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Properties of GGBS Concrete Under Various Curing Conditions

B. Rama Krishna[1], K. Harish Kumar[2], T. Mani Kumar[3], I. Likitha[4]
[1]Assitant Professor, Department of Civil Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, Andhra Pradesh, India, bollaraki@gmail.com
[2]Assitant Professor, Department of Civil Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, Andhra Pradesh, India, konaharishkumar@gmail.com
[3,4]U. G Student, Department of Civil Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, Andhra Pradesh, India

ABSTRACT

Consumption of cement is increasing rapidly in the construction industry. Manufacturing of cement is an energy intensive process and releases hazardous gases leads to environmental problems. Cement consumption is reduced by using supplementary materials like GGBS, fly ash, rice husk etc. GGBS is a waste material and this is a good supplementary material to cement, because GGBS rich in lime and silica. Cement is replaced by GGBS up to 50% even in some studies it is up to 70%. This paper investigates on mechanical properties of GGBS concrete under immersed curing and membrane curing methods (M30 Grade concrete). Air tight polyethylene covers are used for membrane curing.

Key words: Cement, Compressive Strength, Ground Granulated Blast Furnace Slag (GGBS), Membrane Curing, Workability.

1. INTRODUCTION

Cement is the prime raw material to produce concrete because of cement having binding property. Generally, production of cement leads to environmental damage. Hence supplementary materials take place major role to replace with cement at different percentages. GGBS is a waste material produced from the steel industry and this waste material creates a lot of problem on disposal [1]. To reduce disposal problem and to increase the usage of supplementary materials GGBS is used as cementations material in concrete. GGBS is high in Cao and silica which are main responsible to binding property and strength. GGBS concrete has high durable and resistant to Sulphate attack [2]. Many researchers said that curing means maintaining the required moisture content in concrete for complete heat of hydration. In this study for comparison purpose immersed curing and membrane curing methods are used. When availability of water is less and there is no accessibility, then membrane curing is most effective curing method. For concrete blocks membrane curing is done by using air tight polyethylene covers at room temperature.

1.1 Objectives

1. At different percentages of GGBS in concrete workability can be determined by using compaction factor test.
2. At different percentages of GGBS compressive strength could be deter med at 7 days and 28 days under immersed curing.
3. At different percentages of GGBS compressive strength can be determined at 7 days and 28 days under membrane curing.
4. Compare the results and Judge the maximum percentage of GGBS as replacement material with cement under immersed and membrane curing conditions.

1.2 Methodology

1. Collection of literature by using journals and articles.
2. Material properties & Mix design of M30 Grade concrete as per IS10262:2009.
3. Workability test on fresh concrete (Compaction Factor Test).
4. Mechanical properties like compressive strength of concrete.
5. Comparison of test results

2. MATERIALS

Use the main units SI (MKS) or CGS. English units may be used as secondary units (SI units strongly encouraged).

2.1 Ordinary Portland cement (OPC)

53 Grade of OPC is used for the proposed experimental work. According to IS 12269-2013 different tests are conducted [3] on OPC are shown in Table 1.

Table 1: Properties of 53 grade OPC

S.No	Properties of cement	Test Result	Standards as per IS:12269-2013
1	Specific gravity	3.15	-
2	Initial setting time	42 Minutes	Should not <30 min
3	Final setting time	520 Minutes	Should not >600 min
4	Soundness(Expansion)	4mm	Should not >10mm
5	Standard consistency (%)	30%	-
6	Fineness (Residue Test)	7%	Should not >10%

2.2 Fine aggregate (FA)

Fine aggregate means Natural sand with mixture of small particles of grains with size less than 4.75 mm. depending up on the texture and grading of aggregates workability and strength is influenced. Different tests are conducted on fine aggregates as shown in Table 2.

Table 2: Properties of FA

Tests conducted	Values
Fineness modulus of fine aggregates	2.34 As per IS 383 this is Zone-III Sand
Specific-gravity	2.56
Water absorption	0.5%

2.3 Coarse aggregate (CA)

CA give shell to the concrete. In this experimental work 20 mm is the maximum size. Depending on the parent rock the properties can be varied [4]. Different tests are conducted on coarse aggregates as shown in Table 3.

Table 3: Properties of CA

Tests conducted	Values
Specific-gravity	2.74
Aggregate crushing Strength	18%
Aggregate Impact value	22%
Water absorption	3%

2.4 Water

Generally potable water which is available locally is used of making and curing of concrete.

2.5 GGBS (Ground Granulated Blast Furnace Slag)

Cement is replaced with GGBS because of GGBS is rich in Cao and Silica [6]. Table 4 describes GGBS 'physical and chemical characteristics.

Table 4: Properties of GGBS

Chemical properties		Physical properties	
Calcium oxide	42%	Colour	Pale-white
Silica	31%	Specific-gravity of GGBS	2.7
Alumina	11%	Bulk density	1160 kg/m^3

3. MIX DESIGN DETAILS

Using material test data [7], According to IS 10262-2009 guidelines, M_{30} is prepared for concrete mix design and the proportions are tabulated in Table 5.

Table 5: Mix proportions

S.No	Ingredient	Quantity
1	Cement	391.3 kg/m^3
2	Fine Aggregates	632 kg/m^3
3	Coarse Aggregates	1264 kg/m^3
4	Water	176.1liters/m^3
5	W/C ratio	0.45

4. EXPERIMENTAL WORK

The test results for workability, compressive strength (at 7 days and 28 days) of concrete mix M_{30} with different GGBS percentages (0%, 10%, 20%, 30%, 40% and 50%) with constant W/C ratio 0.45 are shown in Table 6, Table 7 & Table 8.

4.1 Workability

For determination of workability in the laboratory compaction factor test is most effective one [8] [9]. The ratio of partially compacted to fully compacted gives the compaction factor value which is shown in Table 6 and Figure 1 indicates the compaction factor values.

Table 6: Compaction Factor Test Results

Percentage of GGBS	0	10	20	30	40	50
Compaction factor values	0.87	0.85	0.84	0.83	0.83	0.82

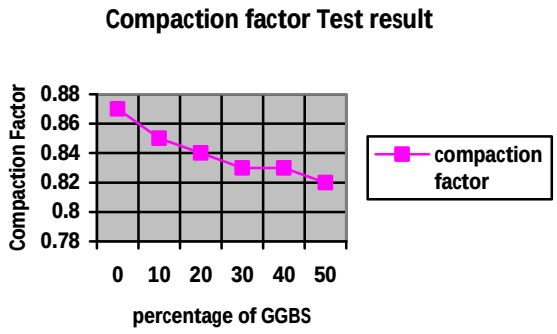

Figure 1: Compaction Factor test results

4.2 Compressive strength test result

4.2.1 Immersed curing environment

After remoulding the concrete cubes, immerse in water sump. After required curing period concrete cubes are sending to testing and the test results are descried in Table 7. Figure 2 shows the Compressive strength at 7 days and 28 days curing for GGBS concrete under immersed curing condition.

Table 7: Compressive strength at 7 days and 28 days curing for GGBS concrete under immersed curing condition

Percentage of cement	100	90	80	70	60	50
Percentage of GGBS	0	10	20	30	40	50
7-Days compressive strength (N/mm^2)	27.42	30.8	34.8	32.6	34.3	32.16
28-Days compressive strength (N/mm^2)	38.75	38.72	41.16	42.75	34.82	35.67

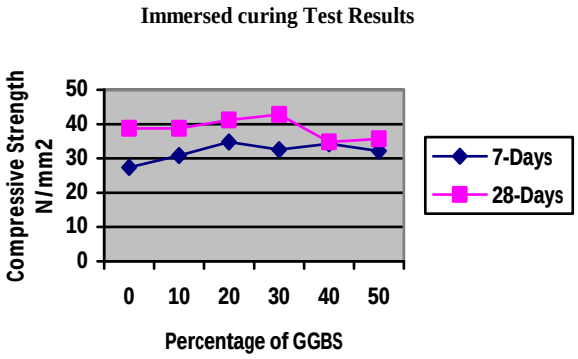

Figure 2: Compressive strength at 7 days and 28 days curing for GGBS concrete under immersed curing condition

4.2.2 Membrane curing environment

Figure 3: Test cubes under membrane curing environment

After remoulding the concrete cubes and sealed in air tight polyethylene covers for membrane curing as shown in Figure 3. After required curing period concrete cubes are sending to testing and the test results are shown in Table 8. Figure 4 shows the Compressive strength at 7 &28 days for GGBS concrete under membrane curing condition.

Table 8: Compressive strength at 7 &28 days for GGBS concrete under membrane curing condition

Percentage of cement	100	90	80	70	60	50
Percentage of GGBS	0	10	20	30	40	50
7-Days compressive strength (N/mm^2)	29.15	28.95	27.6	28.75	31.23	30.26
28-Days compressive strength (N/mm^2)	35.26	33.76	34.23	36.75	35.26	35.16

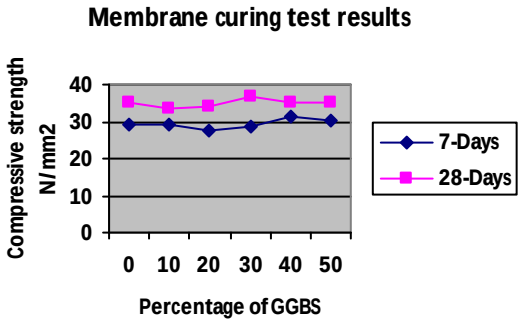

Figure 4: Compressive strength at 7 &28 days curing for GGBS concrete under membrane curing condition

4.2.3 Comparison of 28 days' compressive strength for immersed and membrane curing conditions

Comparisons of 28 days' compressive strength for immersed and member curing conditions are made [10] and the results are tabulated in Table 9 and Figure 5 shows the comparative results of 28 days' compressive strength.

Table 9: Comparison of Compressive strengths at 28 days for GGBS concrete under immersed and membrane curing condition

Percentage of cement	100	90	80	70	60	50
Percentage of GGBS	0	10	20	30	40	50
28-Days compressive strength under immersed curing (N/mm^2)	36.75	38.72	41.16	42.75	34.82	35.67
28-Days compressive strength under membrane curing (N/mm^2)	35.26	33.76	34.23	36.75	35.36	35.16

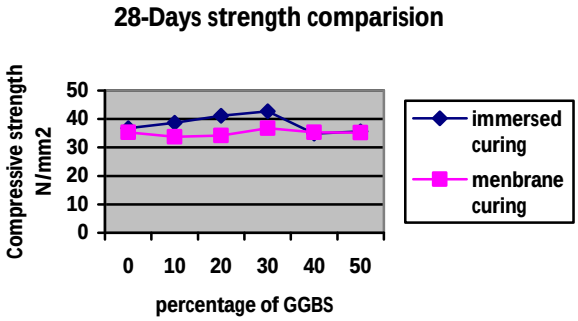

Figure 5: Comparison of Compressive strengths at 28 days for GGBS concrete under immersed and membrane curing condition

5. CONCLUSION

- Concrete workability is decreased as the percentage of GGBS increases.
- Target strength is achieved for M30 Grade mix design.
- Compressive strength of concrete is increased up to 30% replacement of cement with GGBS under immersed curing condition and membrane curing condition.
- The optimum GGBS percentage is 30% of the test results is under normal curing condition and membrane curing condition, but in membrane curing target strength is not reached.

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