

# A Comparative Study ON Mechanical Properties of OPC 53 and OPC 53 S Cement Concrete with GGBS

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**ABSTRACT:** In this project laboratory experiment study is made to compare the mechanical properties of Ground Granulated Blast Furnace Slag (GGBS) blended cement concrete using 53 Grade Ordinary Portland Cement (OPC) and OPC 53 Special (OPC S) cement. To investigate the mechanical strength, laboratory tests like compressive strength of cubes, split tensile strength of cylinder, and flexural strength of beams are carried out. In this project the GGBS is partially replaced with 10%, 20%, 30% & 40% in both OPC and OPC S cements. Each test consists of three sample specimen and is cured in normal water and tested at different age, their corresponding test results are obtained. The samples are compared for their variation in compressive, tensile & flexural strength at different ages.

**KEYWORDS:** Mechanical properties, GGBS, 53 grade OPC and OPC 53 S cement, partial replacement, compressive strength, split tensile strength and flexural strength.

## I. INTRODUCTION

.Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material. Cements used in construction are usually inorganic; often lime based, and can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water.

The Special Cements are a special type of cements which are used for the specified requirements. Among its OPC 53 S is the special type of cements which are used for construction of sleepers. OPC represents Ordinary Portland Cement, 53 represent the compressive strength of cement after 28 days curing, and S represents the special cements.

**Special Cements:** OPC 53-S is a special type of cement. It is an example for Portland pozzolona cement. It is generally used in construction of railway sleeper and marine structures. It is a specialty cement, manufactured as per specifications originally formulated by the Indian Railways vide their specification No.IRS T-40 for manufacturing concrete sleepers, its negligible chloride content protects it against corrosion. High fineness enhances workability, and high early strength enables improved mass production cycle of Railway Sleepers. Apart from its main usage in the manufacture of concrete sleepers, it can also be put to use in concrete elements or high rise buildings where early strength is required. The main differences between Ordinary Portland Cement and Ordinary Portland Special cements is that the Minimum Fineness = 225m<sup>2</sup>/kg for OPC53 & 370m<sup>2</sup>/kg for OPC 53 S as per IS4031 ( part -2), Maximum Tricalcium Aluminate content is 10.0 % by mass, Maximum Tricalcium silicate is 45.0 % by mass.

**Ground Granulated Blast Furnaces:** GGBS is collected from RINL (Visakhapatnam Steel Plant). Ground granulated blast furnace slag (GGBS) which is a byproduct of from pig iron manufacturing in a blast furnace which iron ore, limestone and coke are melted to 1500<sup>0</sup>C. GGBS is used as a direct replacement for Portland cement vary from 30% to up to 85%. Typically 40 to 50% is used in most instances. Concrete containing GGBS cement has a higher ultimate

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

strength than concrete made with Portland cement. Concrete made with GGBS continues to gain strength over time, and has been shown to double its 28-day strength over periods of 10 to 12 years.

## II. EXPERIMENTAL PROGRAMME

The special cement of OPC 53 S is used in this project, it is collected from the railway sleeper plant, and ordinary cement OPC 53 of JP cement is used. The sand used for our investigation is collected from Godavari river sand which is conforming to Zone III as per Indian Specification IS: 383-1970 codal provisions. The coarse aggregate used is of max 20mm size with an angular shape which is well graded.

**Table 1: Physical Properties of F.A and C.A**

Physical Properties	F.A	C.A
Specific Gravity	2.52	2.73
Fineness Modulus	2.2	6.6
Bulk Density	1.69	1.67
Water Absorption	-----	0.5%
Agg. Impact Value	-----	24%

**Table 2: Physical Properties of OPC-53 Grade and OPC-53-S Grade Cements**

Physical Properties	OPC 53	OPC 53-S
Fineness	8%	1%
Std. Consistency	32%	35%
Specific Gravity	3.15	3.15
Initial Setting Time	40 min.	22min.
Final Setting Time	330 min.	150 min.
Soundness	2mm	2mm

**Table 3: Fineness Modulus of GGBS**

IS Sieve	Retained Weight in (Kg)	Weight Retained Cumulative (Kg)	Retained Cumulative % Weight	Cumulative % Passing
4.75mm	0	0	0	100
2.36mm	0.002	0.002	0.2	99.8
1.18mm	0.35	0.352	35.2	64.8
600µ	0.52	0.382	87.2	12.8
300µ	0.126	0.998	99.8	0.2
150µ	0.002	1	100	0

$$\text{Fineness modulus of GGBS} = (\sum \text{Cumulative weight retained})/100 = 322.4/100 = \mathbf{3.224}$$

## III. MIX DESIGN

In this project we consider the design specifications such as the grade of concrete is M40, exposure condition is severe, W/C as 0.45, slump of 100mm. Required quantity of cement fine aggregate coarse aggregate is designed and final mix

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

proportions is obtained. By considering the above design specifications and by considering the codal provisions IS 10262-2009, the obtained mix design for **M40 mix is 1: 1.3:2.7.**

**Mix Proportion:** By considering the 7 days 28 days compressive strength of all three trail mix design the mix proportion is considered. By considering the below trail mix calculations the mix proportions consider to this work is cement, sand, coarse aggregate, water for 1 m<sup>3</sup> is given below. Cement = 410kg, F.A = 584 kg, C.A = 1174 kg, Water = 197 liter.

**Table 4: Compressive Strength of Trail Mix**

Mix Designations	Comp. Strength in (N/mm <sup>2</sup> )For 7 Days	Comp. Strength in (N/mm <sup>2</sup> )For 28 Days
M1	37.4	54.33
M2	25.06	34.18
M3	31.6	45

## IV. TESTS ON FRESH AND HARDENED CONCRETE

**Slump Cone Test:** Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or at the construction site during the progress of the work. In this project to find the workability of concrete slump cone test is carried out in laboratory for different percentage of GGBS blended OPC Cement as well as OPC S Cements and the slump values obtained are, G0=70mm, G10=70mm, G20=68mm, G30=68mm & G40=65mm, GS0=70mm, GS10=68mm, GS20=68mm, GS30=65 & GS40=65mm, respectively.

**Compressive Strength:** After 3, 7, 14, 28, 56 & 90 days of curing the sample cubes of 150x150x150mm for different percentage of GGBS blended OPC Cement as well as OPC S Cements is tested for compressive strength under compressive testing machine. For each trail mix three sample specimens are tested.

**Split Tensile Strength:** The Cylindrical specimens of 150mm dia. and 300mm long after 7 & 28 days of curing for different percentage of GGBS blended OPC Cement as well as OPC S Cements is tested for split tensile strength under compressive testing machine. For each trail mix three sample specimens are tested.

**Flexural Strength:** Flexural strength of the concrete for beam specimen is done using the universal testing machine. The test was conducted after 28 days of curing for three samples under normal water for different percentage of GGBS blended OPC Cement as well as OPC S Cements.

## V. RESULT AND DISCUSSION

The experimental result values of standard test specimen like cube, cylinder and beams for different proportions of GGBS blending with OPC and OPC S cement is given below. Here the cube of 150mmx150mmx150mm were casted and cured for 3, 7,14,28,56 and 90 days in potable water, Split tensile strength test carried out on cylinder of 150mm diameter and 300mm length which is water cured for 28 days and Flexural strength of beam specimen of 500mmx100mmx100mm is carried out after water curing for a period of 28 days.



**Fig 1: shows the compressive strength set up for 150mm cube specimen**



**Fig 2: shows the split tensile set up for cylindrical specimen**



**Fig 3: shows the flexural strength set up for beam specimen**

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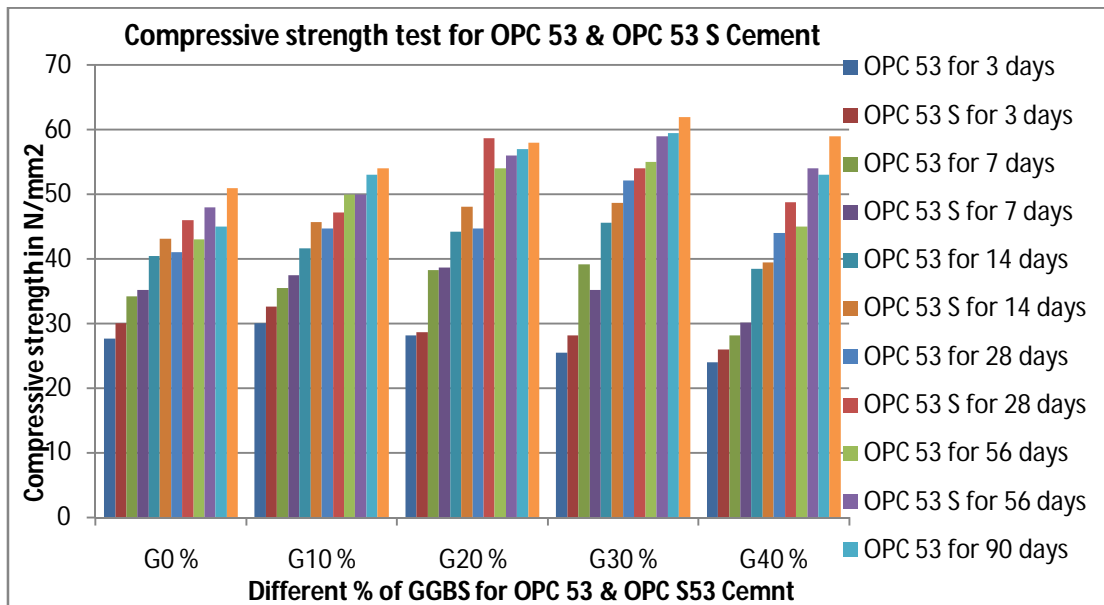
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Vol. 5, Issue 11, November 2016

**Table 5: shows compressive strength in N/mm<sup>2</sup> for 3, 7,14,28,56 & 90 days of curing**

Mix Designation	Compressive Strength in N/mm <sup>2</sup>					
	3 days	7 days	14 days	28 days	56 days	90 days
G0	27.7	34.2	40.5	41	43	45
G10	30	35.5	41.6	44.7	50	53
G20	28.2	38.3	44.2	44.7	54	57
G30	25.5	39.2	45.6	52.2	55	59.5
G40	24	28.2	38.5	44	45	53
GS0	30.06	35.16	43.1	46	48	51
GS10	32.66	37.5	45.7	47.16	50	54
GS20	28.66	38.66	48.1	58.66	56	58
GS30	28.16	35.16	48.7	54	59	62
GS40	26	30.16	39.5	48.83	54	59

**Compressive strength for OPC 53 & OPC S 53 Cement for 3, 7,14,28,56 & 90 days curing**





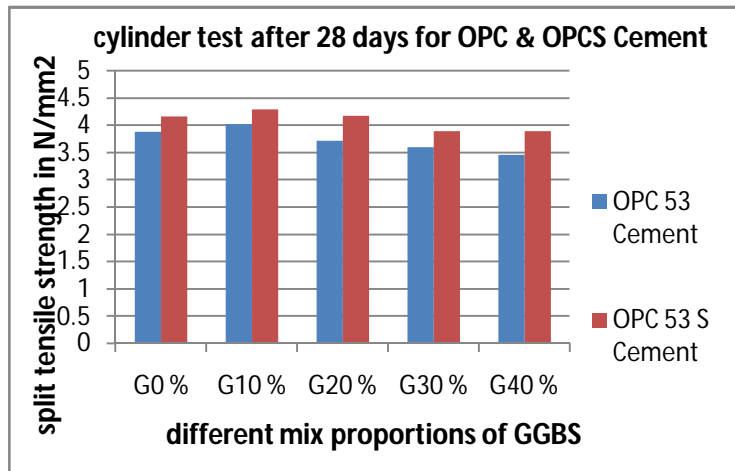
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Vol. 5, Issue 11, November 2016

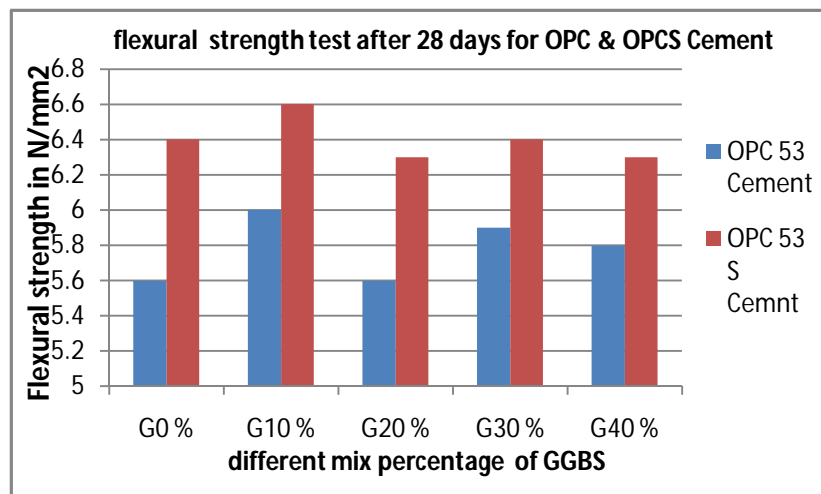
The table and graph given below shows the variation in tensile strength at 7 & 28 days curing

Mix Designation	Split Tensile Strength in N/mm <sup>2</sup>
G0	3.89
G10	4.03
G20	3.72
G30	3.6
G40	3.46
GS0	4.17
GS10	4.3
GS20	4.18
GS30	3.9
GS40	3.9



The table and graph given below shows the variation in Flexural strength at 28days curing

Mix Designation	Flexural Strength in N/mm <sup>2</sup>
G0	5.6
G10	6
G20	5.6
G30	5.9
G40	5.8
GS0	6.4
GS10	6.6
GS20	6.3
GS30	6.4
GS40	6.3



## VI. CONCLUSIONS

1. The compressive strength result of GGBBS blended cement concrete when replaced up to 30 % is more than conventional aggregate concrete at the end of 28 days for normal curing
2. The split tensile, flexure strength result of GGBS blended cement concretes when replaced up to 10 % is more than the conventional aggregate concrete at the end of 28 days for normal curing.
3. An increase of around 27.3 %, 28.8%, 33.3% compressive strength for GGBS blended cement concrete when replaced with 30% of OPC 53 cement at the age of 28, 56, 90 days respectively under normal curing.
4. An increase of around 17.4 %, 31.2%, and 32% of compressive strength is observed for GGBS blended cement concrete when replaced with 30% of OPC 53S cements at the age of 28, 56, 90 days respectively.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 11, November 2016

5. 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
6. An increase of about 3.1 % of split tensile strength at 10 % replacement level after 28 days normal curing when the GGBS is replaced with OPC 53 S
7. 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
8. An increase of about 3.12 % of flexure strength at 10 % replacement level after 28 days normal curing when the GGBS is replaced with OPC 53 S grade cement
9. GGBS can be use as partial replacement of cement up to 30% with satisfactorily.

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