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Experimental Investigation of Partial Replacement of Cement with GGBS and Fine Aggregate with Glass Powder

Siddharth Pandey[1], Priyanka Gupt[2], Chandan Maddheshiya[3], Rajat Kumar Maurya[4] Vijay Kumar Srivastava[5]

[1,2,3,4]UG Student [5]Head of Department

[1,2,3,4,5]Buddha Institute of Technology, India

Abstract— *Due to the day to day innovations and development in construction field, values of natural aggregate is increased tremendously and at same time the production of solid waste glass and industry waste such as from (iron& steel industry) is also quite high. So because of these reasons the reuse of waste glasses in the form of glass powder and byproduct of iron industry wastes like GGBS are came into the picture to reduce the solid waste and to reduce the scarcity of natural aggregate making concrete. Some studies show that about 20-30% of material prepared in the manufacturing plants are transforming into waste. These waste materials should have to be reused in order to deal with the limited resource of natural aggregate ad to reduce the industrial waste. The glass powder were partially replaced in the place of aggregate by 10%, 20%, 30%, 40%, 50% GGBS powder where replaced in the place of cement by 10%, 20%, 30%, 40%, 50% along with the glass powder. M20 (1: 1.5: 3) grade of concrete was designed and tested. The mix design for different types of mixes were prepared by replacing the fine aggregate and cement at different percentages of glass powder and GGBS. Experimental Investigation like workability, compressive strength test, split tensile test for different concrete mixes with different percentages of waste after 7, 14,& 28 days curing period has to be done. It has been observed that the workability increases with increase in the percentage of replacement of GGBS increases.*

Keywords: *GGBS, Glass Powder, cement, M20(1:1.5:3), Waste Glasses.*

1. INTRODUCTION

Concrete is a widely used material in the world based on the global usage it is placed at second position after water. Concrete has been major instrument for providing stable and reliable infrastructure since the days of Greek and Roman civilization. A concrete is a mixture of cement, water and aggregate with or without chemical admixture. The most important part of concrete is the cement. Due to the highly increment in the innovation and development in construction field, the values of utilization of natural resources is increased tremendously. The major problem facing by mankind today is about the utilization

of natural resources in order to melt the human needs and maintain the economic growth, without exhausting the available resources on which the life of economic prosperity and our security depend.

Now in 21st century, non-degradable wastes has been major issues, because of more and more of these wastes are piling up in our world today and being disposed of in landfill areas without being recycled which takes up a very long period of time to decompose. The large amount of wastes are mainly obtained from the Industries or factories. In this paper we are taking some industrial waste such as GGBS (Ground Granulated Blast Furnace Slag) and waste glasses (Glass Powder) as the substitute for the Cement and Fine aggregate.

In the concrete industry some efforts are made to use waste glass as partial replacement of coarse and fine aggregates. Some of the studies shows that if the waste glasses is finely ground under 150 micron, then the mortar durability is guaranteed. Most of existing studies recommended the waste glasses to use only as fine powder because fine particles of glasses usually present pozzolanic activity beneficial to the concrete. There is a huge potential for using waste glasses as glass powder in concrete construction sector. When the waste glasses are reused in making concrete products, the production cost will go down easily.

Ground Granulated Blast Furnace Slag (GGBS) as a by-product obtained in the pig iron in the blast furnace which is a solid waste discharged in a large quantities by the iron-steel industries in India. An important measure is taken for the environmental protection by recycling these slags. Nowadays the researchers has been carried out the effective ways to reduce the CO_2 emission from the cement industries is to use the industrial by-products such as GGBS, Fly Ash etc. To overcome these problems an experimental attempt is made to replace the cement by GGBS. Hence the most important objective of this study is to evaluate the possibility of using the GGBS as partial replacement of cement.

1.1. GGBS

Ground Granulated Blast Furnace Slag is a by-product discharged in a large quantities by the iron-steel industries as a solid wastes from the Blast furnace at a temperature of 1500 degree centigrade and are fed with a carefully controlled mixture of iron-ore, coke, limestone.

Slag is a by-product of steel plants, which is obtained from the blast furnace, during the separation of iron from the iron-ore. The process involves cooling of the slag through the high-pressure water jets, this leads to the formation of granular particles. Then the granulated slag is further processed by drying and then grinding in a vertical roller mill or rotating ball mill or roller press to a very fine powder, which is called GGBS.

GGBS is a uniform composition depending on a particular source ad has got both hydraulic and pozzolonic property. It is highly reactive when it is mixed with OPC. Its chemical composition is very similar to OPC.

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1.2. GLASS POWDER

Waste Glasses are easily available in local shops that has been collected and made into glass powder. Glass Waste is a very hard material, therefore before adding glass powder in the concrete it has to be finely grinded in a powdered form to obtain a desired size less than 150micron and 300microns. Glass powder is added to the cement separately before dry mixing with other material.Some sources of waste glasses are – Window repair shops, Glass food and beverages container, Glass decorative items, old tube lights or electric bulbs, defective glass waste from Industries, etc.

1.3. OBJECTIVE

- To study the fresh properties of concrete.
- To determine the variation of workability of concrete by partially replacing the cement by GGBS and fine aggregate by Glass powder.
- To decrease the cost of concrete production by using GGBS and glass powder.
- To determine the most optimized mix of GGBS-based concrete.
- To investigate the structural behavior of concrete by adding replacing materials.

2. METHODOLOGY

- Collection of the raw materials & Study of physical properties of materials.
- Material Test

- Casting, curing and testing of specimen.
- Results and Discussion
- Conclusion
- Scope for Future Study
- Reference

3. MATERIAL

- Cement
- Coarse Aggregate
- Fine Aggregate
- GGBS
- Glass Powder
- Super Plasticizer

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 together. Ordinary Portland Cement (OPC) of 53 grade is used in which the composition and properties are in compliance with the Indian standard organization.

S.NO.	Property	Result
1	Brand of Cement	53 grade OPC
2	Standard Consistency	35
3	Initial setting time (in minutes)	30
4	Final setting time (in minutes)	10
5	Specific Gravity	3.16

S.NO.	Chemical Composition	Limits%
1	CaO	61-67
2	SiO_2	19-23
3	Al^2O	2.5-6
4	Fe^2O^3	0-6
5	SO^3	1.5-4.5

3.2. Coarse Aggregate

Coarse aggregate are naturally occurring and can be obtain by blasting quarries or crushing them by hand. The aggregates or particles which passes through the 75mm IS sieve and retained on 4.75mm IS sieve are the coarse aggregate.

Properties	Coarse Aggregate
Specific Gravity	2.65
Water Absorption	0.39%

3.3.Fine Aggregate

Fine aggregate consist of natural sand or any crushed stone particles which passes through 4.75mm IS sieve and retain on 75micron IS sieve. Fine aggregates are basically sand won from the land or from marine environment.

Properties	Fine Aggregate
Specific Gravity	2.62
Water Absorption	1.45%

3.4.GGBS

GGBS is a waste industrial by-product from the blast furnaces used to make iron. GGBS used in this project was collected from Sri Sai Building Material's from Raptinagar, Arogyamandir in Gorakhpur.

Physical Properties	GGBS
Color	White
Water Absorption	0.75
Specific Gravity	2.77
Fineness	3%

3.5. GLASS POWDER

Glass powder was obtained from the collection of waste glasses from local areas and then grinded into the powdered form or into cementitious frame as to procure a certain degree of concrete substitution. In this study the resulted in particle size less than in size 150micron and sieved in 75micron.

Physical Properties	Glass Powder
Color	Grayish White
Specific Gravity	2.6
Fineness passing 150micron	99.5
Fineness passing 90micron	98

3.6. SUPER PLASTICIZER

To increase the workability, 0.5% of super plasticizer by weight of cement is added to the mix concrete. **Superplasticizers** are usually chemical compounds such as sulphonated melamine formaldehyde (SMF), sulphonated naphthalene formaldehyde (SNF), modified lingosulphonates (MLS) and polycarboxylate derivatives. The name of super plasticizer which is used is sulphonated melamine formaldehyde (SMF).

4. EXPERIMENTAL PROCEDURE & TESTING

In this experimental investigation an attempt has been made to find out the strength of concrete produced by replacing the cement by GGBS and fine aggregate with glass powder by replacing it by 30%, 40%, 50% and 60% of the binder and the mix design was prepared. These results are compared with nominal concrete (0% replacement of GGBS and glass powder).

In this experimental project various tests are conducted on cement, fine aggregate, coarse aggregate as well as workability measurements are conducting by using different methods. The observation is tabulated and the results are calculated. The various parameters of the strength characteristics studied are-

4.1.Material Testing on Cement :-

- Fineness Test
- Consistency Test
- Initial and Final Setting Time
- Soundness test

4.2.Material Testing on Aggregate:-

- Sieve analysis of aggregate
- Aggregate crushing value test
- Aggregate Impact value test
- Aggregate Abrasion value test

4.3.Workability of Fresh Concrete

The workability of a fresh concrete is defined as the concrete which are easily mixed, placed and compacted without any difficulty. Workability is one of the most major factor of the concrete. In this present the workability of the concrete is measured by slump cone test.

S.NO.	% of GGBS and Glass Powder	Values
1	0%	75
2	30%	90
3	40%	107
4	50%	111
5	60%	116

4.4. Compressive Strength Test

In this project the dimension of the specimen 150x150x150mm were prepared. They are tested on 2000kN capacity compression testing machine. The compressive strength is calculated by using the specimen.

F= P/A

Where,

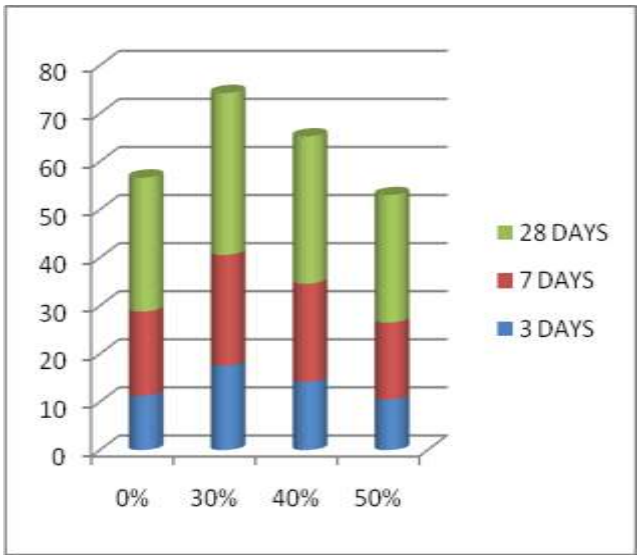
F= compressive strength of the specimen (in MPa).

P= maximum load applied to the specimen (in N).

A= cross-sectional area of the specimen(in mm^2) = 22,500mm^2

From the result it states that the compressive strength increases by the increase in there replacement level of cement and fine aggregate by GGBS and glass powder upto 30%, beyond the 30% there was a marginal decrease in the strength of the concrete.

Designation	0%	30%	40%	50%
3 Days	11.28	17.54	14.21	10.51
7 Days	17.57	23.08	20.42	16.02
28 Days	27.85	33.68	30.63	26.54



5. CONCLUSION

The experimental results obtained show that partial substitution of cement and fine aggregate by GGBS and with glass powder gives better results over the verified range from 30%, 40%, 50%, and 60% replacement. The conclusion are drawn below:

- Maximum compressive strength obtained for replacement of cement and fine aggregate by 30% of GGBS and glass powder.
- It is economical when compared to normal concrete mixtures.
- From experimental results it has been observed that the compressive strength is improved.
- From the environmental point of view, its use in construction industries, save maximum land space and

minimum reduction of soil fertility.

- Finally the result of this project work have revealed that demolished waste advantages to be used in concrete production.
- With some modification in design mixes, can result in utilization of waste glass powder and GGBS as substitute in concrete, thus save considerable investment in construction and partially solving the disposal of wastes.
- From the considerations of economy and availability, waste glass powder and the use of GGBS are suitable as binding material as compared with cement generally used in concrete mix.

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SIDDHARTH PANDEY
(1852500922)
PRIYANKA GUPTA
(1852500914)
CHANDAN MADDHESHIYA
(1852500905)
RAJAT KUMAR MAURYA
(1852500915)
B. Tech (Civil Engineering)
BIT GIDA GORAKHPUR .

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