"Experimental Studies on Strength Properties of M30 Concrete with Partial Replacement of Cement by GGBS and Fly Ash"

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ABTRACTS

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. Experiments have been conducted to study the effects of Fly Ash and GGBS with various percentages on mechanical properties of M30 grade of concrete. Compressive strength of concrete cubes with proposed replacement was determined after 7, 14 and 28 days of curing**.** The cubes, cylinders and prisms are tested for compressive strength, split tensile strength, flexural strength.

Key words: 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, as can be seen in Figure 1.1).

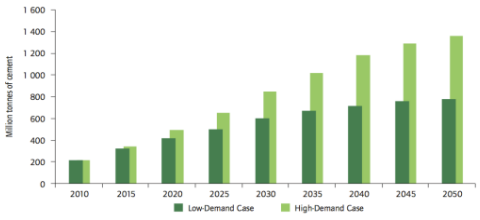


Figure 1. 1 Estimated cement production (WBCSD-IEA 2006)

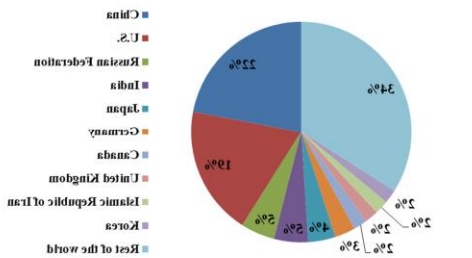


Figure 1. 2 CO2 emission by ten largest emitters worldwide (adapted from IEA 2014)

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.

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 (Figure 2)

GGBS

Applications and Uses Of GGBS

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Two major uses of GGBS [2] 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.

II LITERATURE REVIEW

2.1 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

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.

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.

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.

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.

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

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.

III OBJECTIVE

To find out the mechanical properties of control concrete of M-30 grade at various percentage of fly ash and ground granulated blast furnace slag as a partial replacement of cement at 7 day ,14 day and 28 days tests are conducted.

To find the optimum % of replacement of cement by GGBS and Fly ash by imparting better strength and durability properties.

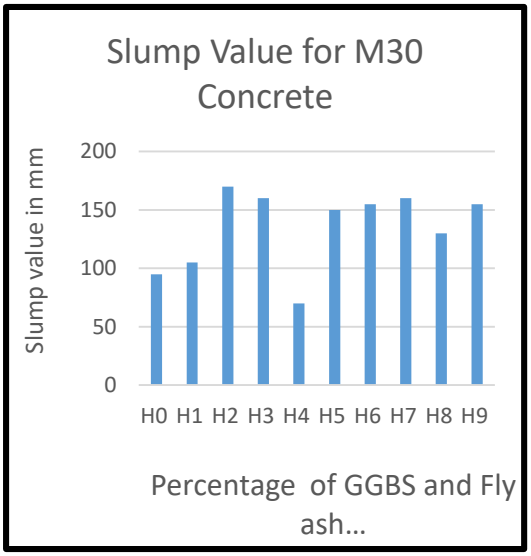
To find the optimum percentage of GGBS and Fly ash to give the maximum value of cpomppresive ,flexural and split tensile strength .

IV EXPERIMENTAL RESULT

The test conducted on fresh properties of control concrete and concrete made with fly ash and GGBS as partial replacement of cement. The tests conducted for workability of concrete are slump test,. The variation of slump values, in the form of graph is as shown in the figure 1 to figure 3

slump values for control concrete and concrete made with fly ash and ggbs as partial replacement of cement

Mix	Description	Slump (mm)
H0	100% CEMENT + 0% FLY ASH + 0% GGBS	95
H1	60% CEMENT + 10% FLY ASH +30% GGBS	105
H2	60% CEMENT + 20% FLY ASH +20% GGBS	170
H3	60% CEMENT + 30% FLY ASH +10% GGBS	160
H4	40% CEMENT + 10% FLY ASH +50% GGBS	70
H5	40% CEMENT + 20% FLY ASH +40% GGBS	150
H6	40% CEMENT + 30% FLY ASH +30% GGBS	155
H7	40% CEMENT + 40% FLY ASH +20% GGBS	160
H8	40% CEMENT + 50% FLY ASH 10% GGBS	130
H9	50% CEMENT +25 % FLY ASH +25% GGBS	155



slump values for control concrete and concrete made with fly ash and ggbs as partial replacement of cement

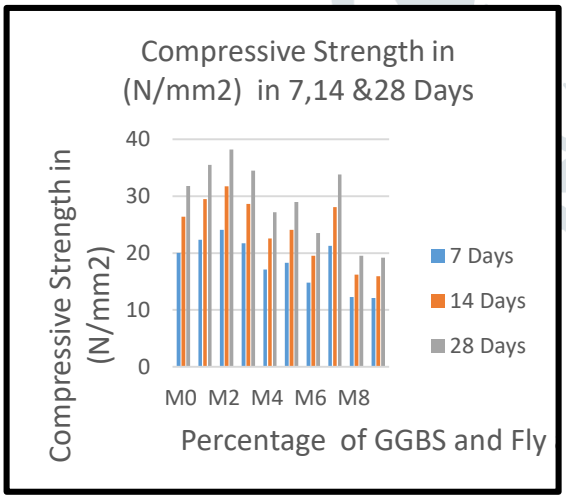
The following observations were made from the experiment conducted. To study the fresh properties of concrete Slum cone test are conducted for control concrete and concrete made with fly ash and GGBS as a partial replacement of cement. From the results obtained from workability test, it is clearly observed that increasing in fly ash and decrease in the GGBS content leads to the increase in workability.

4.2 Compressive Strength Test:-

For each concrete mix, the compressive strength is determined on three 150x150x150 mm cubes at 7, 14 and 28 days of curing. Following table gives the compressive strength test results of control concrete and concrete made with fly ash and GGBS as partial replacement of cement.

Compressive strength after7,14 28 days curing for M30

MIX DESIGNATION	COMPRESSIVE STRENGTH (N/mm2)		
	7 Days	14 Days	28 Days
M0	20.034	26.394	31.8
M1	22.365	29.465	35.5
M2	24.066	31.706	38.2
M3	21.735	28.635	34.5
M4	17.136	22.576	27.2
M5	18.27	24.07	29
M6	14.805	19.505	23.5
M7	21.294	28.054	33.8
M8	12.285	16.185	19.5
M9	12.096	15.936	19.2



Compressive strength after 7&14 28 days curing for M30

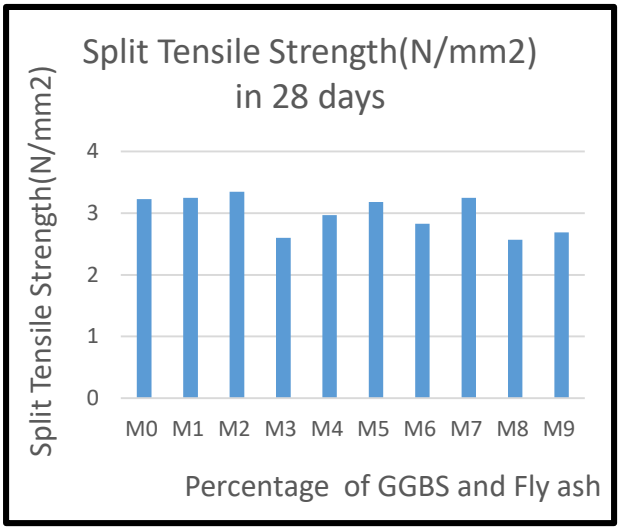
From the Experiment, it was found that Mix M2 is having higher compressive strength than all other mixes that is M1 & M3. The percentage increase in strength of mix M2 compared to control concrete are 16.75%, 18.08%, 22.17% at 7, 14 and 28 days respectively. The mix M7 (40%Flyash+20%GGBS+40%OPC) is giving good result in all the ages of curing and it is compared in high volume replacement category. Mix M7 is having higher compressive strength than all other mixes that is M4, M5, M6 and M8. Mix M2 is having higher compressive strength is 38.2 N/mm2 and Mix M7 is having higher compressive strength is 33.8 N/mm2**.** M2 (20% Flyash+20%GGBS+60%OPC) is giving good results in all ages of curing when it is compared with low volume replacement category. Mix M2 (the mixes with low volume replacement) is having higher compressive strength as compare to Mix M7(the mixes with high volume replacement).

Split Tensile Strength Experiment

The test has been conducted after 28days of curing. Split tensile test conducted on 150mm diameter and 300mm length cylinder as per IS: 5186-1999.

Flexural strength after 28 days curing for M30

MIX DESIGNATION	Description	SPLIT TENSILE STRENGTH (N/mm2)
		28 days
M0	100% CEMENT + 0% FLY ASH + 0% GGBS	3.23
M1	60% CEMENT + 10% FLY ASH +30% GGBS	3.25
M2	60% CEMENT + 20% FLY ASH +20% GGBS	3.35
M3	60% CEMENT + 30% FLY ASH +10% GGBS	2.6
M4	40% CEMENT + 10% FLY ASH +50% GGBS	2.97
M5	40% CEMENT + 20% FLY ASH +40% GGBS	3.18
M6	40% CEMENT + 30% FLY ASH +30% GGBS	2.83
M7	40% CEMENT + 40% FLY ASH +20% GGBS	3.25
M8	40% CEMENT + 50% FLY ASH 10% GGBS	2.57
M9	50% CEMENT +25 % FLY ASH +25% GGBS	2.69



Flexural strength after 28 days curing for M30

From the Experiment, it was found that M2 (20% Flyash+20%GGBS+60%OPC) is giving good results in all ages of curing when it is compared with low volume replacement category. Mix M2 is having higher split tensile strength than mix M1 & M3. The percentage increase in split tensile strength of mix M2 compared to controlled concrete at 3.58%, at 28, days respectively. The mix M7 (40%Flyash+20%GGBS+40%OPC)is giving good result in all the ages of curing and it is compared in high volume replacement category. Mix M7 is having higher split tensile strength than all other mixes in high volume replacement category that is M4, M5, M6, & M8. The percentage increase in split tensile strength of mix M7 compared to control concrete are 0.61% at 28, days respectively. . Mix M2 is having higher Split tensile strength is 3.35 N/mm2 and Mix M7 is having higher Split tensile strength is 3.25 N/mm2.M2(20%Flyash+20%GGBS+60%OPC) is giving good results in all ages of curing when it is compared with low volume replacement category. Mix M2 (the mixes with low volume replacement)

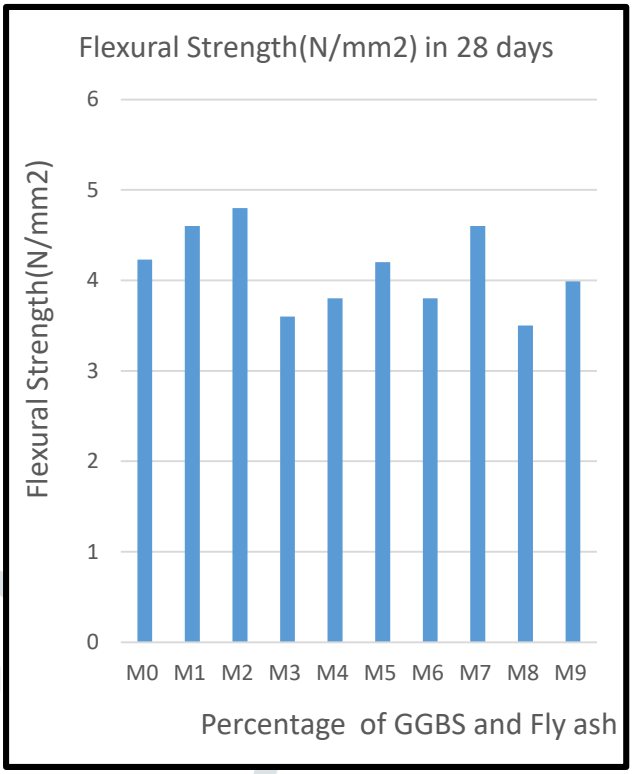
is having higher Split tensile strength as compare to Mix M7(the mixes with high volume replacement).

Flexural Strength

The test has been conducted after 28days of curing.

Flexural strength after 28 days curing for M30

MIX DESIGNATION	Description	Flexural trength (N/mm2) 28 days
M0	100% CEMENT + 0% FLY ASH + 0% GGBS	4.23
M1	60% CEMENT + 10% FLY ASH +30% GGBS	4.6
M2	60% CEMENT + 20% FLY ASH +20% GGBS	4.8
M3	60% CEMENT + 30% FLY ASH +10% GGBS	3.6
M4	40% CEMENT + 10% FLY ASH +50% GGBS	3.8
M5	40% CEMENT + 20% FLY ASH +40% GGBS	4.2
M6	40% CEMENT + 30% FLY ASH +30% GGBS	3.8
M7	40% CEMENT + 40% FLY ASH +20% GGBS	4.6
M8	40% CEMENT + 50% FLY ASH 10% GGBS	3.5
M9	50% CEMENT +25 % FLY ASH +25% GGBS	3.99



Flexural strength after 28 days curing for M30

From the Experiment, it was found that M2 (20% Flyash+20%GGBS+60%OPC) is giving good results in all ages of curing when it is compared with low volume replacement category. Mix M2 is having higher flexural strength than mix M1 & M3. The percentage increase in flexural strength of mix M2 compared to controlled concrete at 3.58%, at 28, days respectively. The mix M7 (40%Flyash+20%GGBS+40%OPC)is giving good result in all the ages of curing and it is compared in high volume replacement category. Mix M7 is having higher flexural strength than all other mixes in high volume replacement category that is M4, M5, M6, & M8. The percentage increase in flexural strength of mix M7 compared to control concrete are 0.61% at 28, days respectively. . Mix M2 is having higher flexural strength is 4.8 N/mm2 and Mix M7 is having higher flexural strength is 4.3 N/mm2.M2(20%Flyash+20%GGBS+60%OPC) is giving good results in all ages of curing when it is

compared with low volume replacement category. Mix M2 (the mixes with low volume replacement) is having higher flexural strength as compare to Mix M7 (the mixes with high volume replacement).

V CONCLUSION

- From the experiment it was fund that Incorporation of Fly ash and GGBS as a partial replacement of cement in concrete gives good results in both fresh and hardened state.
- MixM2(20%Flyash+20%GGBS+60%OPC) at In low volume replacement gives good workability and strength.
- MixM7(40%Flyash+20%GGBS+40%OPC) at In high volume replacement gives good workability and strength.
- From the experiment it was fund that low volume replacement mix M2 (20% Flyash+20% GGBS+60% OPC) is giving good result than high volume replacement Mix M7 (40%Flyash+20% GGBS+40% OPC) at all ages of curing.

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