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Influence of Ground Granulated Blast Furnace Slag on Design of Cement Concrete Pavement

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Abstract: ***The vision of being a developed nation is today's scenario wherein considering the lowest level of individuality; everyone is focused towards ones benefits rather being philanthropists. The field of concrete technology runs in the same track wherein lot of advancement has come in where still basics play the major role. The changes adopted with respect to construction and building materials made a scope for change in the traditional way of concrete and bitumen. This is a study based on effects of Admixtures on concrete; where in the natural behavior of such is compared to that of changes in their behavior when such substances are added. It definitely causes an impact to its physical, material and characterized properties, but its implementation to the advantage of human environment makes a sensible part wherein the adverse effects are either reduced or omitted dependently. Most of the construction companies today prefer RMC from Concrete mix plants being transported to sites adding to an advantage of suitable properties of the concrete as required. Ground Granulated Blast Furnace Slag is taken as admixture used in the concrete of respective grading and following its suitability for various purposes is categorized depending upon the results obtained.***

Keywords: introduction, Literature review, Mix Design, conclusion and discursion

1. Introduction

It is known that for rapid development of any country, budget allocation would be one of the primary reasons to be focused on. When we discuss about budget allocation for improvement of living facilities it is all about sustainable development and proper use of available resources. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. GROUND GRANULATED BLAST FURNACE SLAG (GGBS) is a new mineral admixture, whose potential is not fully utilized. Moreover only limited studies have been carried out in India on the use of slag for the development of high strength concrete.

The study focuses on the compressive strength performance of the blended concrete containing different percentage of slag and as a partial replacement of OPC.

- The cement in concrete is replaced accordingly with the percentage of 15 %, 20%, 25%, and 30% by weight of slag.
- Concrete cubes are tested at the age of 3,7,14 and 28 days of curing.
- Finally, the strength performance of slag blended fiber reinforced concrete is compared with the performance of conventional concrete.
- M30 and M40 graded concrete mixes are considered where M30 grade concrete mix's Compressive strength is improved by adding optimum percentage of GGBS and compared with conventional M40 mix.

2. Literature Review

Experimental Study on Partial Replacement of Cement by Fly ash and GGBS

By Syed Asif Ali in his paper presents a laboratory investigation on optimum level of fly ash and Ground Granulated blast furnace slag GGBS as a partial replacement of cement to study the strength characteristics of concrete. Portland cement was partially replaced by 5%, 6%,7%,8%,9% 10% of ggbs and fly ash by 20% 40% and 60% respectively. The water to cementation materials ratio was maintained at 0.45 for all mixes.The strength characteristics of concrete were evaluated by conducting Compressive strength test, Split tensile strength and following results were evaluated. And Mr. **Vinayak Awasare, and Prof. M. V. Nagendra** presented a paper on Today's construction industry, use of concrete is going on increasing rapidly. Cement is major constituent material of the concrete which produced by natural raw material like lime and silica. Once situation may occurs there will be no lime on earth for production of cement. This situation leads to think all people working in construction industry to do research work on cement replacing material and use of it. Industrial wastes like Ground Granulated Blast Furnace Slag (GGBS) show chemical properties similar to cement. Use of GGBS as cement replacement will simultaneously reduces cost of concrete and help to reduce rate of cement consumption. This 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 M20 grade concrete with replacement of cement by GGBS with 20%, 30%, 40% and 50% and compare with plain cement concrete. Now days crush sand is used to replace natural sand, so study area extends to find best percentage of replacement by using both crush and natural sand.

3. Mix Design

Grade Designation : **M30**
- **Type of Cement** : OPC 53 Grade
- **Maximum Nominal Size of Aggregate** : 10-20mm
- **Minimum Cement Content** : 300 kg/m^3
- **Water-Cement Ratio** : 0.40
- **Workability** : 100mm (Slump)
- **Exposure Condition** : Moderate
- **Method of Concrete Placing** : Hand
- **Degree of Supervision** : Good
- **Type Of Aggregate** : Crushed Angular Aggregates
- **Maximum Cement Content** : 465 kg/m^3

Test data for materials
- **Cement Used** : OPC 53 Grade
- **Specific Gravity of Cement** : 3.1

Water absorption:
Coarse Aggregate (20 down) : 0.019 %
Fine Aggregate : 0.29 %

Free (Surface) Moisture:
Coarse aggregate : NIL
Fine aggregate : NIL

Sieve Analysis:
Coarse aggregate : Graded
Fine aggregate : Graded (ZONE I)

Target Strength for Mix Proportioning
Fck = fck+ 1.65 x S
= 30 + 1.65 x 5
= **38.25 N/mm^2.**

Water Cement Ratio
The maximum w/c ratio for 20 mm aggregate is 186 kg/m^3
W/c = 0.40
186/c = 0.40
C =465 kg/m^3

Calculation of Fine Aggregate:

$$V = (W + \frac{C}{Sc} + (\frac{1}{P} \times \frac{Fagg}{SFagg})) \times 1/100$$

$$0.98 = \{ 186 + \frac{465}{3.15} + (\frac{1}{0.315} \times \frac{Fagg}{2.8})) \times 1/100$$

Fagg = 570.15 kg/m^3.

Calculation of Coarse aggregates

$$V = \{ W + \frac{C}{Sc} + \frac{1}{1-P} \times \frac{Cagg}{SCagg}\} \times 1/100$$

$$0.98 = \{ 186 + \frac{465}{3.15} + \frac{1}{1-0.315} x \frac{Cagg}{2.6})x\ 1/100$$

Cagg = 1154.25 kg/m^3.

Mix Proportion for M30 is

465:570.15:1154.25

1: 1.2: 2.4

Table 1: Mix Proportions for (M30) Grade for GGBS

S. No	GGBS (%)	W/C ratio	Mix Proportion (Kg/m^3)				
			Cement	GGBS	Fine Agg.	Coarse Agg.	Water
1	0	0.4	465	0	570.15	1154.25	186
2	15	0.4	395.25	69.75	570.15	1154.25	186
3	20	0.4	372.0	93.0	570.15	1154.25	186
4	25	0.4	348.75	116.25	570.15	1154.25	186
5	30	0.4	325.50	139.50	570.15	1154.25	186

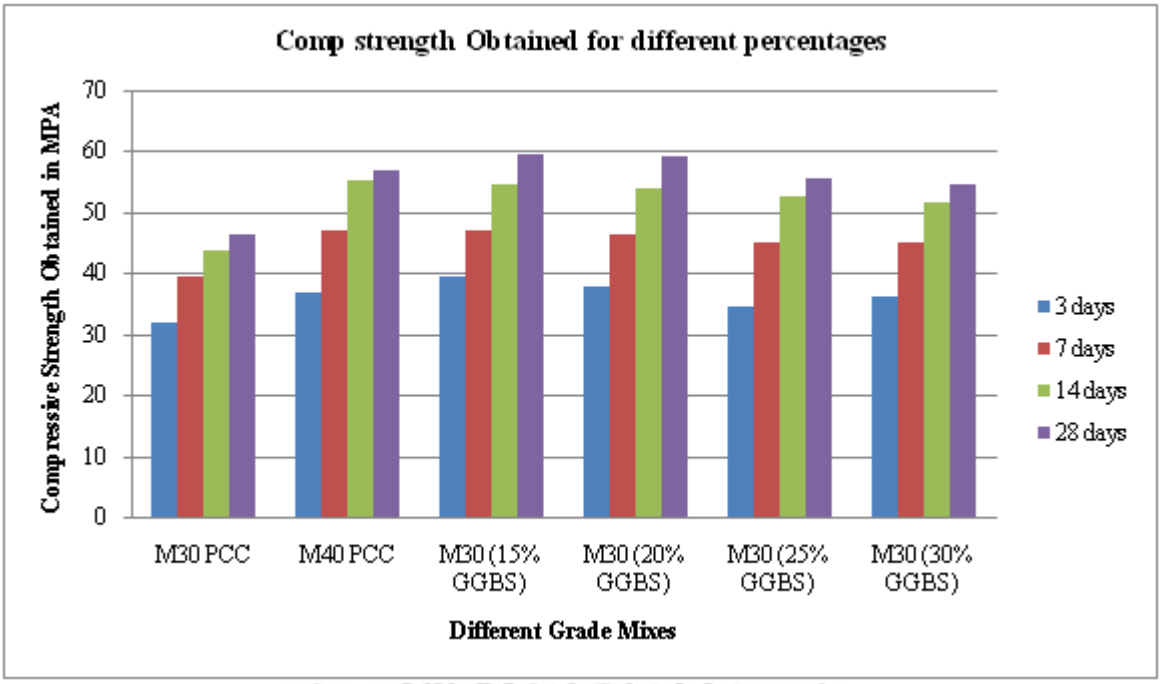
4. Results and Discussion

Table 2: Load obtained on cubes

Grade Of Concrete (% S Mentioned)	Load Taken at 3 Days (KN)	Load Taken at 7 Days (KN)	Load Taken at 14 Days (KN)	Load Taken at 28 Days (KN)
M30 PCC	720	890	980	1040
M40 PCC	830	1060	1240	1280
M30 (15% GGBS)	890	1060	1230	1340
M30 (20% GGBS)	850	1040	1210	1330
M30 (25% GGBS)	780	1010	1180	1250
M30 (30% GGBS)	810	1010	1160	1230

Table 3: Strength obtained on cubes

Grade Of Concrete (% S Mentioned)	Strength Obtained at 3 days (MPa)	Strength Obtained at 7 Days (MPa)	Strength Obtained at 14 Days (MPa)	Strength Obtained at 28 Days (MPa)
M30 PCC	32.00	39.55	43.55	46.22
M40 PCC	36.88	47.11	55.11	56.88
M30 (15% GGBS)	39.55	47.11	54.66	59.55
M30 (20% GGBS)	37.77	46.22	53.77	59.11
M30 (25% GGBS)	34.66	44.88	52.44	82.50
M30 (30% GGBS)	36.00	44.88	51.55	54.66



Graph 1: Different grade mixes

5. Conclusion and Discursion

- The Optimum percentage of GGBS was found to be between 15% and 20% respectively.
- The Optimum value of compressive strength for M30 grade at 15% of GGBS of as partial replace of cement was found to be 47.11N/mm2 at 7 days of curing.
- The Optimum value of compressive strength for M30 grade at 15% of GGBS of as partial replace of cement was found to be 60.47 N/mm2 at 28 days of curing.
- The compressive strength increases as the percentage of GGBS and increases as partial replace of cement.
- The Optimum value of split tensile strength for M30 grade at 15% of GGBS of as partial replace of cement was found to be 35.78 N/mm2 at 28 days of curing.
- The Optimum value of flexural strength (safety check) for M30 grade at 15% of GGBS of as partial replace of cement is calculated.
- The Objective is obtained as M30 grade (GGBS15%) concrete mix attains the Compressive strength of that of Conventional M40 grade concrete mix which plays a major difference in economy and sustainability.

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