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Performance of concrete by partial replacement of cement by silica fume and fine aggregate by ground Granulated blast furnace slag

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Abstract: The Average of River sand for construction has various undesirable and ecological consequences. As a solution for this industrial waste such as Ground Granulated Blast Furnace Slag (GGBS) can be used to replace partially by sand and cement by Silica fume. This research aims to investigate possibility of replacing GGBS as a sand substitute in concrete. In this investigation, natural sand was replaced by GGBS in various percentage (10%, 20%, 30%, 40% and 50%), with water cement ratio of 0.4 and cement was partially replaced by 15% Silica Fume. Material Tests were done for fine aggregate and GGBS sample. Different mix proportions for different percentage replacement of fine aggregate was obtain for M30 grade of concrete as per IS 10262:1982. The Compressive strength test, split Tensile strength test, Flexural strength test and Non-destructive Test (NDT) were done for concrete with various % of GGBS and constant % of Silica Fume in concrete.

Key Words: Ground Granulated Furnace Slag, Silica Fume, NDT, concrete strength

I. INTRODUCTION

Concrete is typically the most massive individual material element in the built environment. If the embodied energy of concrete can be reduced without decreasing the performance or increasing the cost, significant

environmental and economic benefits may be realized. Concrete is primarily comprised of Portland cement, aggregates, and water. Although Portland cement typically comprises only 12% of the concrete mass, it accounts for approximately 93% of the strength necessary for the design of the structures. Some of the recent studies in various parts of the world have revealed that Ground granulated blast furnace slag concrete can protect the steel reinforcement most efficiently, so that it can resist corrosion, and thus the structure as a whole. In this project concrete is a type of concrete in which a part of the cement is replaced Silica fume and sand replaced by ground granulated blast furnace slag, which is an industrial waste. Thus the implementation of GGBS concrete can minimize corrosion in an effective way. Moreover it can lead to much durable structure without considerable increase in cost.

Ground granulated blast furnace slag from modern thermal power plants generally does not require processing prior to being incorporated into concrete and is therefore considered to be an environmentally free input material. When used in concrete,

ground granulated blast furnace slag is a cementations ‘material that can act as a partial 2 Replacement for sand without significantly compromising the compressive strength. In the present work an attempt has been made to study the suitability of Silica Fume by Cement. Its effect on the properties concrete. Concrete mixes were made using Ordinary Portland cement with 15% replacing of Silica Fume and River sand by GGBS(Ground Granulated Blast Furnace Slag) with 10%,20%,30%,40% and 50%. The physical properties and mechanical strength of concrete were measured.

Literature Review

Kasu naveena, et.al., ***International Conference On Science, Technology, Engineering And Management, Guntur, India,***

ABSTRACT

Due to exponential growing in urbanization and industrialization, by product from industries is becoming an increasing concern for recycling and waste management. Ground granulated blast furnace slag (GGBS) is by product from blast furnace of iron and steel industries. GGBS is very useful in design and development of high quality cement paste. It effects on strength and durability properties. Concrete occupies unique position among the modern construction materials & is widely used in all types of constructions. It consists of a hard, chemically inert particulate substance. Due to increase in demand of concrete more &more new methods &materials are being developed. This paper presents the use of ground granulated blast furnace slag (GGBS) on strength development of concrete and the use of GGBS and mineral admixture metakaolin. Experimental investigation conducted by complete replacement of slag with cement and partial replacement of slag and mineral admixtures by weight in the form of 3cubes by using M30 grade. Results of GGBS with concrete are compared with the results of partial replacement of GGBS and mineral admixtures. A total of cubes were cast and compressive strength of the concrete specimens were determined at curing age of 3, 7, 28 days. Test results show that strength increases with the increase of slag up to optimum value and also the strength increases by adding of mineral admixture metakaolin. The study of workability of concrete with GGBS as a replacement material with and without adding of mineral admixture.

D. Suresh, et.al., IOSR Journal of Mechanical Issue 4 Ver. VI (Jul. - Aug. 2015), PP 76-82

ABSTRACT

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc. leading to utilization of large quantity of concrete. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production. This requirement is drawn the attention of investigators to explore new replacements of ingredients of concrete. The present technical report focuses on investigating characteristics of concrete with partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS). The topic deals with the usage of GGBS and advantages as well as disadvantages in using it in concrete. This usage of GGBS serves as replacement to already depleting conventional building materials and the recent years and also as being a by product it serves as an Eco Friendly way of utilizing the product without dumping it on ground

Er. Kimmi Garg, et,al., International Journal of Engineering Research And Management

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II. MATERIAL PROPERTIES

2.1 Cement

Cement is a binding material in concrete which binds the other material to forms a compact mass. In this project work, OPC 53 grade cement is used for experimental study.

Table 2.1 Properties of Cement

Fineness value	8.5
Consistency	29.5%
Initial setting time	32min
Specific gravity	3.17

2.2 Water

Water conforming to the requirements of IS 456-2000 is found be satisfactory for making concrete. In the present investigation, portable drinking water available in the industrial company was used for mixing and curing the paver block.

2.3 Coarse Aggregate

Locally available crushed stone aggregates of nominal size 10mm.wherever possible size of aggregate 10mm used in the project.

Table 2.2 Properties of Coarse Aggregate

Description of test	Test result obtained	Permissible limits as per IS:383-1970
Specific gravity	2.71	Minimum 2.5
Fineness modulus	7.86	
Unit weight (kg/m^3)	1603	

2.4 Fine Aggregate

A concrete with better quality can be made with sand consisting of rounded grains rather than angular grains. River or pit sand must be used but not used sea sand as it contains salt and other impurities. In this study, river sand has been used as fine aggregate.

Table 2.3 Properties of Fine Aggregate

Description of test	Test result obtained	Permissible limits as per IS 383:1970
Specific gravity	2.63	Minimum 2.5
Fineness modulus	3.06	
Unit weight of sand (kg/m^3)	1687	

2.6 Slump Test

This is a test extensively used in construction site. It is very useful in detecting the variation in the uniformity of mix of given nominal proportion. It also give an idea of water cement ratio need for concrete to be used for different works.

III. MIX PROPORTION

In this study, control mix was designed as per IS 10262:2009 for M_{25} grade. GGBS is replaced by river sand by 10%, 20%, 30%, 40%,50% also cement is replaced by 15% Silica Fume by weight of concrete. The details of the mix proportions of concrete were given in following table 3.1.

Mix Proportion : 1:0.5: 1

Table 3.1Mix Design

Title	Specification
Grade of Concrete	M30
Type and Grade of Cement	OPC 53 Grade
Size of Coarse Aggregate	10mm & 20mm
Specific Gravity of Coarse Aggregate	2.66
Specific Gravity of Fine Aggregate	2.63
W/C Ratio	0.5

Table 3.2 Mix Proportion Details

Materials	**cement kg**	**Silica fume kg**	**% of GGBS**	**Fine aggregate**	**Coarse aggregate**	**Water Lit**
				kg		
Cc	12	-	-	25	40	5
M1	12	15	10, 20, 30, 40, 50	25	40	5

IV. EXPERIMENTAL METHODOLOGY

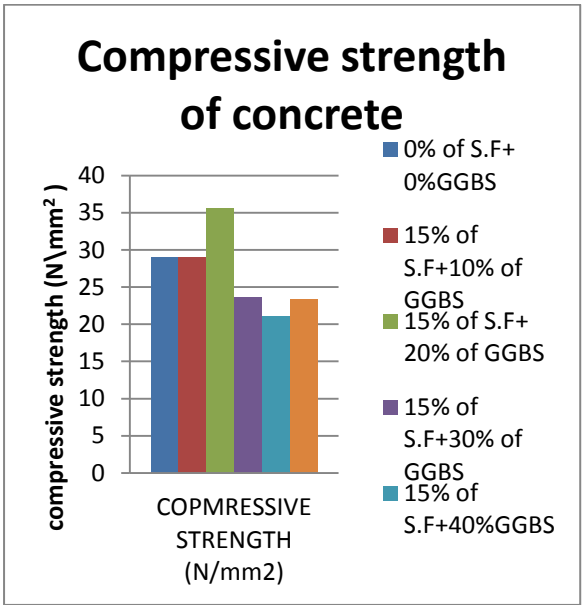
4.1 Compressive strength test

Fig 4.1 Compressive strength test

Table 4.1 Compressive Strength Test

Mix	At 28 Days (N/mm^2)
M conventional	29
M1 (15% of SM 10% of GGBS)	29
M2(15% of SM 30% of GGBS)	35.56
M3(15% of SM 30% of GGBS)	23.55
M4(15% of SM 40% of GGBS)	21
M5(15% of SM 50% of GGBS)	23.32

Fig 4.2 Compressive Strength Test



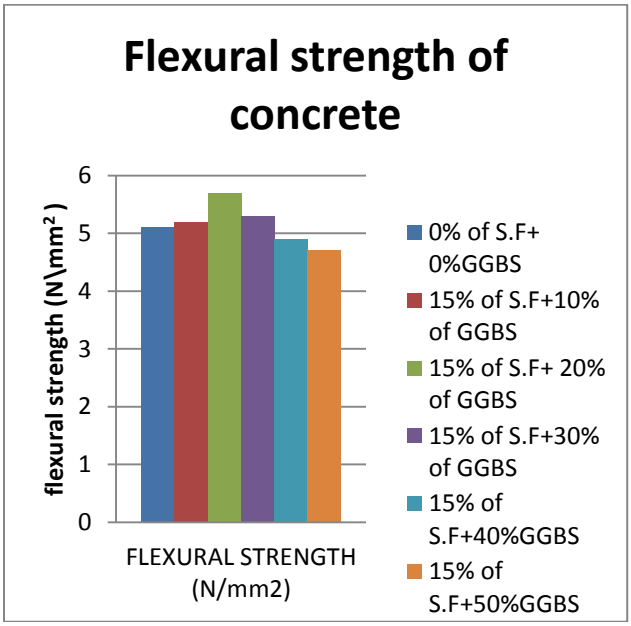


Table 4.1 split tensile test

Mix	At 28 Days (N/mm²)
M conventional	29
M1 (15% of SM 10% of GGBS)	29
M2(15% of SM 30% of GGBS)	35.56
M3(15% of SM 30% of GGBS)	23.55
M4(15% of SM 40% of GGBS)	21
M5(15% of SM 50% of GGBS)	23.32

Table 4.3 flexural test

Mix	At 28 Days (N/mm²)
M conventional	29
M1 (15% of SM 10% of GGBS)	29
M2(15% of SM 30% of GGBS)	35.56
M3(15% of SM 30% of GGBS)	23.55
M4(15% of SM 40% of GGBS)	21
M5(15% of SM 50% of GGBS)	23.32

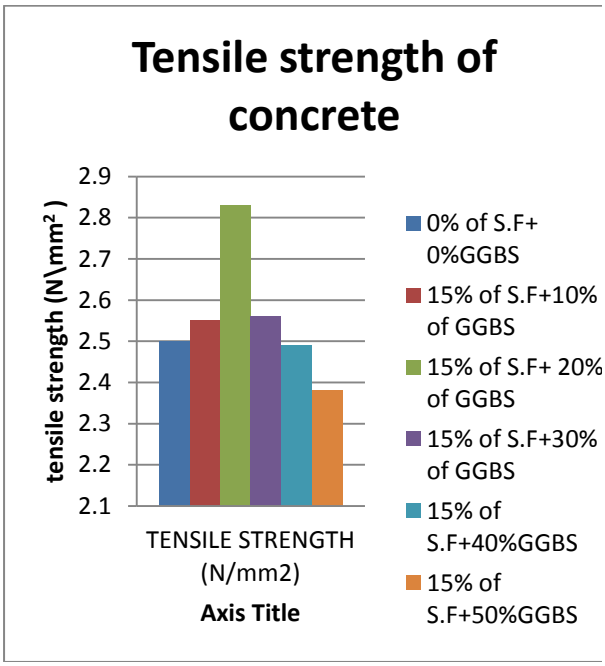
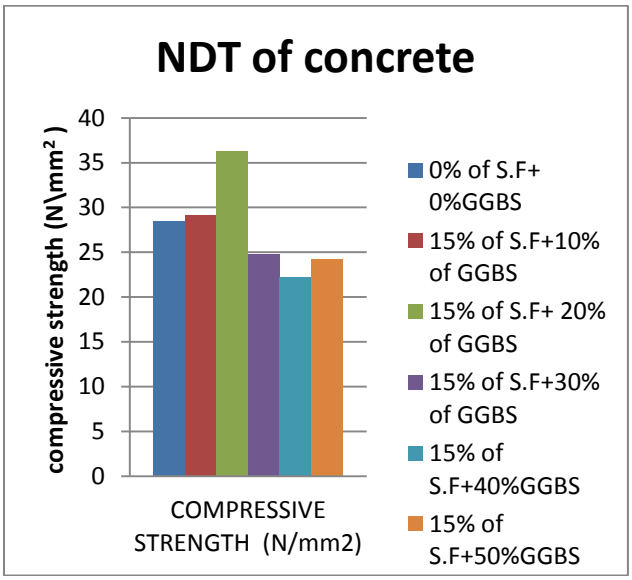


Table 4.2 NDT Test

Mix	At 28 Days %
M conventional	**28.5**
M1(15% of SM 10% of GGBS)	**29.2**
M2(15% of SM 20% of GGBS)	**36.3**
M3(15% of SM 30% of GGBS)	**24.8**
M4(15% of SM 40% of GGBS)	**22.2**
M5(15% of SM 50% of GGBS)	**24.2**

Fig 4.3 NDT Test



V. RESULTS & DISCUSSION

From the designed mix proportions of M30 grade of concrete the desired characteristic compressive strengths for cubes are achieved in conventional concrete, GGBS (Ground Granulated Furnace slag) and Silica Fume.

The strengths achieved in concrete made with percentage use of GGBS (Ground Granulated Furnace slag) and Silica Fume achieved high strengths when compared with cement.

Super plasticizer is used to attain workability.

At 28 days curing, the 20% replacement of Fine Aggregate and cement with GGBS (Ground Granulated Furnace slag) and Silica Fume gave very high strength.

From the above experimental results, it is proved that GGBS can be used as an alternative material for River Sand and Silica Fume as an alternative material for Cement, reducing cement consumption and reducing the cost of construction. Use of industrial waste products saves the

environment and conserves natural resource

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