EFFECT OF STRENGTH PARAMETERS IN CONCRETE USING DOUBLE BLENDING FLYASH AND GGBS

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Abstract:* Concrete which meets special performance and uniformity requirements that cannot always be achieved by conventional materials, normal mixing, placing and curing practices. Special performance requirements using conventional materials can be achieved only by adopting low water binder ratio, which necessitate the use of high cement content. But the addition of chemical and mineral admixtures can reduce the cement content and this result in the economical HPC. The effect of a mineral admixture on the strength of concrete varies significantly with its properties and replacement levels. The use of mineral admixtures (Fly ash and GGBS) in concrete production improves the compressive strength, pore structure, and permeability of the concrete this is attributed to the pozzolanic reaction. This approach will have the potential to reduce costs, conserve energy, and waste minimization. In this experimental investigation the strength properties of concrete for M40 grade concrete at various replacement levels of Fly ash and GGBS (20%, 30%, 40%) was done. The effect of variation in strength parameters i.e., Compressive Strength, Split Tensile Strength and Flexural Strength were studied for different replacement proportions was done. The test results showed that higher tensile strength and flexural strength than conventional concrete and almost same compressive strength as conventional concrete.
Keywords: Fly ash, GGBS, Cement, Strength Comparison.

I. INTRODUCTION

Concrete is the key material used in various types of construction, from the flooringt to a multi-storied high rise structures form pathway to airport runway, from an underground tunnel and deep sea platform to high-rise chimneys and TV Towers. In the last millennium concrete has demanding requirements both in terms of technical performance and economy while greatly varying from architectural masterpiece to the simplest of utilities. It is the most widely used construction material of construction which is as versatile as concrete. Concrete is one of the versatile heterogeneous materials, civil engineering has ever known. With the advent of concrete civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be cast and with equal strength or rather more strength than the conventional building stones. It is the material of choice where strength, permanence, durability, impermeability, fire resistance and abrasion resistance are required. Cement concrete is one of the seemingly simple but actually complex materials. The properties of concrete mainly depend on the constituents used in concrete making. The main important material used in making concrete is cement, sand, crushed stone and water. Even though the manufacturer guarantees the quality of cement, it is difficult to produce a fault proof concrete. It is because of the fact that the building material is concrete and not only cement. The properties of sand, crushed stone and water, if not used as specified, cause considerable trouble in concrete. In addition to this workmanship, quality control and methods of placing also plays the leading role on the concrete properties.

1.1 HIGH PERFORMANCE CONCRETE

Concrete is considered as durable and strong material. Reinforced concrete is one of the most popular materials used for construction around the world. Reinforced concrete is exposed to deterioration in some regions especially in coastal regions. There for researchers around the world are directing their efforts towards developing a new material to overcome this problem. Invention of large construction plants and equipments around the world added to the increased use of material. This scenario led to the use of additive materials to improve the quality of concrete. As an outcome of the experiments and researches cement based concrete which meets special performance with respect to workability, strength and durability known as" High Performance Concrete" was developed.

1.2 ADVANTAGES OF USING HPC

The advantages of using high strength HPCs often balance the increase in material cost. The following are the major advantages that can be accomplished.

- Increase in Girder spans.
- Increasing the spacing between girders.
- Permeability of concrete decreased (increased durability).
- Further, it is predicted that an HPC girder would not require web shear reinforcement except for an amount required to connect the cast-in-place deck slab to the girder.
- Reduction in member size, resulting in increase in plinth area or useable area and direct savings in the concrete volume saved.
- High strength allows the use of smaller columns and, therefore, a reduction in weight and, hence, a lower load on the foundation.
- Reduction in the self-weight and super-imposed dead load with the accompanying saving due to

smaller foundations.

- Reduction in form-work area and cost with the accompanying reduction in shoring and stripping time due to high early-age gain in strength.
- Reduced axial shortening of compression supporting members.
- Reduction in the number of supports and the supporting foundations due to the increase in spans.
- Superior long term service performance under static, dynamic and fatigue loading.
- Low creep and shrinkage.
- Greater stiffness as a result of a higher modulus.
- Higher resistance to freezing and thawing, chemical attack, and significantly improved long-term durability and crack propagation.
- Smaller depreciation as a fixed cost.

High Performance Concrete (HPC) is widely used as a construction and repair material in the civil infrastructure.

II. MATERIALS AND THEIR PROPERTIES

2.1 FLY ASH

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases. Fly ash is produced by coal-fired electric and steam generating plants.Typically, coal is pulverized and blown with air into the boiler's combustion chamber where it immediately ignites, generating heat and producing a molten material residue. Boiler tubes extract heat from the boiler, cooling the flue gas and causing the molten mineral residue to harden and form ash. Coarse ash particles, referred to as bottom ash or slag,fall to the bottom of the combustion chamber, while the lighter fine ash particles, termed as fly ash, remain suspended flue gas. The technical benefits of fly ash in concrete such as improved workability, decreased water demand, reduced heat of hydration, increased ultimate strength, reduced permeability.

Constituents	Indian Flyash	Cement
SiO_2	49-67	17-25
Al_2O_3	16-33	3-8
Fe_2O_3	4-10	0.5-6
CaO	1-4	60-65
MgO	0.2-2.0	0.5-4
SO_3	0.1-2.0	1-2
Na_2O	0.1-0.2	0.5
K_2O	0.1-1.0	0.5
LOI	0.1-16	1-3

2.2 PROPORTIONING OF FLYASH CONCRETES

Using of Flyash in concrete has to meet one or more of the following objectives.

- Reduction in cement content,
- Reduced heat of hydration,
- Improved workability,
- Gaining levels of strength in concrete beyond 90 days of testing.

2.3 GGBS (GROUND GRANULATED BLAST FURNACE SLAG)

Ground granulated blast furnace slag is by-product from the blast furnaces used to make iron. These operate at a temperature of 1500°C and are fed with a carefully controlled mixture of iron ore, coke and lime stone. The iron-ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be usedfor the manufacture of GGBS it has to be rapidly quenched in large volumes of water.

TYPICAL CHEMICAL COMPOSITION		TYPICAL PHYSICAL PROPERTIES	
Calcium oxide	40%	Colour	Off-white
Silica	35%	Relative gravity	2.9
Alumina	13%	Bulk density	1200kg/m^3
Magnesia	8%	Fineness	>350m^2/kg

Strength gain in GGBS concrete:

- With the same content of cementitious material (the total weight of Portland cement + GGBS), similar 28 days strengths to Portland cement will normally be achieved when using up to 50% GGBS. At higher GGBS percentages the cementitious content may need to be increased to achieve equivalent 28 day strength.
- GGBS concrete gains strength more steadily than equivalent concrete made with Portland cement. For the same 28 day strength, a GGBS concrete will have lower strength at early ages but its long-term strength will be greater. The reduction in early-strength will be most noticeable at high GGBS levels and low temperatures.
- Typically a Portland cement concrete will achieve about 75% of its 28 day strength at seven days, with a small increase of 5-10% between 28 and 90 days. By comparison, a 50% GGBS concrete will typically achieve about 45-55% of its 28 day strength at 7 days, with a gain of between 10-20% from 28-90 days. A 70% GGBS, the 7day strength would be typically around 40-50% of the 28 day strength, with a continued strength gain of 15-30% from 28-90 days.
- Under normal circumstances, concretes with upto 70% GGBS will achieve sufficient strength within one day of casting to allow removal of vertical formwork without mechanical damage. At high GGBS percentages, extra care should be taken with thin sections poured during winter conditions when the concrete hardening may have been affected by the cold ambient air.

2.4 CEMENT

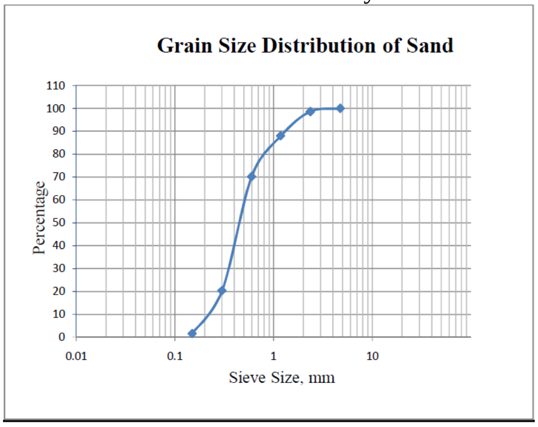
Ordinary Portland cement 53 grade brand conforming to I.S.I standard is used in the present investigation. The cement is tested for its various properties as per IS code. The results on cement are shown

TYPICAL CHEMICAL COMPOSITION		TYPICAL PHYSICAL PROPERTIES	
Calcium oxide	40%	Colour	Off-white
Silica	35%	Relative gravity	2.9
Alumina	13%	Bulk density	1200kg/m^3
Magnesia	8%	Fineness	>350m^2/kg

2.5 FINE AGGREGATE

The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386-1963(28).

Grain size distribution of sand shows that it is close to the zone III of IS 383-1970(29). The properties of sand are shown in table 3.6. Details of sieve analysis are shown



Grain size distribution of sand

S.No	Property	Fine Aggregate
1.	Specific gravity	2.68
2.	Density	1640 kg/m³
3.	Fineness Modulus	2.78

properties of fine aggregate

S.No	I.S.Sieve Size	Weight Retained	Percentage Weight Retained	Cumulative Percentage Weight Retained	Percentage of passing
1	4.75mm	30.30	1.50	1.50	98.50
2	2.36mm	40.00	2.00	3.50	96.50
3	1.18mm	324.20	16.21	19.71	80.29
4	600µ	822.00	41.10	60.81	39.19
5	300 µ	664.00	33.20	94.01	5.99
6	150 µ	106.00	5.30	99.31	0.69
	Total	2000		278.04	

Fineness modulus =2.78

sieve analysis for fine aggregate sample- 2000gms

2.6 COARSE AGGREGATE

Machine crushed angular granite metal from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties. The specific gravity and fineness modulus of coarse aggregate are 2.64, 7.14 respectively. The bulk density of coarse aggregate is 1700 kg/m³. The details are tabulated in table . Sieve analysis is carried out ant grading results are shown,

S.No	Property	Coarse Aggregate
1.	Specific Gravity	2.64
2.	Density	1600kg/m³
3.	Fineness Modulus	7.14

2.7 GLENIUM B233

GLENIUM B233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in HPC where the highest durability and performance is required. GLENIUM B233 is free of chloride and low alkali. It is compatible with all types of cements. Advantages of superplasticizer are:

- Elimination of vibration and reduced labour cost in placing.
- Marked increase in early & ultimate strengths
- Higher E modulus.
- Improved adhesion to reinforcing and stressing steel.
- Better resistance to carbonation and other aggressive atmospheric conditions.

GLENIUM B233 consists of a carboxylic ether polymer with long side chains. At the beginning of the mixing process it initiates the same electrostatic dispersion mechanism as the traditional superplasticisers, but the side chains linked to the polymer backbone generates a steric hindrance which greatly stabilises the cement particles ability to separate and disperse. Steric hindrance provides a physical barrier (alongside the electrostatic barrier) between the cement grains. With this process, flowable concrete with greatly reduced water content is obtained. The optimum dosage of SP should be determined with trial mixes.

III. MIX DESIGN

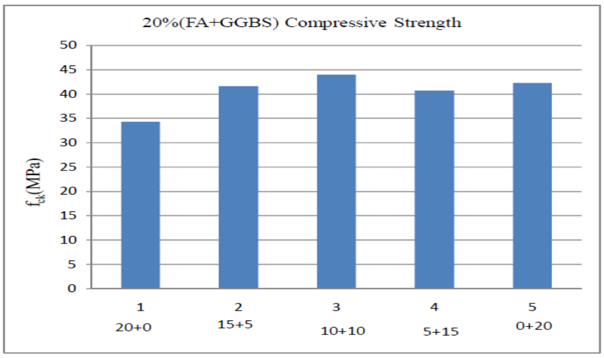
W/C	CEMENT	F.A	C.A
0.35	1	1.69	1.88

IV. RESULTS AND DISCUSSIONS

Compressive strength :

SI.NO.	PROPORTIONS OF FA&GGBS		COMPRESSIVE STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	44.7
2	20	0	34.3
3	15	5	41.6
4	10	10	44.0
5	5	15	40.7
6	0	20	42.3

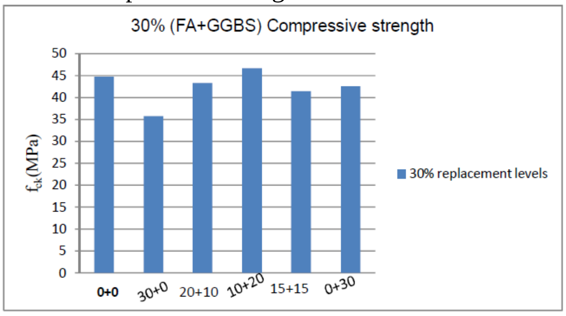
Compressive strength of M40 concrete



28 days compressive strength results for M40 grade concrete by 20% replacement

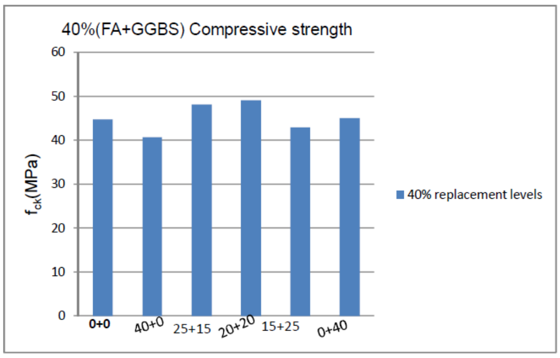
SI.NO.	PROPORTIONS OF FA&GGBS		COMPRESSIVE STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	44.7
2	30	0	35.7
3	20	10	43.3
4	10	20	46.6
5	15	15	41.4
6	0	30	42.6

Compressive strength of M40 concrete



28 days compressive strength results for M40 grade concrete by 30% replacement

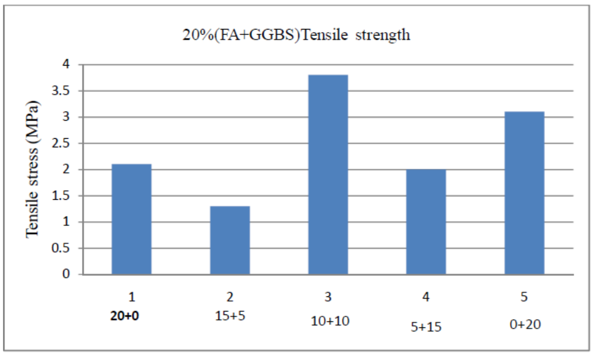
SI.NO.	PROPORTIONS OF FA&GGBS		COMPRESSIVE STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	44.7
2	40	0	40.6
3	25	15	48.1
4	20	20	49
5	15	2	42.9
6	0	40	45



28 days compressive strength results for M40 grade concrete by 40% replacement

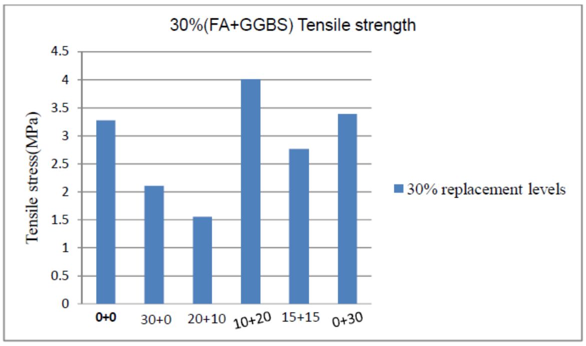
Split tensile strength:

SI.NO.	PROPORTIONS OF FA&GGBS		SPLIT TENSILE STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	3.28
2	20	0	2.1
3	15	5	1.3
4	10	10	3.8
5	5	15	2.0
6	0	20	3.1



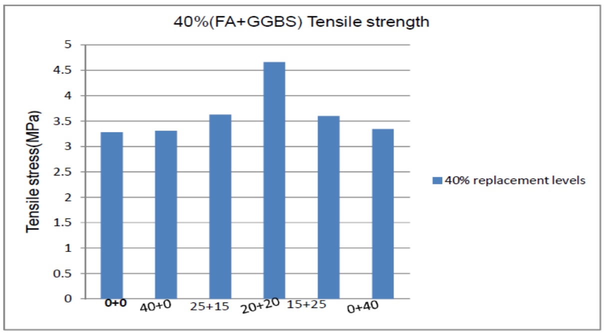
28 days split tensile strength results for M40 grade concrete by 20% replacement

SI.NO.	PROPORTIONS OF FA&GGBS		SPLIT TENSILE STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	3.28
2	30	0	2.11
3	20	10	1.55
4	10	20	4.01
5	15	15	2.77
6	0	30	3.39



28 days split tensile strength results for M40 grade concrete by 30% replacement

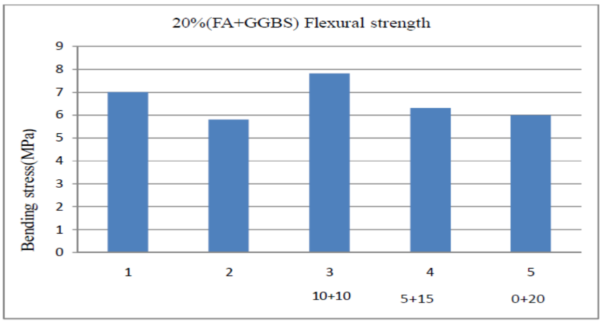
SI.NO.	PROPORTIONS OF FA&GGBS		SPLIT TENSILE STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	3.28
2	40	0	3.31
3	25	15	3.63
4	20	20	4.66
5	15	25	3.60
6	0	40	3.34



28 days split tensile strength results for M40 grade concrete by 40% replacement

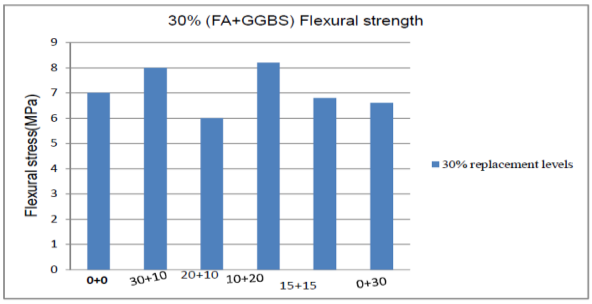
Flexural strength:

SI.NO.	PROPORTIONS OF FA&GGBS		FLEXURAL STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	7
2	20	0	7
3	15	5	5.8
4	10	10	7.8
5	5	15	6.3
6	0	20	6



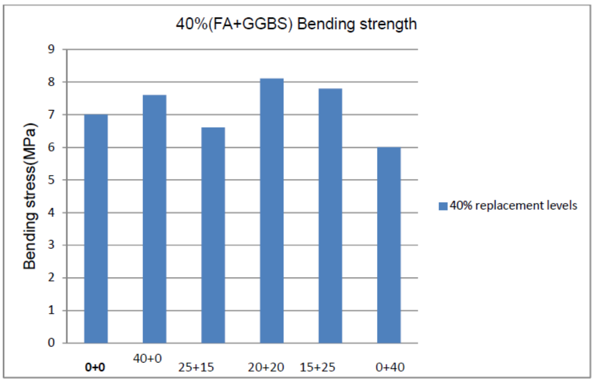
28 days split tensile strength results for M40 grade concrete by 20% replacement

SI.NO.	PROPORTIONS OF FA&GGBS		FLEXURAL STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	7
2	30	0	8
3	20	10	6
4	10	20	8.2
5	15	15	6.8
6	0	30	6.6



28 days split tensile strength results for M40 grade concrete by 30% replacement

SI.NO.	PROPORTIONS OF FA&GGBS		FLEXURAL STRENGTH(MPa) 28 DAYS
	F.A	GGBS	
1	0	0	7
2	40	0	7.6
3	25	15	6.6
4	20	20	8.1
5	15	25	7.8
6	0	40	6.0



28 days split tensile strength results for M40 grade concrete by 40% replacement

V. CONCLUSIONS

Based on the extensive experimental investigations carried out on the Fly ash and GGBS as the partial replacements in the cement the fallowing conclusion has been drawn.
It is observed that the

- Replacements of cement (20%) by Fly Ash and GGBS with individual proportions of (10+10)% (Fly Ash+GGBS) respectively increases the Compressive Strength, Flexural Strength and Split Tensile Strength of concrete about 1.56 %,11.42 %, 15.85 % respectively at 28 days strength.
- Replacements of cement (30%) by Fly Ash and GGBS with individual proportions of (10+20)% (Fly Ash+GGBS) respectively increases the Compressive Strength, Flexural Strength and Split Tensile Strength of concrete about 4.25 %,17.14 %, 22.25 % respectively at 28 days strength.
- Replacements of cement (40%) by Fly Ash and GGBS with individual proportions of (20+20)% (FlyAsh+GGBS) respectively increases the Compressive Strength, Flexural Strength and Split Tensile Strength of concrete about 9.61 %,15.71 %, 42.07 % respectively at 28 days strength.

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