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EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE USING FIBRE REINFORCEMENT & GGBS AS 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 approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked 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 addition of steel fibres.

The study focuses on the flexural strength performance of the blended concrete containing 20% percentage of slag and different 1.5% of steel fibres as a partial replacement of OPC. The cement in concrete is replaced accordingly with the percentage of 20% by weight of slag and 1.5% by weight of steel fiber. Concrete Samples are tested at the age of 7,14 and 28 days of curing. Finally, the strength performance of slag blended fiber reinforced concrete is compared with the performance of conventional concrete. From the experimental investigations, it has been observed that, the optimum replacement of Ground Granulated Blast Furnace Slag Powder to cement and steel fiber without changing much the compressive strength is 20 % & 1.5 % respectively for M30 Grade

Key Words: High performance concrete (HPC),, Ground Granulated Blast Furnace Slag (GGBS), Steel Fibres, and Strength etc.

1. INTRODUCTION

Improvement of quality of structural materials is a general trend which may be observed in our civilization. At different periods that trend has a foem of a steady continuous function or of a step function. High Performance Concretes appeared a few years ago and now develop rapidly representing a new generation of composite materials in building and civil engineering. Without any doubt their application will be increased in many kinds of structures where special requirements are imposed.

High Performance Fibre Reinforced Concrete (HPFRC) is a concrete meeting special combinations of performance and uniformity requirements that cannot be always achieved routinely by using conventional constituent sand normal mixing. This leads to examine the admixtures to improve the performance of the concrete.

1.1 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

GGBS is a waste product in the manufacture of iron by blast furnace method. The molten slag is lighter and floats on the top of the molten iron. The process of granulating the slag involves cooling the molten slag through high-pressure water jets. This rapid cooling of slag results in formation of granular particles generally not larger than 5 mm in diameter. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has to be rapidly quenched in large volumes of water. The quenching, optimizes the cementitious properties and produces granules similar to a coarse sand. The granulated slag is further processed by drying and then ground to a very fine powder, which is GGBS (ground granulated blast furnace slag). Grinding of the granulated slag is carried out in a rotating ball mill.

GGBS as cement replacement Inclusion of 0% - 40% of GGBS to the mixture was able to increase the compressive strength by 20% as compared to control. Both cement and binder efficiency was also increased 33.3 and 21.3% respectively at age 28 days. However, results showed that 40 % replacement of total binder content by GGBS in the mixes achieved the highest compressive strength in both 7 and 28 days. This was due to the ultra-fines particles allowed better packing of the composite materials and hence densified the interfacial transitions zone. It would then enhance the efficiency of load transfer in the micro structure of hardened concrete. However, further increase of GGBS replacement level adversely affected the compressive strength. The strength was drops. It might be due to the excessive amount of GGBS resulted incompatibility between the

composite materials.

1.2 STEEL FIBRE REINFORCED CONCRETE

Steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking. The net result of all these is to impart to the fibre composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading.

1-2 % of steel fibers to the total volume. the crack preventing effect of steel-fiber to the reinforced concrete is the key to enhance its intensity, stiffness, durability and its usage life. Considerable work has been done on the mechanical properties of fiber reinforced concrete. The effect of addition of steel-fibers on flexural strength ranges from negligible to marginal and sometimes up to 25% has reported. Considerable increase in strain at peak stress and the toughness of the material has been observed.

2. EXPERIMENTAL STUDY

In order to achieve the stated objectives, this study was carried out in few stages. On the initial stage, all the materials and equipments needed must be gathered or checked for availability. Then, the concrete mixes according to the predefined proportions. Concrete samples were tested through concrete tests such as cube test. Finally, the results obtained were analyzed to draw out conclusion.

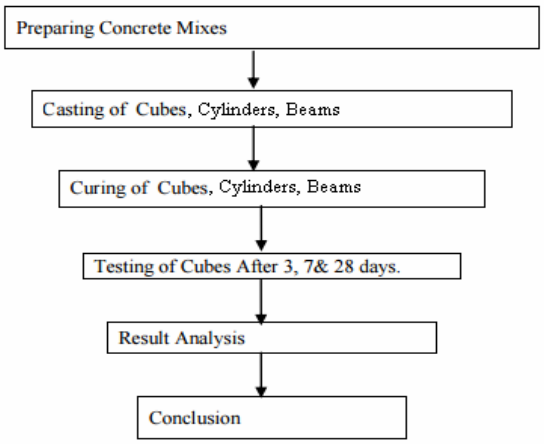

Chart -1: Experimental Procedure Chart

High performance concrete was designed by using Indian Standard method. Trial control mixes for M30 grade concrete with replacement of cement by slag in concrete with different dosages i.e. 20%. In addition of steel fibres with different dosages i.e. 0.5%, 1%, 1.5% respectively. The properties like compressive strength, flexural strength, split tensile strength of concrete using combinations of optimum values of slag and steel fibres are studied.

Fig -1: Steel Fibre Reinforced Concrete Mix

IS code method was used for mix design of M30 grade of concrete. Concrete specimens with various percentages of slag& steel fiber were prepared. The details of various mix proportions for different replacement levels of cement by slag & steel fiber are shown in Table below

Table -1: Mix Proportions for (M30) Grade for GGBS

S N	Slag (%)	W/C Ratio	Mix Proportion (Kg/M^3)				
			Cement	slag	Sand	Agg.	Water
1	0	0.42	380	0	711	1283	160
2	10	0.42	342	38	711	1283	160
3	20	0.42	304	76	711	1283	160

Table -2: Mix Proportions for (M30) Grade for Steel Fibre

S N	S F (%)	W/C Ratio	Mix Proportion (Kg/M^3)				
			Cement	S f	Sand	Agg.	Water
1	0	0.42	380	0	711	1283	160
2	0.5	0.42	378.10	1.9	711	1283	160
3	1.0	0.42	376.20	3.8	711	1283	160
4	1.5	0.42	374.30	5.7	711	1283	160

Tests and Results: A number of tests were carried out to ascertain the design mix properties of concrete in the laboratory. These tests are based on strength as well as durability . The overall performance of any concrete is measured on the basis of mainly two criteria's viz strength and durability of hardened concrete. In case of HPC, strength is major governing factor whereas durability is a measure of performance. In the present work, the strength of the hardened concrete is analysed. The strength criterion includes measurement of following parameters:

- Compressive Strength on cubes
- Flexural Strength
- Split Tensile Strength on Cylinders

Compressive Strength Test: Compressive strength test is carried out on specimen cubes of concrete blended with various percent replacements to cement by GGBS & steel fiber (varying percentages) and conventional concrete at 3, 7 and 28 days of curing with compression testing machine. Optimized Results of Trial Mixes are as shown in tables from the results of trial mix, it is seen that the compressive strength of Concrete for all percentage remains nearly same with replacement of cement by GGBS and S F and found maximum for 20% and 1.5% slag & S F respectively replacement of cement. After testing the concrete (compressive strength) for M30 grade concrete separately for replacement of slag & steel fiber by cement respectively finally combined percentage of slag & steel fiber mix in which maximum strength is obtained was used to get optimized strength.

SN	% Of Slag & Steel Fiber		Compressive Strength (N/mm^2)		
			3 days	7 days	28days
1	0	0	12.07	22.39	34.27
2	20	1.5	14.55	21.00	33.48

Table -3 : Compressive strength of cube for M-30 Grade
(**20 % GGBS & 1.5 % STEEL FIBER**)

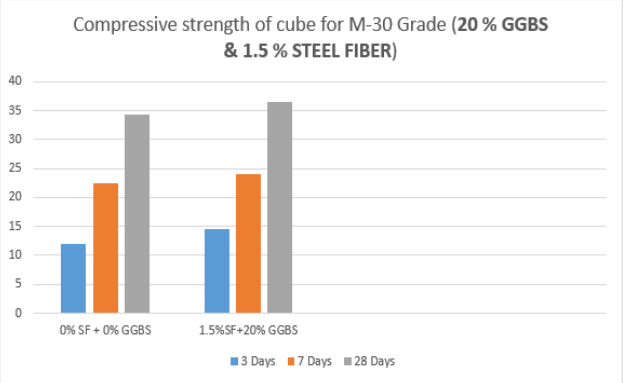

Figure-2: Optimized % of Slag & Steel Fiber for Compressive Strength (M30)

Flexural strength : To find flexural strength of concrete beam, load is applied uniformly on beam. The load was increased until the specimen fails, and maximum load applied to the specimen during the test, was recorded. Table below shows results of flexural strength test.

SN	% Of Slag & Steel Fiber		Flexural Strength (N/mm^2) 28days
1	0	0	6.07
2	20	1.5	7.61

Table -4 : Flexural strength of specimen for M-30 Grade (**20 % GGBS & 1.5 % STEEL FIBER**)

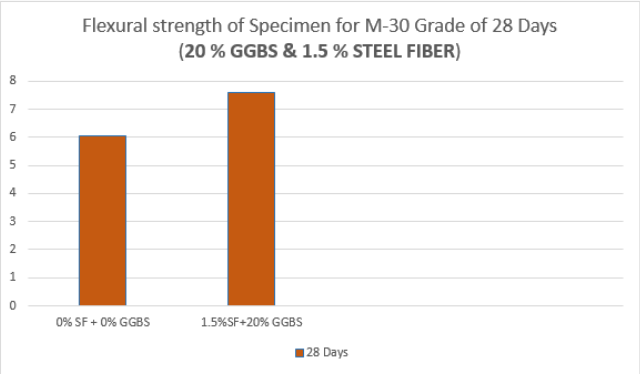

Figure-3: Optimized % of Slag & Steel Fiber for Flexural Strength (M30)

Cylinder split tensile strength test By conducting split tensile strength on cylinder following results were obtained which is given in table. After testing the concrete (split tensile strength) for M30 grade concrete for replacement of slag & steel fiber by cement respectively finally combined percentage of slag & steel fiber mix in which maximum strength is obtained was used to get optimized strength

SN	% Of Slag & Steel Fiber		Tensile Strength (N/mm^2) 28days
1	0	0	3.32
2	20	1.5	5.27

Table -5 : Split Tensile strength of cylinder for M-30 Grade (**20 % GGBS & 1.5 % STEEL FIBER**)

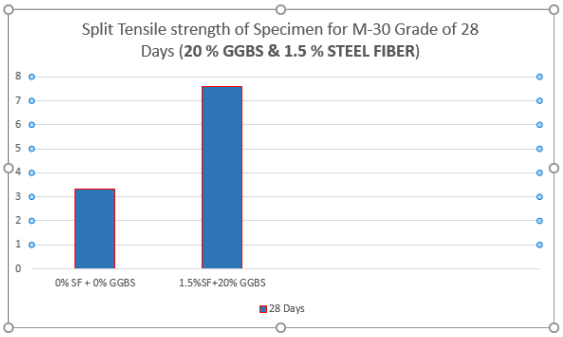

Figure-4: Optimized % of Slag & Steel Fiber for Split Tensile Strength (M30)

3. CONCLUSIONS

- The optimum dosage for partial replacement of cement by ground granulated blast furnace slag is 20%
- The optimum dosage for addition of steel fibred is 1.5%
- For partial replacement of cement with GGBS (20%) + Steel fiber (1.5%) fiber reinforced concrete got maximum strength as compared to conventional concrete, the strength development of the concrete is increases slightly as its age increases. This can be clearly shown in above figures
- The rate of gain of compressive strength of GGBS concrete is slow in the initial Stage i.e. up to 14 days & as the curing period increases strength also increases.
- Test results reveal that higher fiber content has brought about increased compressive strength, flexural strength, abrasion resistance, and fiber crack-control effect. Hence the addition of steel fiber within FRC is more helpful for increase in strength.

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