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A review on some studies on concrete prepare by using fiber reinforcement and GGBS as a partial replacement of cement

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ABSTRACT

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 an approximately equal amount of carbon dioxide in the atmosphere. Cement production is consuming a significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked the 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 an addition of steel fibers.

Keywords— High performance concrete (HPC), Ground Granulated Blast Furnace Slag (GGBS), Steel Fibres, Strength

1. INTRODUCTION

In the modern scenario, desires from concrete have expanded exponentially, different physical parameters of concrete like strength, durability, serviceability and cost needs change i.e. how successfully we can save the cost of cement without bargain the strength and durability of cement [1]. To defeat the inflation, the supplementary cementitious material is utilized as a part of conjunction with OPC so that the durability, maintainability, and cost-effective can be accomplished. In India, 7.8 million ton GGBS as a by-product obtains in the manufacturing in the blast furnace. As the project financial development and improvement in the steel businesses, the measure of generation is probably going to increment numerous folds [2-3]. Because of exponential developing in urbanization and industrialization by item from the steel businesses, for example, GGBS is turning into an expanding worry for reusing and waste material. Being a result utilizing it successfully up to some degree fills in as a stage for a green situation and at the same time remembering that the quality of cement doesn't debased by the use of GGBS [4].

2. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

The Blast-Furnace slag is a result of the iron manufacturing industry. Iron ore, coke, and limestone are fed into the furnace and the resulting molten slag floats over the molten iron at a temperature of around 1500°C to 1600°C [5]. The molten slag has a composition of around 30% to 40% SiO₂ and around 40% CaO, which is almost like the chemical composition of Portland cement. After the molten iron is tapped off, the staying liquid slag, which comprises of for the most part siliceous and aluminous deposit, is then water extinguished and cooled quickly, bringing about the development of a polished crystalline granulates [6-7-8]. This glassy granulates are dried and pulverized which is known as ground granulated blast-furnace slag (GGBS). The generation of GGBS requires less extra vitality as contrasted and the vitality required for the creation of Portland concrete. The replacement of Portland cement with GGBS will prompt noteworthy diminishment of carbon dioxide gas emission. GGBS is along these lines an environmentally friendly construction material. It can be utilized to replace as much as 80% of the Portland cement utilized as a part of the concrete.

Blast furnace slag is an on-metallic created during the process iron making (pig iron) in a 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 an 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 increased and the maintenance cost diminished.

Concrete is porous in nature; regular cement produces a large amount of heat resulting in shrinkage & temperature cracks. The combined effect of surface cracks with porosity in concrete adversely affects the life of steel. Therefore, there is a big, need for an alternative product to strengthen concrete which combats the deterioration of steel. Use of GGBS in the concrete generates less heat while mixing with the water against cement. It also helps to reduce the heat of hydration resulting less shrinkage and temperature cracks in the concrete [11].

The production of Ground Granulated Blast Furnace Slag requires little extra additional energy as contrasted with the energy required for the generation of Portland cement. The replacement of Portland cement with GGBS will prompt noteworthy decrease of carbon dioxide gas emission. It is along these lines a naturally neighborly development material.

GGBS from modern thermal power plants generally does not require handling before being consolidated into concrete and is along these lines thought to be an environmentally free input material. It can be utilized to replace as much as 80% of the Portland cement utilized as a part of cement. It has better water impermeability attributes and also enhanced protection from erosion and sulphate attack. It improves bring down the heat of hydration which decreases the danger of thermal cracking. It has higher durability, workability, reduces penetrability to the agency, which helps in making, setting and compaction less demanding. Thus, the administration life of a structure is upgraded and the upkeep cost diminished. In perspective of the potentially favorable circumstances of utilizing GGBS, the Standing Committee on Concrete Technology (SCCT) supported in 2008 the proposition by the Public Works Central Laboratory (Pa WCL) to lead an examination concentrate to explore the quality advancement and sturdiness of GGBS concrete [12-13].

3. STEEL FIBERS

Fibers are normally utilized as a part of concrete to control cracking because of both plastic shrinkage and drying the 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%. The 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 are 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 a limited effect on the impact resistance of the materials.



Fig. 1: Steel fiber

4. TYPES OF FIBRES

1. Hooked end steel fibre
2. Wavy steel fibre
3. Undulated segment steel fibre.
4. Flat end steel fibre.

5. Cr imped steel fibre.
6. Shotcrete steel fibre.
7. Stainless steel fibre.
8. Promix steel fibre.
9. MS steel fibre.
10. Polypropylene fibres.



Fig. 2: Different types of steel fibres

5. 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 the 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 a 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 comp, ability between fibre and the matrix.
- Shape of fibres
- Strength of fibres
- Fibre orientation
- Specimen size
- Span of specimen
- Spacing of fibres

6. REVIEW OF PAST STUDIES

Vijay Madhavrao Takekar and G. R. Patil (2017) focused on Grounded Blast Furnace Slag (GGBS) as a choice for binder and filler materials in case of ordinary Portland Cement (OPC). The experimental result analyses are investigated for structural houses of fiber reinforced concrete equipped with GGBS. Concrete grade M-50 became taken to have a look at. GGBBS with 0%, 10%, 20%, 30% and forty% with the aid of weight of normal cement turned into brought successively; also 1.5% of steel fiber turned into saved regularly. Variables protected combination size (10mm, 12mm, and 20mm) with the percent of GGBS so that you can observe the impact on compressive energy, tensile electricity, and flexural power. 150mmX150mmX150mm size of dice and 100mmX100mmX500mm length of the beam have been examined for energy overall performance in shape of compressive and flexural electricity respectively. Samples with duplication of GGBS were cured for fifty six days in assessment to normal cement which calls for up to twenty-eight days. Experiments with these samples had been executed to study the strength characteristics of the concrete. Outcomes indicate that as the percentage of GGBS will increase, the workability of GGBS fiber reinforced concrete additionally increases. The result additionally consists of the effect of price and compressive electricity for GBBS fiber reinforced concrete. K. Vidhya et al. (2017) studied the steel fiber (Hooked end and crimped) percentage in addition to the weight of cement. The Compressive strength, tensile strength and flexural behaviour of steel fiber reinforced concrete beam with the varying percentage of the fiber of M40 grade of concrete. Namani Saikrishna & Syed Moizuddin (2017) investigated the strength, split tensile strength tests have been performed by means of silica fume in various percentage of 5%, 7%, 10% and 15% to the weight of cement and 0.5%, 1%, 1.5%, and 2% of steel fibers to the weight of concrete of round crimped kind having aspect ratio 45.45 (length 25 & diameter 0.55) were used. Concrete cubes are examined at the age of 7, and 28 days of curing. Sooner or later, the strength performance of steel fiber concrete is compared with the performance of conventional concrete. Pooja et al (2017) obtained a result on higher the strength of steel fiber resistant concrete. Those fibers added may be affected at the workability, density and on various strengths of M60 grade concrete. On this, fiber content material could be various from 0.5% to 2% by using the weight of concrete at the period of 0.5%. Here the replacement of cement through 20% of fly ash and 10% of GGBS. GGBS cement will be having higher ultimate strength than the material which is made with the aid of Portland cement. Water-cement ratio may be very critical to keep within the minimum limit, for that we can be the use of the water falling admixture on the way to be a superb plasticizer, for you to be the very vital position. As this fibre content will increase the workability of soggy blend up is found to be reasonably priced. As the fibre content will increase in most, it is discovered to be energy structured. FRC

over plain high SSC will increase the electricity and mechanical load carrying ability. Better for cracking and breaking flow is its important assets of steel fibers. To find out the compressive force, cut up tensile force and additionally combating for cracking with the aid of figuring out the flexural force of M45 grade 0%, 0.5%, 1%, 1.5%, 2% through quantity fractions as its element ratio is 50.GGBS of the particle diameter of fewer than three micrometers just contributes to the early strength of mortar. For long-term strength of mortar, GGBS with extra most effective has a micro-aggregate impact. Anjali Prajapati et. al. (2017) studied the effect of the performance of HPC using mineral admixture i.e. fly ash and GGBS with M-60 grade of cube specimen. We partially replaced Portland cement by weight of the binder. Fly ash and GGBS replacement vary from 10% to 30%. We used complast SP430-Sulphonated Naphthalene Polymers as a superplasticizer for better workability for high performance concrete. Dosage for superplasticizers is same for all mix proportions. Also, we have replaced fine aggregate in different proportions with foundry sand. We have investigated compressive strength, split tensile strength and flexural strength for all different cases. The HPC mix, grade M 60 concrete is designed as per Indian standards. Muthu Kumar T. et. al. (2016) researched on high performance concrete the usage of M50 magnificence mix ratio. Excessive overall performance concrete this is performed replaces 100% the best aggregate through grinding sand and partial cement substitute through micro-silica (i.e., five%, 10%, 15%, 20% and 25%). Glenium B233 became added for the workability of the concrete mix. A result obtained has been analysed and as compared with a managed sample. A dating among compressive strength as opposed to days, tensile electricity versus days and bending power as opposed to days, shown graphically. End result facts really show a growth in the percentage in 7 and 28 days Compressive strength, tensile electricity and flexural power for M-50 grade of concrete. A mixture of micro-silica, grinder-sand, and super-plasticizer on this experimental research display an exquisite development in compressive power in addition to tensile homes. The cement becomes changed by using micro-silica with 20%, but the energy extended via 16.5%. Powerful high concrete strength is attainable with micro-silica. Ishwar Chandra Thakur et. al. (2016) focused on the utilization of GGBS in concrete which may be suitably used below the Indian conditions. For this cause, the diverse assessments on houses of inexperienced and hardened concrete have been executed. The homes of green concrete have been analysed by using workability of concrete in terms of hunch fee whereas the houses of hardened concrete had been analysed in phrases of mechanical and bodily properties of concrete. The mechanical houses of hardened concrete encompass the compressive strength, flexural power and break up tensile energy whereas physical homes include the dry & moist density and water absorption of hardened concrete. On the idea of present paintings, we determined that GGBS in concrete improves workability, compressive power, flexural electricity, cut up tensile energy and decreases the density & water absorption traits of hardened concrete and as a result the cost of concrete decreases. Additionally, GGBS results in the big reduction in the amount of cement which permits the reduction in CO₂ emission and reduction in electricity consumption in the production of cement.

7. CONCLUSION

A survey of journal articles published between 2010 and 2017 yields studies that vary in scope and level of analysis, yet with consistently good results.

As our purpose is to develop concrete which does not only concern on the strength of concrete, it also has many different aspects to be satisfied like workability, performance, durability and also the 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 pozzolanas. 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 microcracks within the mortar-aggregate interface is liable for the inherent weakness of simple concrete. The weak point can be eliminated through the 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 microcracks.

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 to various fibres, its properties, significance, effect, impact on strength and durability properties are focused and brought into the picture for the study and future research. Following conclusions could be drawn from present papers.

- 1)The Mechanical properties such as compressive strength, tensile strength, toughness, impact, flexural etc are greatly influenced by the addition of fibres, optimum dosage of fibres governs these properties and must carry out optimality study on various fibres.
- 2)The Type of fibres, selection of fibres, properties like length, diameter aspect ratio, its effect on properties of concrete changes with the addition of dosage. The prime importance must be given for the selection of fibre, its type etc.
- 3)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.
- 4)The Addition of fibres with additional supplementary cementations material such as fly ash, silica fumes etc. should better performance by improving the workability of concrete and inherent properties of concrete.
- 5)The Addition of fibres is carried out for a special category such as self- compacting concrete, high-performance concrete, high strength concrete etc.

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