties with less environmental effects. This paper critically reviews the literatures available on GGBS used in cement concrete. In this paper, the literature available on GGBS are grouped into engineering properties of GGBS concrete, hydraulic action of GGBS in concrete, durability properties of GGBS concrete, self compacting GGBS concrete and ultrafine GGBS are highlighted. From the review of literature, it was found that the use of GGBS in concrete construction will be eco-friendly and economical. The optimum percentage of replacement of cement by GGBS lies between 40 – 45 % by weight. New materials that can be added in addition to GGBS for getting better strength and durability also highlighted.

In this Chapter an elaborate discussion is made regarding works done so far in this area as literature review. Partial replacement of cement by Ground Granulated Blast Furnace Slag (GGBS) and addition of Carbon Fiber to the concrete to find their properties, strength and behavior.

## 3. MATERIALS TO BE USED

### 3.1 CEMENT

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most-consumed resource.

### 3.2 M-SAND

Manufactured is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of river sand in most part of the world. Due to depletion of good quality 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.

### 3.3 COARSE AGGREGATE

Coarse aggregate is mined from rock quarries or dredged from river beds, therefore the size, shape, hardness, texture and many other properties can vary greatly based on location. Even materials coming from the same quarry or pit and type of stone can vary greatly. Most generally, coarse aggregate can be characterized as either smooth or rounded (such as river gravel) or angular (such as crushed stone).

### 3.4 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. Ground-granulated blast furnace slag is highly cementitious and high in CSH (calcium silicate hydrates) which is a strength enhancing compound which improves the strength, durability and appearance of the concrete.

### 3.4.1 PARTIAL REPLACEMENT OF GGBS

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct from steel industry. It has good structural and durable properties with less environmental effects. This paper critically reviews the literatures available on GGBS used in cement concrete. In this paper, the literature available on GGBS are grouped into engineering properties of GGBS concrete, hydraulic action of GGBS in concrete, durability properties of GGBS concrete, self-compacting GGBS concrete and ultrafine GGBS are highlighted. From the review of literature, it was found that the use of GGBS in concrete construction will be ecofriendly and economical. The optimum percentage of replacement of cement by GGBS lies between 40 - 45 % by weight. New materials that can be added in addition to GGBS for getting better strength and durability also highlighted. This paper highlights the review of research works conducted on GGBS. The inclusion of GGBS in concrete has several advantages like reduced heat of hydration, adequate ductility, reduction in the size of the concrete pores, improved strength at later stages, reduced primary energy usage and carbon emissions, lighter color and better aesthetics etc. The fineness of GGBS increases the strength and durability properties by providing lower permeability. The concrete in which the cement is replaced 35-40% by GGBS have advanced durability properties such as increased resistance to sulphate attack, increased resistance to alkali silica reaction, reduced chloride ion ingress which enhances corrosion resistance The ultrafine GGBS have improved strength and durability properties. Calcium oxide which formed during the reaction between Portland cement and water can activate the reaction of GGBS which can improve the strength properties. Applications of optimum percentage of cement replacement by GGBS can be extend up to all structural elements of a building, bridges, prestressed elements etc.

### 3.4.2 ADVANTAGE OF GGBS:

Good workability which helps in better placing and compaction. Due to the less heat of hydration the temperature rise will be less avoiding the risk of thermal cracking in large volume of concrete. High resistance to chloride attack which reduces the risk of corrosion in concrete. High resistance to sulphide attack and also other chemicals. Good sustainability.

### 3.5 CARBON FIBER

Carbon Fiber is a polymer and is sometimes known as graphite fiber. It is a very strong material that is also very lightweight. Carbon fiber is five-times stronger than steel and twice as stiff. Though carbon fiber is stronger and stiffer than steel, it is lighter than steel making it the ideal manufacturing material for many parts. These are just a few reasons why carbon fiber is favored by engineers and designers for manufacturing Carbon fiber is made of thin, strong crystalline filaments of carbon that is used to strengthen material. Carbon fiber can be thinner than a strand of human hair and gets its strength when twisted together like yarn. Then it can be woven together to form cloth and if needed to take a permanent shape, carbon fiber can be laid over a mold and coated in resin or plastic

### 3.5.1 ADDITION OF CARBON FIBER

The concept of using fibers as reinforcement is not new. Fibers are used to increase the strength of the structures. Carbon fibers also offer an economical benefit as they are readily available as a waste product from the aerospace industry and offers 2 to 5 times more rigidity than the other fibers. Carbon fibers possess many potential benefits over other fibers, including a higher strength, higher modulus, and increased durability. Addition of fibers to the concrete enhances, ductility, tensile strength, flexural strength. Further more, adding fibers reduces the possibility of spalling and scabbing failures, prevents crack propagation, and extends the softening region in the concrete matrix.

### 3.5.2 ADVANTAGE OF CARBON FIBER:

High stiffness, High strength, High Modulus, Light weight Corrosion resistant, X-ray transparency, Low CTE (Coefficient of Thermal Expansion), Chemical resistivity.

## 4. TESTS TO BE CONDUCTED

Fresh concrete tests such as Slump cone test, L-Box test, V-Funnel test are to be performed. Compressive strength test, Split tensile test and Flexural strength test are also proposed to be conducted. Mix designs are arrived by using IS 10262-2019

## 5. CONCLUSION

From the above journals it is evident that High Strength Concrete plays a vital role in construction industry. In addition to that the GGBS and Carbon fibers are added and works been done

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