

# An Experimental Development on Properties of Concrete with GGBS in Addition with Alkaline Solution of Sodium Hydroxide and Sodium Silicate



Veera Lakshmi S, Divya Anusha Naidu, Dumpa Venkateswarlu

**Abstract:** *Becoming modern waste have discovered the need to transfer of mechanical waste, The waste that must be arranged would two be able to be spared to use in some way, among the two modern waste preparing cementation nature substances can be supplanted as folio include number in cement to separated. Ground Granulated Blast Furnaces Slag (GGBS) which used to be squander from an iron assembling industry, which used to be utilized as substitute of bond in cement because of its characteristic solidifying properties. To increase the strength of the concrete some of the special cements are used. Due to various codal specifications the binding material replacements of GGBS have been restricted up to 80% in maximum. In this project replacement of GGBS is done by an amount of 10% ,20% ,30% and 40%. In accordance with above restrictions the replacement variations in binding material have been decoded in a high strength concrete mixture. The research work have been extensively executed in almost all areas of testing like compressive strength , split tensile strength, and flexural strength, and also various primary tests like specific gravity , granular gradation etc. have also been excited to achieve high strength concrete.*

**Keywords :** *About four key words or phrases in alphabetical order, separated by commas.*

## I. INTRODUCTION

Cement is created by method for blending bond, sand, coarse blend and transportable water. The vitality of cement depends upon the homes of fixings. By modifying the extents of the fixings, cement of particular quality can be prepared. In shining and solidified conditions of cement to change certain exact houses admixtures. Normally concrete is a fortified material brought to increase real properties that are wanted by methods for the basic component. At the point when every one of these materials solidify together they structure a hard stone like tally to determine any reason. Cement has end up

the most wanted texture by methods for man in subject of improvement .Concrete was once utilized given that numerous decades and is anticipated to occur so in the coming future moreover. Strengthened solid developments, Mass solid dam development, precast solid development, prestressed solid extensions building and so forth, about all segment of development are typical instances of utilization of cement in development. The construction industry is in huge need of raw materials and hence cost of construction has been increasing dramatically and also increased pollution. This led to the usage of admixtures to replace cement thereby reducing pollution to some extent without compromising in strength properties of concrete. The usage of mineral admixtures like GGBS improved the strength of concrete.

### Strength development:

Cement performed by methods for GGBS achieves a similar 28-days power as concrete made with customary solid two for substitution dimensions of GGBS to 85% over an extremely long span of cement manufactured two with GGBS keeps on accomplishing quality, and the rest of the quality of cement made with GGBS reliably more prominent than cement made with OPC. It is presently normal for a GGBS cement to make greater its 28-days vitality through a further 20% at 90days. The more prominent shutting quality of cement made with GGBS is because of reality that there is an expanded level of the CSH (calcium silicate hydrate and parcels less lime (calcium hydroxide) in the solid, when GGBS is utilized. The CSH gel is the folio that holds together the totals and offers solid quality, though the lime contributes little to solid quality .

### Features of GGBS concrete:

- Low heat of hydration-less thermal stresses.
- Less permeability increased resistance to sulfate attack, corrosion and alkali aggregate reaction.
- Enhanced workability to concrete and mortar.
- Specified in Indian Standard IS : 456.
- Reduced cost of concrete as usage of cement is reduced.
- Used in several remarkable structures in the world for high performance and durable concrete.
- High volume GGBS concrete using more than 50% GGBS developed ideal for road pavements.

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## II. LITERATURE REVIEW

**Bharat et al (2005)** explored the impact of GGBS and slag on the break qualities of HPC. Shaft examples (geometrically comparable and single size variable score) with locally available GGBS (25%) and slag (half) as concrete substitution materials have been sorted out and analyzed in a servo control Universal Testing Machine (UTM) underneath dislodging control. From the charge of the pinnacle load for each bar, in excess of a couple of break parameters had been determined. The impacts demonstrated that there is a rebate in the break power because of expansion of GGBS or slag, which can be ascribed to the nearness of unhydrated particles of measurement enormous than that of typical imperfections in cement. Additionally because of densification, the set up pinnacle conduct is more extreme for the GGBS or slag principally based HPC blends.

**Elsayed (2011)** explored tentatively in his examinations, the aftereffects of mineral admixtures on water porousness and compressive quality of cement containing Silica Fume(SF) and GGBS (FA). The impacts were rather than the control solid, normal portland bond concrete barring admixtures. The most alluring concrete supplanting with the guide of FA and SF in this test was 10%. It was once reasoned that the power and porousness of cement containing silica smoke, GGBS and unnecessary slag bond could be fitting in the use of these waste materials in solid work, explicitly regarding toughness.

**Fulton (1974)** explored the functionality of cement containing GGBS in higher detail and directed that the cementitious framework containing GGBS displayed more noteworthy usefulness because of the quickened glue content material and expanded cohesiveness of the glue. He likewise expressed that the water interest for regular cement is ordinarily three to 5% lower than cement with GGBS.

**Ganesh and Dinakar (2008)** proposed that the extent option of pozzolana is the essential parameter in choosing the amount of water for appropriate float and no longer the top notch plasticizer. It used to be discovered that on account of GGBS there was a persistent reach out of stream with stretch out in the rate, though if there should be an occurrence of GGBS and silica smolder there was at one time a first class share past which there was an abatement in the stream. For each GGBS and silica smolder the most perfectly awesome flowability that should be possible is round 45% and 10% separately. Likewise, compressive power variety used to be furthermore found with water to cover proportion of all glues with 2 % incredible plasticizer measurement bringing about qualities of cycle 20 to 80 N/mm<sup>2</sup> two for the select glue blends. This fills in as a core value for the intensity of unique cements under scrutiny.

**Li-Ping et al (2007)** investigated the flexural exhaustion in general execution of cement with half and 80% extents of floor granulated impact heater slag with the guide of mass of entire cementitious materials in cement. The effect of explicit extents of GGBS on solid exhaustion by and large execution used to be examined by examinations and used to be evaluated by the fractal thought from 5 angles, for example the 1-D fractal measurements of essential surface breaks, the forecast region of broke profiles, the proportions between the area of debonded coarse totals and the spot of cracked profile, crack quality altered by utilizing fractal hypothesis, and the fragility list. They had proposed a dim model to assess these

fractal parameters on-line. Those trial and numerical outcomes demonstrated that the fragility of cement was once impeded through the consolidation of GGBS, which make a commitment to higher crack quality and additional precarious attributes on broke profiles of cement.

**Matsuda et al (2005)** investigated the applications of GGBS to reduce seismic earth pressure. GGBS shows a similar particle formation similar to natural sand and also lowweight, high shear strength, well permeability and especially a latent hydraulic property by which

GGBS hardens like a rock. Model wall tests were carried out on GGBS, in which the resultant earth pressure, wall friction and the earth pressure distribution at the wall surface were measured, and the test results were compared with those of standard sand. It was clarified that the resultant earth pressure obtained by using GGBS was smaller than sand, especially in the active-earth pressure side.

**V.S.Tamilarasan(2012):**In this paper studies on workability of concrete with GGBS as cementitious material for cement with and without superplasticiser. The studies were carried out for the mix design of M 20 and M25. And the GGBS is added up to 100%. They concluded that the degree of workability is increased up to the 45% replacement level for M 25 grade. By the obtained results the for M 25 grade concrete has better workable than M 20 grade concrete.

**Wang Ling et al. (2004)** analyzed the execution of GGBS and the effect of GGBS on clean concrete and solidified cement. GGBS cement is described with the guide of inordinate quality, decline warmth of hydration and protection from compound consumption.

**Yogendra et al (2013)** presented the exploratory investigation on flexural intensity of cement composed with OPC, to a limited extent changed by methods for GGBS in extraordinary extents different from 0% to 40%. It used to be seen from the examination that the vitality of cement is conversely relative to the extent of substitute of concrete with GGBS. The creators had presumed that up to 20% substitute of concrete is suitable without trading off the quality with ninety days relieving.

## III. EXPERIMENTAL INVESTIGATION

### 3.1. Materials used:

**3.1.1.Cement:** The cement of OPC 53 grade cement is collected from local shops.

Properties of OPC 53 grade cement:

Fineness of cement is 6%, standard consistency is 38%, specific gravity is 3.14, initial setting time is 40 minutes, final setting time is 330 minutes, soundness is 2mm.

### 3.1.2.Fine

**aggregate:** The sand used for our investigation is collected from Godavari river sand which is conforming to Zone III as per Indian Specification 383-1970 code provisions

Properties of fine aggregate:

Specific gravity is 2.62, fineness modulus is 2.2, bulk density is 1.30kg/lit

**3.1.3.Coarse**

**aggregate:**The coarse aggregate of max20mm size with an angular shapewhichiswell graded.

Properties of coarse aggregate:

Specific gravity is 2.79,bulk density is 2.1kg/lit,water absorption is 0.5,fineness modulus is 6.9,aggregate impact value is 24%,aggregate crushing value is 28%,flakiness index is 11.3%,elongation index is 18.9%

**3.1.4.GroundGranulated Blast Furnace Slag:**GGBS is collected from RIN (Visakhapatnam Steel Plant).

Properties of GGBS:

Fineness modulus is 3.3,moisture content is 2.44%,specific gravity is 2.82,fineness is 8%.

**3.1.5.Alkaline Solutions**

The most successive antacid fluid utilized in geopolymerisationis a blend of sodium hydroxide (NaOH) or Sodium Silicate(Na<sub>2</sub>SiO<sub>3</sub>)orPotassiumHydroxideor potassium silicate.The basic fluids are from dissolvable salt metals that areordinarily sodium or potassium based .The mass of geopolymer solids is the wholeof themass two GGBS, the mass of sodium hydroxide solids used to make the sodium hydroxidearrangement, and the mass of solids in the sodium silicate arrangement (for example the mass of Na<sub>2</sub>O and SiO<sub>2</sub>).

Mixes of sodium hydroxide (NaOH) and sodium silicate (Na<sub>2</sub>SiO<sub>3</sub>) have been utilized to acquire the initiation of the fly slag material. This basic arrangement was readied twenty-four hours preceding use. groupings of sodium hydroxide and Sodium silicate had been utilized to be specific and 10 Molarity.

**3.1.6. Polymerization:**

Blending the two arrangements aggregately in any event 24 hours preceding use for the soluble fluid is prescribed. The utilization of the sodium silicate arrangement A53 with a SiO<sub>2</sub>-to-Na<sub>2</sub>O proportion by methods for mass of roughly 2.5 and sodium hydroxide with 97-98% immaculateness is furthermore prescribed. The convergences of the sodium hydroxide arrangement that can be utilized fluctuate from 8 to 16 M. In our investigation, we found that the 10M NaOH arrangement offers the most noteworthy compressive strength.This final product is upheld by past research that moreover seen that a 12 M NaOH answer delivered higher results than the corresponding18M NaOH arrangement. In any case, various analysts found that developing NaOH molarity expands the compressive quality of the geopolymer. As per discoveries articulated in such investigations, when the activator mindfulness is over a 10 M NaOH arrangement, a lower cost of polymer development is delivered because of the high grouping of NaOH, bringing about a brought down quality.

**3.1.7.Preparation of solutionfor 10M NaOH and Na<sub>2</sub>SiO<sub>3</sub>:**

Molecular Weight of NaOH = 40

For 10M NaOH = 10 x40 = 400 gm/lit.

Total NaOH to be mixed = 400/(specific gravity of NaOH)  
= 400/2.541

= 157.43 gm/lit

Take the ratio of sodium silicate solution-to-sodium hydroxide solution by mass as 2.5 sodium hydroxide

Na<sub>2</sub>SiO<sub>3</sub> = 2.5 x NaOH

= 2.5 x 400

= 1000gm/lit

Total Na<sub>2</sub>SiO<sub>3</sub> = 1000/(specific gravity of Na<sub>2</sub>Sio<sub>3</sub>)

= 1000/2.7

= 370.37 gm/lit

**3.1.8.Water:**

This

is the least expensive but most importantingredient in concrete.The water, whichis used for making concrete, should be clean and free from harmful impurities such as kali

and acid etc. in general, the water is fit for drinking, should be used for concrete.

**3.2.Tests performed:**

**3.2.1.Test for compressive strength:**

After 28 days of restoring the example 3D shapes are analyzed for compressive power underneath compressive looking at machine. The look at tests are taken from relieving tank at any rate 4 to 5 hours of testing. For one way in any event three examples are to be tried. The 3D squares are put under the compressive testing PC such that the heap ought to be connected inverse appearances of the other than the threew countenances. The heap is connected on the shakers constantly at the charge of 140kg/cm<sup>2</sup>/min. the heap is connected until the heap ruin down and no more noteworthy burden can be taken for example the red needle returns back. The last burden is noted. The compressive power is chosen by method for partitioning the last power by bones pass sectional territory. So also the remaining two examples are additionally tried. The regular of the three examples of one specific cluster of join offers the compressive quality. The variety of the quality of individual vitality should now not surpass additional than 15%. Whenever gave rehash the test.

**3.2.2.Test for split tensile strength:**

The examples are tried for rigidity for 28 days on separation elastic testing machine. Example, preferably from unique clusters, bunches, should be made for going for each picked age, example are expelled from water sooner than four to 5 hours of testing. Where as in chambers they are put beneath the compacting testing figuring gadget such that the heap is connected close by the measure of the chamber. Nonstop burden at the expense of 140 kg/cm<sup>2</sup>/min is used till the most opposing burden is accomplished, for example the purple needle returns back. A definitive burden is noted.Split elastic vitality of the example is determined with the guide of jumping the multiple times of the heap sooner or later of the check by means of partitioning the multiple times of the heap over the span of the check by utilizing the surface region, determined from the recommend measurements of the segment. For one explicit clump the normal of the example are to be finished. The normal of the three examples of one specific clump of blend gives the compressive quality. The variety of the intensity of individual power need to now not surpass more noteworthy than 15%. Whenever gave rehash the test.

**3.2.3.Test for flexural strength:**

Flexural strength of the concrete is done using the universal testing machine. The bearing surface of the supporting and loading rollers of the machine should be cleaned. The prism should be placed under the rollers in such a way that the load is applied on the uppermost surface of the casted mould. The prism should be marked at the spacing of 13.3 a part.The loading should be applied continuously at the rate of 180kg/cm<sup>2</sup>/mmin without any shock.

# An Experimental Development on Properties of Concrete with GGBS in Addition with Alkaline Solution of Sodium Hydroxide and Sodium Silicate

The load is applied gradually until the specimen fails the failure load is to be noted. It is to be noted at which part the failure i.e. whether in first or second or third. Based on part in which failure occurred the flexural strength.

## IV. RESULTS AND DISCUSSIONS

### 4.1. Mix methodology table:

Table of mix proportions for 1 m<sup>3</sup>

Mix designations	Cement content	GGBS	F.A content	C.A content	Water
G0	410	0	584	1174	197
G10	369	41	584	1174	197
G20	328	82	584	1174	197
G30	287	123	584	1174	197
G40	246	164	584	1174	197

#### Note :

Go means the mix with 0 % replacement of GGBS with OPC 53 ,G 10 represents the mix with 10 % replacement of GGBS with OPC 53 in the same way in G 20 , G30, G40.

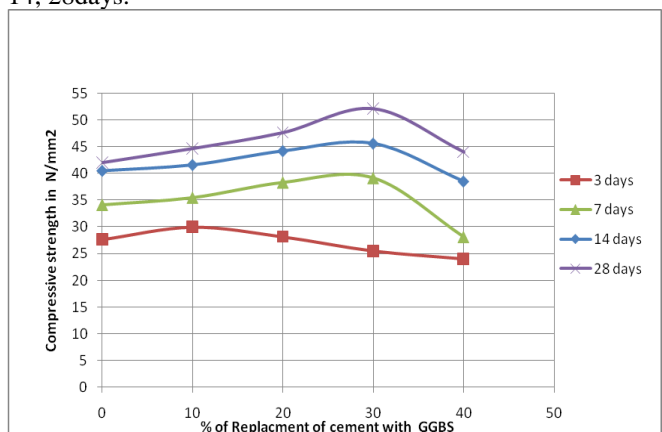
### 4.2. Compressive strength results:

Result representing the compressive strength values from 3 days curing to 28 days curing at various replacement levels i.e. at 0 % to 40 % replacement of GGBS in OPC 53 gradecement.

Table Of Compressive Strength Results

MIX DESIGNATION	COMPRESSIVE-STRENGTH IN N/mm <sup>2</sup>			
	3	7	14	28
G0	27.7	34.2	40.5	41
G10	30	35.5	41.6	44.7
G20	28.2	38.3	44.2	47.7
G30	25.5	39.2	45.6	52.2
G40	24	28.2	38.5	44

Graph -1 the compressive strength of G0toG40 mix for 3,7, 14, 28days.

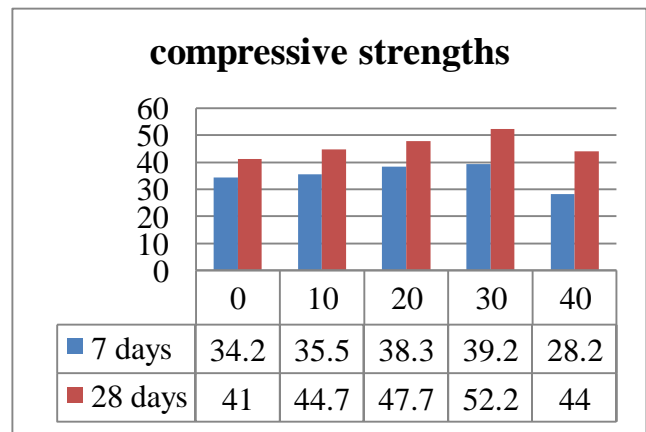


#### Note :

G0 means the mix with 0 % replacement of GGBS with OPC 53 ,G 10 represents the

mix with 10 % replacement of GGBS with OPC 53 in the same way in G 20, G30, G40.

Graph-2 Comparison of compressive strengths of G0toG40 mix at 7 days and 28 days:



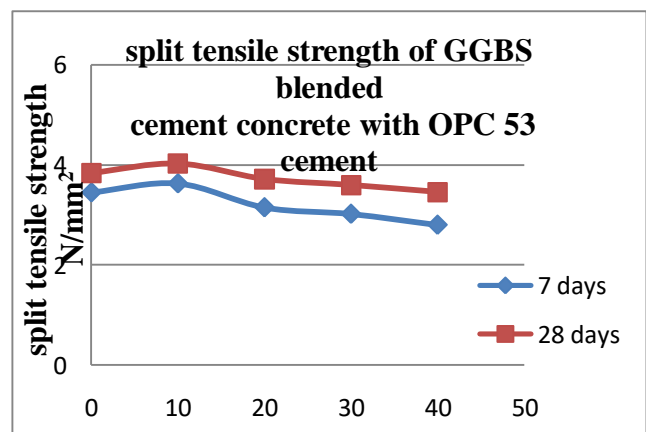
### 4.3. Split tensile strength result:

The standard size of cylinders of 300mm long and 150 mm diameter, cylinders are casted with the designed mix proportions in both OPC 53 and OPC 53 S ,and they are tested the specimens after 28 days curing in normal water.

Table of split tensile strength results

MIX DESIGNATION	SPLIT TENSILE STRENGTH IN N/mm <sup>2</sup>	
	7 days	28 days
G0	3.45	3.89
G10	3.63	4.03
G20	3.15	3.72
G30	3.02	3.6
G40	2.80	3.46

Graph-3 split tensile strength of G0toG40 mix for 7 and 28days:



### 4.4. FLEXURE STRENGTH:

The standard size of prisms of 500mm\*100mm\*100mm .prisms are casted with the designed mix proportions O and they are tested the specimens after 28 days curing in normal water.

**Table of flexure strength results**

MIX DESIGNATION	FLEXURE STRENGTH IN N/mm <sup>2</sup>	
	7 days	28 days
G0	4.42	5.6
G10	4.80	6
G20	4.43	5.6
G30	4.61	5.9
G40	4.54	5.8

7. As per specification for granulated slag for the manufacture of Portland slag cement. (IS:12089-1987).
8. The percentage replacement of cement as per IS 455:1989 (25-65% cement replacement).
9. Indian standard code book for chemical requirements of GGBS (as per IS: 44032)
10. Indian standard code book for the specification's of Admixtures specifications as per IS:9031

Graph-4 flexural strength of G0toG40 mix for 7 and 28days:  
ssssssssss

**V. CONCLUSION**

- Early strength is compared with GGBS blended cement concrete is slightly lower than conventional aggregate concrete.
- The compressive strength result of GGBS blended cement concrete when replaced up to 30 % is more than a conventional aggregate concrete at the end of 28 days for normal curing .
- The split tensile, flexure strength result of GGBS blended cementconcretes whenreplaced up to 10 % is more than the conventional aggregate concrete at the end of28 days for normal curing
- The degree of workability is normal in GGBS cement concrete up to 40 % level of replacement
- An increase of around 27.3 % compressivestrength for GGBS blendedcement concretewhenreplaced with 30 % of OPC 53cement at the of 28 daysnormalcuring.
- An increase of about 3.6 % of split tensile strength at 10 % replacement level after 28 days normal curing when the GGBS is replaced with OPC 53.
- An increase of about 7.15 % of flexure strength at 10 % replacement level after 28 days normal curing when the GGBS is replaced with OPC 53 grade cement.
- GGBS is used as an partial replacement of cement.

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