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EXPERIMENTAL INVESTIGATION ON INTEGRAL WATER PROOFING CONCRETE BY PARTIAL REPLACEMENT OF GGBS

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Abstract - The production of cement results in emission of many green house gases in atmosphere , which are responsible for global warming. Hence the results are currently focussed 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 GGBS is a waste product from the iron manufacturing industry , which may be used as a 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 GGBS in different proportions varying from 0%,15%,30% & 45% in M30 grade of concrete. It is observed from the investigation that the strength of concrete is inversely proportional to the % of replacement of cement with GGBS. And in addition crystalline waterproofing agent is added to the ratio of 125ml for 50kg cement bag , it gives better strength.

Key Words: Ground Granulated Blast Furnace Slag (ggbS), Compressive Strength, Split Tensile Strength, Waterproofing compound

1. INTRODUCTION

Concrete is the first choice for construction in many countries today. This has led to the fast vanishing of natural resources. The emission of CO₂ into the atmosphere from the production of cement, deterioration, poor performance, and inadequate resistance to hostile environment of many concrete structures has led to the continuous research on concrete. On the other hand, cost of concrete is attributed to the cost of its ingredients which are becoming increasingly scarce and expensive. This has led to recycling of industrial wastes and By-products that help reduce the cost of waste treatment prior to disposal and eventually in preserving the natural resources and energy. This requirement has drawn the attention of researchers to explore and experiment with various alternative materials as ingredients for concrete which are sustainable. Blast furnance slag is a solid waste discharged in large quantities by the iron and steel industry in India. The re-cycling of these slag's will become an important measure for the environmental protection. Iron and steel are basic materials that underpin modern civilization, and due to many years of research the slag that is generated as a by-product in iron and steel production is now in use

as a material in its own right in various sectors. The primary constituents of slag are lime (CaO) and silica (SiO₂). Portland cement also contains these constituents. The primary constituent of slag is soluble in water and exhibits an alkalinity like that of cement or concrete. Ground Granulated Blast furnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of “Granulated slag”. Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. If slag is properly processed then it develops hydraulic property and it can effectively be used as a pozzolanic material. And also use integral waterproofing compounds in concrete. There are two ways for water to penetrate through the concrete. When concrete is under hydrostatic pressure on one surface, water passes through the channels formed by the interconnecting cracks and voids to the other surface. The other way for the passage of moisture through the concrete from the wet side to the dry side is by capillary action. Water proofing admixtures can be use to improve the pore structure of concrete and hence to reduce the water permeability of concrete. An integral waterproofing admixture is a combination of admixtures that have the ability of producing concrete with reduced permeability.



Fig.1 Integral water proofing concrete block with partial replacement of ggbs

II. EXPERIMENT

2.1 Materials Used: Material used in the present study as follows were cement(OPC), expanded polystyrene, fine aggregate (river sand passing through 4.75mm), coarse aggregate (well graded), and Water.

2.1.1 Cement: Ordinary Portland Cement of super grade confirming to IS 12269:2013.

2.1.2 GGBS: Fine powder GGBS conforming to IS 455

2.1.3 Fine Aggregate: Locally available river sand confirming to Grading zone II of IS 383 – 1970.

2.1.4 Coarse Aggregate: Locally available quarry stone in good strength conforming to IS 383 - 1970.

2.1.5 Water: Portable water free from acidity and alkalinity.

III. LITERATURE REVIEW

3.1 Usman Hasan Jalali, Sher Afgan (2018) “Analysis of Integral Crystalline Waterproofing Technology for Concrete”

In today’s modern competitive design and construction environment where benchmarks such as durable concrete and value engineering are required to be met, the effective use of crystalline waterproofing technology can provide the high performance advantages and benefits that design and construction professionals have come to rely upon in design and construction projects. As compared to the standard waterproofing systems which possess many disadvantages, the crystalline

waterproofing system ensures a denser concrete and chemical resistance by becoming a part of concrete. Thus crystalline systems prove to be highly beneficial for waterproofing structures which will be in contact with water during its life time.

3.2 Chalamcharla Venu, Gopal Suresh, V. Gokul Nath (2017) “partial replacement of cement with ggbs in concrete”

Durability and service life are improved by preparing High-Performance Concrete. With the addition of 40% of GGBS as a replacement of Cement for an M25 grade of concrete, there is an increase in the strength compared to the normal concrete. After casting the molded specimens are stored in the laboratory at a room temperature for 24 hours. After this period the specimens are removed from the molds and immediately submerged in clean, fresh water of curing water tank. The specimens are cured for 28 days in present investigation work 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.

3.3 Lakshmaiah Chowdary , Khaja Khutubuddin , Vinayaka (2017) “An Experimental Study on Cement Replacement by GGBS in Concrete”

Foremost objective of this study is thus realization of sound technology providing significant economic benefits. Additionally, sustainability is promotion. The usage of GGBS in concrete is highly improves the strength, the results carried out the strength in 28 days. GGBS mix reduces the workability. From the above results, it can be concluded that GGBS can be effectively used in concrete. The inclusion of GGBS has desirable effect on concrete mechanical properties which is comparable to normal concrete. The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The usage of GGBS in concrete as cement replacement materials will lessen the CO₂ is being emitted during its manufacture and acts as an eco-friendly material reducing the Greenhouse effect. Incorporation of these types of mineral admixtures in cement helps in making it more economical.

3.4 Sridevi, Madhusudhan , Manikumar Reddy (2016) “Studies on Strength Properties of Concrete with Partial Replacement of Cement by GGBS”

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 follow 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

IV. MIX DESIGN

4.1 MIX PROPORTION

Cement	= 270 Kg/m ³
Water	= 140L/m ³
Fine aggregate	= 839.7 kg
Coarse aggregate	= 1126.25 kg
GGBS	= 115 kg/m ³
Water proofing agent	= 1.155 L/m ³

4.2 MIX RATIO

Cement : fine aggregate : coarse aggregate : ggbs
270 / 270 : 839.7 / 270 : 1126.25 / 270 : 115 / 270
1 : 3.11 : 4.17 : 0.43

V. TESTING ON MATERIALS

5.1 SPECIFIC GRAVITY TEST



Fig.2 Pycnometer Apparatus

5.1.1 SPECIFIC GRAVITY OF CEMENT

Table.1 Specific gravity of cement

Content	Weight in grams
Weight of empty pycnometer (W1)	664
Weight of pycnometer + cement (W2)	761
Weight of pycnometer + cement + water (W3)	1455
Weight of pycnometer + water (W4)	1389

Specific gravity of Cement (G)

$$= \frac{(W2-W1)}{(W2-W1)-(W3-W4)} = \frac{(761-664)}{(761-664)-(1455-1389)}$$

$$= 3.1$$

5.1.2 SPECIFIC GRAVITY OF FINE AGGREGATE

Table.2 Specific gravity of Fine aggregate

Content	Weight in grams
Weight of pycnometer (W1)	680
Weight of pycnometer + fine aggregate (W2)	881
Weight of pycnometer + fine aggregate + water (W3)	1635
Weight of pycnometer +water (W4)	1511

Specific gravity of Fine aggregate (G)

$$= \frac{(W2-W1)}{(W2-W1)-(W3-W4)} = \frac{(881-680)}{(881-680)-(1635-1511)}$$

$$= 2.61$$

5.1.3 SPECIFIC GRAVITY OF COARSE AGGREGATE

Table.3 Specific gravity of Coarse aggregate

Content	Weight in grams
Weight of empty pycnometer (W1)	680
Weight of pycnometer + coarse aggregate (W2)	1039
Weight of pycnometer + coarse aggregate + water (W3)	1736
Weight of pycnometer +water (W4)	1510

Specific gravity of Coarse aggregate (G)

$$= \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)} = \frac{(1039 - 680)}{(1039 - 680) - (1736 - 1510)} = 2.7$$

5.2 SIEVE ANALYSIS TEST



Fig.3 Sieve Analysis

5.2.1 SIEVE ANALYSIS OF FINE AGGREGATE

Table.4 Sieve analysis of Fine aggregate

Weight of sample taken is 1000g

IS sieve size	Weight retained in grams			Cumulative weight retained W4	Cumulative % retained W5 = $\frac{W_4 \times 100}{1000}$	% finer 100- W5
	Empty weight of sieve W1	Retained weight of sieve W2	Retained weight of sand W3			
4.75 mm	375	440	65	65	6.5	93.5
2.36 mm	344	414	70	135	13.5	86.5
1.18 mm	363	453	90	225	22.5	77.5
1 mm	348	448	100	325	32.5	67.5
600μ	301	321	20	345	34.5	65.5
300μ	300	600	300	645	64.5	35.5
150μ	307	582	275	920	92.0	8
Pan	303	383	80	1000	100	0

Total cumulative % retained = 266

Fineness modulus = 266/100 = 2.66

5.2.2 SIEVE ANALYSIS OF COARSE AGGREGATE (20 mm)

Table.5 Sieve analysis of coarse aggregate

Weight of sample taken is 3000g

IS-Sieve (mm)	Wt. Retained (gm)	%age retained	%age passing	Cumulative % retained
80	0.00	0.00	100.00	0.00
40	12.5	0.41	99.59	0.41
20	63.0	2.1	97.9	2.51
10	2756	91.87	8.13	94.38
4.75	126.5	4.21	95.8	98.59
Pan	0	0	0	0

Total cumulative % retained = 195.89+500=695.89

Fineness modulus = 695.89/100 = 6.96

5.3 COMPRESSIVE STRENGTH OF CONVENTIONAL AND GGBS CONCRETE

Size of the cube = 15cm*15cm*15cm

Area of the specimen (Calculated from the mean size of the specimen) = 225cm²

Expected maximum load = $f_{ck} \cdot \text{area} \cdot f_s$

Table.6 Compressive strengths of Conventional and GGBS Concrete

%OF REPLACEMENT OF GGBS	CURING PERIOD		
	3days	14days	28days
UNIT	Mpa	Mpa	Mpa
0%	13.33	25.78	30.14
		26.67	31.18
		27.55	32.92
		25.91	30.88

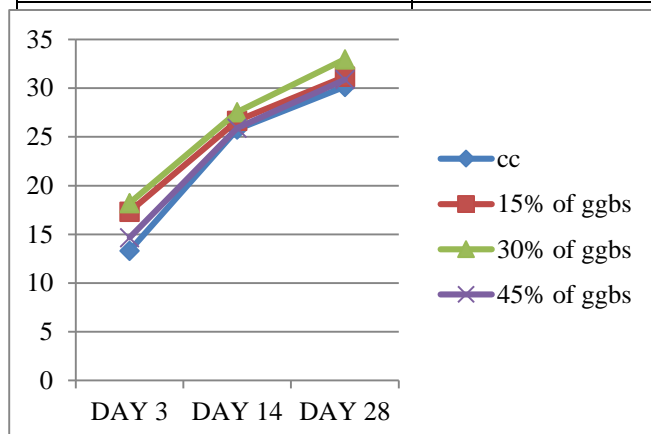


Fig.4 compressive strength

5.4 SPLIT TENSILE STRENGTH OF CONVENTIONAL AND GGBS CONCRETE

Table.7 Tensile strength of Conventional and GGBS Concrete

%OF REPLACEMENT OF GGBS	CURING PERIOD		
	3days	14days	28days
UNIT	Mpa	Mpa	Mpa
0%	1.61	2.9	3.31
15%	1.88	2.96	3.72
30%	2.14	3.24	3.88
45%	1.63	2.87	3.43

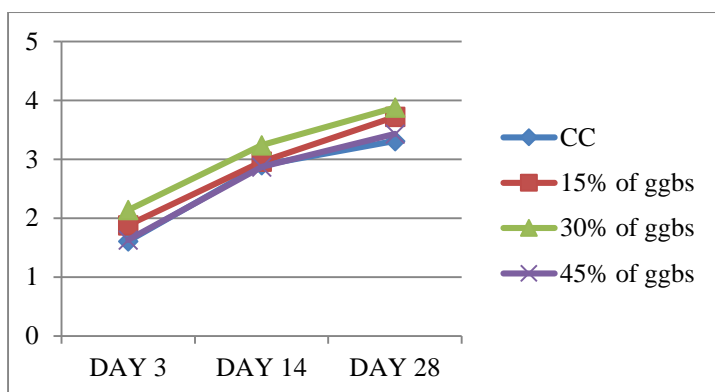


Fig.5 compressive strength

V. CONCLUSION

In today's modern competitive design and construction environment where benchmarks such as durable concrete and value engineering are required to be met, the effective use of crystalline waterproofing technology can provide the high performance advantages and benefits that design and construction professionals have come to rely upon in design and construction projects. And addition of integral crystalline waterproofing agent is added to the ratio of 125ml for 50kg cement bag to prevent the permeability of water through concrete. As compared to the standard waterproofing systems which possess many disadvantages, the integral crystalline waterproofing system ensures a denser concrete and chemical resistance by becoming a part of concrete. Thus crystalline systems prove to be highly beneficial for waterproofing structures which will be in contact with water during its life time.

By casting of M30 grade concrete cubes by partially replacement of Ground Granulated Blast Furnace Slag (GGBS) with the increasing percentage of 0%,15%,30% & 45%. However the higher compression strength of concrete achieved by the replacement of GGBS with the ratio of 30%.

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