An Experimental Investigation on Partial Replacement of Cement by GGBS & Full Replacement of River Sand by Robo Sand in Concrete

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Abstract - *The cost of building supplies today has an impact on every structure's economy. It is a key element influencing environmental housing systems all over the world. Sand will be utilized as the fine aggregate in concrete, along with traditional materials like gravel. While Robo sand (Stone dust) will be used to full replace the natural sand in concrete, GGBS is used as partial replacement of cement in concrete. In this study, M30 grade of concrete with a combination of GGBS as partial replacement in the proportion of 0%, 10%, 20%, 30% , 40% and 50% will be replaced and Robo sand (stone dust) as fine aggregate with a full 100% replacement of natural sand, sample specimens are prepared and will be tested for workability, displaying the comparative results with conventional M30 grade concrete as well as the compressive strength, split tensile strength and flexural strength for 7, 14, and 28 days, respectively. With the help of this project's inquiry, concrete may become high dense while using robo sand and it gets excellent workability with GGBS as well as carbon content as heat of hydration will gets reduced.*

Key Words: **compressive strength, tensile strength and flexural strength. GGBS (Ground Granulated Blast Furnace Slag), Robo sand (M-sand).**

1. INTRODUCTION

Man's three fundamental requirements are for food, clothes, and shelter. All of a person's fundamental needs are directly or indirectly relevant to civil engineers. Humankind has made significant advancements in the way that shelter is built. Man, first lived in huts, which through time transformed into load-bearing homes. The rising cost of building construction materials is a major worry in this built environment. The price of construction supplies is increasing daily. Aggregates, cement, and water are the most often used composite materials in concrete, which is used by people all over the world. The growth of infrastructure around the world has boosted the need for construction materials. Production is anticipated to rise to more than billion tons per year. The demand for its components, including aggregates, cement, water, and admixtures, has increased because to the rapid growth of infrastructure development and building activities worldwide.

The majority of researchers are now concentrating on use of the waste materials in concrete according to their properties. Concrete can be partially replaced by fly ash, rice husk, slag, and sludge from the treatment of home and industrial waste water. In addition to the waste materials already mentioned, research suggests that Ground Granulated Blast Furnace Slag waste from steel industry can also be used as cementitious material in concrete.

Robo sand, also referred to as quarry dust, is a product of crushed stone quarries. The challenge of preserving natural sand can be solved by using robo sand, and several states have already outlawed the use of river sand for building. According to sources, Robo sand is widely used throughout the world, and all projects worldwide insist on utilizing it in place of natural sand.

The primary goal of this project is to investigate the qualities of concrete utilizing Granulated Blast Furnace Slag (GBS), which is used in place of natural sand and cement in percentages of 0, 10, 20, 30, 40, and 50%. This study focused on the workability, compressive strength, and split tensile strength of concrete made with M30 grade mix. Therefore, the concrete made from GGBS and robo sand is the subject of this thesis.

2. LITERATURE REVIEW

Dr. Chandrashekar A, Pramod K, and Chaithra H L (2015). Based on their experimental examination, it was discovered that the amount of GGBS in concrete increased with workability. As the proportion of quarry sand rises, it further falls. Maximum compressive and flexural strength was achieved when 40% GGBS was used to replace cement. Maximum split tensile strength is attained when sand is replaced with 40% QS and 50% GGBS in the cement.

C. S. Mallikarjuna and Dr. D. V. Prasada Rao (2016). According to their test results, using 40% GGBS and 50% Quarry Dust leads in an increase of 18% in Compressive Strength at 28 days. At a replacement rate of 40% GGBS and 50% quarry dust, split tensile strength increases by a maximum of 23.5 percent when compared to control concrete. At 40% and 50% substitutions of cement and fine aggregate with GGBS and quarry dust, respectively, the greatest percentage gain of 29% in flexural strength compared to control concrete is achieved. The Water Absorption has the lowest value with a replacement percentage of 40% cement with GGBS and 50% fine aggregate with Quarry Dust. Finally, it is fascinating to see that different test variations in test results followed the similar trend.

Nidhi Gupta and Yogesh Soni (2016). Based on their experimental examination, it was discovered that when GGBS in concrete grows, so does workability. As the proportion of quarry sand rises, it further falls. Maximum flexural strength was attained when 40% GGBS was used to replace cement. Maximum flexural strength was attained by replacing half the cement with GGBS and half the sand with QS.

Rahul (2016) To solve the issue of disposing of solid waste, the concrete industry is continually looking for additional cementitious material. Among the solid wastes produced by industry are rice husk ash, quarry sand, and ground granulated blast furnace slag (GGBS), to name a few. An economically viable solution to this dilemma is the partial substitution of cement with GGBS and RHA and natural sand (NS) with Quarry sand. This study is conducted in two phases. I have a first phase. Analysis and comparison of the results with the nominal mix will be done after the strength properties of the concrete mix are examined for 7 days, 14 days, and 28 days of curing. These characteristics include compressive strength and split tensile strength.

Ananthi Arunachalam (2018). Based on her findings, relevant inferences can be drawn about the workability, strength, durability, and other properties of concrete. Natural sand is replaced with manufacturing sand, and cement is partially replaced with 20 percent GGBS in concrete of the M25, M30, and M40 classes. Overall, it has been found that artificial sand is the strongest and most durable alternative to natural sand. After using GGBS and M-sand, the concrete's compressive strength rose. At the seventh day, the M30 grade concrete reaches a higher starting strength than the M25 and M40 grade concretes. The M30 grade of concrete is discovered to be more effective from the comparison results of the three classes of concrete.

T. Venkat Das and S. K. Sirajuddin (2019). They came to the conclusion from their inquiry that the test results showed an increase of 10%, 12%, and 15% in Compressive strength, spilt tensile strength, and Flexural strength attained at 40% GGBS and 50% QD replacements of cement and fine aggregate, respectively. Finally, we draw the conclusion that substituting 40% GGBS for cement and 50% QD for fine aggregate will result in mixes with greater strengths than the control mix.

Sajidulla Jamkhandi, Mallesh M., and Nandeesh M. (2019). In their investigation, the mean goal strength for concrete of grade M25 is attained by partially substituting GGBS for cement and fine aggregate for robo sand. According to the results of this experimental study, the ideal replacement ratio for M25 grade concrete mix is 20% GGBS replacement for cement and 25% Robo sand replacement for fine aggregate, which results in a 61 percent increase in compressive strength over conventional concrete results and the M25 Mix target strength. Experimental research has shown to be a more effective method of getting rid of industrial waste and byproducts like ground-granulated blast furnace slag and Robo sand. We can reduce environmental waste and improve economics by reinforcing concrete with readily accessible GGBS and Robo sand.

3. MATERIALS & METHODOLGY

1. Cement

We had collected the cement from nearest store and using Ultra techOrdinary Portland cement 53 grade in this project research.

Table – 1: Test results on Cement

S.NO.	Particulars	Test results
1	Specific gravity of cement	3.15
2	Consistency of cement	30%
3	Initial & Final Setting of cement	45 min. & 9 hrs. 40 min.
4	Fineness	6.5%

2. Robo Sand

Well graded crushed stone powder passing through 4.75 mm was used as fine aggregate. Prior to mixing, the stone dust was air dried and sieved to remove any impurities. We are testing stone dust for its ability to absorb water, its specific gravity, and its fineness modulus.

Fig – 1: Robo sand

Table - 2 Test results of Fine Aggregate

S.NO.	Particulars	Result
1	Specific gravity	2.69
2	Water Absorption	2.4%
3	Fineness modulus	2.77

3. Crushed Stone Aggregate

The typical coarse material used for this project is crushed granite with a maximum particle size of 20 mm. We are testing coarse aggregate for its ability to absorb water as well as its specific gravity and fineness modulus.

Fig – 2: Crushed coarse aggregate (20 mm)

Table - 3: Test results on Coarse Aggregate

S.NO.	Particulars	Result
1	Specific Gravity	2.75
2	Water Absorption	0.5%

4. Ground Granulated Blast Furnace Slag

The major use of GGBS is in ready mixed concrete, and it is utilized in a third of all UK "ready-mix" deliveries. Specifiers are well aware of the technical benefits, which GGBS imparts to concrete, including:

1. Better workability, which facilitates placement and compaction

2. A lower rise in early age temperature, which lowers the chance of thermal cracking in huge pours.

3. Reducing the possibility of harmful internal reactions such ASR

4. High chloride ingress resistance, lowering the risk of reinforcing corrosion

5. High resilience to chemical and sulphate attack.

6. Considerable environmental advantages.

METHODOLOGY

The method which is used to mix design in the research is IS recommendations (i.e., as per IS:10262-2019) of all test results of fresh and hardened properties of concrete.

Choosing the right mix grade, designing it using the right procedure, creating test batches, and determining the final mix ratios.

- Calculating the total amount of concrete needed to complete the job.

- Calculating how much cement, stone dust, coarse aggregate, and GGBS will be needed to complete the job.

- Testing the properties of GGBS, cement, stone dust, and coarse aggregate.

Indian Standard method is used for finding the properties of materials to mix grade.

Table – 4: Combination of Replacement of GGBS & Robo sand

S.NO.	Particulars %GGBS+%RS	Cement	GGBS	RS	CA
1	0%+100%	505	0	605.12	1120.4
2	10%+100%	454.5	50.5	605.12	1120.4
3	20%+100%	4.4	101	605.12	1120.4
4	30%+100%	353.5	151.5	605.12	1120.4
5	40%+100%	303	202	605.12	1120.4
6	50%+100%	252.5	252.5	605.12	1120.4

Table – 5: Mix proportions of M_{30} grade concrete

Cement	Fine Aggregate	Coarse Aggregate	Water
505	605.12	1120.4	222.51
1	1.20	2.22	0.44

4. RESULTS AND ANALYSIS

The analysis of workability, compressive strength, split tensile strength, and flexural strength of concrete of M30 grade mix concrete for 7, 14, and 28 days with the replacement of GGBS as cementitious material by 0%, 10%, 20%, 30%, 40%, and 50% respectively, and natural sand with Robo sand is shown in the tables and graphs below.

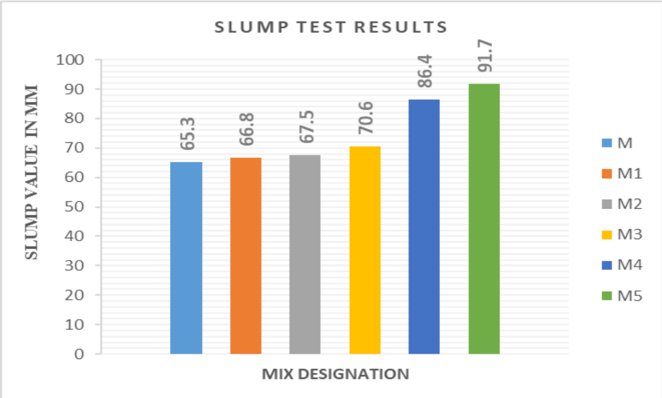

Chart -1: Slump test values

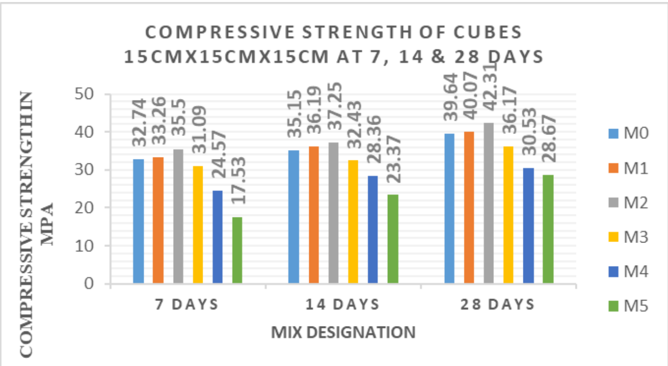

Chart -2: Compressive strength test values

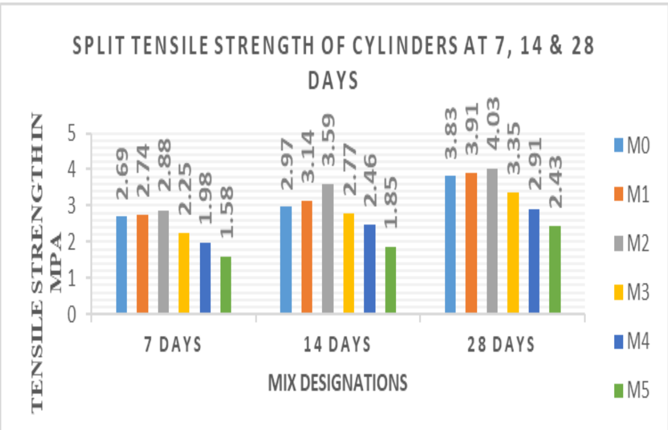

Chart -3: Split tensile strength test values

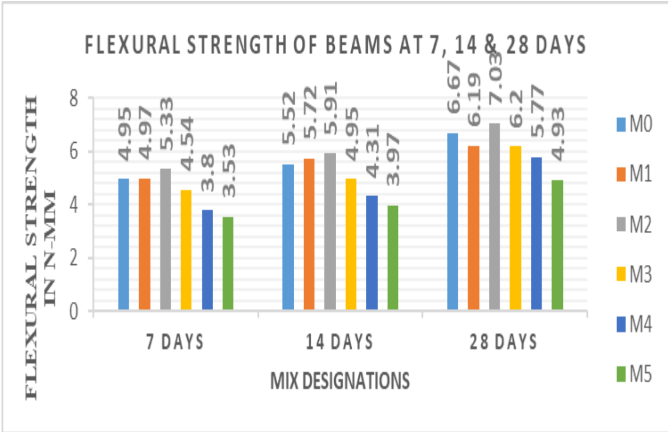

Chart -4: Flexural strength test values

5. CONCLUSIONS

On the basis of results obtained by this experimental investigation of M30 grade concrete, following conclusions are shown below: -

1. The workability of the fresh concrete is excellent with granulated blast furnace slag by replacement of cement. The slump values increase with increasing percentage of slag in the mix maximum value occurs at M5.
2. The compressive strength of hardened concrete is almost above M30 grade at 7 days and 14 days of mixes M0, M1, M2 and M3 and below 30 N/mm² for mixes M4 and M5. After 28 days the maximum strength occurs at mix M2 that is 20% of slag with 100% of robo sand.
3. Further, the strength gets reduces gradually for other mixes M3, M4 and M5. Therefore, the best mix for producing concrete is M2. And it is above the value of target mean strength i.e., 38.25 N/mm².
4. And also, if further wants to decrease the cement content with acceptance of strength the mixes M3 and M4 can also be used for making M30 grade concrete.
5. The tensile strength of concrete increases when compared to conventional concrete mix M0 with adding mineral admixture. And the strength gets gradually increases from 7 days to 28 days for the mixes M1 to M3 with increase of slag and further it gets reduces for the mixes M4 and M5.
6. From the code guidelines the required tensile strength of concrete from the empirical formula is 3.83 N/mm³. As per the concerned strength considered the mix for tensile strength of concrete is preferrable M0, M1 and M2.

7. And the remaining mixes are neglected i.e., M4 and M5. The maximum tensile strength of concrete will get for the mix M2 i.e., 4.03 N/mm^2 which is greater than the required.

8. The flexural strength of concrete is increase with gradual increase in adding admixture in the mixture of concrete proportions. The strength gets increases from 7 days to 28 days for the mixes M0, M1 and M2. The maximum flexural strength occurs for the mix M2 when compared to M0 and M2.

9. And further the flexural strength gets reduces gradually for the mixes M3, M4 and M5 from 7 days to 28 days.

10. Therefore, from the investigation point of view the partial replacement of cement by granulated blast furnace slag with robo sand is giving excellent results when compared to conventional concrete.

11. And also, by the use GGBS in the concrete with partial replacement of cement decreases the cement production and also it helps the reduce the large carbon emission gases in the environment from cement industries.

12. So, it is environmental eco-friendly and good advantage in the case of cost of production cost and also strength points of view and good workability properties.

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