Effect of Partial Replacement of Cement By GGBS & Fine Aggregate By Steel Slag on Strength of Concrete

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Abstract- *The infrastructure are developing day by day so demand is more for concrete. Our construction life is readily depend on concrete directly or indirectly. By this significant demand for natural resources like sand etc., are depleting day by day and heavy release of carbon dioxide gas in cement manufacturing process, Destruction of environment taking place. To overcome these problems, Partially use of industrial waste in concrete in place of cement and sand are necessary. In this study, partial replacement of cement with GGBS and sand with Steel slag considered. Experimental study is conducted to evaluate the strength characteristics of hardened concrete. Properties of concrete have been assessed by partially replacing cement with GGBS and sand with Steel slag. The cement has been replaced by GGBS accordingly in the range of 0%, 5%, 10%, 15%, 20% and 25% by weight of cement. The sand has been replaced by Steel slag accordingly in the range of 0%, 10%, 20%, 30% and 40% by weight of sand for M25 grade mix. Concrete cubes were casted and tested after 7 days and 28 days curing for compressive strength and compared with the conventional concrete specimens. So that optimum percentage of GGBS and Steel slag are to be determined.*

Keywords- Consistency, Ground Granulated Blast furnace Slag, Impermeability, Specific gravity, Steel slag

I. INTRODUCTION

Concrete is one of the significantly accepted construction material in the development of infrastructure. It is perfectly matches with several requirements such as strength, durability, impermeability and fire resistant and abrasion resistant. The current consumption of concrete is approximately 500 million tons per annum and demand is expected to reach one billion tons in next decade. Concrete is a heterogeneous mix of cement, aggregates and water. Cement is an artificial material manufactured with naturally available limestone, silica and gypsum. Aggregates are considered to be one of main constituents of concrete since they occupy more than 70% of concrete matrix. In the recent years, green concrete has draws serious attention of researchers and investigators because a concept of eco friendly. The contribution of ordinary Portland cement production worldwide to green house gas emissions is estimated to be approximately 1.35 billion tons per year. To keep the global environment safe from the consequence of cement production, it is essential to explore the alternative materials than can at least partially eliminate the use of cement in concrete and no environment destruction.

II. MATERIALS AND METHODOLOGY

1. **Cement:** Ordinary Portland cement (OPC) of 43 Grade with respect to IS 8112-1989 was considered for present study

Physical properties of cement

Table 1.

Sl No.	Parameter	Value
1	Specific gravity	3.09
2	Normal Consistency	29%
3	Initial setting time	45min
4	Final setting time	360min
5	fineness	4%

2. **Ground granulated blast furnace slag (GGBS):**Ground granulated blast furnace slag (GGBS) is a byproduct from the iron and steel industries from their blast furnaces which are used to make iron and steel. For our research work

Table 2

Sl No.	Parameter	Value/Remark
1	Appearance	Very Fine Powder
2	Color	Off White
3	Odor	Odorless
4	Specific Gravity	3.18

GGBS used is bought from JSW steel industry.

Physical Properties of GGBS

Chemical compositions of GGBS [9]

3. **Fine aggregate :** Sand used in this investigation is naturally available river sand passing through 4.75mm size sieve after sieve analysis it is determined that the sand confirms to grading zone I as per IS:383-1970.

Physical properties of fine aggregate

Table 3.

Sl No.	Parameter	Value
1	Finess modulus	3.17
2	Specific gravity	2.53
3	Grading Zone	Zone I

4. **Coarse aggregate:** The crushed stone aggregate were collected from the local quarry. 20mm down & 12.5mm down sized aggregates are blended in equal proportion and tested as per IS:383-1970 to form 20mm well graded aggregates.

Physical properties of coarse aggregate

Table 4.

Sl No.	Parameter	Result
1	Specific gravity	2.67
2	Shape	Angular
3	Size	20mm and 12.5mm down

5. **Steel Slag:** Steel slag is bi-product obtained either from conversion of iron to steel in basic oxygen furnace(BOF) or by melting of scrap to make steel in the electric arc furnace(EAF). JSW steel slag was used as replacement material for fine aggregate in the current investigation.

Physical Properties of Steel slag

Table 5.

Parameter	Value/Remark
Specific gravity	2.59
Fineness modulus	2.90
Colour	Light grey

Chemical compositions of Steel Slag

Table 6.

Constituents	Composition(%)
Calcium oxide	40-52
Silica	10-19
Iron oxide	10-40
Manganese oxide	5-8
Magnesium oxide	5-10
Alumina oxide	1-3
Phosphorous oxide	0.5-1

6. **Water :** Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials and other deleterious materials. Potable water is generally used to satisfy the requirements of IS:456-2000.

7. **Super plasticizer:** In the present experimental work Conp1ast SP 430 is used obtained from Fosroc Chemicals (India) pvt. ltd. Its advantage is improved workability, Increased Strength, Higher cohesion and free from Ch1oride. Conp1ast SP 430 is based on Su1phonated Naphthalene polymers and supplied as a brown liquid instantly dispersible in water. Its has Specific Gravity of 1.220 to 1.225 at 30oC.

METHODOLOGY

In present investigation, partial replacement of cement with GGBS and sand with Steel slag considered. Experimental study is conducted to evaluate the strength characteristics of hardened concrete. Properties of concrete have been assessed by partially replacing cement with GGBS and sand with Steel slag. The cement has been replaced by GGBS accordingly in the range of 0%, 5%, 10%, 15%, 20% and 25% by weight of cement. The sand has been replaced by Steel slag accordingly in the range of 0%, 10%, 20%, 30% and 40% by weight of sand for M25 grade mix. Concrete cubes were casted and tested after 7 days and 28 days curing for compressive strength and compared with the conventional concrete specimens. So that optimum percentage of GGBS and Steel Slag are to be determined.

The present work is divided in to 6 phases. Each phase has constant GGBS replacement for Cement and varying Steel slag Replacement for Sand in the range 0% to

40%. For each phase, 2 sets of cubes (6 specimens) were casted . One set of cubes were tested for compressive strength after 7 days of curing and other set of cubes were tested after 28 days of curing.

Table 7.

GGBS % Replacement for cement	STEEL SLAG % Replacement for fine aggregate				
0	0	10	20	30	40
5	0	10	20	30	40
10	0	10	20	30	40
15	0	10	20	30	40
20	0	10	20	30	40
25	0	10	20	30	40

NOTE: GGBS % = Percentage by weight of cement

STEEL SLAG % = Percentage by weight of Fine aggregate.

Mix design:

The M25 grade concrete is adopted for the present work. A test on different trial mixes has carried out. The mix proportion that gives0required cube compressive strength for 28 days with minimum cement content. Detailed mix proportion is obtained as per code IS: 10260-2009
Mix ratio

Table 8.

W/C	Cement	Sand	Coarse Aggregate
0.475	1	1.64	3.59

III. RESULTS AND DISCUSSIONS

The Concrete cubes of different replacement proportion were subjected to Compressive strength test and results obtained from test are tabulated and the corresponding graphs were plotted to analyse the variation of strength.

Compressive strength of concrete - 0%, 5%, 10%, 15%, 20% &25% Replacement for cement by GGBS is restricted with varying % Replacement of Sand by Steel slag.

Table 9.

Sl.N0	**Mix (GGBS+SS)**	**Compressive Strength (MPa)**	
		7days	**28days**
1	**Convectional**	**28**	**35.55**
2	0+10	25.33	29.04
3	0+20	27.26	33.63
4	0+30	25.92	30.22
5	0+40	23.7	25.63
6	5+0	21.93	28.6
7	5+10	24.59	29.62
8	**5+20**	**26.96**	**33.63**
9	5+30	25.11	30.37
10	5+40	23.11	27.7
11	10+0	23.7	31.11
12	10+10	25.19	33.03
13	**10+20**	**27.55**	**34.81**
14	10+30	24.89	32
15	10+40	22.81	30.07
16	15+0	24.88	33.33
17	15+10	25.92	33.63
18	**15+20**	**28.29**	**34.07**
19	15+30	24	28.74
20	15+40	22.22	26.67
21	20+0	26.96	34.07
22	20+10	28	35.11
23	**20+20**	**30.96**	**38.97**
24	20+30	26.07	31.11
25	20+40	21.03	28.89
26	**25+0**	**26.81**	**32.89**
27	25+10	25.03	30
28	25+20	24.15	29.19
29	25+30	23.26	26.81
30	25+40	20.22	24.15

Optimum Compressive strength of concrete

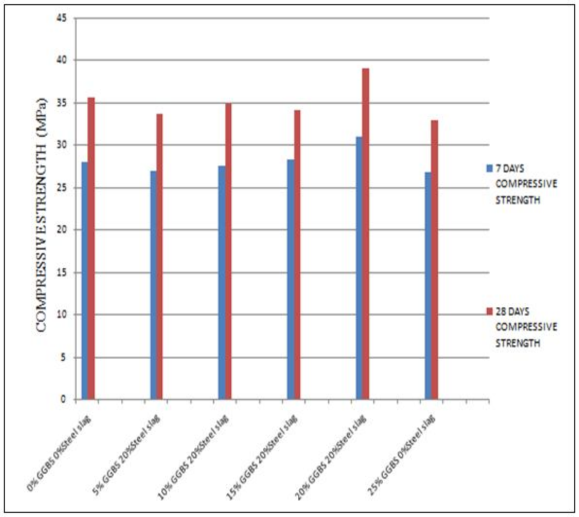

Figure 1.

The optimum replacement ratio for M 25 grade concrete mix are 20% replacement of Cement by GGBS & 20% replacement of Fine aggregate by Steel slag, which gives nearly 10% more Compressive strength than the results of conventional concrete of M25 mix.

IV. CONCLUSIONS

Behaviour of Concrete by partial replacement of Cement & Fine aggregate by GGBS & Steel slag were studied. From the results the following Conclusions were drawn.

1) With this study , the mean target strength of M 25 grade concrete is achieved with the combined effect of using GGBS & Steel slag as a partial replacement for Cement and Sand respectively.
2) By this investigation, the optimum replacement ratio for M 25 grade concrete mix are 20% replacement of Cement by GGBS & 20% replacement of Fine aggregate by Steel slag, which gives nearly 10% more Compressive strength than results of conventional concrete of M25 mix.
3) This experimental study has proved to be better way to disposal of industrial by-product and waste such as Ground granulated blast furnace slag and Steel slag.

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