An Experimental Investigation on Behaviour of Concrete Against Treated Sewage Water using GGBS as a Partial Replacement for Cement

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***Abstract*— Traditionally, everyday Portland cement concrete is used to make structures. Increasing production prices and the want to lessen environmental effects on the way to make production sustainable have made it vital to analyze the usage of opportunity substances, mainly regionally to be had substances that could update conventional substances utilized in concrete manufacture. In the current study, experimental investigations is done assess the results of changing OPC with GGBS and handled wastewater. GGBS is a commercial waste and a fabric that has acquired tremendous interest in each study and application. It's a derivative of the metallic industry. Here cement is replaced with GGBS with specific proportioned of 0%, 30%, 35% and 40% and up to 100% treated sewage water as ingesting water substitute.**

Keywords: Ground Granulated Blast Furnace Slag (GGBS), Treated sewage water, Compressive Strength, Split Tensile, Flextural Strength, Workability.

I. INTRODUCTION

Concrete is one in all the oldest and maximumly used substances within the world, notably owing to its low price, availability, its long sturdiness and skill to resist aggressive climatical conditions. The international producing of concrete is ten additional that of bimetal production in tonnage. On the choice hand, totally different production substances consisting of metallic and polymers are larger steeply-priced and are least used than concrete substances. Concrete may be a brittle in nature that contains a excessive compressive strength, but has a low tensile strength. Thus, reinforcement of concrete is finished by the utilization of high strength steel

The composition of the molten slag which is almost the chemical composition of Portland cement. GrainyMolten slag contains, in particular, residues containing silicic acid and aluminum. These glassy granules are dried and crushed to the desired size, referred to as ground granulated blast furnace slag (GGBS).

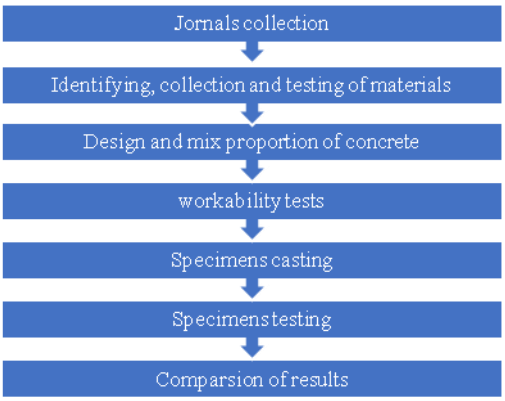
The increase within the human activities further because the high rate in Asian nation resulted in essential increase in the water demand and since water is changing into scanty, it's necessary to lower H2O consumption altogether areas as well as the development field. Finding possible different to utilize waste water decline the pressure on potable water resources and thus creates a balance between production and demand. The fresh water is extremely suggested due to its chemical properties that are inside the IS standards in infrastructural field. within the construction industry.

A. Objectives

The main objectives of these study are

- To study the workability of concrete in which the cement is partially replaced by GGBS and sewage treated water (nearby treatment plant) used for mixing.
- To study the strength parameters of concrete after 7, 21 and 28 days of curing and compare the results with the conventional concrete.
- To find the optimal dosage for GGBS when it is partially replaced at intervals of 30%, 35% & 40% with sewage treated water.

B. Methodology



Flow chart

II. EXPERIMENTAL INVESTIGATION

The objective of the experimental research is to study and compare the replacement of GGBS and drinking water (portable water) with treated wastewater to achieve the optimal percentage replacement of GGBS for M30 grade concrete.

A. Materials

- *Ordinary Portland cement (OPC)*

OPC Grade 43 is used for the proposed experimental work. According to IS standards, various tests are performed on OPCs, which are shown in Table I.

TABLE I. PROPERTIES OF 43 GRADE OPC

Sl. No.	Test	Reference	Final result	Permissible value
1.	Fineness of cement	IS 4031-1976	7%	Max 10%
2.	Normal consistency	IS 4031-Pt-4	28%	26 to 33%
3.	Specific gravity	IS 2720-Pt-3	3.1	3.12 to 3.19
4.	Initial setting time	IS 4031-1968	38 min	Min 30 min
5.	Final setting time	IS 4031-1968	300 min	Max 600min

- *Ground Granulated Blast furnace Slag (GGBS)*

Cement is partially replaced by GGBS because GGBS is rich in Cao and Silica. Table II describes the desirable properties of GGBS.

TABLE II. PHYSICAL & CHEMICAL COMPOSITION

Chemical properties		Physical properties	
Calcium oxide	40%	Colour	Pale white
Silica	35%	Specific gravity	2.85
Alumina	13%	Bulk density	1200 Kg/m^3

- *Fine Aggregate (FA)*

Fine aggregate means natural river sand with a mixture of small grain particles less than 4.75mm in size. Depending Various tests are performed on fine aggregates as shown in Table III.

TABLE III. PROPERTIES OF F A

Title	Average result
Fineness modulus	2.72 As per IS 383 is in Zone II Sand
Specific Gravity	2.6
Water Absorption	1.0%

- *Coarse Aggregate (CA)*

The coarse aggregate used here has a size of 20 mm and smaller. Various tests were performed on coarse aggregates as shown in Table IV.

TABLE IV. PROPERTIES OF COARSE AGGREGATE

Name of test	Average result
Specific gravity	2.64
Aggregate crushing Strength	27%
Aggregate Impact Value	20%
Water Absorption	1.4%

- *Treated Sewage Water*

Treated wastewater is collected from a nearby sewage treatment plant. The analysis is carried out according to the standard method for examining waste water. Table V shows the methods of various parameters.

TABLE V. CHEMICAL ANALYSIS OF TREATED SEWAGE WATER

Sl. No.	Test	Average value	Standard value
1.	Total Suspended Solids	1383 Mg/l	2000 Mg/l
2.	Sulphates	14 Mg/l	400 Mg/l
3.	Ph Value	7.41	6.5-8.5
4.	Alkalinity	132 Mg/l	3000 Mg/l
5.	Chloride	111.2 Mg/l	2000 Mg/l
6.	Total Solids	1568 Mg/l	5000 Mg/l

- *Superplasticizer*

Conplast SP430 is a super plasticizer additive, confirms IS: 9103- 99. Conplast SP430 is based on sulfonated naphthalene polymers and is supplied as a brown liquid ready to be dissolved in H_2O. It has been specifically arranged to provide greater water reduction of up to 25% without compromising workability, producing higher quality concrete with lower permeability.

B. Mix Design and Mix Proportion

Mix design is for M30 class concrete using material test data according to the guidelines of IS 10262- 2019. Table VI contains mix ratio values.

TABLE VI. MIX PROPORTION

Sl. No.	Materials	Quantity
1.	Cement	362 kg/m^3
2.	F A	796 kg/m^3
3.	C A	1086 kg/m^3
4.	Water content	173 liters/m^3
5.	W/C ratio	0.48

The mix ratio is 1:2.2:3. A total of four mixes were prepared, namely M1, M2, M3 and M4, representing 0%, 30%, 35% and 40% cement replacement with GGBS, respectively. Table VII gives the amounts of the ingredients in percent.

TABLE VII. QUANTITIES OF INGREDIENTS (%)

Mix	Cement	GGBS	Fine aggregates	Coarse aggregates	Portable water	Treated water
M1	100	0	100	100	100	0
M2	70	30	100	100	0	100
M3	65	35	100	100	0	100
M4	60	40	100	100	0	100

C. Details of number of specimens

TABLE VIII. DETAILSOF NUMBER OF SPECIMENS

Sl. No.	Property	Specimen	Size (in mm)	Numbers
1.	Compressive strength	Cube	150x150x150mm	36
2.	Splitting tensile strength	Cylinder	150mm diameter, 300mm height	36
3.	Flexural strength	Beam	500x100x100mm	36
			Total	108

D. Casting of specimens

The molds for casting cubes, cylinders and beams have been thoroughly cleaned. To prevent the concrete from sticking to the inner surface of the forms and from spilling out, inner surface of the forms are oiled. The 150mm x 150mm x 150mm molds were used to cast cubes for compressive strength testing. Cylindrical molds with a height of 300 mm and a diameter of 150 mm were used to mold cylinders for tensile tests. Size 500mm x 100mm x 100mm for carrying out bending tests on beams. The concrete was then poured into the forms (cube, beam and cylinder) and compacted in 3 layers giving 25 blows for each layer with a tamping rod and finally done Hardened concrete test.

E. Tests on specimens

1. Test on workability
   - Slump test
2. Test on Hardened concrete
   - Compressive strength
   - Split tensile strength
   - Flexural strength

III. RESULTS AND DISCUSSION

A. General

Tests were carried out on freshly prepared concrete and hardened concrete. The slump cone test was carried out on fresh concrete. Hardened concrete tests include compressive strength, splitting tensile strength and flexural strength tests.

B. Properties of fresh concrete

Mix	Slump value (in mm)
M1	100
M2	75
M3	72
M4	68

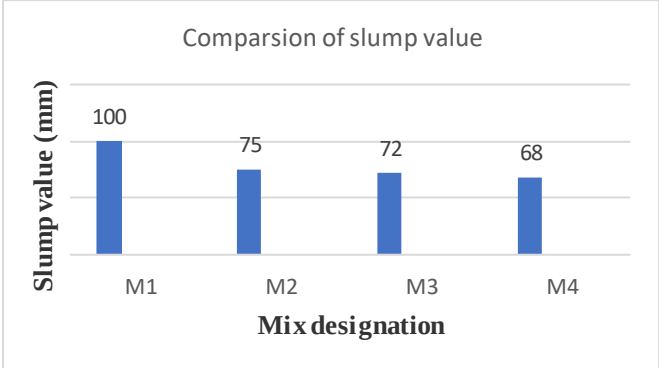


FIG I. Variation slump value with different percentage of GGBS

C. Properties of hardened concrete

Hardened concrete testing plays a vital role in checking and to confirm the quality of cement concrete works.

- *Compressive strength test*

The compressive concrete test is done by prepared concrete cubes of 7,14 and 28 days of curing as shown in fig II.

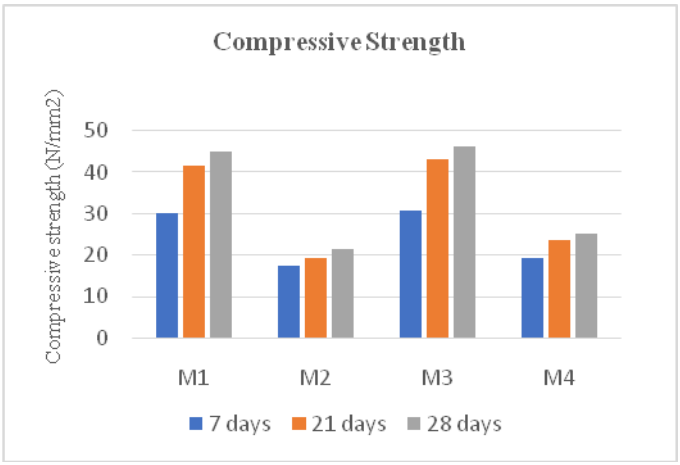


FIG II. Variation of Compressive strength

- *Split tensile strength test*

It is an indirect test to determine the tensile strength of concrete. The test was carried out according to IS: 5816:1999. The splitting tensile strength test was performed on cylindrical samples placed horizontally in the compression testing machine. Fig. III shows the variation in tensile strength by dividing the cylindrical specimens for 7, 21 and 28 days healing.

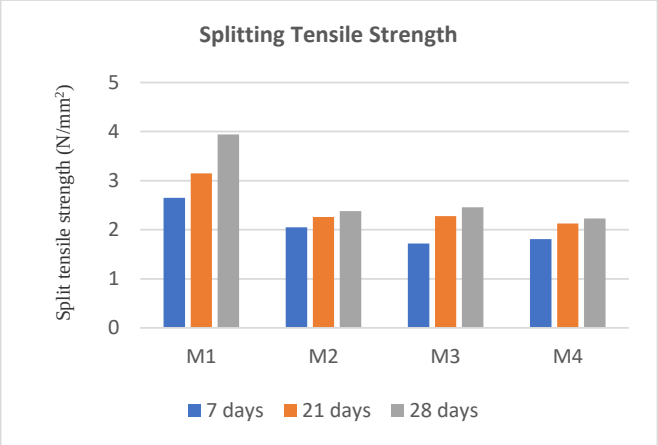


FIG III. Variation of split tensile strength

- *Flexural strength test*

The bending test indirectly evaluates the tensile strength of concrete. The results are expressed as modulus of rupture, given as Fr in N/mm2. The 500 x 100 x 100 mm beam was tested at two points under load. The modulus of rupture is typically 10-15% of the compressive strength of the concrete. Fig. VI shows the course of the flexural strength of beam samples after 7, 21 and 28 days of hardening.

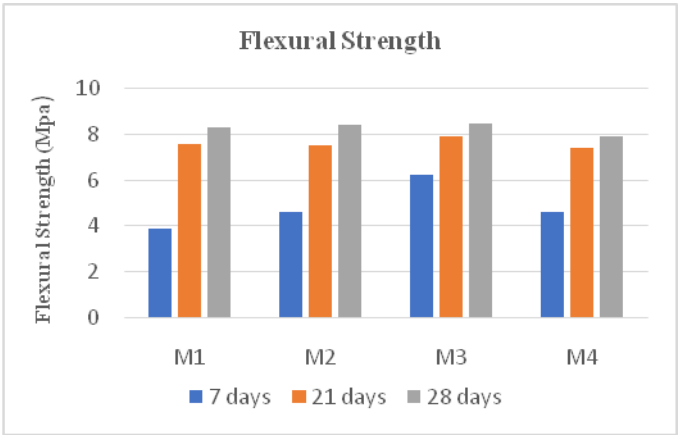


FIG IV. Variation of flexural strength

VI. CONCLUTION

In present study, an attempt was made to study the strength properties of concrete by partially replacing cement with GGBS and using treated sewage water instead of portable water. From the experimental investigation it was found that M3 mix as an optimal mix based on the result of compressive strength and flexural strength tests.

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