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"STRENGTH AND DURABILITY OF CONCRETE WITH PARTIALREPLACEMENT OF CEMENT BY GGBS"

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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 experimental program investigates strength characteristic and durability aspect of concrete with partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS). The study deals with the usage of GGBS and its 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 byproduct it serves as an Eco Friendly way of utilizing the product without dumping it on ground.

KEY WORDS: Fly Ash, Puzzolonic behavior, partial, replacement, compressive strength. GGBS, Ground Granular Blast Furnace Slag, Durabilty.

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INTRODUCTION

With the increased industrialization, generation of industrial by-products has increased significantly. There are many types of industrial by-products depending upon the industry. Utilization of such types of by-products has become an enormous challenge.One such type of by-product is ground granulated blast furnace slag (GGBS) which is produced from the blast-furnaces of iron and steel industries. GGBS is very useful in the design and development of high quality cement paste/mortar and concrete. Generally, incorporating GGBS into cementitious binders of cement-based composites can increase the material total porosity but refine the pore size.

The pore refinement by GGBS is attributed, at macro-scale, to the filling effect of GGBS particles in the binder particle packing, and, at micro-scale, to the pozzolanic reaction of active silica-alumina in GGBS particles. The beneficial effect of GGBS on pore refinement can improve the durability performance of materials with respect to external environmental actions, such as freezing action, carbonation, sulphate attack, gas penetration, chloride migration and reinforced bar corrosion

This experimental work presents the compressive strength and durability of concrete. Ground Granulated Blast furnace Slag (GGBS) is a byproduct from the blast furnaces used to make iron. These operate at a temperature of about 1500 degrees centigrade and are fed with a carefully controlled mixture of iron ore, coke and limestone.The iron ore is reduced to iron and the remaining materials from a slag that floats on topof the iron.

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 cementations properties and produces granules similar to coarse sand. This granulate slag is then dried and ground to a fine powder. Although normally designated as “GGBS” in the UK, it can also be referred to as “GGBS” or “Slag cement” Concrete is basically a mix of fine aggregate, coarse aggregate and cement. The main problem is the original conventional materials are depleting and we are in hunt for alternate building materials which lands us here on the

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purpose of GGBS. Being a product as waste using it effectively up to some extent serves as a step for a greener environment and at the same time keeping in mind that the strength of the concrete doesn't degrade by the usage GGBS. The increased quest for sustainable and eco-friendly materials in the construction industry has led to research on partial replacement of the conventional constituents of concrete by two selected waste materials. The broad aim of this work was to investigate the effects of partially replaced Ordinary Portland Cement (OPC) by ground granulated blast furnace slag (GGBS) on the properties of concrete including compressive strength, tensile splitting strength, flexure, modulus of elasticity, drying shrinkage and initial surface absorption. Results showed that the compressive and tensile splitting strengths, flexure and modulus of elastic increased as the GGBS content increased. The percentage drying shrinkage showed a slight increment with the partial replacement of OPC with GGBS. However, concrete containing GGBS failed the initial surface absorption test confirming that GGBS decreases the permeability of concrete. The optimum mix was the one with 50% GGBS replacement.

GGBS is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS is obtained by quenching the same slag to the size of fine aggregate. The granulated blast-furnace slag is sand-type slag manufactured by spraying high-pressure water jets on a blast-furnace molten slag. GGBS is a by-product from the blast furnaces used to make iron. Blast-furnaces are fed with controlled mixture of iron-ore, coke and limestone and operated at a temperature of about 1500°C. When iron-ore, coke and limestone melt in the blast-furnace, two products are produced-molten iron, and molten slag. The molten slag is lighter and floats on the top of the molten iron. GGBS is used to make durable concrete structures in combination with ordinary port land cement and/or other pozzolanic materials.

Concrete has basic naturally, cheaply and easily available ingredients as cement, sand, aggregate and water. After the water, cement is second most used material in the world. But this rapid production of cement creates two big environmental problems for which we have to find out civil engineering solutions. First environmental problem is emission of CO_2 in the production process of the cement. We know that CO_2 emission is very harmful which creates

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lots of environmental changes. 1 tone of carbon dioxide is estimated to be released to the atmosphere when 1 tone of ordinary Portland cement is manufactured. Peoples working in the environmental field creates awareness in the public about the energy sources like petrol, diesel are limited in earth crest and for future generation we have to save it or we have to find alternative energy sources. But the peoples working in the construction field are having the same awareness about the lime consumption. This is second environmental problem related to consumption of lime. As there is no alternative binding material which totally replace the cement so the utilization of partial replacement of cement is well accepted for concrete composites

In order to fulfill its commitment to the sustainable development of the whole society, the concrete of tomorrow will not only be more durable, but also should be developed to satisfy socioeconomic needs at the lowest environmental impact. So the problem is related to environment, problem is related to cost minimization but structural engineer will give the solution by proper analyzing the properties of concrete made by using industrial waste material. GGBS means the ground granulated blast furnace slag is aby-product of the manufacturing of pig iron.

The molten slag has a composition close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue is then water-quenched rapidly, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size, which is known as ground granulated blast furnace slag (GGBS).

Advantages

The major use of GGBS is in ready mixed concrete:

Specifiers are well aware of the technical benefits, which GGBS imparts to concrete, including:

1. Better workability, making placing and compaction easier
2. Lower early age temperature rise, reducing the risk of thermal cracking in large pours

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3. Elimination of the risk of damaging internal reactions such as ASR
4. High resistance to chloride ingress, reducing the risk of reinforcement corrosion
5. High resistance to attack by sulphate and other chemicals
6. Considerable sustainability benefits

Disadvantages:

There are some of the dis-advantages as given below :

1. The aspect that most concerns people is the lower early age strength. Because concrete made with GGBS goes through a 2-stage hydration process the initial reaction is slower.
2. Concrete with a high percentage of GGBS used in a thin element in cold weather will have a lower strength and may require formwork to be in place longer.
3. Again at higher percentages the initial carbonation rate may be a little higher although this tends not be an issue as for standard cover the depth of carbonation typically doesn't impact.
4. The concrete standard permits the use of 50% in all exposure classes. For freeze thaw there are some restrictions at the higher replacement rates.

MATERIALS

Materials :

The materials used in this study include ordinary Portland cement, fine aggregate, coarse aggregate, water and GGBS. The properties of the materials are described below.

Cement :

The cements used in this experimental works are ordinary Portland cement (43 grades). All properties of cement are tested by referring IS Specification for Ordinary Portland cement. The specific gravity test was conducted and was found to be 3.14.

Fine aggregate :

It was river sand and the specific gravity test was conducted and was found to be 2.62.

Coarse aggregate :

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Coarse aggregates are 20mm down size and the specific gravity test was conducted and was found to be 2.92.

GGBS :

The chemical composition of blast furnace slag is similar to that of cement clinker. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8- 24%), and MgO (1-18%). In general, increasing the CaO content of the slag results in raised slag alkalinity will increase in compressive strength. The MgO and Al_2O_3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. The specific gravity test was conducted and was found to be 2.85.

Water :

Potable water available in laboratory is used for mixing and curing of concrete. A good quality water is used for mixing and curing so that the quality of concrete is well remainsgood and gives good strength and durability

METHODOLOGY

In this experimental work, to study the durability aspect and the compressive strength as obtained from the test on specimens of conventional concrete and concrete with GGBS. Concrete specimens with GGBS for M20 and M25 concrete were prepared to determine the compressive strength using ordinary Portland cement (OPC) 43 grade with cement content of 492.6 Kg /m^3 conforming to IS: 8112 – 1989 was used. Also Natural sand confirming to IS 383-1970 of Zone II [8] and locally available crushed aggregates confirming to IS: 383-1970 is used in this work and Water fit for drinking was used.

Cement concrete Grade M20 and M25 with a proportion of 1:1.51:2.74 and 1:1.29:2.37 respectively were prepared with a water cement ratio of 0.45.

Specific gravities of materials used:

Table No. 1 : Specific gravities of materials used

Material	Specific Gravity

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Cement	3.14
Fine Aggregate	2.62
Coarse Aggregate	2.92

TEST RESULTS AND DISCUSSION

SL. No.	Mould Name	Casting Date	7 Days Date	28 Days Date	7 Days Compressive Strength(N/mm^2)	28 Days Compressive Strength (N/mm^2)	Durability Test : (After 28 days) Compressive strength (N/ mm^2)
1)	P-MM-30 (M20 ,PLAIN)	30/3/19	6/4/19	27/4/19	1) 14.9 2) 13.0 3) 14.6	1) 18.4 2) 18.9 3) 17.6	1) 16.9 2) 17.2 3) 16.4
2)	G-MM-1 (M20, 50% GGBS)	1/4/19	8/4/19	29/4/19	1) 16.6 2) 15.9 3) 16.9	1) 20.2 2) 21.4 3) 22.5	1) 18.5 2) 19.3 3) 19.2
3)	P-MM-2-25 (M25 ,PLAIN)	2/4/19	9/4/19	30/4/19	1) 18.5 2) 16.8 3) 18.3	1) 23.2 2) 22.0 3) 23.1	1) 21.0 2) 21.2 3) 22.2
4)	G-MM-4-25 (M25, 50% GGBS)	4/4/19	11/4/19	2/5/19	1) 22.5 2) 21.8 3) 23.2	1) 25.7 2) 26.3 3) 27.1	1) 23.5 2) 24.3 3) 24.8

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From the experimental results, it shows that the compressive strength of M_{20} conventional concrete for 7 days curing is found to be low, whereas the compressive strength of M_{20} concrete with GGBS is higher. This shows that there is an increase in strength.

Similarly for 28 days curing, the compressive strength of M_{20} conventional concrete is found to be 17.86 low whereas the compressive strength of M_{20} concrete with GGBS is high. This shows that there is an increase in strength.

Now discussing about the other group where in concrete specimens prepared with 50% replacement, from the experimental results, it is clear that the compressive strength of M_{25} conventional concrete for 7 days curing is found to be again low, whereas the compressive strength of M_{25} concrete with GGBS is high. This shows that there is an increase in strength.

Similarly for 28 days curing, the compressive strength of M_{25} conventional concrete is found to be low ,in comparison to compressive strength of M_{25} concrete with GGBS is 26.36 MPa . This shows that there is an increase in strength.

Also from the experiment results it is revealed that the durability aspect of M_{20} conventional concrete for 28 days is low than that of concrete with GGBS. This shows that there is an increase in strength

And the experiment results for M_{25} conventional concrete for 28 days , the compressive strength result is low than that of concrete with GGBS. This shows that there is an increase in strengt

COMPARATIVE RESULTS

The figures below show the variation of compressive strength for plain and GGBSconcrete.

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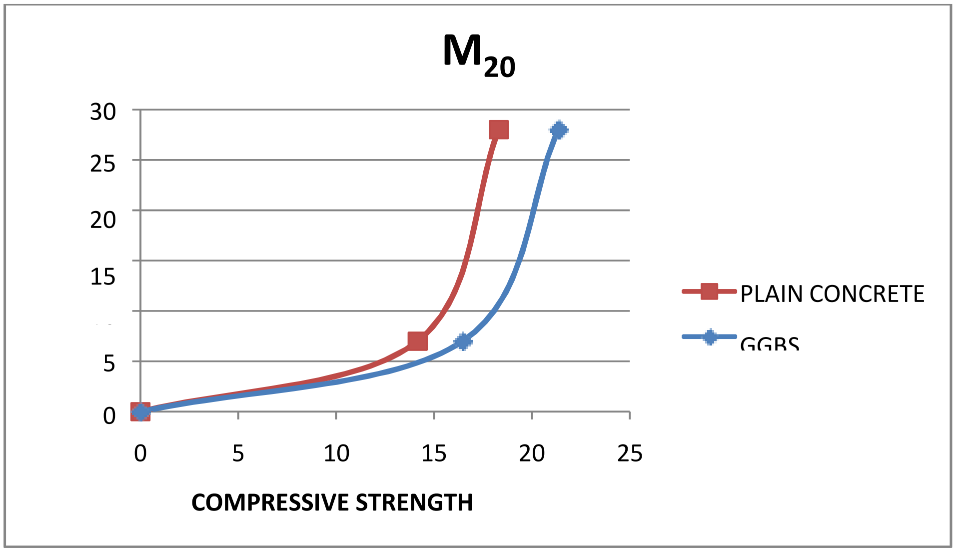

Fig. No. 1 Variation of compressive strength for 7 and 28 days (M_{20})

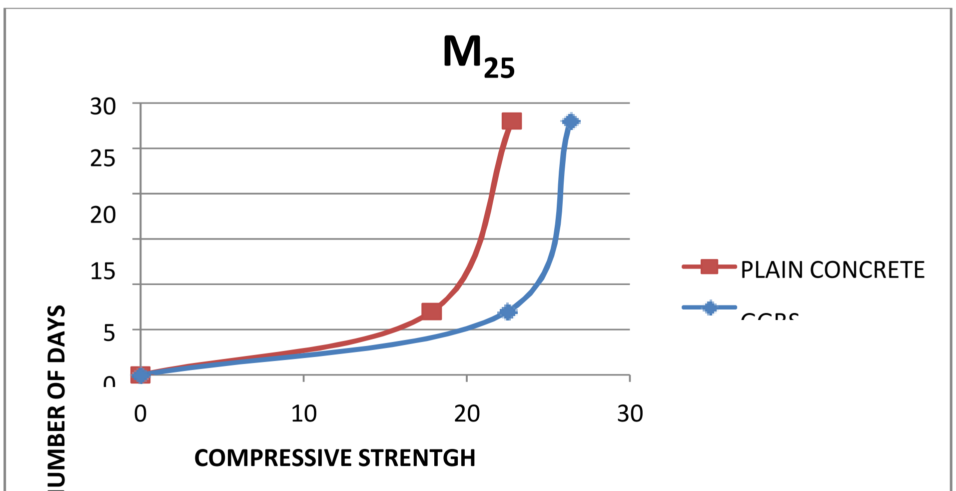

Fig. No. 2 Variation of compressive strength for 7 and 28 days (M_{25})

CONCLUSION

- From the experimental results, it can be concluded that the compressive strength of M_{20} conventional concrete for 7 days curing is found to be 14.16 MPa, whereas the compressive strength of M_{20} concrete with GGBS is 16.46 MPa.This shows that there is an increase in strength by 13.37%.

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- Similarly for 28 days curing, the compressive strength of M_{20} conventional concrete is found to be 17.86 MPa, whereas the compressive strength of M_{20} concrete with GGBS is 21.76 MPa. This shows that there is an increase in strength by 17.92%.
- From the experimental results, it can be concluded that the compressive strength of M_{25} conventional concrete for 7 days curing is found to be 17.86 MPa, whereas the compressive strength of M_{25} concrete with GGBS is 22.5 MPa. This shows that there is an increase in strength by 20.62%.
- Similarly for 28 days curing, the compressive strength of M_{25} conventional concrete is found to be 22.76 MPa , whereas the compressive strength of M_{25} concrete with GGBS is 26.36 MPa . This shows that there is an increase in strength by 13.68%.
- From the experiment results it is revealed that the durability aspect of M_{20} conventional concrete for 28 days is 16.83 MPa and that of concrete with GGBSis 19 MPa. This shows that there is an increase in strength by 11.42%.
- Similarly the experiment results for M_{25} conventional concrete for 28 days , the compressive strength result is 21.46 MPa and that of concrete with GGBS is 24.2 MPa. This shows that there is an increase in strength by 11.32%.
- Hence from results we can conclude that the durability of concrete increases with the additon of GGBS.

SCOPE FOR FUTURE WORK

- In future it can be planned to carry out the other strength characteristics such as flexural strength, tensile strength, .shear test, impact test, etc.
- Also concrete specimens can be checked for chloride attack test.

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