PERFORMANCE OF GGBS BLENDED CONCRETE MADE WITH SPECIAL CEMENT

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Abstract:Cement is aessential commodity that is widely used in the building industry**.**. Limestone, which is used to make cement, is a nonrenewable resource, but the global growth of the building industry necessitates a greater amount of Portland cement for long-term sustainability. It emits a large amount of carbon dioxide into the atmosphere during the manufacturing process. Ground Granulated Blast Furnace Slag is a waste product from the steel and iron industries. We can't fully substitute cement with other materials, but we can do so in part. It has also been shown to increase a number of concrete's efficiency characteristics. The GGBS replacement levels of 25percent, 35 percent, and 45 percent were chosen for this investigational reason. Over a duration of 7, 14, 28, 56, 90, and 120 days, the durability of concrete specimens in terms of chloride, sulphate, and sea water is measured separately. In all replacement levels except 45 percent replacement level and above, the compressive strength test results indicate that GGBS blended cement concrete has strong resistance to chloride, sulphate, and sea water attack.

Index Terms: **GGBS, OPC 53-S, concrete, Sodium Chloride, Sodium Sulphate, Super Plasticizer, Compressive strength.**

I. INTRODUCTION

Cement, water, aggregates, chemicals, and superplasticizers are all common ingredients in concrete. Cement is one of the most important ingredients in concrete. Since it's used to bind fine and coarse aggregates together.The cement production process emits a large amount of greenhouse gases into the atmosphere. Nearly 2.4 percent of carbon dioxide is emitted into the atmosphere, according to records. The best way to reduce CO2 emissions in the cement industry is to use other materials instead of cement. Supplementary cementing materials are another name for these replacement materials. Supplementary cementing materials include GGBS, silica fume, rice husk, fly ash, and others. The granulated blast furnace slag IS; 12089-2009[1] is ground to create GGBS.It is a nonmetallic substance that includes calcium silicates and aluminosilicates. It has the inherent ability to provide concrete with weight, stiffness, and durability. It has the potential to minimize hydration heat during the concrete pouring process.The use of GGBS in concrete improves its resistance to environmental attack [2]. In terms of energy resource efficiency and environmental sustainability, proper waste management would yield the desired results.

Since Sodium Chloride in sea water has a molecular weight of 0.5 M, chloride solutions with strengths of 0.75 M and 0.25 M were used to research chloride attack. Similarly, since the percentage of Sulphate in the soil is about 5%, Sulphate solutions with strengths of 4% and 6% were used in the analysis of Sulphate attack.

II. Literature review

D. Suresh and K. Naga Raju looked into the benefits and drawbacks of GGBS in cement replacement stages.When exposed to harsh environmental conditions, GGBS blended cement concrete has a high level of resistance.After 270 days of curing in Sodium Sulphate solutions, A.A.Ramezanianpour found that concrete with a 50% GGBS replacement level had strong resistance.P. KrishnamRaju investigated the impact of seawater on OPC 53 grade compressive and flexural intensity. There is no discernible decrease in compressive power.

III. Materials:

Cement:

In this experiment, OPC 53-S (special cement) is used. The OPC 53-S cement is primarily used in higher-grade pre-stressed concrete, marine building, and other similar applications. The cement comes from the M.S Raju construction Pvt.Ltd concretesleepersfactory in Visakhapatnam's Pendurthineighborhood.

Table 1
Oxide composition of Portland cement

Oxidecompound	Percentage
CaO	60-67
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-0.6
MgO	0.5-4
SO_3	0.3-1.2
K_2O/Na_2O	2-3.5

GGBS:
It is a by-product of the steel plant in Vizag. It has an off-white tint to it. It has a specific gravity of 2.75 and a specific surface area of 400 m2/kg.

Table 2
Chemical composition of GGBS

Compound	Fraction(%)
SiO_2	34
Al_2O_3	11
Fe_2O_3	1.3
CaO	43
MgO	9

Fine and coarse aggregate:
For this experiment, Zone II River sand was used. The coarse aggregates used are 20mm in size. The fine and coarse aggregate is purchased from a local supplier. Fine and coarse aggregates have specific gravity of 2.74 and 2.76,respectively.

Table 3
Physical Properties Of Cement & GGBS mixture

Properties	OPC53-S	OPC 53-S 75% + 25% GGBS	OPC 53-S 65% + 35%GGBS	OPC 53-S 55%+ 45%GGBS
Fineness	2%	3%	3%	3%
Standard consistency	29%	30%	32%	34%
Initial setting time(mins)	65 340	68 350	74 380	85 430
Final setting time (mins)	2	1	1	1
Soundness(mm)				

Water: Concrete is mixed and cured using potable water**.**

Sea water: Sea water is only used for healing purposes in this experiment. The sea water is changed twice a week. The pH and temperature of sea water are measured on a daily basis**.**

Table 4
Major ion composition of sea water

S.No	Name	ions	mg/lit
1	Sodium	Na^+	10360
2	Magnesium	Mg^{++}	1294
3	Calcium	Ca^{++}	413
4	Potassium	K^+	388
5	Chloride	Cl^-	19355
6	Sulphate	SO_4^{2-}	2712

Table 5
pH and temperature results of different samples of sea water

S.No	Temperature (degrees)	pH
Sample1	29	7.6
Sample2	27	7.5
Sample3	27	7.8
Sample4	28	7.4

Table 6
Mix design for M40 grade concrete as per IS 10262-2009

Cement Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3	Water liters
390	729.9	1242.8	156
1	1.87	3.18	0.4

Table 7
Super plasticizers properties

Properties	Aura Cast 270m
Appearance	Light yellow colored liquid
pH	Minimum6
Volume mass@20^0	1.09 kg/liter
Chloridecontent	<0.2%
Normaldosage	0.5 to 3 liter /100 kg

IV. Experimentalinvestigation

The GGBS replacement levels of 25 percent, 35 percent, and 45 percent were chosen in this experiment to research the chloride. Sulphate, and sea water attack. Concrete experiments was carried out in accordance with IS 516-1959.

Casting of specimens:

The standard moulds of size 100 mm× 100 mm× 100 mm have been selected. Until concrete is poured into the mould, the moulds have been properly fitted and oil has been added to both sides. The mixing took about 3-5 minutes to complete. The concrete is then poured into cubes and mechanically vibrated.

Curing the specimens:

The cubes are demoulded after 24 hours and then held in the appropriate chemical solutions for curing purposes at room temperature for 7, 14, 28, 59, 90, and 120 days, respectively.

Testing the specimens

- Concrete mix design is carried out in accordance with IS 10262: 2009 for concrete preparation.
- The compressive strength of cubes is measured using CTM.
- Formula for compressive strengthis

  $F=P/A$

  Where P= failure load kN

  A=area of cube mm^2

V. Results anddiscussions:

For curing periods of 7,14,28,56,90, and 120 days, an individual comparative strength of concrete with GGBS replacement of 0%,25%, 35%, and 45 percent is produced. Except for 45 percent, all replacement levels meet the target strength.

R0-0 percent GGBS + 100 percent cement, R1-25% GGBS+75 percent cement, R3-35% GGBS+ 65 percent cement, R4-45% GGBS+ 55 percent cement.

Table 8
Slump cone values

S.No	Replacementlevel	Slump value Mm
1	100% cement+0%GGBS	80
2	75% cement+25%GGBS	85
3	65% cement+35%GGBS	90
4	55% cement+45%GGBS	95

Table 9
7 Days Compressive Strength Results

Replacement/ curing	Normal water (N/mm^2)	Sea water (N/mm^2)	0.25M NaCl (N/mm^2)	0.75M NaCl (N/mm^2)	4% Na_2SO_4 (N/mm^2)	6% Na_2SO_4 (N/mm^2)
RO	38	39	36	34	36.5	35
R1	37	38.5	34.5	32.1	35	33
R2	35.8	37	33.3	31	34.2	32
R3	35	36.25	32	30	33.5	31.5

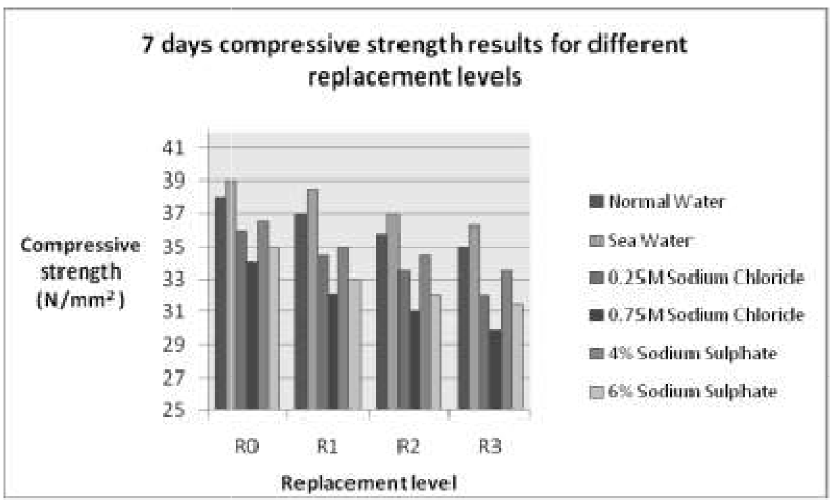

Chart 1 :7 Days Compressive Strength Results For Different Replacement Levels

Table 10
14 Days Compressive Strength Results

Replacement/ curing	Normal water (N/mm^2)	Sea water (N/mm^2)	0.25M NaCl (N/mm^2)	0.75M NaCl (N/mm^2)	4% Na_2SO_4 (N/mm^2)	6% Na_2SO_4 (N/mm^2)
RO	44	45.5	43.1	40	42	41
R1	45.5	46.6	44.2	42	43	42.5
R2	42.9	44	42	41	41.5	40
R3	41	43	39.5	37	38	36.5

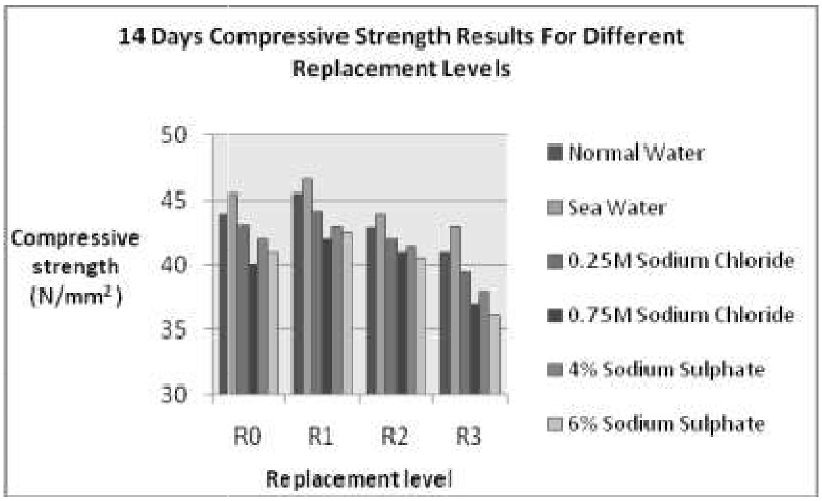

Chart -2 14 Days Compressive Strength Results for Different Replacement Levels

- sea water curing results for 7 and 14 days compressive strength are 4.7 percent to 2.2 percent higher than regular water for all replacement stages. When compared to other replacement levels, RO replacement results in higher compressive strength after 7 days. When compared to other replacement levels, the compressive strength results for R1 replacement level are strong after 14 days.

Table 11: 28 Days Results Compressive Strength

Replacement/ curing	Normal water (N/mm^2)	Sea water (N/mm^2)	0.25M NaCl (N/mm^2)	0.75M NaCl (N/mm^2)	4% Na_2SO_4 (N/mm^2)	6% Na_2SO_4 (N/mm^2)
RO	49.65	48.5	49.6	48.6	49.5	48.6
R1	51	50	50	49	50.2	49
R2	53.5	51.5	52.85	51.1	51.95	50
R3	46	45	43.5	42	45	43

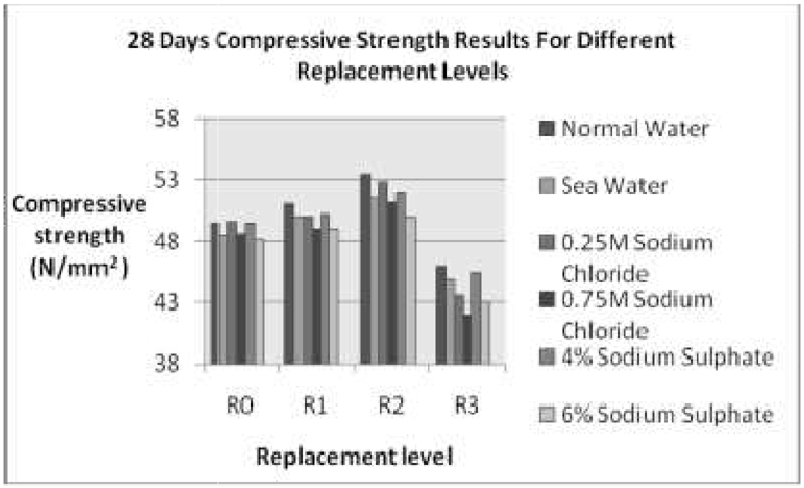

Chart-3: 28 days compressive strength results

- As compared to other replacement levels, the compressive strength results for R3 GGBS replacement level are higher after 28 days. When the concrete is exposed to high concentrations of sodium chloride and sodium sulphate, i.e. 0.75 M NaCl and 6% Na2SO4 solutions, there is no significant difference in compressive power.

Table12

56 Days Compressive Strength Results

Replacement/ curing	Normal water (N/mm^2)	Sea water (N/mm^2)	0.25 M NaCl (N/mm^2)	0.75 M NaCl (N/mm^2)	4% Na_2SO_4 (N/mm^2)	6% Na_2SO_4 (N/mm^2)
RO	52.5	51	52	50.8	51.5	50
R1	55	52.2	53.5	52	53	52.5
R2	58	55.5	56	53	55.5	54.2
R3	47.5	46	44.6	42.5	46	44.5

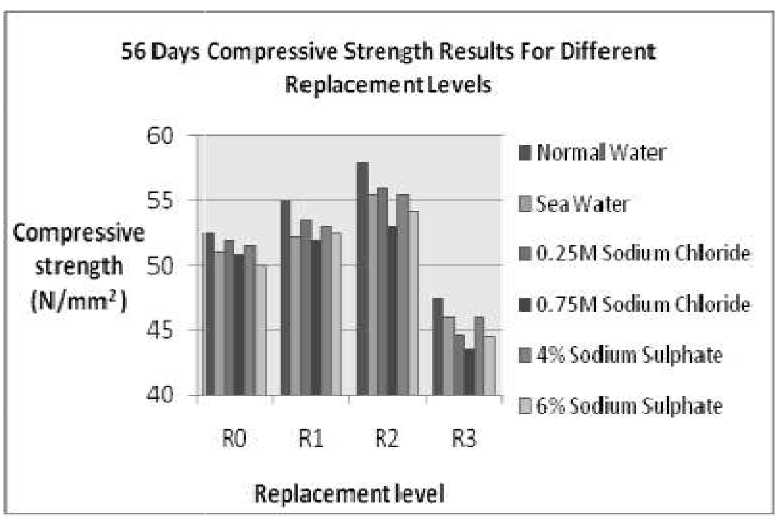

Chart 4- 56 days Compressive strength results

As compared to standard water curing, the percent loss in compressive strength for Chloride attack ranges from 2.72 percent to 16.52 percent lower for all replacement levels. As compared to standard water curing, sulphate and sea water attack is 1.9 percent to 6.55 percent less. For 56 days, the specimens are turning white from grey due to the deposition of salt on the surfaces.

Table 13
90 days compressive strength results

Replacement/ curing	Normal water (N/mm^2)	Sea water (N/mm^2)	0.25 M NaCl (N/mm^2)	0.75 M NaCl (N/mm^2)	4% Na_2SO_4 (N/mm^2)	6% Na_2SO_4 (N/mm^2)
RO	56	55.25	54	51	53.9	52.1
R1	57.5	57	55.6	53	55	54
R2	58	57.55	57.5	55	56.8	55.5
R3	49.65	49.1	46	44	47	45.1

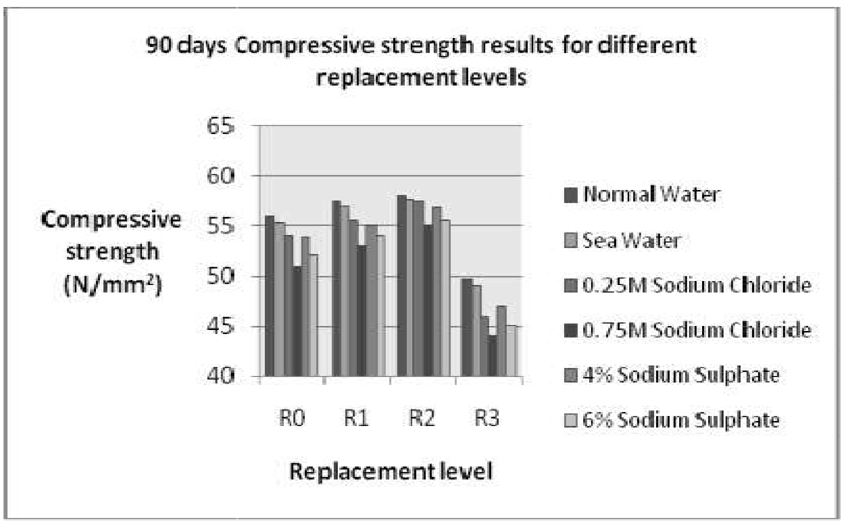

Chart -5 90 days compressive strength results

As compared to normal water, the percent loss in compressive strength for chloride attack ranges from 0.86 to 11.37 percent lower. When compared to standard water curing for 90 days, the percent loss in compressive strength for sulphate attack and sea water attack ranges from 2.06 to 6.96 percent less.

Table 14
120 days compressive strength results for different replacement

Replacement/curing	Normal water (N/mm^2)	Sea water (N/mm^2)	0.25M NaCl (N/mm^2)	0.75M NaCl (N/mm^2)	4% Na_2SO_4 (N/mm^2)	6% Na_2SO_4 (N/mm^2)
RO-0%	59	57	56.25	55	55.2	54
R1-25%	61.1	59	58	57	57.5	56
R2-35%	63	61	60.2	59	59.5	58
R3-45%	52.5	50.65	49.5	47	49	47.5

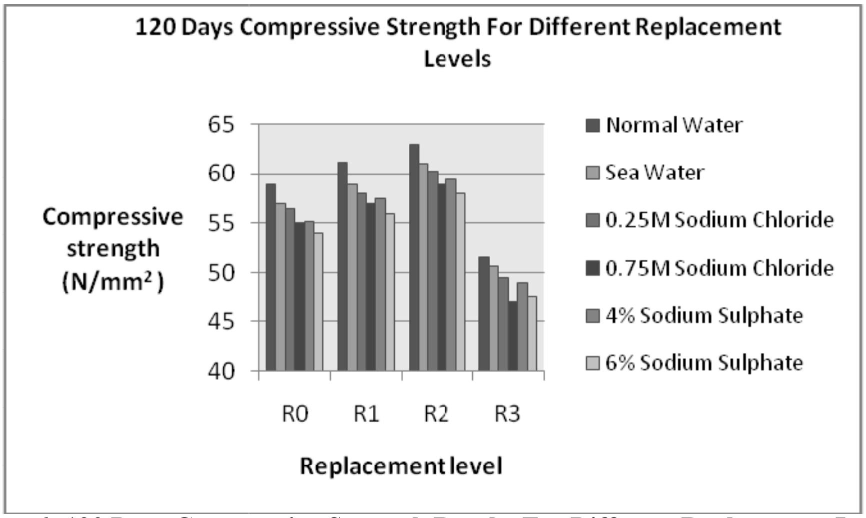

Chart-6: 120 Days Compressive Strength Results For Different Replacement Levels

When concrete is cured in Chloride and Sulphate solutions for 120 days, there is no reduction in compressive strength. So that the concrete containing 35 percent GBBS replacement amount is more resilient against Chloride, Sulphate& sea water assault.

Table 15
% Loss in compressive strength for Chloride, Sulphate& Sea water attack when compared with normal water for 120 days

S.No	Replacement	% Loss in compressive strength in 0.25 M NaCl attack	% Loss in compressive strength in 0.75 M NaCl attack	% Loss in compressive strength in 4% Na_2SO_4 attack	%Loss in compressive strengthin6% Na_2SO_4 attack	% Lossin compressive strength insea water attack
1	**R0**	4.66	3.38	6.44	8.47	3.38
2	**R1**	5.07	6.71	5.89	8.34	3.43
3	**R2**	4.44	6.34	5.55	7.93	3.17
4	**R3**	5.71	10.47	6.66	9.52	3.56

VI. Conclusions &recommendations:

Chloride attack: -

- When the specimens were exposed to 0.25 M and 0.75 M NaCl solutions, no noticeable changes in weight or compressive strength were observed.
- For a 120-day attack with 0.25 M Sodium Chloride, the percentage loss in compressive strength for 0 percent, 25%, 35 percent, and 45 percent GGBS replacement levels is 4.66, 5.07, 4.44, and 3.88. Similarly, for 0.75 M Sodium Chloride solution, the percent loss in compressive strength is 3.38, 6.71, 6.34, and 10.47, respectively.

Sulphateattack: -

- When the specimens were exposed to 4 percent and 6 percent Sodium Sulphate solutions, no major changes in weight were found.
- For 120 days, the percentage loss in compressive strength for 4 percent Sodium Sulphate attack for 0 percent, 25 percent, 35 percent, and 45 percent GGBS replacement levels is 6.44,5.89,5.55 & 4.85, respectively. For 6 percent Sodium Sulphate attack, the percentage loss in compressive strength is 8.47,8.34,7.93 & 7.76.
- When concrete is exposed to high concentrations of water, there is no significant difference in compressive power.

Sea water attack: -

- For 120 days, the percentage loss in compressive strength for 0 percent, 25%, 35 percent, and 45 percent GGBS replacement levels is 3.38, 3.43, 3.17, and 1.65, respectively.
- After 120 days of exposure to sea water, there was no damage to the surface of the test specimens..
- The specimens changed colour after being exposed to sea water for up to 120 days, going from grey to white due to salt formation on the specimens..

Over view: -

- For all different curing conditions, as the replacement level is increased, the compressive strength steadily rises up to 35 percent replacement level..
- Compressive strength decreased dramatically after 35 percent replacement level for all curing conditions..
- For all different curing situations, the goal intensity is met in all replacement amounts except 45 percent.
- It can no longer be used as a binder material after 35 percent GGBS replacement, but it can be used as a filler material in concrete because it no longer participates in the hydration process.
- Chloride, sulphate, and seawater assault are all resistant to concrete with a 35 percent GGBS substitution.

Acknowledgement:

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