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Effect of bacteria on GGBFS concrete

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Abstract:

The study of GGBFS concrete with addition of bacterial cells is discussed in this paper. Strength characteristics of concrete mix are analyzed on mix of grade M25& M40.Significant effect of bacterial cells on fresh and hardened state of concrete properties is seen. Durability properties are also enhance at addition of varying proportion of bacterial cells of species(Bacillus maeaterium) 10ml,15ml,20ml,25ml with GGBFS in partial replacement of OPC43 grade in proportion of 20%,25%,30%,35% .

Keywords

OPC43,SCM, GGBFS, Bacillus mageterium, fresh properties, mechanical properties, Durability properties.

1. Introduction

In modern era cement is replaced by various supplementary cementing materials (SCMs) in concrete mixes to reduce quantity of cement in construction industry. Out of various SCMs GGBFS is rich in lime/silica ratio. It improves durability as well as fresh properties of concrete mix. GGBFS is used in concrete mix as partial replacement of OPC 43. GGBFS is also known as slag, it's a byproduct produced from steel manufacturing industry. The fineness of slag is more than $350m^2/kg$, i.e. it is easily replacing cement in concrete mix. Slag is rich in Cao and Sio_2 which makes it more popular than other SCMs. Generally all SCMs are porous in nature. This porosity of SCMs make easier to attack by chlorides and sulphides. In past few years several researchers proposed the use of bacterial cells as self healing or self repair methodology. [I] Ramakrishna et al. found that bacillus pasteurii, and bacillus sphaericus, are able to calcite production.[V] karambir Singh et al. found the effective results of bacterial cells bacillus subtillis on rice husk ash concrete.[VI] S.krishnapriya et al. found the identification and isolation of bacterium cells to improve the strength of concrete mixes. Bacillus group of bacteria are enhancing the properties of concrete mix by making it more dense and impermeable. In this research work slag is used as partial replacement of OPC 43 grade with addition of bacterium cells of bacillus group bacillus mageterium [4] **Anna reggio et.al.** Investigate that new self healing technique for cement based material.

2. Literature Review

Slag is amorphous crystalline fine material. slag having very high specific surface area which makes it easily mix with cement particles. Out of all SCMs slag having higher percentage of reactive silica.[VII] **chahal et al**. investigate and found the influence of bacteria on strength and durability characteristics of concrete mix incorporating silica fume by using bacterial cells concrete become more resistant to sulphate and chlorides. [VIII] **Venugopal et al.** study the effect of partial replacement of cement with slag in concrete mix. Observe that when slag is replaced up to 40% it enhanced the compressive strength, and flexure strength. [IX] **Anestraj et al.** done the experimental research work on concrete mix by addition of bacterial cells of bacillus group called bacillus subtillis.th they found that up to 30 ml addition of bacterial cells gives the maximum strength at 28 days. Bacterial cells of bacillus group are capable of producing calcite precipitation which makes concrete mix more dense and impermeable. Durability increases due to less number of voids in hardened state of concrete.

3. Experimental Program

3.1 Plan of experimental work

Experimental work is done to investigate the properties of concrete mix grade M25 & M40.

1. To obtain the relative properties of materials cement, sand, GGBFS, and aggregates.
2. To calculate mix design ratio for mix of grade M25 & M40 (IS 10262-2009) is used.
3. Mix proportion of partial replacement 0%, 20%, 25%, 30%, 35%, of GGBFS with OPC 43 is prepared.
4.To see the effect on fresh and hardened state properties of concrete bacterial cells in proportion of 0ml, 10ml, 15ml, 20ml, 25ml is added to concrete mix of grade M25 & M40.

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5. To calculate the hardened sate properties, compressive strength, concrete cubes are prepared, cylinders for split tensile strength are prepared.
6. For durability testing concentration of H_2SO_4 is 5%
7. Concrete specimens are cured for 28 days for obtaining the results.
8. After getting all the observations compare the results.
9. Checking the optimum economical replacement of GGBFS with addition of bacterial cells.

3.2 Properties of materials

Material used in concrete mix is cement, sand, aggregates, GGBFS, bacterial cells, superplastisizer, and water.
Cement, coarse aggregates and fine aggregates are tested in laboratory.
Ordinary Portland cement of 43 grade of binani brand is used for concrete mix design. Properties of cement are given below.

Table 1

Physical Requirements for OPC (43 Grade)

S. No.	Characteristics	Requirement
(1)	Fineness	225cm^2/gm
(2)	Specific gravity	3.15
(3)	Soundness (expansion) By Le-Chatelier method	10 mm (Max.)
(4)	Compressive strength at 7 days	33 N/mm^2
(5)	Compressive strength at 28 days	43 N/mm^2

Table 2
Properties of fine and coarse aggregates

S.NO.	Properties	F.A.	C.A.
1.	Fineness modulus	2.64	10mm=6.70
			20mm=7.40
			10&20mm=7.05
2.	Specific gravity	2.68	2.79
3.	Impact test	-	10mm=12%
			20mm=15%
			10&20mm=13%

Physical properties of GGBS as provided by the manufacturer

Table 3
Properties of GGBFS

S.NO.	PROPERTY	PERCENTAGE
(1)	Color	Off white
(2)	Specific density	2.89
(3)	Bulk density	1200 kg/m^3
(4)	Fineness	>350 m^2/kg

Properties of bacterial cells

Bacterial cells that are used in concrete mix are known as bacillus megaterium. These cells are in liquid suspension available in market. These cells are isolated and sell by green life biotech laboratory tamilnadu named by green phosphor. Population of these bacterium cells are 2×10^8 cfu/ml.

3.3 Mix design

Concrete mix design is prepared as per (IS: 10262-2009). Mix design ratio are given in

Table-4
Mix design

Mix	Cement	FA	CA	Water	SP
M25	1	1.15	2.19	0.42	-
M40	1	2.50	4.06	0.33	2%

4. Result and Discussion

4.1 Fresh properties

The properties of concrete in fresh state are tested by using slump cone test.

4.1.1 Slump observations

Slump test is the measurement of true ease by which we can work with concrete. Slump test is the empirical method to measure fresh state properties of

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concrete. Replacement of cement is made by GGBS in various proportions with addition to bacterial cells in various proportions. For both the grade of concrete slump values are varies in the range of 52 mm to 90 mm.

Table 5.

Slump values of concrete mix

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	M25 Slump in (mm)	M40 Slump in (mm)
Control mix	100+0	0 ml	52	54
Mix-1	80+20	10 ml	61	65
Mix-2	75+25	15 ml	69	73
Mix-3	70+30	20 ml	77	81
Mix-4	65+35	25 ml	83	90

4.2 Hardened state properties

Properties of concrete in hardened state are checked by testing under following test.

Compressive strength

Split tensile strength

Flexural tensile strength

4.2.1 Compressive strength

Compressive strength of concrete cubes are tested by using compressive strength testing machine (CTM).Concrete cubes are cured for a period of 28 days at a temperature of 27 degree Celsius. Humidity is 90% and loading rate is 4 tone/minute/mm^2.

Table 6

Compressive strength for M25 in N/mm^2

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Compressive strength in N/mm^2 M25	
			7 days	28 days
Control mix	100+0	0 ml	17.94	33.56
Mix-1	80+20	10 ml	24.11	36.92
Mix-2	75+25	15 ml	28.76	38.16
Mix-3	70+30	20 ml	29.98	40.21
Mix-4	65+35	25 ml	31.22	42.55

Table 7

Compressive strength for M40 in N/mm^2

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Compressive strength in N/mm^2 M40	
			7 days	28 days
Control mix	100+0	0 ml	34.82	48.72
Mix-1	80+20	10 ml	36.52	51.22
Mix-2	75+25	15 ml	39.26	54.52
Mix-3	70+30	20 ml	43.29	57.62
Mix-4	65+35	25 ml	46.98	59.87

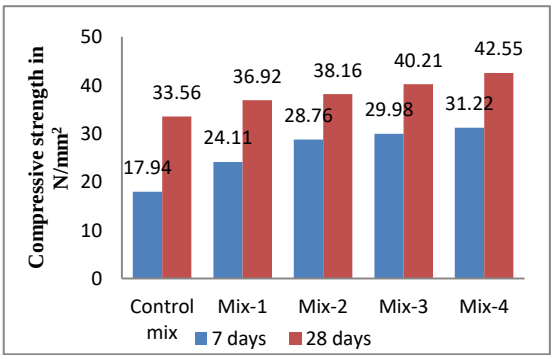

Figure-1 compressive strength for M25 in N/mm^2

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It is observed from figure-1 compressive strength for M25 concrete increases maximum at replacement of 35% with addition of bacterial cells 25 ml. compressive strength increases at an age of 7 days by 42.53% from conventional concrete. Increases in compressive strength at an age of 28 days were observed 21.12%

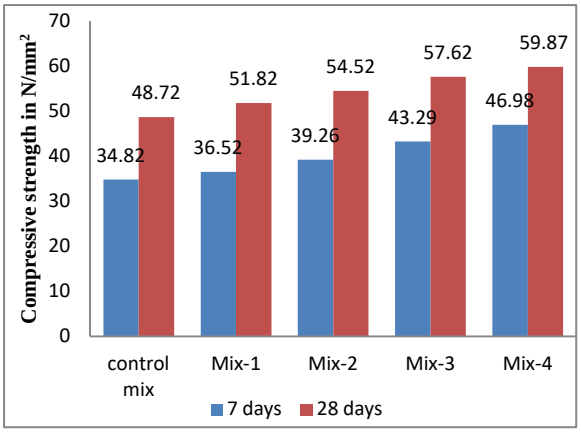

Figure 2 Compressive strength for M40 in N/mm^2

It is observed from figure-2 compressive strength for M40 concrete increases maximum at replacement of 35% with addition of bacterial cells 25 ml. compressive strength increases at an age of 7 days by 25.88% from conventional concrete. Increases in compressive strength at an age of 28 days was observed 18.62%

4.2.2 Flexural Tensile strength

flexure tensile strength test is done to check the tensile strength properties of standard concrete cylindrical specimen.500mm×100mm×100mm beam sample are casted and cured for the same age of 7 days and 28 days for both the concrete mix grade of M25 & M40.values observed during testing are given below.

Table 8

Flexure tensile Strength in (N/mm^2) for M25

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Flexure tensile strength in N/mm^2 M25	
			7 days	28 days
Control mix	100+0	0 ml	5.17	6.40
Mix-1	80+20	10 ml	5.48	6.82
Mix-2	75+25	15 ml	5.80	7.02
Mix-3	70+30	20 ml	5.86	7.21
Mix-4	65+35	25 ml	6.10	7.38

Table 9

Flexure tensile Strength in (N/mm^2) for M25

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Flexure tensile strength in N/mm^2 M25	
			7 days	28 days
Control mix	100+0	0 ml	6.19	7.06
Mix-1	80+20	10 ml	6.27	7.34
Mix-2	75+25	15 ml	7.04	7.66
Mix-3	70+30	20 ml	7.21	7.90
Mix-4	65+35	25 ml	7.34	7.96

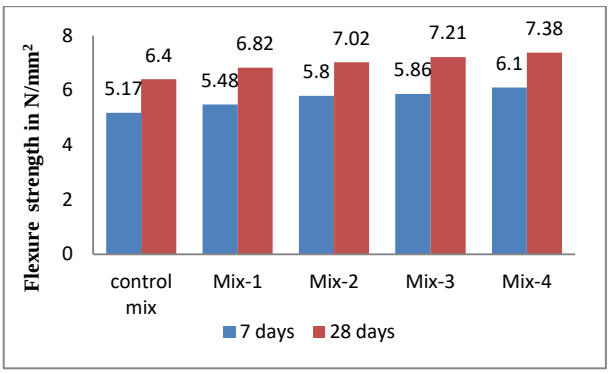

Figure 3 Flexural strength for M25 in N/mm^2

From figure-3 it is observed that flexure tensile strength of M25 grade concrete increases from 16.29% at an age of 7 days from conventional concrete. And flexure tensile strength at an age of 28 days increases from 13.29% from conventional concrete.

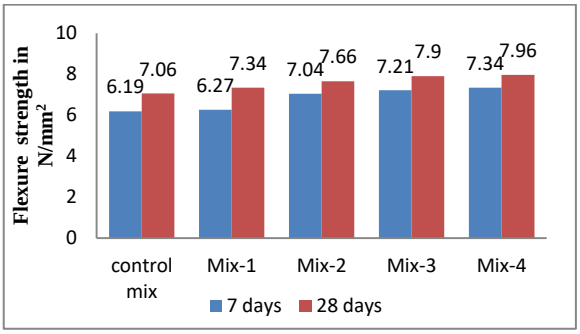

Figure 4 Flexure Tensile Strength of M40 in N/mm^2

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From the figure it is observed that flexure tensile strength of M40 grade concrete increases from 15.66% at an age of 7 days from conventional concrete. And flexure tensile strength at an age of 28 days increases from 11.80% from conventional concrete.

4.2.3 Split tensile strength

Split tensile strength test is done to check the tensile properties of standard concrete cylindrical specimen.150mm×300mm cylindrical sample are casted and cured for the same age of 7 days and 28 days for both the concrete mix grade of M25 & M40.values observed during testing are given below. Maximum load is applied 4 tones in compression testing machine.

Table 10

Split tensile Strength in (N/mm^2) for M25

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Split tensile strength in N/mm^2 M25	
			7 days	28 days
Control mix	100+0	0 ml	2.15	3.42
Mix-1	80+20	10 ml	2.46	3.68
Mix-2	75+25	15 ml	2.98	3.97
Mix-3	70+30	20 ml	3.12	4.12
Mix-4	65+35	25 ml	3.31	4.26

Table 11

Split tensile Strength in (N/mm^2) for M40

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Split tensile strength in N/mm^2 M40	
			7 days	28 days
Control mix	100+0	0 ml	3.09	3.62
Mix-1	80+20	10 ml	3.17	3.85
Mix-2	75+25	15 ml	3.30	4.15
Mix-3	70+30	20 ml	3.74	4.22
Mix-4	65+35	25 ml	3.88	4.31

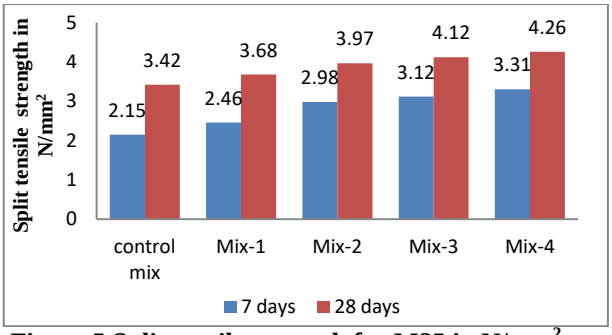

Figure 5 Split tensile strength for M25 in N/mm^2

It is observed from figure-5 splitting tensile strength for M25 concrete increases maximum at replacement of 35% with addition of bacterial cells 25 ml. splitting strength increases at an age of 7 days by 35.04% from conventional concrete. Increases in tensile strength at an age of 28 days were observed 19.71%.

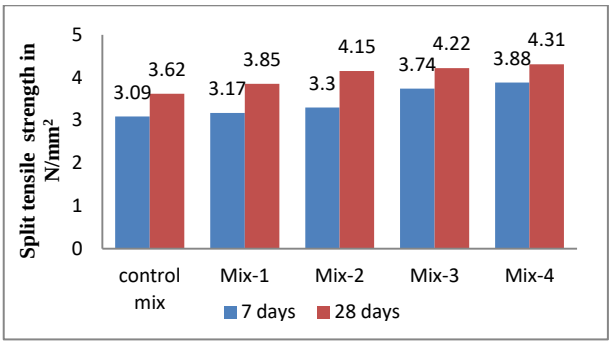

Figure 5 Split tensile strength for M40 in N/mm^2

It is observed from figure-6 split tensile strength for M40 concrete increases maximum at replacement of 35% with addition of bacterial cells 25 ml. split strength increases at an age of 7 days by 20.36% from conventional concrete. Increases in tensile strength at an age of 28 days were observed 16%.

4.3 Durability testing

Durability testing of concrete is done by using following test.

4.3.1 Acid resistivity test

Acid resistivity test is done to checking the acid resistance of concrete. In hardened state concrete cubes of size 100mm×100mm×100mm are casted and submerged in H_2SO_4 for 7 days and 28 days.

Table 12

Loss in Compressive strength value after 28 days

S. No.	CEMENT + GGBS (% wise replacement)	Bacteria cells addition in ml	Compressive strength in N/mm^2 28 days	
			5%H_2SO_4	
			M25	M40
Control mix	100+0	0 ml	10.84	24.82

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Mix-1	80+20	10 ml	18.40	27.52
Mix-2	75+25	15 ml	23.66	34.16
Mix-3	70+30	20 ml	25.72	38.64
Mix-4	65+35	25 ml	27.32	41.78

It is observed from above experimental work at 35% replacement of GGBS with OPC 43 grade cement gives maximum resistance to acid attack for M25 and M40 grade of concrete.

5. Conclusion

1. Compressive strength for concrete is increases maximum when OPC 43 is replaced with GGBS for both the grade of concrete M25 & M40. Maximum increase in compressive strength is observed at 35% replacement of GGBS with addition to 25ml bacterial cells.
2. Split tension and flexure tension strength is increases maximum at percentage replacement of GGBS at 35% with OPC and addition of 25ml bacterial cells.
3. It is observed from above experimental work at 35% replacement of GGBS with OPC 43 grade cement gives maximum resistance to acid attack for M25 and M40 grade of concrete.
4. Bacillus mageterium proved very useful for durability characteristics, biomenralisation is higher for longer duration.
5. Bacterial cells are useful for making concrete impermeable and enhancing the strength.

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