Compressive Strength of Binary and Ternary Concrete made with OPC 53-S

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Abstract: *Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash are chosen mainly due to the durability and its cost effectiveness. Further environment pollution can also be decreased to some extent as the emissions of like carbon monoxide and carbon dioxide are considerably less. In this Paper the study is confined to evaluation of changes in compressive strength both GGBS and Fly Ash concrete with M40 Grade using special grade cement 53-S Four mixes by replacing cement content of0%, 20%, 30%, 40% with GGBS, Four mixes by replacing 0%, 20%, 30%, 40% cement content with Fly Ash (class C), and considered in the study three mixes using GGBS and Fly Ashwithout cement content viz(G25+F15)%, (G20+F20)%, (G15+F25)% one mix with only cement content(G0+F0)% was also done for compaction. The compressive strength tests are conducted on specimens cured for 7,28,56,91 days.*

Keywords: *GGBS, Fly Ash, Compressive Strength, Special cement, Concrete.*

I.INTRODUCTION

Concrete is one of the most widely used construction material. Rapid production of cement creates environmental problems for which a solution has to be found. It was estimated that Emission of CO_2 in the production process of the cement and same can be reduced by using blended cement**[1].** One ton of carbon dioxide is estimated to be released in to the atmosphere when the same quantity ofordinary Portland cement is manufactured. GGBS is a by-product of the manufacturing of pig iron. Iron ore, coke and lime-stone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500ºC to 1600ºC**[2].** Fly ash is one of the by-products of thermal power plants most common mineral admixture used in concrete worldwide. Fly ash largely improves the durability of concrete.The early age strength development of fly ash blended binary concretes shows poor performance than the ordinary concrete. Researchers all over the world are developing Ternary Blended Concretes by adding a super fine mineral admixture like GGBS to the binary blended concretes of Fly ash**[3].** GGBS in the ternary blend improves the early age performance of concrete and Fly ash improves the properties at the later age.

II.LITERATURE REVIEW

Alvin Harison[1] et.alit was also observed that at 28 days and 56 days in20% replacement of PPC by fly Ash, the strength marginally increased from 1.9% to 3.28%. That up to 30% replacement of PPC by fly ash, the strength is almost equal to referral concrete at 56 days.**A.H.L.Swaroop[2] et.al**investigated Fly ashconcrete on the in case of weight loss GGBS offers more resistance than fly ash. From our experimental work carried out as the strength of fly ash concrete with 20% and 40% replacement of cement and it was reported that the compressive strength is increased 20% replaced. Compared to 40% replacement and recommended the use of Fly ash between 20 to 40% replacement of cement with Fly Ash.**K.V.Pratap[3] et.al**thecompressive strength of concrete is improved with the addition of Fly Ash and GGBS as partial replacement to cement. Thecompressive strength of concrete is increased by a maximum of 11.13% at 28days with (4+16) % replacement.**Vinayak Awasare[4] et.al**the plain cement prepared by OPC cement and natural sand of M20 grade. The maximum compressive strength achieved is 32.6Mpa at 30% of GGBS replacement and those achieved for 20%, 40%, and 50% of concrete is 31.1Mpa, 30.7Mpa and 27.7Mpa respectively as compare to 29.1Mpa of strength of plain cement concrete for 28 day.

III. MATERIALS

Cement: The cements used in this experimental works are OPC 53-**S** (**special cement**).The OPC 53-S cement is mostly usedin construction of Railway sleepers.

All properties of cement is tested by referring IS Specification for Ordinary Portland cement.

Table 1.Physical Properties of Cement (Confirming to IS 12269 – 1987)

Properties	OPC 53-S
Fineness	1%
Standard consistency	34%
Initial setting	66min
Final setting	330min
Specific gravity	3.15
Soundness	1mm

Water: Potable water available in laboratory is used for mixing and curing of concrete.

Tests on aggregates

Natural sand from river confirming to IS 383-1970 is used. Various tests such as specific gravity, water absorption, impact strength, sieve crushing strength analysis etc. have been conducted on FA and CA to know their quality and grading. The above said test results are shown in Tables 2 & 3.Crushed black trap basalt rock of aggregate size 20mm.

Admixtures

Fly Ash: In this Project, the fly ash used belongs to class C and was brought from NTPC limited simhadri Thermal power station.

GGBS: Ground granulated blast furnace slag is by-product brought from vizag steel plant.

Tables 2.Physical Properties of Fine Aggregate (sand)

Sr.no	Property	Results
1	Particle shape & size	Round & 4.75mm down
2	Fineness modulus	3.23
3	Silt content	1.67%
4	Specific gravity	2.53
5	Bulking of sand	4.16%
6	Bulk density	1700kg/m^3

Tables 3.Physical Properties of Coarse Aggregate (20mm)size

Sr.no	Property	Results
1	Particle shape & size	Angular & 20mm
2	Fineness modulus of 20mm aggregate	6.87
3	Specific gravity	2.76
4	Water absorption	0.55%
5	Bulk density	1683 kg/m^3

Table.4.Mix design for M40 grade concrete IS 10262-2009

Cement	F.A	C.A	Water
420	584	1174	197
1	1.3	2.7	0.45

IV. EXPERIMENTAL INVESTIGATION

The study work is to analyses the strength properties of partially replaced GGBS and Fly Ash concrete. The tests of concretes are carried out as per IS code for this proposed investigation work. For successful investigation, tests have to be performed on normal concrete and on Fly Ash & GGBS concrete with proportion 20%, 30%, 40% cement replacement.

Collection of materials

The constituent materials used in this investigation were procured from local sources. These materials are used after conducting different tests. The materials used are Cement, Fly ash, GGBS, Fine aggregate, Coarse aggregate, water; the compositions in various materials are as follows:

Table 5.Chemical Composition of materials

Chemical constituent	Portland	GGBS	FLY ASH
CaO	65%	35%	24%
SiO_2	20%	38%	50%
AI_2O_3	5%	13%	16%
MgO	2%	8%	5%

Casting of Specimens

For casting the cube, standard cast iron metal moulds of size 150 mm x 150 mm x 150 mm have been used. The moulds have been cleaned of dust particles and applied with mineral oil on all sides, before concrete is poured into the mould. Thoroughly mixed concrete is filled in to mould.The mixing was carried out for 3-5 minutes duration, then compacted manually using tamping rods.

Curing the Specimens

After casting, the cubes are demoulded after 1 day of casting and then kept in respective solutions for curing at room temperature with a relative humidity of 85% the cubes are taken out from curing after 7, 28, 56, and 91days for testing.

Testing of Specimens

- Studying the properties of cement with GGBS and Fly ash by conducting tests as per BIS such as standard consistency test, initial and final setting time.
- Mix design of concrete is done for preparation of concrete as per IS 10262:2009.
- Tests on fresh concrete conducted at the time of casting of different specimens required for proposed work.
- CTM is used to conduct the tests. Test procedure used as per IS 516.
- The compressive strength of specimen was calculated by the following formula

$f = P/A$

Where,

Pc = Failure load in compression, kN

A = Loaded area of cube, mm^2

V. Results and Discussions

An individual comparison of compressive strength of concrete with GGBS replacement by 0, 20, 30 and 40% is made for curing periods of 7days to 91days vide Fig.1. It is observed that the compressive strength is increased from 7days to 91days at 0% replacement. At 20% and 30% replacement the compressive strength at 28 days and beyond is more than its target strength while at 40% replacement the 28days strength is decreased by 0.99%. However at 91days period of curing the compressive strength is exceeds its target strength.

Table 6.Compressive strength of GGBS concrete

% of the GGBS	7 days N/mm^2	28 days N/mm^2	56 days N/mm^2	91 days N/mm^2
0	36.3	48.6	49.4	51
20	35	48.9	51.6	52.1
30	33.4	49.4	52	53.2
40	30	48	50.3	51.4

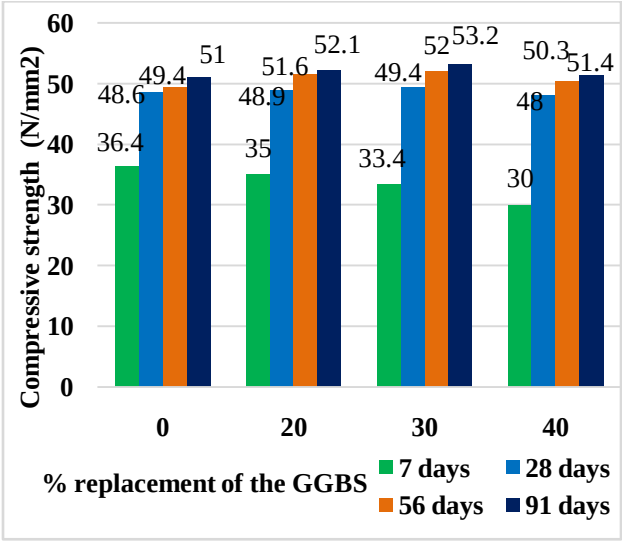

Fig.1. Compressive Strength of GGBS Concrete with M40 grade

Table 7.Compressive strength ofFly Ash concrete

% of the fly ash	7 days N/mm^2	28 days N/mm^2	56days N/mm^2	91days N/mm^2
0	36.3	48.6	49.4	51
20	33	45	51.8	54
30	29.6	43.4	53.3	56.2
40	27.8	41.2	50.6	52.8

A comparison of compressive strength of concrete with Fly ash replacement by 0, 20, 30 and 40% is made for different curing periods vide Fig.2. It is observed that the compressive strength is increased from 7days to 91days at 0% replacement. At 20, 30 and 40% replacement the compressive strength is decreased at 28 days compared to its target strength. However at 56 days period of curing the compressive strength is increased more than its target strength.

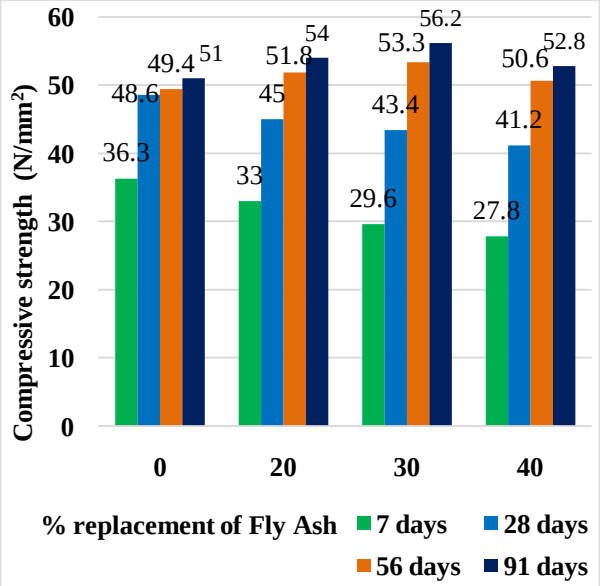

Fig.2.Compressive Strength of fly ash concretewith M40 grade

Table 8.Comparison on compressive strength of GGBS and Fly Ash for 7days

% replacement	**GGBS (N/mm^2)**	**Fly Ash (N/mm^2)**
20	35	33
30	33.4	29.6
40	30	27.8

Increase of compressive strength of GGBS concrete 20 to 40% compared with Fly ash concrete. Fig.3 the Increase of compressive strength of GGBS concrete compared to Fly ash concrete from 7days is observed to be 2to 4.8N/mm^2**.** The decrease in strength may be due to slow hydration process since fly ash is a reactive pozzolans which delays the hydration process.

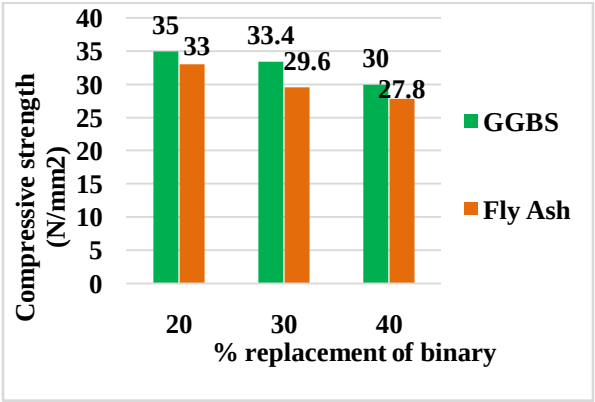

Fig.3. Comparison of Compressive Strength at 7days GGBS and fly ash concrete

Table 9.Comparison on compressive strength of concrete GGBS & Fly Ash for 28days

% replacement	GGBS (N/mm^2)	Fly Ash (N/mm^2)
20	48.9	45
30	49.4	43.4
40	48	41.2

Increase of compressive strength of GGBS concrete 20 to 40% compared with Fly ash concrete. Fig.4 the Increase of compressive strength of GGBS concrete compared to Fly ash concrete from 28 days is observed to be 3.9to 6.8 N/mm^2

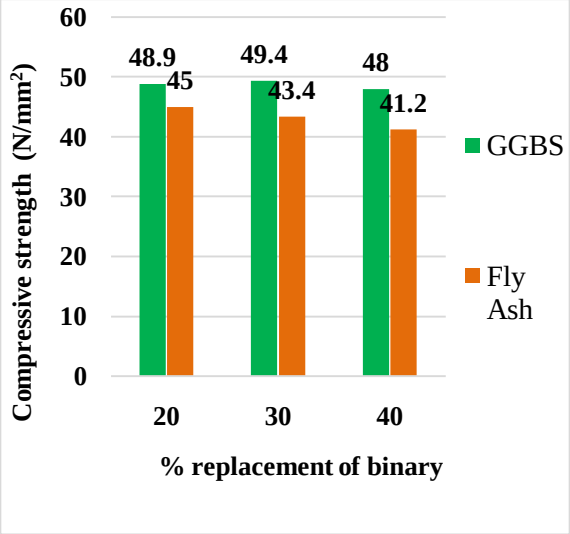

Fig.4. comparison of Compressive Strength at 28days GGBS and fly ash concrete

Table 10.Comparison on compressive strength of concrete GGBS & Fly Ash for 56days

% replacement	GGBS (N/mm^2)	Fly Ash (N/mm^2)
20	51.6	51.8
30	52	53.3
40	50.3	50.6

There is an increase of compressive strength of Fly ash concrete 20 to 40% compared with GGBS concrete. Fig.5. the Increase of compressive strength of Fly ash concrete compared to GGBS concrete from 56 days is observed to be 0.2to 1.3N/mm^2.

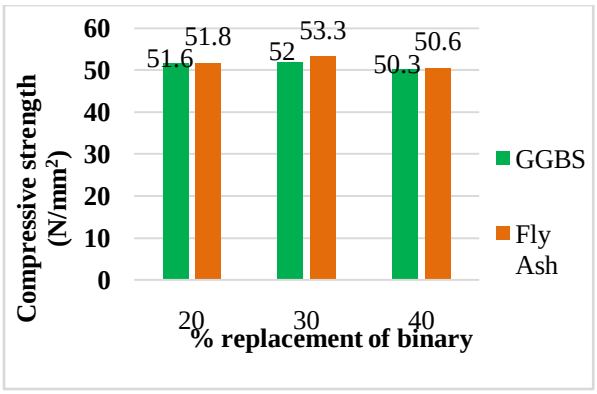

Fig.5. comparison of Compressive Strength at 56days GGBS and fly ash concrete

Table 11.Comparison on compressive strength of concrete GGBS & Fly Ash for 91days

% replacement	GGBS (N/mm^2)	Fly Ash (N/mm^2)
20	52.1	54
30	53.2	56.2
40	51.4	52.8

Increase of compressive strength of Fly ash concrete 20 to 40% compared with GGBS concrete Fig.6. The Increase of compressive strength of Fly ash concrete compared to GGBS concrete from 91 days is observed to be 1.4to 3N/mm^2.

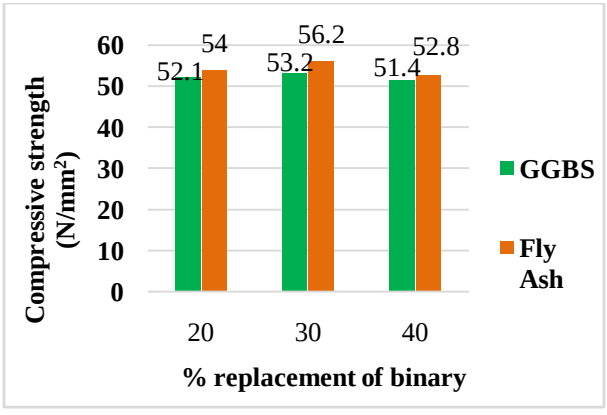

Fig.6. comparison of Compressive Strength at 7days GGBS and fly ash concrete

Table12. Compressive strength of Ternary (GGBS &Fly Ash)

% of the GGBS	7days N/mm^2	28 days N/mm^2	56 days N/mm^2	91days N/mm^2
G0&F0	36.3	48.6	49.4	51
G25&F15	31	45	48.2	49.5
G20&F20	29.2	43.2	48.8	51.7
G15&F25	28.4	41.4	51.8	53.3

A comparison of compressive strength of concrete with GGBS and fly ash replacement of(G0+F0)%, (G25+F15)%, (G20+F20)%, and (G15+F25)% is made for different curing periods vide Fig.7. It is observed that the compressive strength is increased from 7days to 91days at 0% replacement. At (G0+F0)% replacement of cement the compressive strength at 28 days and beyond in more than its target strength while at (G25+F15)%, (G20+F20)%,and (G15+F25)% replacement the 28days strength is decreased by 0.93%,0.89% and 0.85%. However at 91days period of curing the compressive strength is increased more than its target strength.

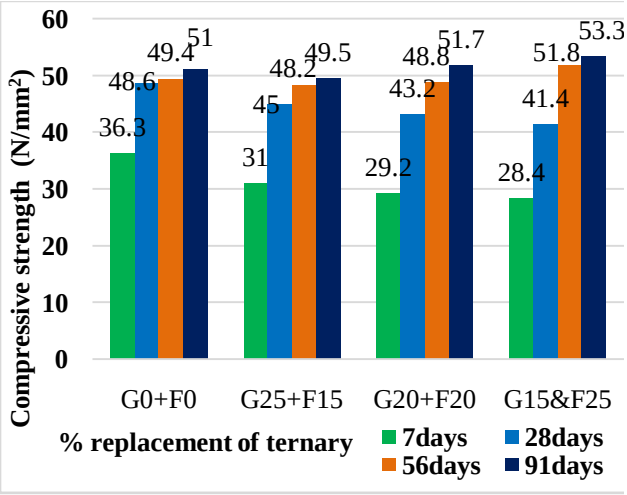

Fig.7.Compressive strength of Ternary (GGBS & Fly Ash) concrete

VI. CONCLUSIONS& RECOMMENDATIONS

- The maximum compressive strength achieved is 53.2Mpa at 30% of GGBS replacement for 91 days.
- The maximum compressive strength achieved is 56.2Mpa at 30% of Fly Ash replacement for 91days.
- The maximum compressive strength achieved is 53.3Mpa at (G15+F25)%of Ternary replacement for 91 days.
- It is concluded at 30% replacement of GGBS the M40 concrete is performed better and hence it is recommended 30% replacement in case of GGBS at 28days.
- It is also observed that an addition of fly ash and ternary 7days strength was decreased at all replacement level.
- PPC gains strength after 56days curing because of very slow hydration process.
- PSC gains strength up to 56days curing because of slow hydration process.
- The compressive strength increases gradually as the curing days increases.
- The binary & ternary blended concrete improves sustainability and reduces the cost compared to OPC.

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