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EXPERIMENTAL STUDY ON STRENGTH CHARACTERISTICS OF CONCRETE USING COMPOSITE MATERIALS

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Abstract: The utilization of supplementary cementitious materials is well accepted because of the several improvements possible in the concrete composites and due to the overall economy. 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 and Fly ash is a fine gray powder consisting mostly of spherical, glassy particles that are produced as a by-product in coal-fired power stations. Therefore, Cement with GGBS and Fly ash replacement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, cost savings, environmental and socio-economic benefits.

This research evaluates the strength gaining characteristics of hardened concrete by partially replacing cement by various percentages of GGBS and Fly ash for M25 grade of concrete at different ages.

In this paper our study is mainly confined to evaluation of changes in both compressive strength and weight reduction of cement in Seven different mixes of M25 Grade composite concrete by replacing 50% cement by GGBS and Fly ash in different proportions. The Compressive Strength and Split Tensile Strength of mixes are determined by these cubes and cylinders for 7days, 14days and 28 days and their respective compressive strength and split tensile strength had observed and up to major extent we can conclude concrete made by that Fly ash and GGBS had good strength and durable properties compared to conventional concrete.

***Index Terms* - Conventional Concrete, GGBS, Fly ash, Composite Material, Industrial byproducts.**

I. INTRODUCTION

INTRODUCTION TO CONCRETE

Concrete is widely used structural material consisting essentially of a binder and mineral filler. It has the unique distinction of being the only construction material actually manufactured on the site, whereas other materials are merely shaped to use at the worksite. Good or bad concrete is made from the same discrete materials like grains of sand, gravel or pieces of crushed rock and the innumerable fine particles of cement powder mixed with water.

Concrete is a composite material composed mainly of water, aggregate, and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily moulded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

INTRODUCTION TO GGBS

Concrete is probably the most extensively used construction material in the world with about six billion tones being produced every year. It is only next to water in terms of percapita consumption. However, environmental sustainability is at stake both in terms of damage caused by the extraction of raw material and CO2 emission during cement manufacture. This brought pressures on researchers for the reduction of cement consumption by partial replacement of cement by supplementary materials. These materials may be naturally occurring, industrial wastes or by-products that are less energy intensive. These materials (called pozzalonas) when combined with calcium hydroxide, exhibits cementitious properties. Most commonly used pozzalonas are fly ash, silica fume, metakaolin, Ground Granulated Blast Furnace Slag (GGBS). This needs to examine the admixtures performance when blended with concrete so as to ensure a reduced life cycle cost. There are competing reasons, in the long term, to extend the practice of partially replacing cement with waste by products and processed materials possessing pozzolanic properties. Lately some attention has been given to the use of natural pozzolans like GGBS as a possible partial replacement for cement. Amongst the various methods used to improve the durability of concrete, and to achieve high performance concrete, the use of GGBS is a relatively new approach, the chief problem is with its extreme finesse and high-water requirement when mixed with Ordinary Portland cement. The present paper focuses on investigating characteristics of M25 grade concrete with partial replacement of cement with GGBS by replacing cement via 30%, 40%, 50%. The cubes, cylinders and beams are tested for compressive strength, split tensile strength, flexural strength. Numerous works have been done researchers across the globe and some of the important contributions are presented here.

Ground Granulated Blast Furnace Slag

Typical chemical composition

The glass content of slag suitable for blending with Portland cement typically varies between 90- 100% and depends on the cooling method and the temperature at which cooling is initiated. The glass structure of the quenched glass largely depends on the proportions of network-forming elements such as Si and Al over network-modifiers such as Ca and Mg to a lesser extent Al. Increased amounts of network-modifiers lead to higher degrees of network DE polymerization and reactivity. It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fineness, and hydrates like Portland cement.

Table 1.1 CHEMICAL COMPOSITION

S No	Chemical formula	Percentage
1	CaO	30-45%
2	SiO2	17-38%
3	Al2O3	15-25%
4	Fe2O3	0.5-2.0%
5	MgO	4.0-17%
6	MnO2	1.0-5%
7	Glass	85-98%

TYPICAL PHYSICAL PROPERTIES

Color: Off white

Specific gravity: 2.9

Bulk density: 1200 kg/m3

Fineness: 350 kg/m.

INTRODUCTION TO FLY ASH

Fly ash also known as pulverized fuel ash and is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash. In modern coal fired power plants, fly ash is generally captured by electro static precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and composition of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

Flyash

It is of 2 types

Class F

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 7% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime-mixed with water to react and produce cementitious compounds. Alternatively, adding a chemical activator such as sodium silicate to a Class F ash can form a geopolymer.

Class C

Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash hardens and gets stronger over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not required an activator. Alkali and sulphate (SO4) contents are generally higher in class C flyash.

Experimental details:

Unit weight of Flyash = 1.33gm/cu.cm

Specific gravity of Flyash = 2.17

MIX DESIGN OF M25GRADE CONCRETE

Grade designation	M25
Type of cement	0PC 53 grade
Maximum nominal aggregate	20mm
Minimum water content	194.37Kg/m^3
Maximum water cement ratio	0.427
Workability-Slump Compacting factor	50 m 0.9
Exposure conditions	Moderate
Type of aggregate	Crushed angular

Test Data for Materials	
Cement used	JP cement OPC
Specific gravity of cement	3.05
Specific gravity of water	1.00
Specific gravity of aggregate	2.74
Specific gravity of sand	2.73

Target Strength for Mix Proportioning	
Target mean strength: $f_{ck}' = f_{ck} + txs = 25+1.65x5.3$	33.74 /mm^2
Characteristic Strength at 28 days	25 /mm^2
Maximum water cement ratio	0.427
Adopted water cement ratio	0.427
Maximum water content	194.37 it
Estimated water content for 50-75 mm	194.37 it
Calculation of cement content	
Water cement ratio	0.427
Cement content	455.199 kg

MATERIALS UTILIZED FOR M25GRADE

Mix proportions for one cum of concrete	
Mass of Cement in kg/m3	455.199 Kg
Mass of Water in kg/m3	194.37lit
Mass of Fine Aggregate in kg/m3	550.083Kg
Mass of Coarse Aggregate in kg/m3	1138.31 Kg
Water Cement Ratio	0.427

Table 4.1

Mix M25	Cement	Fine aggregate	Coarse aggregate	Water
Weight	455.199	550.083	1138.31	194.37
Ratio	1	1.208	2.5	0.427

Mix Proportion: Cement: Fine aggregate: Coarse aggregate = **1:1.2:2.5**

GGBS AND FLYASH

A different percentage varying from 10% to 50% of weight of cement is replaced with GGBS and Fly ash to improve the strength and other properties.

Different percentage weights of GGBS and FLYASH

Percentage of GGBS added	Weight in Kg/m^3	Percentage of Fly ash added	Weight in Kg/m^3
0%	0	0%	0%
50%	14	0%	0
40%	11.2	10%	2.8
30%	8.4	20%	5.6
20%	5.6	30%	8.4
10%	2.8	40%	11.2
0%	0	50%	14
TOTAL	**42**		**42**

CEMENT

Remaining weight of Cement for different percentages of GGBS and Flyash

Weight of CEMENT for different percentages of GGBS and Flyash

Percentage of GGBS added	GGBS Weight in Kg/m^3	CEMENT Weight in Kg/m^3	Percentage of Flyash added	Flyash Weight in Kg/m^3
0%	0	28	0%	0
50%	14	14	0%	0
40%	11.2	14	10%	2.8
30%	8.4	14	20%	5.6
20%	5.6	14	30%	8.4
10%	2.8	14	40%	11.2
0%	0	14	50%	14
TOTAL	**42**	**112**		**42**

Weight materials

Material	Weight in kg/m3
Fine aggregate	238
Coarse aggregate	490
Water	84

5Specific gravity of different materials

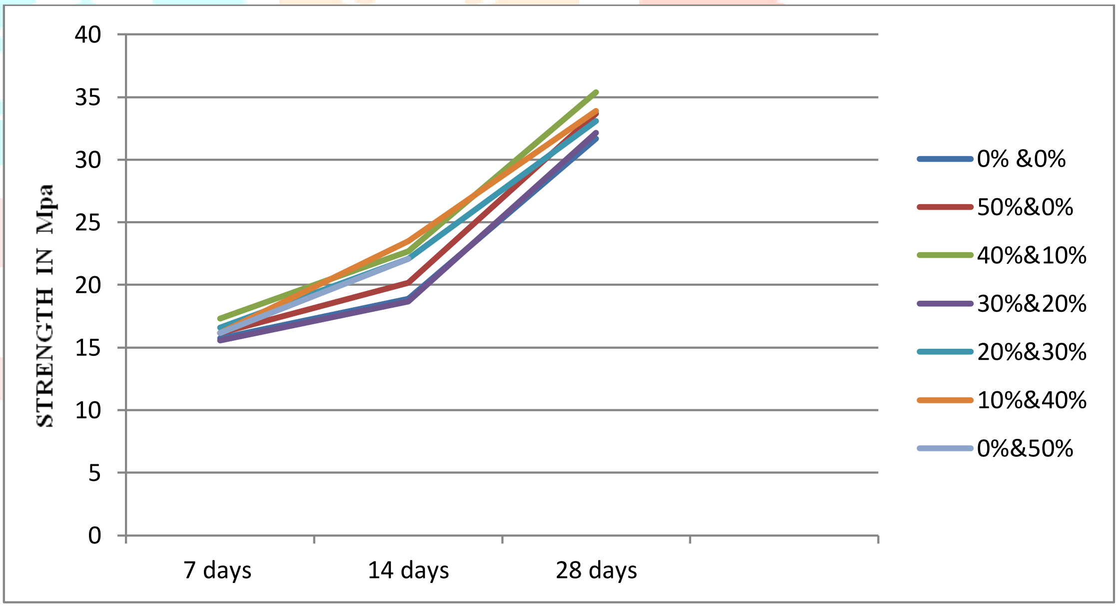
Material	Specific gravity
GGBS	2.85
Flyash	2.17
Cement	3.05
Fine Aggregate	2.73
Coarse Aggregate	2.74

Percentage In Increase Of Compressive Strength In N/mm^{2}Of Concrete With GGBS And Flyash With Respect To Conventional Concrete

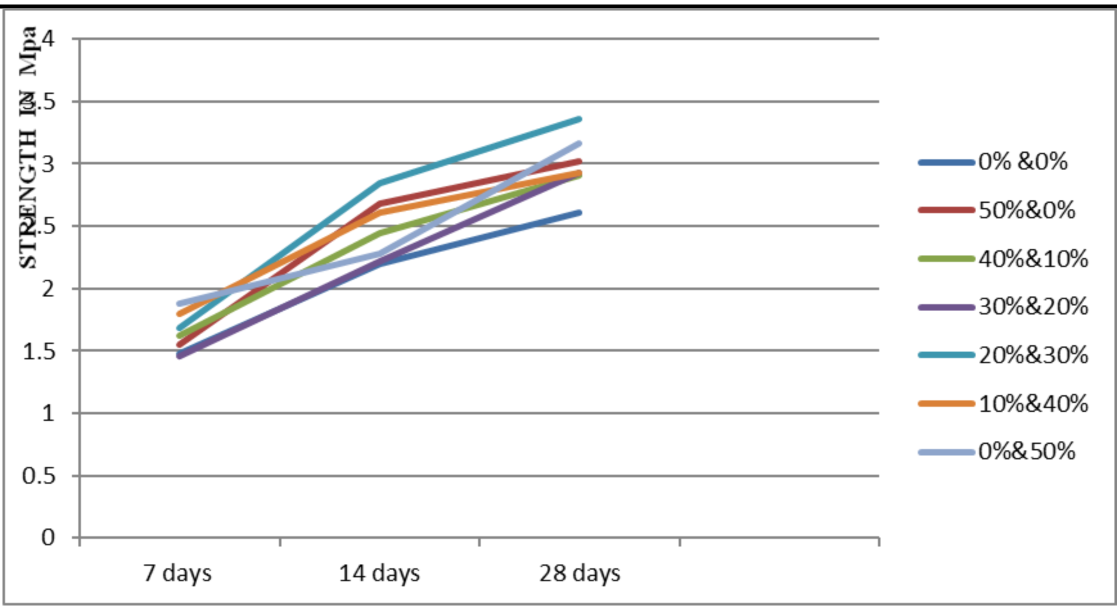
S. No	% of GGBS	% of FLYASH	Compressive strength N/mm2			% increase			% decrease		
			7 days	14 days	28 days	7 Days	14 days	28 days	7 days	14 days	28 days
1	0%	0%	15.72	18.9	31.7	-	-	-	-	-	-
2	50%	0%	16.15	20.15	33.7	2.73	6.62	6.3	-	-	-
3	40%	10%	17.33	25.7	35.4	10.24	20.10	11.67	-	-	-
4	30%	20%	15.55	18.66	32.15	-	-	1.41	1.08	1.26	-
5	20%	30%	16.59	20.07	33.1	5.53	16.77	4.41	-	-	-
6	10%	40%	16.15	23.5	33.9	2.73	24.33	6.94	-	-	-
7	0%	50%	16.15	22.07	32	2.73	16.77	0.94	-	-	-

Percentage Increase of Spilt Tensile Strength In N/mm2 Of Concrete with GGBS And Flyash with Respect to Conventional Concrete

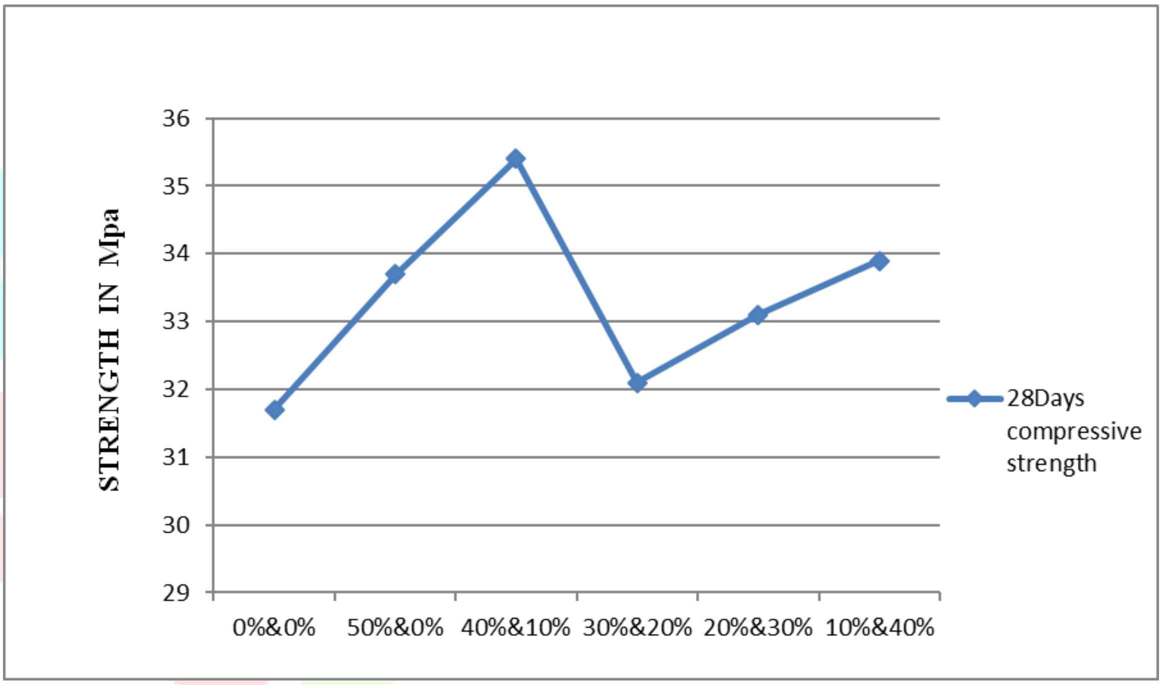
S. No	% of GGBS	% of FLYASH	Split tensile strength N/mm2			% increase			% decrease		
			7 days	14 days	28 days	7 Days	14 days	28 days	7 days	14 days	28 days
1	0%	0%	1.48	2.2	2.61	-	-	-	-	-	-
2	50%	0%	1.55	2.68	3.02	4.73	21.8	15.7	-	-	-
3	40%	10%	1.62	2.44	2.91	9.46	10.9	11.5	-	-	-
4	30%	20%	1.46	2.22	2.93	-	0.9	12.3	0.81	-	-
5	20%	30%	1.68	2.84	3.36	13.51	29.09	28.7	-	-	-
6	10%	40%	1.80	2.61	2.92	21.62	18.63	12.3	-	-	-
7	0%	50%	1.88	2.28	3.16	27.02	3.63	21	-	-	-



Compressive Strength of Concrete



Split Tensile Strength of Concrete



Compressive Strength At 28 Days

Testing Specimen of cylinder

Specimen after testing

Testing Specimen of cube

Specimen after testing

CONCLUSION

- The plain cement concrete prepared by OPC cement and natural sand of M25 grade. The maximum compressive strength achieved is 35.4Mpa at 40% of GGBS and 10% of FLYASH replacement and those achieved for 50% 0f GGBS and 0% FLYASH,20%GGBS and 30% FLYASH of concrete is 33.7Mpa, 33.1Mpa respectively as compare to 31.7Mpa of strength of plain cement concrete for 28 days.
- The tensile strengths achieved are 2.61Mpa, 3.02Mpa, 2.91Mpa, 2.93Mpa, 3.36Mpa, 2.92Mpa, 3.16Mpa at 0%&0%, 50%&10%, 40%&20%, 30%&20%, 20%&30%, 10%&40%, and 0%&50% for GGBS and FLYASH concrete respectively for M25 grade concrete of OPC cement and natural sand.
- The compressive strength at 28 days for 40% GGBS and 10% FLYASH replacement indicated increase in strength compared to conventional concrete.
- The percentage increase of strength with respect to conventional concrete was 11.67% at 28 days for 40%GGBS and 10% FLYASH replacement.
- The tensile strength at 28 days for 20% GGBS and 30% FLYASH replacement indicated increase in strength compared to conventional concrete.
- The percentage increase of strength with respect to conventional concrete was 28.73% at 28 days for 20% GGBS and 30% FLYASH replacement
- GGBS and FLYASH is used to make durable concrete structures in combination with ordinary Portland cement and /or other pozzolanic materials.

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