Cost Analysis & Review of M30 Concrete with Partial Replacement of Cement by GGBS and Fly Ash

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Abstract— Concrete holds unique position among all the modern construction material Concrete is most extensively used material in construction. CO2 is emitted during the manufacture of cement, damaging the environment. Cement one of which play an important role for preparation of concrete. The huge demand of cement is the major problem so we need to find suitable alternative material, which can fulfill the demand of cement. Many research works state that materials like fly ash, GGBS, silica fume, metakaol in can be used as partial replacement for cement. . By utilizing these two products as a partial replacement of cement in concrete, the concrete can be made more eco-friendly by reducing the use of cement. The main aim of this work is to study the fresh and hardened properties of M-30 grade control concrete and concrete made with partial replacement of fly ash and GGBS with various percentages. So it can be say that Fly Ash and GGBS effectively used as Biding material in concrete mix. The use of Fly Ash and GGBS reduces the dependence of cement manufacture as well as cost of construction. The use of Fly Ash and GGBS may also helpful for reducing the solid waste which is a course of environmental problems.

Keywords: GGBS, Fly Ash, Durability, Compressive Strength, Tensile Strength, Flexural Strength, Slum cone Test

I. INTRODUCTION

Concrete is the most important element of infrastructure development across the globe and a well-designed concrete can be a durable construction material. However, there is a growing concern about the environmental aspect of Portland cement, as the cement manufacturing industry is responsible for about 2.5% of total worldwide emission from industrial sources). Particularly, carbon dioxide emission has been a serious problem in the world due to the greenhouse effect. Concrete is the most used construction material in the world. Cement is the main binding material in concrete. Over the past 3 decades, the production of cement has grown rapidly all over the world. The cement production in India is expected to grow three-folds by 2050, However, cement production has major environmental issues that are of concern worldwide .For every one tonne of clinker manufactured, approximately one tonne of CO2 is released to the atmosphere, which contributes almost 5-7% of global anthropogenic carbon dioxide emissions. In the manufacturing process of cement, the main sources of gas emissions are combustion of fuels and decomposition of CaCO3 to CaO and CO2. Supplementary cementitious materials are used to partially replace clinker, which eventually reduces the harmful emissions.

A. Role of Fly Ash in Concrete

Fly ash is a combustion residue (coal mineral impurities) in coal burning electric power plants, which flies out with the flue gas stream and is collected by mechanical separators, electrostatic precipitators or big filters. Fly ash has been widely utilized in concrete since it reduces cost of concrete materials, conserves energy resources and reduces environmental problems. It has become an essential ingredient in concrete mixtures.

Over the years, ash consumption level has reached from meagre 0.3 million ton in 1991 - 1992 to 30 million tons in 2012-13. The important areas for this utilisation are cement industry, bricks industry, road embankment, mine filling, land development and ash dyke raising. It is also a source of micro and macro-nutrients in agriculture.

B. Ground Granulated Blast Furnace Slag

Blast furnace slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed in to the furnace, and the resulting molten slag floats above the molten iron at a temperature of about 1500-1600c. After the molten is tapped off, the remaining molten slag, it mainly consist of granulated siliceous and aluminous residues is then rapidly water quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as GGBS

II. LITERATURE REVIEW

A. Literature Review

Many works have been carry out to explore the benefits of using various waste materials such as GGBS, Fly ash , stone dust and glass powder in making and enhancing the properties of concrete. The work done by various authors describe below

1) Amnon Katz 2003 studied the properties of concrete containing 100% recycled aggregate. He reported that the strength of concrete containing recycled aggregate was less compared to strength of concrete containing natural aggregate.
2) Khatib 2005 studied the properties of concrete containing recycled fine aggregate using crushed concrete and crushed brick. The results indicated that the

strength of concrete containing crushed concrete is 15% - 30% less than the normal concrete.

3) Brendt 2009 studied the properties of concrete containing recycled aggregate and fly ash and slag. Slag and fly ash was used as a replacement for cement in large volumes. From the study it was found that adding slag to recycled aggregate concrete helped to control the strength of concrete.
4) Corinaldesi et.al 2009 studied the effect of mineral additions on concrete containing 100% recycled aggregates. Silica fumes and fly ash was used as mineral additions along with acrylic based superplasticizer. Fly ash was used as a replacement of fine aggregate which proved to be effective in improving the pore structure particularly macro pores and thereby improving the mechanical properties of concrete.
5) Ozkan Sengul et.al, 2009 studied the properties of concrete containing ground fly ash and slag. Portland cement was replaced up to 50% by fly ash and slag and combination of fly ash and slag. The tests concluded that the compressive strength was lower at higher water binder ratio in comparison with normal concrete. At lower water to binder ratio the strength is comparable with normal concrete. Addition of fly ash and slag also reduced rapid chloride permeability of concrete.
6) Meyer 2009 summarized the data available for making the concrete industry greener by using mineral admixtures and recycled aggregate in concrete.
7) Venu Malagavelli et. al. 2010 'High performance concrete with GGBS and robo sand'
8) E. Dapena et.al, 2011 studied the effect of recycled sand content on characteristics of mortars and concrete. The study found that recycled fine aggregate replacement up to 100% had no appreciable effect on the compressive strength but the modulus of elasticity of concrete decreases with the increase in recycled sand content.
9) Mrs. Veena G. Pathan, et al, (2012) 'Evaluation of concrete properties using ground granulated blast Furnace slag',
10) Patrick L Maier et.al, 2012 studied the use of GGBFS, recycled concrete aggregate and crushed waste glass in concrete. The study showed that the GGBFS can be used up to 50% along with recycled aggregate in concrete. Recycled aggregate replacement up to 50% enhanced the properties of concrete
11) Prof. Jayeshkumar Pitroda, Dr. L. B. Zala, and Dr. F.S. Umrigar. (Oct-Dec, 2012) Experimental investigations on partial replacement of cement with fly ash in design mix concrete .This research work describes the feasibility of using the thermal industry waste in concrete production as partial replacement of cement. The use of fly ash in concrete formulations as a supplementary cementations material was tested as an alternative to traditional concrete. The cement has been replaced by fly ash accordingly in the range of 0% (without fly ash), 10%, 20%, 30% & 40% by weight of cement for M-25 and M-40 mix. Concrete mixtures were produced, tested and compared in terms of compressive and split strength with the conventional concrete. These tests were carried out to evaluate the mechanical properties for the test results for compressive strength up to 28 days and split strength for 56 days are taken.
12) A.H.L. Swaroop, K. Venkateswararao, and Prof P. Kodandaramarao (Jul-Aug, 2013) Durability studies on concrete with fly ash and ggbs.
13) In this paper they mainly concentrated on evaluation of changes in both compressive strength and weight reduction in five different mixes of M30 Grade, namely conventional aggregate concrete (CAC), concrete made by replacing 20% of cement by Fly Ash (FAC1), concrete made by replacing 40% of cement by Fly Ash (FAC2), concrete made by replacing20% replacement of cement by GGBS (GAC1) and concrete made by replacing 40% replacement of cement by GGBS(GAC2). The effect of 1% of H2SO4 and sea water on these concrete mixes are determined by immersing those cubes for7days, 28days, and 60days in above solutions
14) Weerachart Tangchirapat et.al, 2013 studied the influence of fly ash on slump loss and strength of concrete containing 100% recycled aggregates. Both the fine and coarse aggregates were replaced by recycled aggregates. Fly ash replacement of up to 35% gave a desirable compressive strength of the recycled aggregate concrete. Incorporation of fly ash did not have more significance on the splitting tensile strength and modulus of elasticity of concrete containing recycled aggregates.
15) Reshma Rughooputh and Jaylina Rana (2014) study Partial replacement of cement by ground granulated blast furnace slag in concrete. In this paper the main aim of the 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.
16) E. Anastasiou et.al, 2014, studied the use of fine recycled aggregate in concrete containing fly ash and steel slag. Fly ash was used as binder for cement replacement and steel slag was used as coarse aggregate replacement. The results showed that incorporating fine recycled aggregate increases the porosity of concrete, this results in decreases of strength and durability of concrete. But addition of fly ash and steel slag resulted in concrete of adequate strength and also considerable environmental gains.
17) Sonali K. Gadpalliwar and R. S. Deotale (2014) investigated, Concrete when subjected to severe environments its durability can significantly decline due to degradation. Degradation of concrete structures by corrosion is a serious problem and has major economic implications
18) Vinayak Awasare and Prof. M. V. Nagendra(2014), "Analysis of Strength Characteristics of GGBS Concrete". By considering those works, this work is

carried out to study the durability and strength characteristics of high strength concrete with partial replacement of GGBS and fly ash under acidic environment.

19) Sonali K. Gadpalliwar and R. S. Deotale.,(2014) To Study the Partial Replacement of Cement by GGBS & RHA and Natural Sand by Quarry Sand In Concrete.
20) Neeraja.D 2013. "Experimental Investigations on Strength Characteristics of Steel Fiber Reinforced Concrete
21) K.V. Pratap, M. Bhasker, and P.S.S.R.Teja (Jan-Jun, 2014) study Triple blending of cement concrete with fly ash and ground granulated blast furnace slag
22) In this paper they mainly concentrated on compressive strength, split tensile strength and flexural strength of concrete mix of M-60 grade, with partial replacement of cement with Ground Granulated Blast furnace Slag and FLY-ASH. They use the concept of triple blending of cement with GGBS and FLY-ASH, this triple blend cement exploits the beneficial characteristics of both pozzolanic materials in producing a better concrete. They concluded that, the compressive strength, flexural strength and split tensile strength of concrete are improved with the addition of fly ash and GGBS as partial replacement to cement. The compressive strength of concrete is increased by a maximum of 11.13 % at 28days with (4+16) % replacement. The flexural strength of concrete is increased by a maximum of 11.74% at 28days with (4+16) % replacement. The split tensile strength of concrete is increased by a maximum of 23.01 %at 28 days with (4+16) % replacement.
23) T.G.S Kiran, and M.K.M.V Ratnam (December, 2014) studie Fly ash as a partial replacement of cement in concrete and durability study of fly ash in acidic (H2SO4) environment. In this project report the results of the tests carried out on sulphate attack on concrete cubes in water curing along with H2SO4 solution. Also, aiming the use of fly-ash as cement replacement. The present experimental investigation were carried on fly ash and has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 10%, 15%, 20% by weight of cement in concrete. Fresh concrete tests like compaction factor test was hardened concrete tests like compressive Strength at the age of 28 days, 60 days, 90 days was obtained and also durability aspect of fly ash concrete for sulphate attack was tested. The result indicates that fly ash improves concrete durability.

III. OBJECTIVE

The objective of this study is to search alternatives material which can fully or partially replaced naturally available material in construction.

The main purpose of this study is to reduce the use of conventional material for making the concrete.

IV. ECONOMIC COMPARISON

Economic Feasibility of Replacement
Concrete is manufactured using production cement; production cement such as fly ash and GGBS is considered an environmentally friendly alternative to Cement. The most important natural and cheapest sources of cement are waste of iron industries and thermal plant... For various reasons, good cement is not always immediately available and must be transported from large distances. Transport is an important factor in the construction.

A. Cost Analysis

Analysis of the Cost of Concrete With and Without Ggbs and Fly Ash for Mix Designation M2 (60% Cement + 20% Fly Ash +20% Ggbs)

Material estimation includes costs for water, cement, natural sand, manufacturing sand and coarse aggregate for a particular design mix and transportation cost. According to the mix design calculation we achieved the weight of water, cement, natural sand, manufacturing sand and coarse aggregate for concrete. As the water is largely available in India, its costs can therefore be neglected. Current study shows that replacement of cement using manufacturing cement which obtain waste of industries. Analysis of the cost of concrete with and without manufacturing cement (fly ash and GGBS) for M30 grade.

Ratio= 1:1.41:2.58

Total volume = 1+1.41+2.58=4.99

Vol. of cement= $\frac{1}{4.99}$*1.57=.3146

No. of cement bags=450/50=9

Vol. of sand = $\frac{1.41}{4.99}$*1.57=.44336

Vol. of concrete = $\frac{2.58}{4.99}$*1.57=.811

B. Quantities per unit volume of concrete constituents for M30

Concrete Constituent	Quantities per unit vol.
	1:1.41:2.58
Cement	450 Kg (9bags)
Natural Sand	0.44330m^3
Coarse Aggregate	0.811m^3

SN	Material	Rate	Conventional Concrete		M 30 (Optimum Fly Ash and GGBS Concrete		Saving %
	Quantity	Cost	Quantity	Cost(Rs)	Quantity	Cost(Rs)	
1	Cement	Rs 400 per bag	9 bags	3600	5.4 bags	2160	12.45%
2	Fly Ash	Rs 2.75/ kg	0	0	90Kg	247.5	
3	GGBS	Rs 0.5/Kg	0	0	90Kg	45	
4	Fine Aggregate	Rs 860/m3	0..44 m3	378.4	0.249 m3	378.4	

5	Coarse Aggregate	Rs 2500/m3	0..811 m3	2027.5	0.428 m3	2027.5	
6	Super Plasticizer	Rs 40/Kg	0	0	10 Kg	400	
				6005.9		5258.4	

Table 2: Cost of Material per Cubic Meter of Concrete (60% CEMENT + 20% FLY ASH +20% GGBS)

From the above table we note that the use of GGBS and Fly ash in concrete saves money up to 12.45 % over the conventional cement concrete. This is a significant saving of money. There are good prospects of obtaining a good concrete strength at relatively cheaper cost even while replacing part of the cement with GGBS and Fly ash.

SN	Material	Rate	Conventional Concrete		M 30 (Optimum Fly Ash and GGBS Concrete		Saving %
	Quantity	Cost	Quantity	Cost(Rs)	Quantity	Cost(Rs)	
1	Cement	Rs 400 per bag	9 bags	3600	3.6 bags	1440	20.31%
2	Fly Ash	Rs 2.75/ kg	0	0	180Kg	495	
3	GGBS	Rs 0.5/Kg	0	0	90Kg	45	
4	Fine Aggregate	Rs 860/m3	0..44 m3	378.4	0.249 m3	378.4	
5	Coarse Aggregate	Rs 2500/m3	0..811 m3	2027.5	0.428 m3	2027.5	
6	Super Plasticizer	Rs 40/Kg	0	0	10 Kg	400	
				6005.9		4785.9	

Table 3: Analysis of the Cost of Concrete with and Without Ggbs and Fly Ash for Mix Designation M7 (40% Cement + 40% Fly Ash +20% Ggbs)

From the above table we note that the use of GGBS and Fly ash in concrete saves money up to 20.31 % over the conventional cement concrete. This is a significant saving of money. There are good prospects of obtaining a good concrete strength at relatively cheaper cost even while replacing part of the cement with GGBS and Fly ash.

V. CONCLUSION

Making concrete with the combination of Fly ash and GGBS and cement with different percentages gives good results compared to control concrete. So the best way to use these materials is in combination. Due to environmental issues in the production of cement, industrial by products like fly ash and GGBS are used as supplementary materials in concrete and it saves cost of production of concrete, and makes it eco-friendly

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