Analysis & Design of High-Performance Concrete By Using Ground Granulated Blast Furnace Slag

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Abstract- *In concrete, cement is a binding material, but cement is expensive due to excessive cost of transportation from manufacturing plant, also large-scale depletion of these sources creates environmental problems. The blast furnace slag is a by-product of the iron manufacturing industry as a waste product is best alternative material to cement, and GGBS can gives better bond strength which are having properties more than cement. However, the gradual reduction in the number of skilled workers in construction industries has led to a similar reduction in the quality of construction works. Infrastructural Development is at its peak all over the world and is a symbol of growth for any country. But as every coin has two faces - Concrete is no exception. The negativity attached to construction industry is that concrete, the most popular construction material, involves use of cement which is responsible for 7% of total world's carbon dioxide emissions. Carbon dioxide is the main threat in causing global warming of the environment. Though attempts have been made to reduce CO2 emissions in environment by all possible means, but cement has not found a suitable replacement till date. Therefore, there is a serious need to find replacement for cement. To overcome this problem ground granulated blast furnace slag (GGBS) which is a pozzolanic material can be used as a partial replacement to cement. As ground granulated blast furnace slag (GGBS) is a waste from iron industry and has chemical and physical properties similar to cement. We oriented that direction the study of experimental investigations on High performance concrete with partial replacement of cement by GGBS with various compositions and study its Compressive strength and Workability test etc.*

Keywords- Ground Granulated Blast Furnace Slag (GGBS), Workability Test, Compressive Strength

I. INTRODUCTION

Concrete is a widely used material in construction industry, because it has naturally and easily available ingredients like cement aggregate and water. Cement is one of the most important ingredients of concrete because of its blinding properties. But rapid production of cement creates environmental problem like emission of CO2 in the production process of cement. One tone of CO2 is reduced to the atmosphere when one tone of CO is manufactured which has a very harmful effect on the environment. Therefore, there is a serious need to find replacement for cement. To overcome this problem ground granulated blast furnace slag (GGBS) which is a pozzolanic material can be used as a partial replacement to cement. As ground granulated blast furnace slag (GGBS) is a waste from iron industry and has chemical and physical properties similar to cement. Therefore, it serves two purposes.

1. To replace cement partially.
2. To overcome the problem of disposal of GGBS.

Ground Granulated Blast Furnace Slag: Ground granulated blast furnace Slag (GGBS) also known as slag cement is hydraulic cement which improves the strength and durability of concrete. Slag cement is produced in iron blast furnace. The controlled amounts of iron ore, along with limestone are fed into blast furnace and heated to 1300 to 1500 degree Celsius. When molten, the iron is tapped for steel production and the slag is diverted to a granulator. Here, the slag is rapidly mixed with large quantities of water. The process minimizes crystallisation and forms “Granulated Slag," which is composed principally of calcium alumina silicate glass (formation of this glass provides slag cement with its cementitious properties). At this point, the slag is uniformly fine sand and is dewatered and dried. Finally, the slag is grinded to fine powder and becomes ground granulated blast furnace slag (GGBS) which is a pozzolanic material.

Problem Statement:

GGBS is around for 150 years and has been used all over the world. GGBS is used as all partial replacement for ordinary cement in concrete. Research on GGBS has gradually increased throughout the years. There is a trend that GGBS will be replacing cement as it is eco-friendlier and more cost effective. Also, as the cement is weak in tensile, flexure, impact strength and has low resistance against cracking. So, to tackle the problem of brittleness addition of GGBS can be used as replacement. The characteristics of GGBS

replacement enhances lower heat of hydration, higher durability and higher resistance to sulphate and chloride attack, when compared with normal ordinary cement. As the strength of GGBS is more than cement, the chances of appearing cracks are less. In the building construction technique, if cement is used as the binding material the lifespan of the structure is less and is not able to provide desired service duration. At worst, it will lead to structure failure with undesired casualties and deaths. Hence, in order to cater to the problems, GGBS is used a partially replacement of cement. In structures like bridges, tunnel or concluded structure having cement as the binding component there is a higher possibility of developing cracks in a short period of time. If GGBS is used as a binding component in partial replacement of cement, cracks develop after a long period of time.

Objective:

- Investigate the properties of concrete with Partial replacement of Ground granulated blast furnace slag (GGBS). • To investigate the preliminary properties of the required material.
- To find optimum percentage of replacement of GGBS and steel fibre to obtain desired compressive strength of high-performance concrete.
- To conduct compressive strength test of concrete.
- To provide economical construction material.
- Provide safe guard to the environment by utilizing the product properly.
- To reduce harmful effect on environment.
- To solve the problem of disposal of GGBS.

Scope of Project:

The Original scope of this research is to investigate the properties of concrete with Partial replacement of Ground granulated blast furnace slag (GGBS). The fresh and hardened properties of concrete will be tested with ground granulated blast furnace slag (GGBS). In this research compressive strength is determined. The replacement of Ground granulated blast furnace slag (GGBS) will be done at 0%, 5% ,10% ,15%, 20%, 25% thus replacing cement with Ground granulated blast furnace slag (GGBS) will lead to considerable environmental benefits and higher resistance to compressive strength.

II. METHODS AND MATERIAL

Collection of materials:

A. Ground granulated blast furnace slag (GGBS)

The ground granulated blast furnace slag (GGBS) used in this research was provided by Poona cement, Pune which is involved in the manufacture of many types of steel. Ground granulated blast furnace slag (GGBS) is an industrial waste. It is a by-product of the iron and steel making process. Ground granulated blast furnace slag (GGBS) is defined by American society for testing and materials (ASTM).

B. Coarse Aggregate

The coarse aggregate used in 20 mm aggregate confirming to IS 383:1970 the maximum size of aggregate considered is 20 mm IS retaining. The fineness modulus of coarse aggregate is 5.82.

C. Fine Aggregates

The fine aggregate used by Sand passing from 4.75 mm sieve and of specific gravity of 2.65.

D. Water

E. Cement

The cement used for this work is OPC 53 grade the specific grade of cement was tested as per IS 8112. The physical properties of cement obtained are confirming to IS 10262-2009. A cementitious material is one that has the adhesive and cohesive properties to form a proper bond in aggregates into a solid mass with adequate strength and durability.

E. Plasticizer

Casting:

The standard cubes of 150x150x150 mm size were cast in steel molds and compacted. The specimens were cured in water for 20 days by immersion and tested immediately after 7 & 28 days. The 12 cube specimens were tested for determining the compressive strength. Method of casting:

- 0% replacement of GGBS = 2 cubes
- 5% replacement of GGBS = 2 cubes
- 10% replacement of GGBS = 2 cubes
- 15% replacement of GGBS = 2 cubes
- 20% replacement of GGBS = 2 cubes
- 25% replacement of GGBS = 2 cubes

Mix Proportions:

Table I: Mix Proportions of Concrete (Kg/m³)

Nomenclature	W/C	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water (Kg)	Plasticizers (Kg)	GGBS (Kg)
HPC1	0.29	511	773	1044	143	5.11	0
HPC2	0.29	486	773	1044	143	5.11	25.55
HPC3	0.29	461	773	1044	143	5.11	51.10
HPC4	0.29	436	773	1044	143	5.11	76.65
HPC5	0.29	411	773	1044	143	5.11	102.20
HPC6	0.29	386	773	1044	143	5.11	127.75

III. RESULTS AND DISCUSSION

Compressive Strength Result:

Since we see the increase in strength of the sample, we further test it for optimum percentage of GGBS mixing. So, sample no-4 is added 15% of GGBS by weight. And when tested for compression it is observed that the strength gained by the block on 7th day is not as close as the strength gained by earlier samples. But the final strength on 28th day is at a higher margin than compared to other samples. The strength gained by the block on 28th day is 71.11Mpa which is the highest difference between days 7 to day 28 of any other sample.

Table II: Compressive Strength Result

Nomenclature	Cube compressive strength (fck) 7 days	Cube compressive strength (fck) 28 days
HPC1	53.6	59.55
HPC2	56.40	62.67
HPC3	58.88	65.33
HPC4	60.0	71.11
HPC5	58.88	63.33
HPC6	56.80	63.11

Discussion:

With this experiment on HPC it is observed the increase in strength of the sample, we further test it for optimum percentage of GGBS mixing. So, sample no-4 is added 15% of GGBS by weight. And when tested for compression it is observed that the strength gained by the block on 7th day is not as close as the strength gained by earlier samples. But the final strength on 28th day is at a higher margin than compared to other samples. The strength gained by the block on 28th day is 71.11Mpa which is the highest difference between day 7 to day 28 of any other sample.

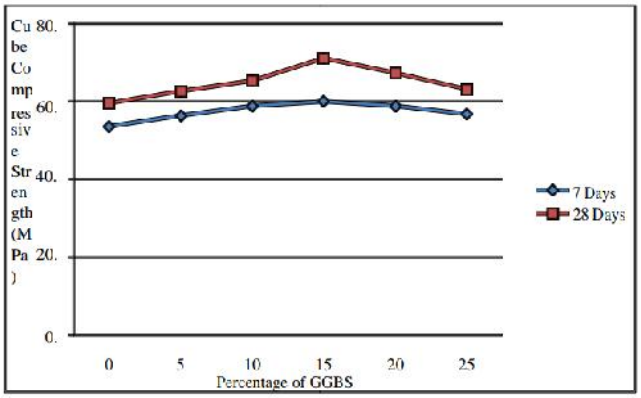

Figure: Compressive Strength (N/Mm2) V/S Replacement % Of GGBS.

IV. CONCLUSION

The concrete mixture with 15% GGBS achieved highest compressive strength at end of curing day with all variations in comparison to plain concrete mixture.

- The optimum value is achieved for 15% replacement of GGBS.
- After achieving the optimum value, it is seen that there is gradual decrease in the graph.
- While testing the specimen, the plain concrete specimens showed a typical crackling pattern.
- GGBS can be used as a mineral admixture or pozzolanic material in concrete due to economic and environmental, without any compromise in its performance.
- From the above experimental analysis, it is proved that GGBS can be used as an alternative material for cement, reducing the cement consumption.

REFERENCES

[1] Mr. Amit Gavali, Mrs. Sneha Sawant & Mr. Mithun Sawant, "Experimental Study on Ground Granulated Blast Furnace Slag in Concrete."
[2] Yogendra O. Patil, "GGBS as Partial Replacement of OPC in Cement Concrete an Experimental Study."
[3] Arvind. Nakum, Vatsal.N. Patel, "Experimental Study on Mechanical and Durability Properties of High Strength Concrete Incorporating GGBS and Steel Fibers."
[4] Vinayak Awasare, Prof.M.V.Nagendra, "Analysi of Strength Characteristics of GGBS Concrete."
[5] S. Arivalagan, "Sustainable Studies On Concrete with GGBS as AReplacement Material in A Cement."
[6] A.H.L. Swaroop, K. Venkateswararao, Prof P Kodandaramarao, "Durability Studies on Concrete with Fly Ash & GGBS."
[7] Mohammed Areeb Qidwai, "To Study the Properties of Geopolymer Concrete Using GGBS."