Strength Development Of Concrete By Replacing Cement With Ground Granulated Blast Furnace Slag (Ggbs)

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***Abstract*:** Industrial wastes like Ground Granulated Blast Furnace Slag (GGBS) show chemical properties similar to cement. Use of GGBS as cement replacement will simultaneously reduce cost of concrete and help to reduce rate of cement consumption. This paper on study report of strength analysis of GGBS concrete will give assurance to encourage people working in the construction industry for the beneficial use of it. This research work focuses on strength characteristics analysis of M30 grade concrete with replacement of cement by GGBS with 10%, 20%, and 30% and compare with plain cement concrete.

INTRODUCTION

GGBS has been widely used in developed economies for years and of late was also getting used in major construction projects in India.

The product promised to be a sustainable and cost effective material, will not only increase compressive strength and durability of the concrete, but also significantly reduce the carbon foot-print.

This has also shown usage in AAC (LIGHT WEIGHT CONCRETE INDUSTRY) as binder raw material and is used as replacement of cement partially to replace cement Thus reduces production cost in manufacturing.

LITERATURE REVIEW

Chatterjee, (2011) reported that about 50 % of fly ash generated is utilised with present efforts. He also reported that, one may achieve up to 70% replacement of cement with fly ash when high strength cement and very high reactive fly ash is used along with the sulphonated naphthalene formaldehyde superplasticizer. He reported improvement in fly ash property could be achieved by grinding and getting particles in sub micro crystalline range.

Bhanumathidas, &Kalidas, (2002) with their research on Indian fly ashes reported that the increase in ground fineness by 52% could increase the strength by 13%. Whereas, with the increase in native fineness by 64% the strength was reported to increase by 77%. Looking in to the results it was proposed that no considerable improvement of reactivity could be achieved on grinding a coarse fly ash. Authors also uphold that the study on lime reactivity strength had more relevance when fly ash is used in association with lime but preferred pozzolanic activity index in case of blending with cement.

Poon, Lam & Wong, (1999) from their experimental results concluded that replacement of cement by 15% to 25% by fly ash results in lower porosity of concrete and plain cement mortars. Literature discussed has shown improvement in the workability and durability of concrete by partial replacement of cement with fly ash. However 28 days strength was reported to be lower by replacement of cement with fly ash, than concrete without replacement of cement with fly ash. Analysing the literature it is seen than grinding of fly ash is less effective. This may be due to destruction of spherical shape of fly ash which is helpful in increasing workability and reducing voids. Grinding cost also offsets partial cost advantage of cheaper fly ash over cement. Low reactivity of low lime Indian fly ashes as compared to high lime fly ash restricts use of higher volumes of fly ashes for cement replacement. Lower reactivity of fly ash makes it urgent to develop a method for replacing higher volumes of cement with fly ash without grinding or activation of fly ash.

(Rebeiz, Serhal& Craft, 2004) reported investigation on the use of fly ash as replacement of sand in polymer concrete. In the weight mix design 15% sand was replaced by fly ash. This replacement of 15% sand with fly ash by weight increased compressive strength by about 30%. Also there was improvement in the stress strain curve. They also reported good surface finish due to addition of fly ash as replacement of sand which also reduce permeability and have an attractive dark colour. Flexural strength of steel reinforced polymer concrete beams was increased by 15%. When subjected to 80 thermal cycles polymer concrete with fly ash exhibits slightly better thermal cycling resistance (about 7% improvement) than polymer concrete without fly ash

BENEFITS OF GGBS:

1. GGBS is used to make durable concrete structures in combination with ordinary portland cement and/or other pozzolanic materials.
2.Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready mixed or site-batched durable concrete.
3.Use of GGBS significantly reduces the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress — reducing the risk of reinforcement corrosion — and provides higher resistance to attacks by sulfate and other chemicals.
4. Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required.

Fig. GGBS

Mix Proportion

A constant mix proportion is used for preparing M_{30} grade concrete ie., 0.4:1:1.08:2.36.

Cement uesd	PPC
Specific gravity of cement	3.15
Specific gravity of CA	2.60
Specific gravity of FA	2.60
Water absorption of CA	0.5%
Water absorption of FA	1.0%
Free surface moisture of CA	Nil
Free surface moisture of FA	2.0%

Fig. Test data for materials.

Testing Program

The tests are conducted on cement to see the suitability of sample in concrete. Required quantity of materials is calculated for grade of concrete and in different percentages of GGBS The required uniform mix is obtained by mixing of materials. The tests are held on fresh concrete and hardened concrete.

Fineness of cement

Fineness or particle size of cement affects the hydration rate of cement and thus the rate of strength gain. The smaller the particle size, the greater the surface area to volume ratio and thus the more area available for watercement interaction per unit volume. The test is conducted by IS-90μ sieve conforming to IS:460-1965, standard balance.

Specific gravity of cement

Specific Gravity is just a comparison between the weight of a volume of a particular material to the weight of the same volume of water at a specified temperature. Every material has solid particles and pores which may contain water on it. If the cement has exposed to extreme moisture content then it influences the water-cement ratio. W/C ratio is an important factor as it is directly proportional to workability and strength of bonding. Test is conducted by specific gravity bottle. Cement,water and kerosene is used to determine specific gravity.

Normal consistency of cement

The main purpose of the test is to determine the percentage of water to the weight of cement to complete hydration process or to produce a cement paste of standard consistency. Vicats apparatus with plunger 10mm dia is used in this test. It plays an important role in determining the required water percentage of initial and final setting time, soundness of cement and compressive strength of cement.

Disscussion of results

TESTS	Result
Fineness of cement	8%
Noramal consistency of cement	34%
Specific Gravity	3.15

Fig.Tests On Cement.

Slump cone test

Slump is a measurement of concrete fluidity/workability. It is an indirect measurement of concrete consistency or stiffness in a fresh state. By this test we come to know about the placing conditions of concrete.

Slump test	Slump in mm
Concventional concrete	10mm
10% replacement of GGBS	20mm
20% replacement of GGBS	25mm
30% replacement of GGBS	60mm

Fig .Tests on concrete

GGBS MIX	7days	28days
0%	$36N/mm^2$	$60N/mm^2$
10%	$37.6N/mm^2$	$58N/mm^2$
20%	$37.1N/mm^2$	$53.9N/mm^2$
30%	$29.9N/mm^2$	$43.8N/mm^2$

Fig. Compressive Strength values.

Compressive Strength

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 or 10cm x 10cm x 10cm 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.

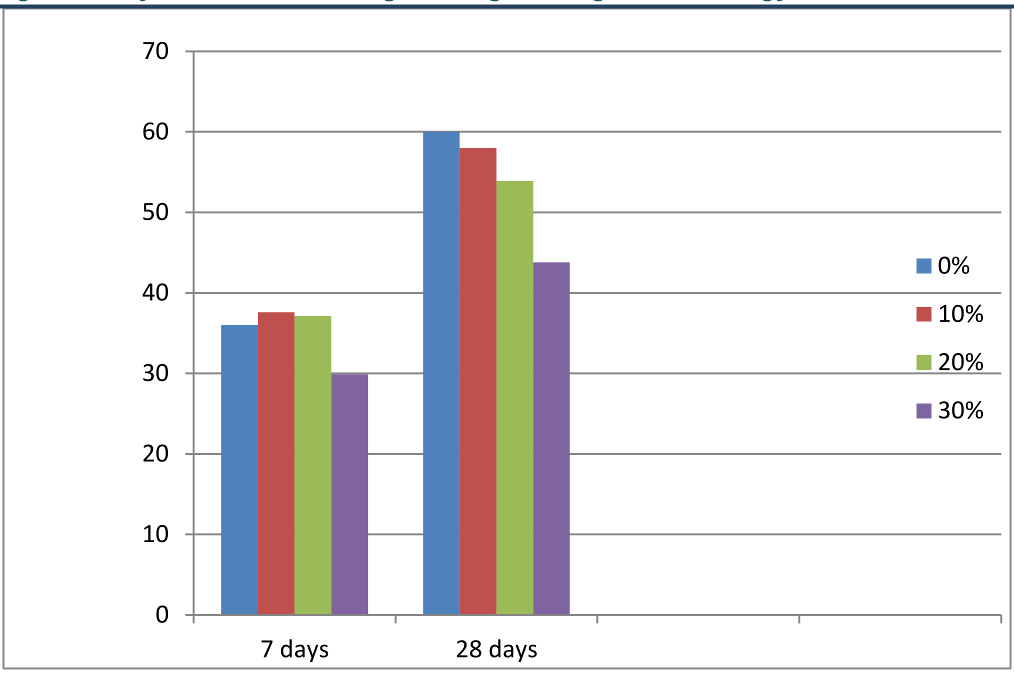
Fig. Compression testing.

Cube no/ % of GGBs	0% GGBS	10% GGBS	20% GGBS	30% GGBS
1.	760KN	760KN	810KN	950KN
2.	840KN	850KN	900KN	800KN
3.	860KN	950KN	800KN	900KN

Table. 7 days LOAD Variation.

	7days	28days
0%	36N/mm2	60N/mm2
10%	37.6N/mm2	58N/mm2
20%	37.1N/mm2	53.9N/mm2
30%	29.9N/mm2	43.8N/mm2

Table. Comparision of strength at 7days and 28 days for different percentages of ggbs



Strength variation graph.

Conclusions

1. The increment in % of ggbs brings about abatement in quantity of cement.

2. The diminishment in the cost of cement at the present market is 14%, on account of GGBS as substitution of PPC in concrete by GGBS gives the economy in the development as well as encourages ecological inviting transfer of the waste slag which is created in tremendous amounts from the steel ventures.

3. It can surely be presumed that GGBS, which till the years has been dealt with as a waste result of steel making plant, is in actually an important asset material. It's fitting use can give a monetary bonaza worth more than a billion dollars.

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