"Studies on Strength Properties of Concrete with Partial Replacement of Cement by GGBS"

Dr. G. Sridevi[1] L. Madhusudhan[2], V. Manikumar Reddy [2], C.Phaneendra[2] and G.Prajwala[2]

[1] Professor Department of Civil Engineering BVRIT Narsapur
Medak District Hyderabad,

[2] *UG Student Department of Civil Engineering, BVRIT Narsapur*
Medak District Hyderabad

Abstract

The production of cement results in emission of many green house gases in atmosphere, which are responsible for global warming. Hence, the researchers are currently focused on use of waste material having cementing properties, which can be added in cement concrete as partial replacement of cement, without compromising on its strength and durability, which will result in decrease of cement production thus reduction in emission in green house gases, in addition to sustainable management of the waste. The ground granulated blast furnace slag is a waste product from the iron manufacturing industry, which may be used as partial replacement of cement in concrete due to its inherent cementing properties. This paper presents an experimental study of compressive and flexural strength of concrete prepared with Ordinary Portland Cement, partially replaced by ground granulated blast furnace slag in different proportions varying from 30% , 40%,50%and 60% Compressive strength and Flexural strength of GGBS concrete increased for GGBS addition of 30%. GGBS concrete showed marginal decrease in compressive and flexural for the further replacement.

Keywords: Cement, Natural Sand, GGBS and Aggregate.

1. Introduction

Blast furnace slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500oC to 1600oC. The molten slag has a composition of 30% to 40% silicon dioxide (SiO2) and approximately 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBS). The production of GGBS requires little additional energy compared with the energy required for the production of Portland cement. The replacement of Portland cement with GGBS will lead to a significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace as much as 80% of the Portland cement when used in concrete. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced. High volume eco-friendly replacement slag leads to the development of concrete which not only utilizes the industrial wastes but also saves significant

2. EXPERIMENTAL PROGRAMME

Objectives:

It is aimed to study the performance of GGBS in the concrete with respect to the strength and durability properties.

Objectives of the experimental investigation are as follows:

- To study the mechanical properties such as compressive strength, flexural strength of concrete at the end of 3, 7 and 28 days of curing period using GGBS as cement at different replacement levels. The percentage replacement levels of cement with GGBS used were 30%, 40%, 50% and 60%
- To compare the mechanical properties of GGBS concrete with that of conventional concrete.
- To determine the optimum replacement of cement by GGBS.
- To study the workability property of fresh concrete with partial replacement of cement by GGBS.

Materials Used

The materials used in this experiment were cement, GGBS, fine aggregate, coarse aggregate and water.

1) Cement:

OPC 43 grade cement conforming to IS 8112-1989, from a single batch was used throughout the course of the project work. In laboratory various tests were conducted on cement and its results are shown in Table1

Table 1. Properties of Fine aggregates

S.No	Characteristics	Values
1	**Consistency**	**32%**
2	**Initial Setting Time**	**36 min**
3	**Final Setting Time**	**270 min**
4	**Finesse of cement**	**4%**
5	**Soundness of cement**	**2mm**

2) Fine Aggregate:

Locally available river sand conforming to zone II of IS 383-1970 was used in this project work. The sieve analysis data and physical properties of fine aggregates used are shown in Table 2.

Table 2. Properties of Fine aggregates

S.No	Characteristics	Values
1.	Type	Uncrushed (natural)
2.	Specific gravity	2.54
3.	Bulk Density	1668 kg/m3
4.	Fineness modulus	2.76
5.	Grading zone	Zone II

3) Coarse Aggregate:

Locally available coarse aggregate having the maximum size of (10 - 20mm) were used in this project. Properties of the coarse aggregate are tabulated in Table 3

Table 3. Properties of Coarse aggregates

S.No	Characteristics	Values
1.	Type	Crushed
2.	Specific gravity	2.7
3.	Bulk Density	1765 kg/m3
4.	Fineness modulus	6.45
5.	Maximum size	20mm

4) Water*:*

Potable clean water was used in the present investigation for both casting and curing of concrete.

5) GGBS: The chemical composition of blast furnace slag is similar to that of cement clinker.

Cao 30-45%, SiO_2 17-38%, Al2O3 15-25%,Fe_2O_3 0.5-2.0% MgO 4.0-17.0%, Mno2 1.0-5.0%,Glass 85-98%

3. Mix proportion of concrete:

In this study, control mix was designed as per IS 10262:2009 for M40 grade. Cement replacement levels of 30%,40%,50% and 60% with GGBS were used in the investigation. Different mix proportions used are shown in Table 4

Table 4: Mix proportions for different replacement proportions with GGBS (water cement ratio 0.35)

Components	0%	30%	40%	50%	60%
Water(lit)	148.8	148.8	148.8	148.8	148.8
Cement(kg)	425.14	297.590	255.085	212.570	170.056
GGBS(kg)	0	127.542	170.056	212.570	255.085
Fine Aggregate(kg)	698.89	696.50	695.70	694.91	694.11
Coarse Aggregate(kg)	1221.09	1216.91	1215.52	1214.12	1212.73
Chemical Admixture(kg)	4.25	4.25	4.25	4.25	4.25
Density(Kg)	2498.17	2491.60	2489.41	2487.22	2485.03

3.1 Workability of Fresh concrete

Workability is one of the major a factor of the concrete. Workability is defined as the ease with which concrete is mixed, placed and compacted without any difficulty. Workability of fresh concrete can be measured by slump cone test, vee-bee consistometer test and compaction factor test. In the present workability of fresh concrete is measured by slump cone test.

Table.5. Workability of concrete with varied percentages of GGBS

S NO	% of GGBS	Slump values(mm)
1	0%	75
2	30%	92
3	40%	108
4	50%	110
5	60%	115

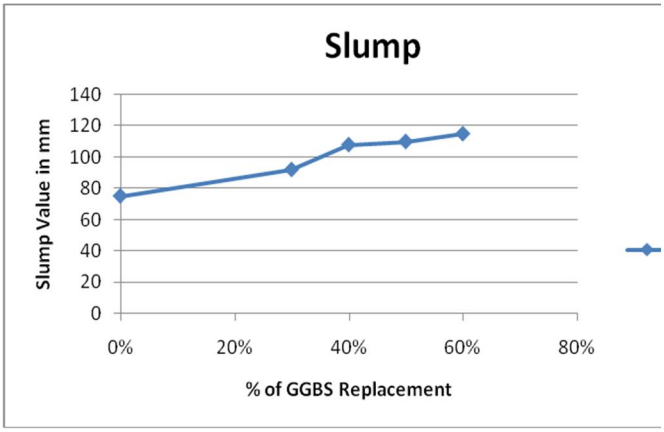

Fig.1: Variation in Slump with GGBS repalcement

5. RESULT AND DISCUSSION

Compressive Strength*:*

The result of compressive strength tests are tabulated in Table.6 From the result it was observed that the compression strength of the concrete increases with increase in there placement level of cement by GGBS up to 30%, beyond 30% replacement levels there was a marginal decrease in the strength of the concrete.

For 3 days curing period, the strength of the concrete is increased about10.4% for 30% and decreased about 3.51%, 16.37%, and 25.13% for 40%, 50% and 60% replacement level respectively when compared with that of conventional concrete.

For 28 days curing period, the strength of the concrete is increased about 13.13% for 30% and decreased about 2.40%, 11.05%, 20.92% for 40%, 50% and 60% replacement level respectively when compared with that of conventional concrete

Table:6 Compressive Strength of cubes

Designation	Compressive Strength in N/mm2		
	3 Days	7 Days	28Days
G 0%	46.12	50.67	55.63
G 30%	51.5	55.33	64.04
G 40%	44.5	47	57
G 50%	38.57	45.26	49.48
G60%	34.53	41.93	43.99

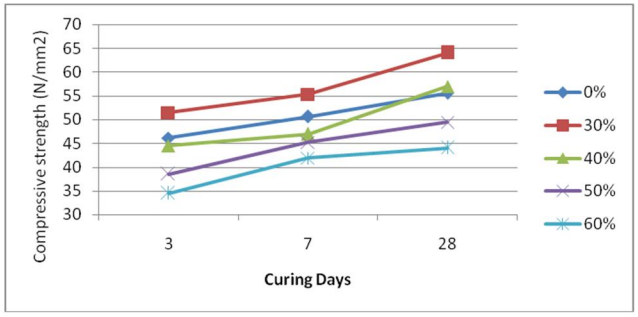

Fig.2: Variation in Compressive Strength at age of curing

Flexural Strength

The results of flexural strength test are tabulated in Table 7 From the result it was observed that the flexural strength of the concrete increases with increase in the replacement level of cement by GGBS up to 30%, beyond 30% replacement level there was a marginal decrease in the strength of the concrete.

For 3 days curing period, the strength of the concrete is increased about 4.06% for 30% and decreased about 5%, 6.51%, and 16.16% for 40%, 50% and 60% replacement level respectively when compared with that of conventional concrete.

For 28 days curing period, the strength of the concrete is increased about6.97% for 30% and decreased about 1.6%, 6.25%, 10.37% for 40%, 50% and 60% replacement level respectively when compared with that of conventional concrete

Table: 7 Flexural Strength of Prism

Designation	Flexural Strength in N/mm2		
	3 Days	7 Days	28Days
G 0%	6.6	7.5	8
G 30%	6.88	8.5	8.6
G 40%	6.33	7.75	8.13
G 50%	6.17	6.5	7.5
G60%	5.5	6	7.17

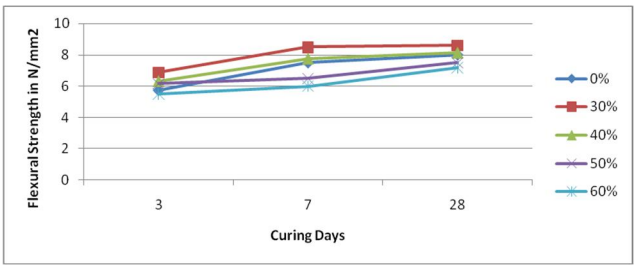

Fig.3: Variation in Flexural Strength at age of curing

6. CONCLUSIONS:

The experimental results obtained show that partial substitution of cement by GGBS gives better result over the verified range from 30%, 40%, 50%, and 60% replacement. The conclusions are drawn as below:

- From mechanical properties optimum cement replacement by GGBS was found to be 30%.
- Compressive and flexural strength values increased for 30% cement replacement level. Beyond 30% all the strength values decrease when compared with that of control concrete.
- The maximum percentage increase in compressive strength at 30% cement replacement was 13.13%. The corresponding increase in flexural strength value was 6.97% for 28 days.
- There is a fall in strength for the further replacement of GGBS.
- It can be concluded that concrete mix with cement replacement by GGBS will be an economical and environmentally sustainable option

References

[1] Comparision of Normal Concrete and GGBS Concrete", by sri. V.Mallikarjun reddy

[2] "Flexural Behaviour Of Reinforced Concrete Beams Replacing Ggbs As Cement And Slag Sand As Fine Aggregate" work was carried by Sagar Patel, Dr. H. B.Balakrishna[2]

[3] "Effects of Ground Granulated Blast Furnace Slag in Portland Cement Concrete (PCC)"By Irene K. Labarca, Ryan D. Foley, Steven M. Cramer[3]

[4] "Application of GGBS in China"bydr.En Yi Chen [4]. 2nd Global Slag Conference & Exhibition, 20-22 November 2006, Bangkok, Thailand

[5] "Fast Track Construction with High-Strength Concrete Mixes Containing Ground Granulated Blast Furnace Slag" by M.N. Soutsos, S.J. Barnett, J.H. Bungey, and S.G. Millard[5].

[6] GGBS as Partial Replacement of OPC in Cement Concrete – An Experimental Study By Prof.P.N.Patil, Yogendra O. Patil and Dr.Arun Kumar Dwivedi. International Journal of Scientific Research Volume : 2 | Issue : 11 | November 2013 • ISSN No 2277 - 8179

[7] "Durability of concretes containing ground granulated blast furnace GGBS against sulphate attack" By A.A. Ramezanianpour1, S. Atarodi1, M. Sami1.

[8] "Analysis of strength characteristics of GGBS Concrete" By Vinayak Awasare, Prof. M. V. Nagendra [8] Awasare et al., International Journal of Advanced Engineering Technology E-ISSN 0976-3945

[9] IS: 8112-1989: Specification for 53-grade Ordinary Portland Cement, Bureau of Indian Standards, New Delhi,2001

[10] IS: 516-1959, Method of Tests for Strength of Concrete, Bureau of Indian Standard (Eleven reprint), New Delhi, 1985.

[11] IS: 383-1970: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi, 1993.

[12] IS 456-2000, Indian standard, plain and reinforced concrete-code practice.

[13] M.S.Shetty, Concrete technology text book