STUDY ON HIGH PERFORMANCE DOUBLE BLEND CONCRETE WITH SUPPLEMENTRY CEMENTITIOUS MATERIAL

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Abstract - *The industrial by-products used as cement replacement materials were ground granulated blast furnace slag, silica fume.. Lot of works focus on the supplementary cementitious materials used as cement replacement material in concrete. In addition we add sisal fiber for increase the tensile strength of concrete .The limited studies that had been carried out show that the GGBS, silica fume was used as cement replacement material in concrete. Limited studies had been carried out on the durability studies of concrete using GGBS, silica fume, Sisal fibre. In the test we mix conventional concrete with GGBS in three proportions (45%.55%,65%) and Conventional concrete with silica fume in (5%,10%,15%)And we get the optimum value of these two cementitious material of GGBS, Silica fume and finally we blend with sisal fiber at (1%) then find out the maximum strength of double blend concrete then conventional concrete.*

Key Words: **Cement, GGBS, Silica Fume, Sisal Fibre, Double Blend Concrete**

1. INTRODUCTION

Nowadays high-strength and high-performance concrete are widely used throughout the world and to produce them it is necessary to reduce the water/binder ratio and increase the binder content. Super plasticizers are used in these concretes to achieve the required workability; moreover, different kinds of cement replacement materials are usually added to them because a low porosity and permeability are desirable. Mineral admixtures such as ground granulated blast furnace slag (GGBS), fly ash and silica fume are commonly used in concrete because they improve durability and reduce porosity; improve the interface with the aggregate. Economics (lower cement requirement), energy and environmental considerations have had a role in the mineral admixture usage as well as better engineering and performance properties. The lower cement requirement also leads to a reduction for CO2 generation by the production of cement. Granulated blast-furnace slag is a by-product in the manufacture of pig iron and the amounts of iron and slag obtained are of the same order. The slag is a mixture of lime, silica, and alumina, the same oxides that make up Portland cement, but not in the same proportion. The composition of blast-furnace slag is determined by that of the ores, fluxing stone and impurities in the coke charged into the blast furnace. Typically, silicon, calcium, aluminum, magnesium, and oxygen constitute 95% or more of the blast-furnace slag. To maximize hydraulic (cementitious) properties, the molten slag must be chilled rapidly as it leaves the blast furnace.
Silica fume is the one of the most popular pozzolanas, whose addition to concrete mixtures results in lower porosity, permeability and bleeding because their oxides (SiO2) react with and consume calcium hydroxides, which are produced by the hydration of ordinary Portland cement. The main results of pozzolanic reactions are: lower heat liberation and strength development; lime-consuming activity; smaller pore size distribution. In high-performance concrete, which contains high quality and expensive materials, cracking provides the greatest concerns for the designers because harmful materials can penetrate from them to the concrete easily and start to destroy it and also corrode reinforcement. Some of these cracks are related to drying and autogenous shrinkage of concrete. Therefore, to improve the durability of high-strength concrete, its autogenous and drying shrinkage should be addressed and necessary work on its mix design should be done to minimize them. It is worth noting that autogenous shrinkage of concrete is because of chemical reactions during the hydration of cementitious materials; nevertheless, drying shrinkage occurs as a result of moisture movement from concrete to the atmosphere.

High-performance concrete should be controlled during its early ages. For instance, fresh concrete may bleed or coarse aggregates may separate from the paste. Also its volume changes at this age are very important. Of course before initial set, concrete has plastic properties and has high-tension strain capacity; consequently, the possibility of cracking in it is low. However, shrinkage at this age may weaken the transition zone between aggregates and paste, thus drying shrinkage cracking may increase in future. Therefore it is very sensitive to shrinkage cracks.

2. MATERIAL INVESTIGATION

2.1 Cement

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and many plasters. English masonry worker Joseph Aspdin patented Portland cement in 1824. It was named because of the similarity of its color to Portland limestone, quarried from the English Isle of Portland and used extensively in

London architecture. It consists of a mixture of calcium silicates (alite, belite), aluminates and ferrites - compounds which combine calcium, silicon, aluminium and iron in forms which will react with water. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay and/or shale (a source of silicon, aluminium and iron) and grinding this product (called clinker) with a source of sulfate (most commonly gypsum).The physical properties of cement are given in Table1.

Table -1: Physical Properties of Cement (OPC 43 GRADE)

Sl. No	Property	Value
1	Specific gravity	3.24
2	Standard consistency	30 %
3	Initial setting time	75 min
4	Final setting time	500 min

2.2 Aggregates

Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel, and crushed stone are used mainly for this purpose. Recycled aggregates (from construction, demolition, and excavation waste) are increasingly used as partial replacements for natural aggregates, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted.. The physical properties of fine aggregate and coarse aggregates are shown in Table 2 & Table 3.

Table -2: Physical Properties of Fine aggregate

Sl. No	Description	Quantity
1	Specific gravity	2.63
2	Water absorption (%)	1.2
3	Bulk density(kg/m^3)	1487.18
4	Fineness modulus	3.041

Table -3: Physical Properties of Coarse aggregate

Sl. No	Description	Quantity
1	Specific gravity	2.6
2	Water absorption (%)	1.65
3	Bulk density(kg/m^3)	1518.5
4	Fineness modulus	4.083

2.3 Ground granulated blast furnace slag (GGBS)

GGBS obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam to produce a glassy granular product that is dried and ground into a fine powderComponents of GGBS are CaO(30%-50%), SiO_2(28%-38%), AL_2O_3(8%-24%), MgO(1%-18%). The physical properties GGBS are shown in Table 4

Table -4: Physical Properties of GGBS

Sl. No	Description	Quantity
1	Specific gravity	400 – 600 m^2/kg
2	pH	9 -11
3	Bulk density(kg/m^3)	1.0 – 1.11
4	Particle size	0.1 – 40 µ

2.4 Silica fume

Silica fume is also known as micro silica, it's an ultrafine powder collected as a by-product of the silicone and ferrosilicon alloy production and consists of spherical particles with an average particle diameter is 150mm. The main field of application is a pozzolanic materials for high performance concrete. The physical properties Silica fume are shown in Table 5

Table -5: Physical Properties of Silica Fume

Sl. No	Description	Quantity
1	Specific Gravity	2.2
2	Particle size	0.2 micron
3	Specific area(cm^2/gm)	150000
4	Bulk density(lb/ft^3)	8 to 27

2.5 Sisal Fibre

Sisal is a hard fibre extracted from the leaves of sisal plant which are perennial succulents that grow best in hot and dry areas. Sisal is an environmentally friendly fibre as its biodegradeble and almost no pesticides or fertilizers are used in its cultivation. The physical properties sisal fibre are shown in Table 6

Table -6: Physical Properties of Sisal Fibre

Sl.No	Description	Quantity
1	Density (gm/cm^3)	1.5
2	Elongation (%)	2.0 -2.5

3	Tensile strength (MPa)	511 – 635
4	Young's Modulus	9.4

3. MIX PROPORTIONING

The experimental program was designated to study the mechanical properties of concrete with replacement of GGBS, silica fume in cement and addition of sisal fibre in cement for M30 grade of concrete. The compressive, flexural and split tensile strength of the specimens after the replacement of GGBS, silica fume in cement and addition of sisal fibre in cement for M30 grade of concrete is studied after 7 & 28 days of curing. For the test specimen 43 grade of ordinary Portland cement, Natural River sand and coarse aggregate, GGBS, silica fume, sisal fibre is being utilized. The maximum size of the coarse aggregate was limited to 20mm.

The mix proportion based on IS 10262 (2009) arrived for M30 grade of concrete using the above materials is given in the Table 7

Table -7: Mix Proportion for W/C 0.4

Sl.No	Materials	Quantity
1	Cement (kg/m^3)	350
2	Sand (kg/m^3)	730.49
4	Coarse aggregate (kg/m^3)	1270.49
5	Water (l/m^3)	140
6	Super plasticizer (%)	1

4. EXPERIMENTAL SCHEME

A total of 60 specimens of cubes,30 specimens of beams and 30 specimens of cylinders were prepared and tested for its compressive strength at 7 & 28 days ,flexural and split tensile strength at 28 day using 100mm×100mm×100mm cube, 500mm×100mm×100mm beam and 200mm×100mm diameter cylinder specimens after proper curing..

5. TESTING OF SPECIMENS

5.1 Compressive Strength

Compression test were performed on samples made during at various curing ages. As discussed above a targeted compressive strength was used for this study. Results from compression strength tests performed. Here cube samples of size 100mm×100mm×100mm, were prepared and tested at 7and 28 days of curing in water under controlled lab conditions.

5.2 Tensile Strength

Split tensile test were performed on samples made during at curing ages. As discussed above a targeted split tensile strength was used for this study. Results from split tensile strength tests performed. Here beam samples of size 200mm×100mm, were prepared and tested at 28 days of curing in water under controlled lab conditions.

5.3 Flexural Strength

Flexural test were performed on samples made during at various curing ages. As discussed above a targeted flexural was used for this study. Results from flexure strength tests performed. Here samples of size 500mm×100mm×100mm, were prepared and tested at 7and 28 days of curing in water under controlled lab conditions.

6. RESULT AND DISCUSSION

6.1 Compressive Strength

Totally 6 concrete cubes were casted for each percentage of replacement and it is allowed for 7 days and 28 days curing. After drying, cubes were tested in Compression Testing Machine (CTM) to determine the ultimate load. Replacement made for cement by using GGBS (45%,55%,65%) and silica fume (5%,10%,15%) and double blend (55% GGBS and (5%,10%,15%) silica fume with addition of sisal fibre 1%) For this study the water cement ratio of 0.4 is maintained uniformly.

The results of compressive strength obtained for the concrete mixes contain different proportions of GGBS and silica fume and sisal fibre presented. The compressive strength of all the mixes are been observed.

Table -8: Compressive Strength for Various Concrete Mixes (MPa)

Mix designation	w/c 0.4	
	7 days	28 days
Control mix	20.1	31.4
GGBS 45 %	21.6	28.08
GGBS 55 %	25.61	32.03
GGBS 65 %	25.08	29.76
Silica fume 5%	22.57	36.47
Silica fume 10%	34.32	46.80
Silica fume 15%	32.42	41.24

Table 8 shown the compressive strength for various concrete mixes for w/c 0.4

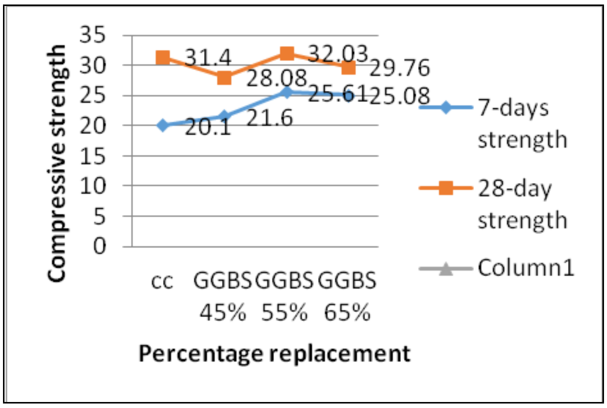

Chart -1: compressive strength of GGBS for various concrete mixes at 7 & 28 days

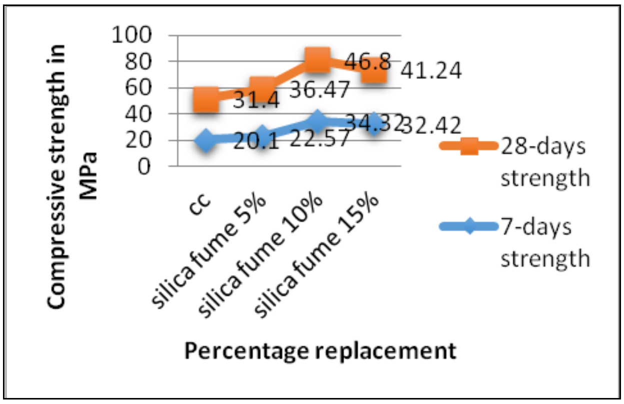

Chart -2: compressive strength of silica fume for various concrete mixes at 7 & 28 days

Table 9 shown the compressive strength for double blend mix for w/c 0.4

Table -9: Compressive Strength For Double Blend Mix (MPa)

Mix designation	w/c 0.4	
	7 days	28 days
GGBS (55%), SF(5%), Sisal(1%)	17. 14	41.3
GGBS (55%), SF(10%), Sisal(1%)	23. 27	46.32
GGBS (55%), SF(15%), Sisal(1%)	19. 35	44.2

6.2 Split Tensile Strength

Totally3 concrete cylinders were casted for each percentage of replacement and it is allowed for 28 days of curing. After drying cubes were tested in split tensile testing machine (FTM) to determine the tensile strength test. Replacement made for cement by using GGBS (45%,55%,65%) and silica fume (5%,10%,15%) and double blend (55% GGBS and (5%,10%,15%) silica fume with addition of sisal fibre 1%) For this study the water cement ratio of 0.4 is maintained uniformly.

The results of split tensile strength obtained for the concrete mixes contain different proportions of GGBS and silica fume and sisal fibre presented. The split tensile strength of all the mixes are been observed

Table -10: Split Tensile Strength For Various Concrete Mixes (MPa)

Mix designation	w/c 0.4
	28 days
Control mix	3.7
GGBS 45 %	4.1
GGBS 55 %	4.3
GGBS 65 %	4
Silica fume 5%	4.4
Silica fume 10%	4.6
Silica fume 15%	4.5

Table 10 shown the split tensile strength for various concrete mixes for w/c 0.4

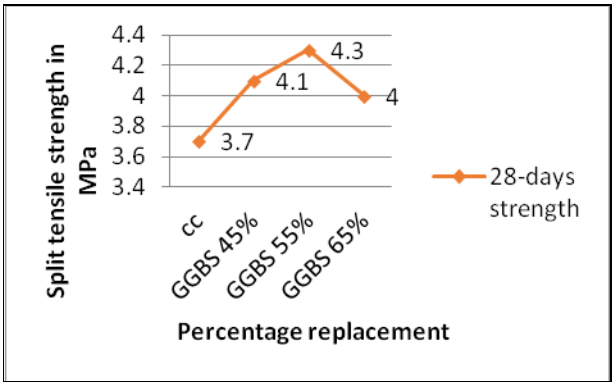

Chart -3: split tensile strength of GGBS for various concrete mixes at 28 days

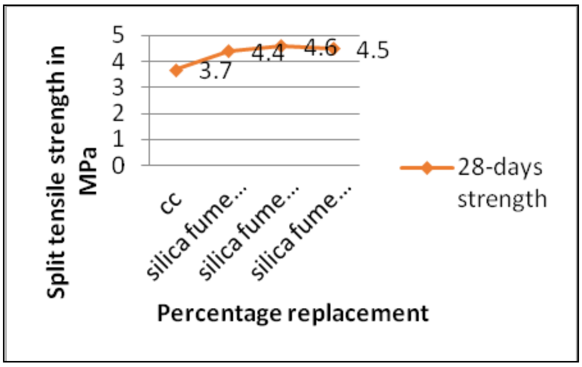

Chart -4: split tensile strength of Silica fume for various concrete mixes at 28 days

Table 11 shown the split tensile strength for double blend mix for w/c 0.4

Table -11 Split Tensile Strength For Double Blend Mix (MPa)

Mix designation	w/c 0.4
	28 days
GGBS (55%), SF(5%), Sisal(1%)	4.2
GGBS (55%), SF(10%), Sisal(1%)	3.8
GGBS (55%), SF(15%), Sisal(1%)	3.9

6.3 Flexural Strength

Totally 3 concrete prisms were casted for each percentage of replacement and it is allowed for 28 days of curing. After drying cubes were tested in flexural testing machine (FTM) to determine the tensile strength test. Replacement made for cement by using GGBS (45%,55%,65%) and silica fume (5%,10%,15%) and double blend (55% GGBS and (5%,10%,15%) silica fume with addition of sisal fibre 1%) For this study the water cement ratio of 0.4 is maintained uniformly.

The results of flexural strength obtained for the concrete mixes contain different proportions of GGBS and silica fume and sisal fibre presented. The flexural strength of all the mixes are been observed.

Table -12 Flexural Strength For Various Concrete Mixes (MPa)

Mix designation	w/c 0.4
	28 days
Control mix	6.58
GGBS 45 %	7.3
GGBS 55 %	7.1
GGBS 65 %	7
Silica fume 5%	8.08
Silica fume 10%	9.58
Silica fume 15%	8.8

Table 12 shown the flexural strength for various concrete mixes for w/c 0.4

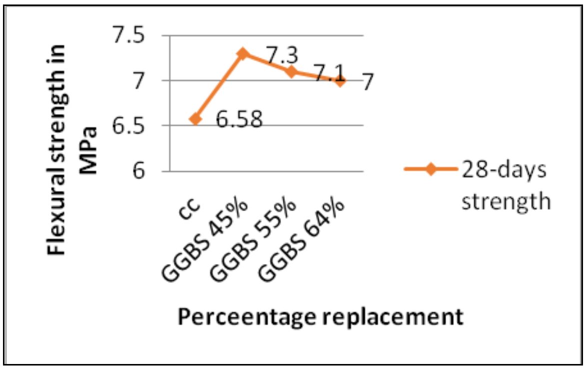

Chart -5: Flexural strength of GGBS for various concrete mixes at 28 days

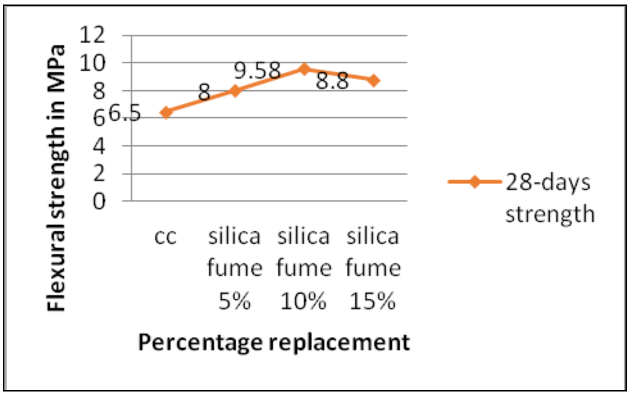

Chart -6: Flexural strength of silica fume for various concrete mixes at 28 days

Table 13 shown the flexural strength for double blend mix for w/c 0.4

Table -13 Flexural Strength For Double Blend Mix (MPa)

Mix designation	w/c 0.4
	28 days
GGBS (55%), SF(5%), Sisal(1%)	7.2
GGBS (55%), SF(10%), Sisal(1%)	7.5
GGBS (55%), SF(15%), Sisal(1%)	7.9

7. CONCLUSIONS

- In compression strength of GGBS 55% is optimum &its compressive strength increased up to 2% with compared to conventional concrete.
- In GGBS 55% flexure strength increased up to 7% with compared to conventional concrete.
- In GGBS 55% split tensile strength increased up to 16% when compared to conventional concrete.
- Compressive strength of silica fume 10% is optimum and its compressive strength increased up to 49% when compared to conventional concrete.
- In silica fume 10% flexure strength is increased up to 45% when compared with conventional concrete.
- In silica fume 10% split tensile strength increased up to 24% when compared with conventional concrete.
- The double blend concrete of (GGBS 55%, Silica fume 10%) which is optimum their compressive strength increased up to 47 % with compared to conventional concrete.
- In double blend concrete of (GGBS 55%, Silica fume 10%) flexure strength increased up to 13%.
- In double blend concrete of (GGBS 55%, Silica fume 10%) split tensile strength increased up to 2%.

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