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Workability And Strength Characteristics Of Concrete When Fine Aggregate Is Replaced By Granulated Blast Slag

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Abstract - *Concrete is the most popularly used substance for major infrastructure construction. Environmental issues are worsening as a result of the growing appetite for concrete caused by urbanization. Thus, there is a requirement for alternative construction materials. The main component of concrete, fine aggregate has a significant influence in mix composition. The largest consumer of material resources is the construction industry, which has caused the exploitation of natural sand. This circumstance prompted the development of novel alternative material. The motive of this investigation is to decrease the usage of natural sand by substituting it with Granulated Blast Furnace Slag (GBS). In this study, natural sand is partially replaced by GBS in 0%, 5%, 10%, 15%, 20%, 25% and 30%. The grade of the concrete is M_{20} and the w/c ratio is 0.5. The characteristics of the concrete like workability, compressive strength, split tensile strength and flexural strength are examined. The outcomes shows that the optimum replacement of fine aggregates by GBS is 20%.*

Key Words: Construction, Concrete, Fine Aggregates, Workability, Strength.

1.INTRODUCTION

India is a growing nation right now. There are several ongoing construction projects today. It can be a result of globalization. Concrete technology has made major growth in the last decade, which have led to cost-effective enhancements in strength of the concrete. This economic expansion relies on using the resources that are readily available efficiently. Natural sand or river sand, which is widely used component as fine aggregates in the manufacturing of standard concrete, is getting very costly. Sand extraction from riverbeds in large quantities endangers the ecosystem and can result in riverbank slides and the eradication of riverbank flora. To overcome these problems the utilization of natural river sand in concrete should be reduced and it can be replaced with low-cost industrial waste substances, for instance Granulated Blast Furnace Slag.

When the molten slag from melted iron ore is quickly quenched and then turned into a powder, it is transformed into granulated blast furnace slag (GBS), a reusable material. For more than a century, this substance has been utilized as a cement substitute due to its cementitious characteristics. The engineers have recently used it in some of the highway construction projects. In this study, the attempt is made to use GBS as fine aggregates in concrete. It consists of calcium, silicon, aluminium, magnesium in various percentages.

2. METHODOLOGY

The various methods that are employed in this study are as follows

- The materials such as cement, river sand, GBS and coarse aggregates that are required for the production of concrete are procured from available sources.
- The collected materials are subjected to basic testing in the laboratory.
- The mix design for concrete of grade M_{20} is done as per IS: 10262-2009 with the water to cement ratio of 0.5.
- The various mix combinations are calculated by partially replacing fine aggregates of concrete by GBS in 0%, 5%, 10%, 15%, 20%, 25% and 30%.
- The workability test of concrete is performed as per IS: 1199-1959 before the casting of specimen.
- The specimens are casted on various mix combinations and cured as per test requirements.
- The compressive strength is performed as per IS:516-1959 on 150mm*150mm*150 mm cube specimens that are cured for 3 days, 7 days and 28 days.
- The split tensile strength is performed as per IS:5816-1999 on cylindrical specimens of dia. 150mm and height 300mm that are cured for 3 days, 7 days and 28 days.
- The flexural strength is performed as per IS: 516-1959 on 100mm*100mm*500mm beam specimens that are cured for 28 days.

3.MATERIALS

3.1 Cement

The OPC cement of Ambuja of grade 53 in accordance to IS: 12269-1987 is utilized throughout the study. The basic characteristics of cement are specified in the below table 1.

Table -1: Characteristics of Cement

Sl. No.	Characteristics	Outcomes
1	Specific Gravity	3.10
2	Standard Consistency	37%
3	Initial Setting Time	34 min.
4	Final Setting Time	362 min.

3.2 Fine Aggregates

The natural sand that is available in the nearby area is used in this study. The basic tests and grading of fine aggregates are carried out as per IS: 2386 (PART 3)-1963 and IS: 383-1970 respectively. The basic characteristics of natural sand are specified in the below table 2.

Table -2: Characteristics of Fine Aggregates

Sl. No.	Characteristics	Outcomes
1	Specific Gravity	2.56
2	Sieve Analysis	2.68(Zone III)
3	Bulking	4%

3.3 Coarse Aggregates

The coarse aggregates having maximum size of 20mm is utilized in this study. The basic tests are carried out as per IS 2386 (PART 3)-1963. The basic characteristics of coarse aggregates are specified in the below table 3.

Table -3: Characteristics of Coarse Aggregates

SN.	Characteristics	Outcomes
1	Specific Gravity	2.66
2	Sieve Analysis	6.8
3	Water Absorption	0.44%

3.4 Granulated Blast Furnace Slag

The GBS having size ranging from 2.36mm to 150µm is obtained from the J.S.W steel factory, Bellary, Karnataka, India. The basic tests are carried out as per IS 2386 (PART 3)-1963. The characteristics of GBS are given in the table 4.

Table -4: Characteristics of GBS

Sl. No.	Characteristics	Outcomes
1	Specific Gravity	2.7
2	Bulking	6%
3	Sieve Analysis	2.62(Zone II)

3.5 Water

The portable water which is free from hazardous materials, such as acids, alkalis or oils is used in this study. The pH of the water scales from 5.5 to 7.5.

3.6 Mix Design

The mix design of concrete with M_{20} grade is carried out as per IS:10262-2009. The water to cement ratio maintained is 0.5. The obtained mix proportions are specified in the table 5 and various mix designations are specified in the table 6.

Table -5: Mix Proportion

Sl. No.	Materials	Proportion	Weight (Kg/m^3)
1	Cement	1	395.2
2	Fine Aggregates	1.56	616.51
3	Coarse Aggregates	2.94	1161.88
4	Water	0.5	197.6

Table -6: Mix Designation

Sl. No.	Mix	Designation
1	C_0	0% GBS Replacement
2	C_1	5% GBS Replacement
3	C_2	10% GBS Replacement
4	C_3	15% GBS Replacement
5	C_4	20% GBS Replacement
6	C_5	25% GBS Replacement
7	C_6	30% GBS Replacement

4.RESULTS AND DISCUSSIONS

4.1 Workability Test

The outcomes of the slump cone test of concrete are given in the table 7. It is examined that the workability of the concrete reduces with rise in percentage of GBS. This trend is observed because the water absorption of GBS is more when compared to the natural sand. The graphical results of workability test are given in the chart 1.

Table -7: Workability Test Results

Sl. No.	Mix Designation	Slump Value(mm)
1	C_0	110
2	C_1	108
3	C_2	107
4	C_3	105
5	C_4	105
6	C_5	103
7	C_6	101

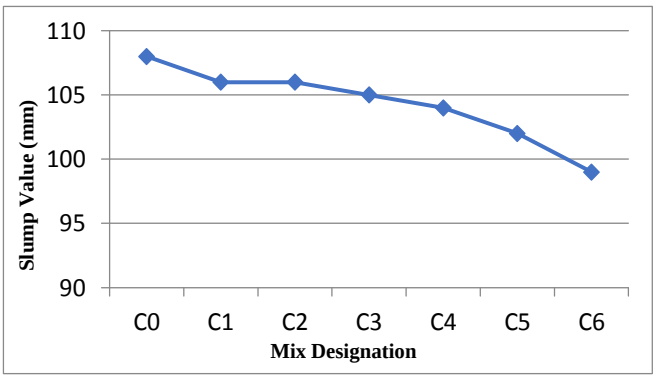

Chart -1: Workability Test Results

4.2 Compressive Strength Test

The outcomes of compressive strength test are specified in the table 7. The compressive strength of C_0 is 27.66 N/mm² at 28 days. The C_4 has the highest compressive strength of 31.94 N/mm² at 28 days which is 15.47% more when compared to the C_0. It can be observed that the C_6 also has the satisfactory results compared to C_0. The graphical results of compressive strength are drawn in the chart 2.

Table -7: Compressive Strength Test Results

Sl. No.	Mix Designation	Compressive Strength(N/mm²)		
		3 Days	7 Days	28 Days
1	C_0	18.30	22.25	27.66
2	C_1	18.86	23.12	28.53
3	C_2	19.34	23.56	29.42
4	C_3	20.32	24.33	30.61
5	C_4	21.65	25.52	31.94
6	C_5	20.92	24.62	31.55
7	C_6	20.38	23.75	30.60

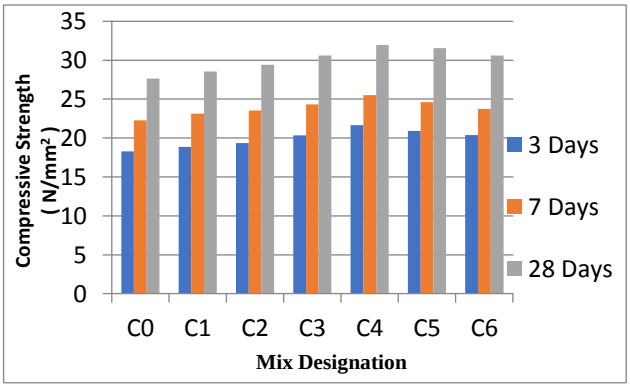

Chart -2: Compressive Strength Test Results

4.3 Split Tensile Strength Test

The outcomes of the split-tensile strength test are given in the table 8. The conventional concrete has the split tensile strength of 3.75 N/mm² at 28 days. The split-tensile strength of C_4 is the highest i.e., 4.08 N/mm² which is 8.8% more when compared to the C_0 at 28 days. The graphical outcomes of the split tensile strength are drawn in the chart 3.

Table -8: Split Tensile Strength Test Results

Sl. No.	Mix Designation	Split-tensile Strength(N/mm²)		
		3 Days	7 Days	28 Days
1	C_0	2.62	2.98	3.75
2	C_1	2.71	3.08	3.88
3	C_2	2.79	3.14	3.97
4	C_3	2.84	3.23	4.04
5	C_4	2.98	3.38	4.08
6	C_5	2.91	3.32	4.06
7	C_6	2.88	3.29	4.02

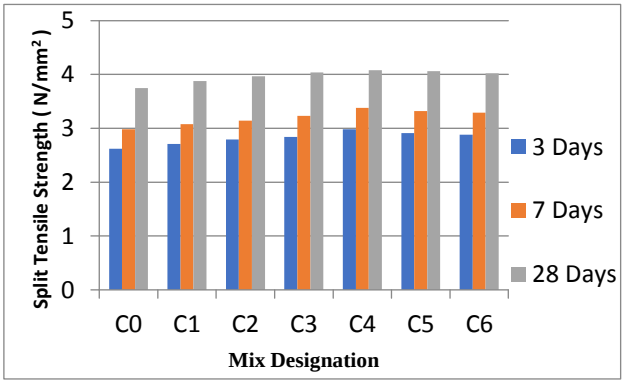

Chart -3: Split Tensile Strength Test Results

4.4 Flexural Strength Test

The outcomes of flexural strength test are specified in the table 9. The flexural strength of conventional concrete at 28 days is 5.88 N/mm². The C_4 has the highest flexural strength of 6.82 N/mm² at 28 days which is 16% more when compared to the C_0. It can be observed that C_6 has result that is satisfactory to C_0. The graphical outcomes of flexural strength test are given in the chart 3.

Table -9: Flexural Strength Test Results

SN.	Mix Designation	Flexural Strength(N/mm²)
1	C_0	5.88
2	C_1	6.15
3	C_2	6.36
4	C_3	6.74
5	C_4	6.82
6	C_5	6.65
7	C_6	6.24

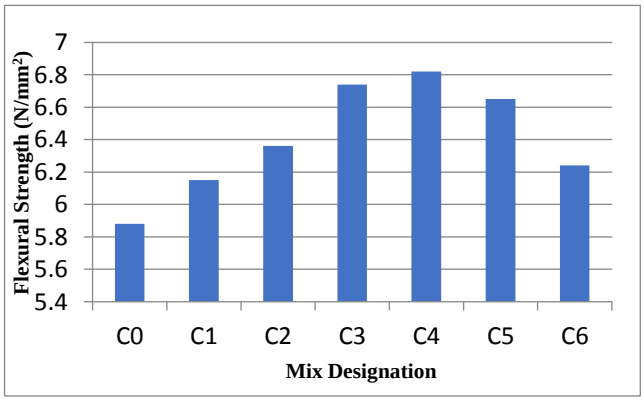

Chart 4: Flexural Strength Test Results

5. CONCLUSIONS

The conclusions that are obtained from the study are as follows.

- The workability of the concrete reduces with the rise in percentage replacement of GBS.
- The C_4 has the highest compressive strength of 31.94 N/mm² at 28 days which is 15.47% more when compared to the C_0.
- The highest split-tensile strength of 4.08 N/mm² is examined for C_4 which is 8.8% more when compared to the at C_0 28 days.
- The flexural strength at 28 days is highest for C_4 which is 16% more when compared to the C_0.
- The optimum replacement of fine aggregates by GBS in concrete is 20%.

REFERENCES

[1] Dodda Srinivas, Hardik Chitirala, Srinivasarao C H and Dibyendu Adak, "A study on partial and full replacement of fine aggregate in high-performance concrete with granulated blast furnace slag," IOP Conf. Series: Materials Science and Engineering 989, 2020.

[2] Mr. Dr. Vivek R Das, Mr. Nagarjun Gowda B. S, Ms. Apoorva M, "Comparative Study on Concrete Mix with Replacement of Fine Aggregate," International Research Journal of Engineering and Technology, Vol 7, Issue 9, Sep 2020.

[3] Sagar S, Kalappa U.P. Jyothipriya G.S and Umar Mohd Nousheen, "Performance of Concrete by Partially Replacing Fine Aggregate with GBS and Cement with Fly Ash," International Journal of Advanced Science and Technology, Vol. 29, No. 7, 2020.

[4] Patel Hardik Vinubhai, Nihil Sorathia and Amol D. Pund, "Effect of Partial Replacement of River Sand by GBS Sand and Crushed Sand on Strength Characteristics of Concrete," International Journal for Scientific Research & Development|, Vol. 6, Issue 02, 2018.

[5] M.M.Patil, Sana Shaikh, Sunil Talwar, Reddy Shivakumar and Vanajakshi Gaji, "Experimental study of engineered cement composites with partial replacement of fine aggregates by GBS," International Journal of Application or Innovation in Engineering & Management, Volume 7, Issue 8, August 2018.

[6] Rakesh Kumar Patra and Bibhuti Bhusan Mukharjee, "Properties of concrete incorporating granulated blast furnace slag as fine aggregate," Advances in Concrete Construction, Vol. 5, No. 5, 2017.

[7] B. Naga Niranjan Kumar, J. Saran Kumar and R.V. Naga Rajarao, "An Experimental Investigation on M30 Concrete with Partial Replacement of Fine Aggregate by GBS," International Journal of Scientific Research in Science and Technology, Vol. 3, Issue 3, 2017.

[8] Rajith M and Amritha E K, "Performance of Concrete with Partial Replacement of Cement and Fine Aggregate by GGBS and GBS," International Journal of Research in Advent Technology (E-ISSN: 2321-9637) Special Issue International Conference on Technological Advancements in Structures and Construction "TASC-15", 10-11 June 2015.