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Influence of Addition of GGBS on Strength Properties of M30 Grade of Concrete

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***Abstract*-- The Ordinary Portland cement is most widely used material in the production of concrete. Construction industry consumes a vast volume of cement every year. There is no alternative material used in construction industry. However, the manufacture and consumption of cement causes pollution to the environment due to the emissions of large amount of Carbon dioxide gas in the environment and reduction of raw material (limestone). Use of GGBFS (Ground Granulated Blast Furnace Slag) as cement replacement will simultaneously reduce cost of concrete and help to reduce rate of cement consumption. In this research we present found on to investigate the strength properties of GGBFS. The partial replacement of GGBFS with cement is performed in this experiment. GGBFS is the waste product attained from steel manufacturing industry is formed by the partition of molten steel from impurities. M30 grade of concrete is used in this experiment and 10% to 40% of GGBFS was used as a cement replacement. The specimens for testing were prepared, the cube, cylinders are cured for 7& 28 days. All the properties were determined by performing different tests like split tensile strength, flexural strength and compressive strength and. The cement are substituted by GGBFS by 20%, 30%, 40% and then compared with that of cement and the ideal percentage of GGBFS is obtained. At last, workability, setting time, compressive strength is investigated. The maximum strength for the concrete specimen is obtained when 30% of GGBFS is replaced with cement.**

***Keywords*-- M-30 Grade of concrete, GGBFS, Workability, Split tensile strength, Flexural strength and Compressive strength**

I. INTRODUCTION

Concrete made with cement was commonly used material for construction purpose. In development of cement, bulk amount of CO2 is emitted into the atmosphere, causes environmental pollution. Concrete is a moderately fragile material. Expansion of strands to substantial makes it a more pliable material. Plain concrete cement has a few weaknesses like low elastic, restricted pliability, little protection from breaking, high fragility helpless sturdiness.

Exploratory examinations have shown that strands improve the mechanical properties of cement, for example, flexural strength, compressive strength, rigidity, creep conduct and sway opposition and sturdiness. Among them, polymer filaments and the steel strands appreciate prevalence in the area of cement. Clearly the conduct of HFRC relies upon the viewpoint proportions, directions, mathematical shapes, circulations and mechanical properties of strands in substantial blends form a fragile to more flexible material. In terms of per capita consumption, it is only next to water. The most enormous individual material element in the built environment is concrete. Concrete is a composite product obtained artificially by hardening of mixture of cement, sand Gravel and water in pre-determined proportions. When these ingredients are mixed, they form a plastic mass that can be moulded in the desired shape. It gets hardened into hard solid mass. Water is one of the important ingredients of concrete. This is required not only for chemical reaction, but also for curing purposes. The chemical reaction of cement and water, in the mix is relatively slow and requires time and farourable temperature for its completion.

GGBS (Ground Granulated Blast Furnace Slag)

GGBS comprises mainly of calcium oxide, silicon di-oxide, aluminum oxide, magnesium oxide. It has the same chief chemical elements as ordinary Portland cement but in different proportions and the addition of GGBS in geopolymer concrete (GPC) increases the strength of the concrete and also curing of Geo-Polymer concrete at room temperature is possible. GGBS was purchased from Laxmi steel Industries Jabalpur.

Table no. 1
physical properties of GGBS

Properties	Unit	Results	National Code GB/T-18046
Density	g/cm^3	2.940	≥2.80
Specific surface area	m^2/kg	455.000	400.00–500.00
Mass loss on ignition	%	0.600	≤3.00
MgO percentage	%	9.910	≤14.00
SO_3 percentage	%	1.825	≤4.00
Cl^{-1} percentage	%	0.012	≤0.06
Water percentage	%	0.010	≤1.00
Activity index (7 days)	%	90.000	≥75.00
Activity index (28 days)	%	98.000	≥95.00

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Table no. 2
Chemical properties of GGBS

Chemical Properties	Values
CaO	42%
SiO_2	31%
S	0.40%
SO_3	2.40%
MgO	5.70%
Al_2O_3	12.70%
FeO	0.80%
MnO	0.10%
Cl	0.01%
Insoluble Residue Content	0.20%

II. Objectives

Following are objectives of the study.

1. To find out the effect of Ground-granulated blast-furnace slag (GGBS or GGBFS) on strength when mixed with concrete sample. To study the workability of concrete on variation in different percentage of steel slag when mixed with concrete.
2. To find out the change in slump value.
3. To perform the sieve analysis and specific gravity of aggregate used Reduce the maintenance cost.
4. Increase the economy of the construction with using the cheaper material as a replacement of the cement.
5. To increase the service life.

III. Problem Statement

In this work an attempt has been made to use ground granulated blast furnace slag (GGBS) as supplementary binding material for cement. The fundamental goal is to research the adjustment of qualities strength properties of cement at various levels. Following destinations are observed-

1. Cement in concrete gets integrated in presence of alkalies, sulfates which lead to expansion, cracking, strength loss and disintegrated of cement.
2. GGBS concrete generally better resistance compare to ordinary Portland cement concrete to resist sulfate attack and alkalies aggregate reaction.
3. Concrete has tensile strength. GGBFS increases the tensile strength of concrete.
4. To increase the service life.

IV. Proposed Methodology

In this experiment the take a look at of usage of GGBFS in concrete in area of cement is performed.

- First of all, cement and river sand become collected and the take a look at are performed for physical properties like gradation, specific gravity, fineness, and many others. GGBFS become amassed from Laxmi metallic manufacturing facility Jabalpur.
- The water contents must be taken into consideration because they are distinct in special samples. Then blend turned into designed for M30 concrete. Sparkling concrete houses had been determined by means of mixing concrete.
- The waste product GGBFS at the proportions of zero%, 20%, 30% ,40% become partially replaced for cement for the curing length of 7 and 28 days.

The performance of concrete in which the cements are changed by means of GGBFS by means of 20%, 30% ,40% eighty%, are as compared to that of predictable concrete and the maximum favorable percent of GGBS is observed.

V. Experimental Work

Aggregates

The aggregates are the key constituents of the concrete which greatly varies the strength, density and other properties of the concrete. Local aggregates, comprising 20 mm and 10mm coarse aggregates and fine aggregates, in saturated surface dry state, were used. The coarse aggregates were crushed granite-type aggregates and the fine aggregate was fine sand. Different types of aggregates have obtained locally for experimental work is discussed below.

1. Fine aggregate

Narmada coarser sand is used as fine aggregate in experimental work. It is obtained from local supplier in Jabalpur. Specific gravity of sand is obtained by pycnometer test. Sieve analysis has performed to find the fineness modulus of sand. The physical properties and sieve analysis of fine aggregate has been shown in table 03.

Table no. 3
Physical properties of fine aggregate

S. No.	Characteristics	Result
1	Aggregate type	Natural (Sand)
2	Specific gravity	2.69
3	Fineness modulus	2.78
4	Water Absorption	0.81

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2. Coarse aggregates

In this study, coarse aggregates of size 10 mm and 20 mm conforming to specifications as given in IS: 383- 1970 is used. Pycnometer test is carried out to find the specific gravity of aggregates. Sieve analysis has been done to find the fineness modulus of aggregate. The physical properties and sieve analysis result of the coarse aggregate have been displayed in table 04 and 05.

Total weight taken for sieve analysis = 10 kg

Fineness modulus = ∑C/1OO

Where ∑C is cumulative weight retained

Table no. 4
Physical properties of 20 mm coarse aggregate

S. No.	Characteristics	Result
1	Aggregate type	Crushed Stone
2	Maximum size of aggregate	20 mm
3	Specific gravity	2.71
4	Fineness modulus	2.92

Table no. 5
Physical properties of 10 mm coarse aggregate

S. No.	Characteristics	Result
1	Aggregate type	Crushed Stone
2	Maximum size of aggregate	10 mm
3	Specific gravity	2.65
4	Fineness modulus	2.97

3. Compressive Strength Test (IS: 516-1959)

The compressive strength test was conducted as per IS: 516-1959. The concrete specimens were tested for compressive strength after 7, 28 days of direct sun light curing. This test was performed on cube of standard size 150 mm x l50 mm x 150 mm. the compressive strength of any mix was taken as average of strength of three samples. All the specimens were tested using a compression testing machine (CTM) of 2000 KN capacity equipped with a monitor to display the results. The failure load and corresponding compressive stress value was read from the screen and noted down.

Out of many tests applied to the concrete, this is the outmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. For cube test two types of specimens either cubes of 15cm x 15cm x 15cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

Table no. 6
Compressive strength at 7 days and 28 days
For different percentages of GGBS

Design Mix	Percentage replaced	compressive strength for cube(N/mm^2) at 7 days	compressive strength for cube(N/mm^2) at 28 days
M-1	0	24.50	38.10
M-2	20	24.20	36.50
M-3	30	25.15	39.65
M-4	40	23.95	34.35

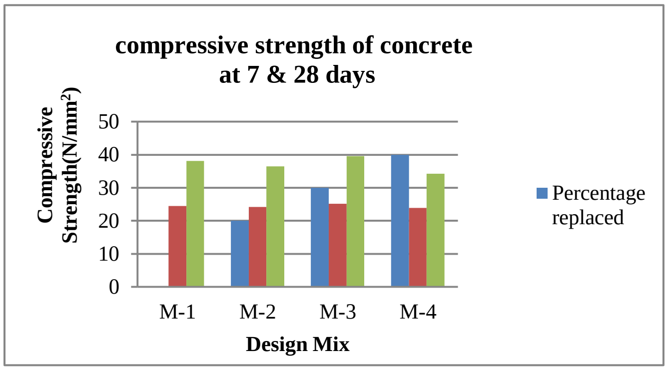

Fig 6.10 compressive strength of concrete at 7 & 28 days

Fig 6.11 compressive strength of concrete at 7 days

Split Tensile Strength Test (IS: 516-1959)

This test is used to determine the tensile strength of concrete. This is indirect method to finding the tensile strength of concrete.

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In this test lined compressive force is applied to the specimen in such way that specimen fails due to tensile stress develop inside the specimen. To find split tensile strength of GGBS concrete after curing age of 7 and 28 days, cylinders of standard size 150 mm diameter and 300 mm length were casted. All the test GPC samples were tested using a compression testing machine (CTM) of 2000 K.N capacity equipped with a monitor to display the results.

Table no. 7.
12 days and 28 days split tensile strength

Design Mix	Percentage replaced	Spilt tensile strength (N/mm2) At 7 days	Spilt tensile strength (N/mm2) At 28 days
M-1	0	3.52	4.52
M-2	20	3.4	4.49
M-3	30	3.57	4.61
M-4	40	3.35	4.42

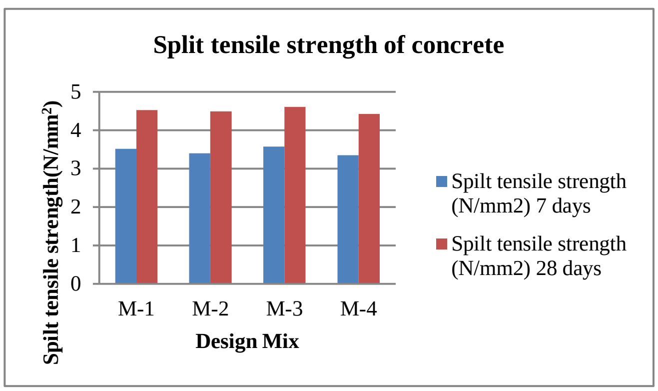

Fig 6.17; 7 & 28 days split tensile strength of concrete

Flexural Strength Test (IS: 516 -1959)

Flexural strength test is carried out to find the flexural strength of specimen. For this test beam of size 100mm x l00mm x 500mm is to be casted. In this study beam samples of size l00 mm x l00 mm x 100 mm were casted and cured in direct sun light for 7,and 28 days. All these specimens were tested by using a hydraulic machine.

Table no. 8
days and 28 days' Flexural strength

Design Mix	Percentage replaced	Flexural strength (N/mm^2) 7 days	Flexural strength (N/mm^2) 28 days
M-1	0	4.55	5.65
M-2	20	3.75	4.95
M-3	30	4.85	6.75
M-4	40	3.65	4.55

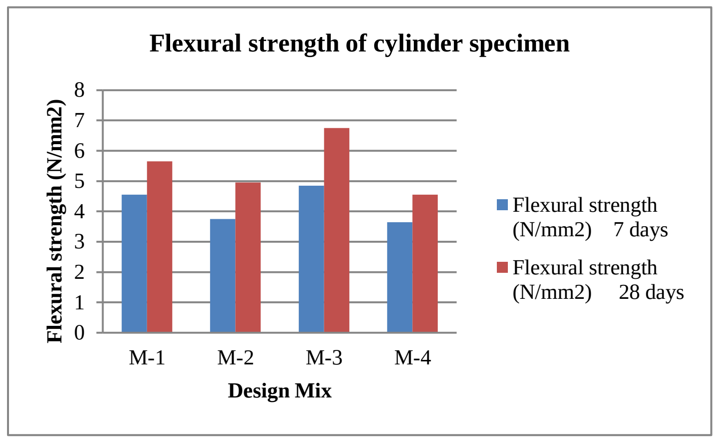

Fig 6. 21 7 & 28 days flexural strength of concrete

VI. Results And Discussions

No major difficulty in handling the concrete which incorporated GGBS was encountered except at 30% or higher replacement percentages.

There were no major changes in the fresh or hardened properties of concrete with GGBS. The size and grading of steel slag aggregates were similar to natural limestone aggregates.

The shapes of the steel slag aggregates were more or less angular in nature, which made the concrete mixture workable.

The reason for failing of concrete samples with 100% steel slag aggregates might be due to presence of excessive entrapped air and less entrained air in the mixture during the mixing of concrete.

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During the research, it was found that, as the percentage of steel slag aggregates in concrete increased, the mixture became stiffer and more water was required to make the concrete more workable.

Table no. 9
RESULT of mix design concrete with using GGBS

Characteristics Strength	Percentage Replaced By GGBS	Strength Before Replacement (M-1)		Strength After Replacement		Percentage Increased	
		At 7 Days	At 14 Days	At 7 Days	At 28 Days	At 7 Days	At 28 Days
Compressive Strength (N/mm²)	(M-3) 30	24.5	38.1	25.15	39.6	0.65	1.50
Split Tensile Strength (N/mm²)	(M-3) 30	3.52	4.52	3.57	4.61	0.05	0.09
Flexural Strength (N/mm²)	(M-3) 30	4.55	5.65	4.85	6.75	0.30	1.10

VII. CONCLUSION

The following conclusions can be drawn from the experimental investigations conducted on the behavior of concretes with GGBS as partial replacements for cement.

- As GGBS is partially replaced with the cement, the consumption of the cement is reduced and also the cost of construction is reduced.
- Thus the workability is improved by the partial replacement of the GGBS with cement.
- The use of GGBS as a replacement of cement helps to reduce the Energy consumption in the manufacturing of cement.
- We find that there is increase in the strength of concrete that compressive strength is 25.15 N/mm^2, Split tensile strength is 3.57 N/mm^2 and Flexural strength is 4.85 N/mm2 at 7 Days.
- We find that there is increase in the strength of concrete that compressive strength is 39.60 N/mm^2, Split tensile strength is 4.61 N/mm^2 and Flexural strength is 6.75 N/mm2 at 28 Days.
- We get the maximum strength at 30% replacement of cement by GGBS.

VIII. FUTURE SCOPE

The following recommendations for future work are suggested to study the behavior of GGBS concrete.

1. Performance under marine and acidic environment for GGBS concrete
2. Performance under temperature effect for same GGBS concrete.
3. Performance under creep and shrinkage of GGBS concrete

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