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A Review of Ggbs and Steel Fibre Performance in High Performance Concrete

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Abstract **- India is producing enormous amounts of industrial by-products out of which 150 million tonnes of GGBS itself. Apart from disposal of this solid waste, engineers strive for its value addition through its use as a construction material for achieving better economy, eco-friendliness without compromising on technical aspects. Varieties of concrete are mixed with GGBS as a replacement material for cement to understand its compressive strength and long term behaviour. It is seen from literature that the fibers enhance the performance of concrete. Accordingly, six trials were made with GGBS replacement along with variation of cement content, water cement ratio and steel fibers with aspect ratio 60 and variation in reinforcing indices. The workability of concrete increased with increasing the GGBS content and also observed there is a reduction in workability in fiber reinforced concrete. The results indicated that the concrete made with GGBS indicates the strength comparable to the concrete made with OPC for all replacement levels. There is a substantial decrease in strength at 80% replacement. While there is a substantial increase in long-term strength. The compressive strength of GGBS concrete was increased up to 19% than that of OPC concrete and also observed 5 to 12% strength increased in fiber reinforced concrete than GGBS concrete. For this purpose studied the compressive strength of concrete at the ages of 3, 7,28,56,90 and 180 days.**

Keywords-**Ground Granulated Blast Furnace Slag (GGBS), Steel Fibres, and Strength etc**

I.INTRODUCTION

Concrete has basic naturally, cheaply and easily available ingredients as cement, sand, aggregate and water. After the water, cement is second most used material in the world. But this rapid production of cement creates two big environmental problems for which we have to find out civil engineering solutions. We know that CO2 emission is very harmful which creates lots of environmental changes whatsoever. Ground Granulated Blast furnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of "Granulated slag".

Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. Fly ash is one of the residues created during the combustion of coal in coal-fired power plants. Fine particles rise with flue gasses and are collected with finelydivided mineral admixture, available in both incompact and compacted forms. This ultra-fine material will better fill voids between cement particles and result in a very dense concrete with higher compressive strengths and extremely low permeability.

II. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground granulated blast furnace slag (GGBS) is a byproduct from the blast-furnaces used to make iron. These operate at a temperature of about 1,500 degrees centigrade and are fed with a carefully controlled mixture of iron-ore, coke and limestone. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching, optimises the cementitious properties and produces granules similar to a coarse sand. This 'granulated' slag is then dried and ground to a fine powder. The composition of minerals and physical properties of GGBS are shown in Table 2. In the present study, the percentages of GGBS used are 20, 40, 60 and 80 to the weight of cement.

Blast furnace slag is an on-metallic created during the process iron making (pig iron) in an blast furnace and 300kg of Blast furnace slag is created when 1 ton of pig iron produced. In India, yearly production of pig iron is 70-80 million tons and relating blast furnace slag are around 21-24 million tons. Blast furnace slag is somewhat alkaline and shows a pH in arrangement in the range of 8 to 10 and does not present an erosion hazard to steel in pilings or to steel inserted in concrete made with blast

furnace slag cement or aggregates. The blast furnace slag could be utilized for the cement raw material, the roadbed material, the mineral admixture for concrete and aggregates for concrete, and so forth [9-10].
Blast Furnace Concrete has better water impermeability qualities and additionally enhanced protection from erosion and sulphate attack. Thus, the service life of a structure is increases and the maintenance cost diminished.

III. STEEL FIBERS

Fibers are normally utilized as a part of concrete to control cracking because of both plastic shrinkage and drying shrinkage. Additionally innovative work uncovered that option of SFs in concrete altogether builds its flexural toughness and the energy absorption capacity, ductile behavior prior to the ultimate failure reduced cracking and improved durability. They likewise diminish the penetrability of concrete and subsequently decrease bleeding of water. A few kinds of fiber created more effect, abrasion and shatter resistance in concrete. Steel fibers are added to cement to enhance the basic properties especially elastic and flexural strength. The degree of change in the mechanical properties accomplished with SFRC over those of plain concrete relies upon a few factors for example, shape, size, volume, percentage and distribution of fibers [14].

For the most part fiber does not build the flexural quality of concrete thus can't replace moment opposing or structural steel reinforcement. Surely, some fiber really reduces the strength of cement. The amount of fiber added to the concrete mix is communicated as a percentage of total volume of the composite (cement and fiber), named volume fraction (VF). VF commonly goes from 0.3 to 5%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Steel fiber reinforced concrete is a composite material having fibers as the extra ingredients, scattered consistently at arbitrary in small percentages i.e. from 0.3% to 5% by volume of concrete. Utilization of high percentage of fiber is probably going to cause the segregation and harshness of concrete and mortar.

The steel fibers are for the most part utilized in shape of flat, circular or hooked for a given shape of fibers. Flexural strength of SFRC was found to increase with aspect ratio. The fiber is frequently depicted by a parameter called "Aspect Ratio". The aspect ratio of the fiber is the ratio of its length and diameter. Typical aspect ratio ranges from 30 to 150. It has been reported for that up to aspect ratio of 75 increases in the aspect ratio increases the ultimate strength of the concrete linearly. In any case, beyond 75 the relative strength and toughness is reduced [15]. Fibre with a non- circular cross section uses an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material increase in the aspect ratio of the fibre usually segments the flexural strength and the toughness of the matrix. Some recent research indicated that using fibre in concrete has limited effect on the impact resistance of the materials.

Fig. 1 Steel fiber.

VI. TYPES OF FIBRES

- Hooked end steel fibre
- Wavy steel fibre
- Undulated segment steel fibre.
- Flat end steel fibre.
- Crimped steel fibre.
- Shotcrete steel fibre.
- Stainless steel fibre.
- Promix steel fibre.
- MS steel fibre.
- Polypropylene fibres.

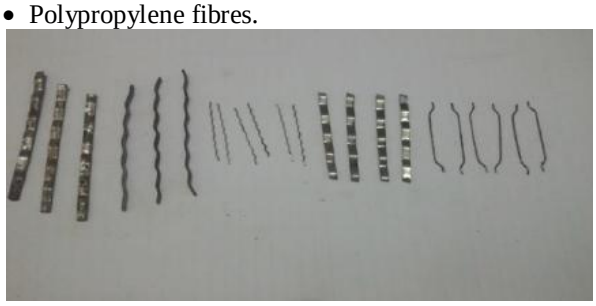

Fig. 2 Different types of Steel Fibres.

V. FACTORS INFLUENCING HIGH STRENGTH FIBRE REINFORCED CONCRETE

The effective reinforcement of the matrix and the efficient transfer of stress between the matrix and the fibre depend upon many factors. Many of these factors are intimately interdependent, and exercise a profound but complex influence on the properties of the composite. Incorporation of steel fiber decreases the workability considerably. This situation adversely affects the consolidation of fresh mix. Even prolonged external vibration fails to compact the concrete [18]. The fiber volume at which this situation is reached depends on the length and diameter of the fiber. Another consequence of

poor workability is non-uniform distribution of the fibers. Generally, the workability and compaction standard of the mix is improved through increased water/ cement ratio or by the use of some kind of water reducing admixtures.

Following are the factors stated.

- The relative fibre matrix stiffness
- Fibre matrix interfacial bond
- Strain compatibility between fibre and the matrix.
- Shape of fibres
- Strength of fibres
- Fibre orientation
- Specimen size
- Span of specimen
- Spacing of fibres

VI. REVIEW OF PAST STUDIES

Mayank Mishra, K.G.Kirar (2018) Concrete has basic naturally, cheaply and easily available ingredients as cement, sand, aggregate and water. After the water, cement is second most used material in the world. But this rapid production of cement creates two big environmental problems for which we have to find out civil engineering solutions. We know that CO2 emission is very harmful which creates lots of environmental changes whatsoever. Ground Granulated Blast furnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of “Granulated slag”. Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. Fly ash is one of the residues created during the combustion of coal in coal-fired power plants. Fine particles rise with flue gasses and are collected with finelydivided mineral admixture, available in both incompact and compacted forms. This ultra-fine material will better fill voids between cement particles and result in a very dense concrete with higher compressive strengths and extremely low permeability [1].

Ganesh Babu K and Sree Rama Kumar V (2000) studied on efficiency of GGBS in Concrete. According to them the utilization of supplementary cementetious materials is well accepted because of the several improvements possible in the concrete composites and due to the overall economy. This method recognizes that the ``overall strength efficiency factor (k)" of the pozzolana is a combination of the two factors-the ``general efficiency factor (ke)" and the percentage efficiency factor (kp). The evaluations have shown that at 28days, the overall strength efficiency factor (k)" varied from 1.29 to 0.70 for percentage replacement levels varying from 10% to 80%. It was also seen that the overall strength efficiency factor (k) was an algebraic sum of a constant ``general efficiency factor (ke)," with a value of 0.9 at 28 days, and a percentage efficiency factor (kp), varying from +0.39 to -0.20, for the cement replacement levels varying from 10% to 80% studied.

Shaik Asif Ali (2017) Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. ground granulated blast furnace slag (GGBS) is a new mineral admixture, whose potential is not fully utilized. Moreover only limited studies have been carried out in India on the use of slag for the development of high strength concrete with addition of steel fibres. The study focuses on the flexural strength performance of the blended concrete containing 20% percentage of slag and different 1.5% of steel fibres as a partial replacement of OPC.

Dhanya R 1, Arasan G.V (2017) Blast furnace slag, a nonmetallic product consisting of silicates and alumina-silicates of calcium, come from the blast furnace production of iron from ore through the process of water-jetting and water-immersing of the molten blast-furnace slag for granulation. A 55-59% replacement of cement by GGBS was found to produce an optimum strength of concrete The corrosion resistance (mainly due to chlorine), durability and binding power of concrete is improved by using GGBS. It modifies the pore structure of concrete and results in a more hardened concrete and also abrasion resistance The permeability and penetration of chloride ions in concrete is reduced. It can also influence the electrochemical pore solution in cement system by the addition of GGBS to concrete. The resistance to sulfate attack on concrete can also be reduced by the addition of GGBS to concrete for both moderate and severe environment.

P.K. Prasanna, K.Srinivasu (2019) The utilisation of GGBS as mineral admixture needs only grinding, while comparing with the production of OPC it saves extensive amounts of energy. Due to its engineering benefits GGBS is getting more and more attention now, because of the reduction of ill effects on the environmental effects. The lower content of cement requirement for preparation of concrete results to a reduction of CO2 The inclusion of mineral admixture consisting of slag has been recognized to get better engineering properties of concrete. When compared to production of OPC, GGBS releases less greenhouse gases into the environment and also requires less energy.

GGBS is obtained from pig iron industry as a by-product; it contains high alumina and silica content and less lime content when compared to OPC..The slag is generally a

mixture of chemical formation like aluminum, silicon, calcium, magnesium, and oxygen, subsequently a GGBS-blended concrete is an eco-friendly concrete when compared to an OPC concrete and also improves workability and reduction in bleeding of concrete.

Niranjan K, Pallavi H (2016) Geo polymer is taken as an inorganic member and it majorly targets in substituting OPC which is used in producing of concrete. Geo polymer technology as a construction material as a trend is gaining its popularity worldwide towards a sustainable development. Geo polymer technology was implemented by a French Professor by name Joseph Davidovits.

This technology mainly uses alkaline activator solutions like silicates of potassium or sodium and hydroxides of potassium or sodium along with by-products of industries like ground granulated blast furnace slag (GGBS), fly ash etc. The alkaline activator solution mainly undergoes geo polymerization and then get reacted with by-products of industries and produces a binding property and then binds the aggregates. In this study Alcco fine and GGBS are used as cementatious binder, alkaline activators like sodium hydroxide flakes and sodium silicate, slag sand as fine aggregates, 12.5mm down coarse aggregates, fresh water and fibers such as AR glass and Steel fibers were used to produce fiber reinforced geo polymer concrete. Fresh property and hardened property of fiber reinforced geo polymer concrete are studied and curing of specimens is carried out in ambient condition.

D.NEERAJA (2017) It is now well established that one of the important properties of Steel Fibre Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particularly under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking. The net result of all these is to impart to the fibre composite pronounced post cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading. The real contribution of the fibres is to increase the toughness of the concrete. The fibres tend to increase the strain at peak load, and provide a great deal of energy absorption in post-peak portion of the loaddeflection curve. This report presents a laboratory investigation on the strength characteristics of steel fibre reinforced concrete.

Tests were conducted by adding Ground Granulated Blast furnace Slag (GGBS) and steel fibres to concrete in an amount equivalent to approximately 0%, 20%, 40%, 60% and 80% to the weight of cement content and that for steel fibres from 0 to 2% with an increment of 0.5%.

VII. CONCLUSION

As our purpose is to develop concrete which does not only concern on the strength of concrete, it also having many different aspects to be satisfied like workability, performance, durability and also economy.

Some of the early studies works had executed using specific pozzolanic materials with the replacement of cement the using super plasticizer for the improvement high strength concrete and high performance concrete. Additionally the improvement in the subject of fiber reinforced concrete alongside pozzolonas. It is reported that using steel fibres in concrete lower the workability of concrete however split tensile strength, strength, modulus of elasticity and poisons ratio. The presence of micro cracks within the mortar-aggregate interface is liable for the inherent weakness of simple concrete. The weak point can be eliminated through inclusion of fibres inside the combination. Different types of fibers, consisting of those used in conventional composite materials can be added into the concrete aggregate to growth its durability, or capability to withstand crack growth. The fibres assist to transfer loads at the inner micro cracks.Many investigations have been done on replacement of GGBS and fiber with cement in concrete and observed very enthusiastic results.

Studies have shown that the addition of steel fibres in a concrete matrix in proves all the mechanical properties of concrete, especially tensile strength, impact length and toughness. The resulting material possesses higher compressive, tensile strength and better ductility. From the literature papers referred on various fibres, its properties, significance, effect, impact on strength and durability properties are focused and brought into picture for the study and future research. Following conclusions could be drawn from present papers.

- The Mechanical properties such as compressive strength, tensile strength, toughness, impact, flexural etc are greatly influenced by addition of fibres, optimum dosage of fibres governs these properties and must carry out optimality study on various fibres.
- The Type of fibres, selection of fibres, properties like length, diameter aspect ratio, its effect on properties of concrete changes with addition of dosage. The prime importance must be given for selection of fibre, its type etc.
- The Various fibre used in concrete significantly improves many properties of concrete. The combination of fibres thus shows advanced improvement and great changes in properties of concrete.
- The Addition of fibres with additional supplementary cementations material such as fly ash, silica fumes etc. should better performance by improving workability of concrete and inherent properties of concrete.

- The Addition of fibres is carried out for special category such as self- compacting concrete, high performance concrete, high strength concrete etc.

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