

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 6, Issue 12, December 2017

# A Study on Partial Replacement of Cement with GGBS and Coarse Aggregate with Steel Slag

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**ABSTRACT:** This study presents an evaluation of steel slag aggregate concrete with and without adding GGBS in comparison with the conventional natural aggregate concrete. Hardened concrete consist of more than 70% aggregate due to the high demand in building construction and the increase of the amount of disposed waste material, suppliers and researchers are exploring the use of alternative materials which could preserve natural sources and save the environment. Steel slag was used as an aggregate replacement in conventional concrete mixes. Steel slag which is mainly consists of calcium carbonate is produced as a by-product during the oxidation process in steel industry. Steel slag was selected due to its characteristics, which are almost similar to conventional aggregates and the fact that it is easily obtainable as a by-product of the steel industry. As a result, utilization of steel slag will save natural resources and clean environment. Particle packing analysis is made to optimize the gradation of coarse aggregate which would decrease the cement requirement and increase the density of packing which would result in its improved performance in terms of strength and other parameters. GGBS is a by-product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for GGBS is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolanic. Concrete containing GGBS can have very high strength and can be very durable. GGBS is non-metallic and non-hazardous waste of industries. It is suitable for concrete mix and improves properties of concrete i.e. compressive strength etc.

**KEYWORDS:** SCM, steel slag concrete, steel slag, GGBS

## I.INTRODUCTION

### 1.1 GENARAL:

Concrete is a mixture of cement, sand, coarse aggregate and water. Its success lies in its versatility as can be designed to withstand harshest environments while taking on the most inspirational forms. Engineers and scientists are further trying to increase its limits with the help of innovative chemical admixtures and various supplementary cementitious materials SCM's. Early SCM's consisted of natural, readily available materials like volcanic ash or diatomaceous earth. The engineering marvels like Roman aqueducts, the Coliseum are examples of this technique used by Greeks and Romans. Nowadays, most concrete mixture contains SCM's which are mainly by-products or waste materials from other industrial processes.

### 1.2 SCOPE AND OBJECTIVE:

- The scope and objective of this present project investigation is to increase the strength of concrete by using GGBS & steel slag.
- To increase the strength of concrete by partial replacement of coarse aggregate with steel slag which is a waste material produced from steel industries.

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- The main objective of this project is to get high strength by using normal mix proportions with partial replacement of GGBS in cement and steel slag in coarse aggregate.

## II. EXPERIMENTAL PROGRAM

### 2.1. MATERIALS USED:

The different materials used in this investigation are:

- Cement
- Fine aggregates
- Coarse aggregates
- Mineral admixtures - GGBS
- Steel slag
- Water

#### 2.1.1 CEMENT:

Cement is a binding material, which is the combination of two raw materials called calcareous and argillaceous materials. Zuari-53 grade ordinary Portland cement conforming to IS: 12269 were used.

Serial No	Physical tests	Obtained results
1	Fineness	6.8%
2	Standard consistency	31%
3	Initial setting time	40 min
4	Final setting time	290 min
5	Specific gravity	3.15
6	Compressive strength	221.7kg/cm <sup>2</sup>

TABLE – 2.1: Shows the results of physical tests on ordinary Portland cement of 53 grade

#### 2.1.2 FINE AGGREGATE:

The standard sand used in this investigation was obtained from pennar river, Nellore. The standard sand shall be of quartz, light grey or whitish variety and shall be free from silt. The standard sand shall (100 percent) pass through 2-mm IS sieve and shall be (100 percent) retained on 90-micron IS Sieve and the sieves shall conform to IS 460 (Part: 1): 1985.

Serial no	Test	Obtained results
1	Bulking of sand	3.57%
2	Specific gravity of sand	2.65
3	Sieve analysis of sand	ZONE- III as per IS:383-1980

TABLE – 2.2: Shows the results of physical tests on fine aggregate

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### 2.1.3 COARSE AGGREGATES:

According to IS 383: 1970, coarse aggregate may be described as crushed gravel or stone when it results from crushing of gravel or hard stone. The coarse aggregate procured from quarry was sieved through the sieved of sizes 20 mm and 10 mm respectively. The aggregate passing through 20 mm IS sieve and retained on 10 mm IS sieve was taken. Specific gravity of the coarse aggregate is 2.64.

Serial no	Tests	Obtained results
1	Impact test	18.31%
2	Crushing test	24.58%
3	Specific gravity	2.71
4	Water absorption	1%
5	Flakiness index	17.02%
6	Elongation index	21.40%

TABLE – 2.3: Shows the results of physical tests on coarse aggregates

### 2.1.4 GGBS:

GGBS is obtained by quenching molten iron blast furnace slag immediately in water or stream, to produce a glassy granular product that is then dried and ground into a fine powder. It is an excellent binder to produce high performance cement and concrete. Because of its chemical and physical properties, it is a very reactive pozzolanic.

The physical properties of GGBS values are listed as per the manufacturer’s manual in the below tables:

PHYSICAL PROPERTIES	RESULTS
physical state	Micronized Powder
odour	Odourless
appearance	Powder
colour	GREY
pack density	0.76 gm/cc
ph of 5% solution	6.90
specific gfravity	2.9
moisture	0.058%
oil absorption	52 ml / 100 gms

TABLE –2.4: shows the physical properties of GGBS

### 2.1.5 STEEL SLAG:

Serial no	Tests	Obtained results
1	Impact test	17.65%
2	Crushing test	23.86%
3	Specific gravity	3.42
4	Water absorption	1.5%
5	Flakiness index	15.81%
6	Elongation index	19.92%

TABLE – 2.5: Shows the results of physical tests on coarse aggregates (steel slag)

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## 2.1.6 WATER:

Portable water was used in the experimental work for both preparing and curing. The pH value of water taken is not less than 6.

## III. MIX DESIGN

### 3.1 MIX PROPORTION:

Designed mix proportion for M<sub>20</sub> grade concrete is mentioned below table.

Cement	Fine aggregates	Coarse aggregates	Water
1	1.467	3.118	0.49

TABLE – 3.1: shows the designed mix proportion values for M<sub>20</sub> grade concrete mix.

## IV. TESTS ON CONCRETE

Tests conducted on fresh concrete in lab as well as site for quality controls are

### 4.1 SLUMP TEST:

The fresh concrete would vertically settle when the lateral supports are removed. This settlement is called slump and various values of slump are preferred for various constructions. Slump is the measure indicating the consistency or workability of cement concrete and gives the w/c ratio needed in mixing concrete for different works.



Fig no: 4.1 - Slump test apparatus

Mix proportion in %	Slump in cm	Mix proportion in %	Slump in cm
0	1	0	1
10	0	10	1
20	1	20	0
30	2	30	1
40	0	40	0
50	1	50	2

TABLE – 4.1.1: shows the slump values of various mix proportions using GGBS and steel slag.

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### 4.2 COMPRESSIVE STRENGTH TEST:

Representative samples of concrete shall be taken and used for casting cubes 15 cm x 15 cm x 15cm. Compressive strength is calculated by using the following formula:

$$\text{Compressive strength (kg/cm}^2\text{)} = W_f / A_p$$

Where

$W_f$  = Maximum applied load just before load, (kg)

$A_p$  = Plan area of cube mould, (mm<sup>2</sup>)



Fig no: 4.2-Concrete Cube testing

### 4.3 SPLITTING TENSILE OF CONCRETE

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack

The splitting tensile strength is calculated using the formula

$T_{sp} = 2P / \pi DL$  Where P = applied load, D = diameter of the specimen, L = length of the specimen



Fig no: 4.3-split tensile testing

### 4.4 STRESS- STRAIN TEST

A Sample of cylinder is placed in compressometer with its ends fixed tightly and then it is placed in the Compression testing machine and load is applied constantly and initially a dial gauge is fixed to the compressometer. With the help of this deflection readings are taken at constant load. For every 10kN load, deflection values are taken until the specimen breaks. Diameter of cylinder = 150mm Height of the cylinder = 300mm Area = 150 x 150 mm<sup>2</sup> : Gauge Length = 148mm.



Fig no: 4.4(a)-fixed rings and steel rod for stress-strain test

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Fig no: 4.4(b) -loading position for stress-strain test

## 4.5 STRESS-STRAIN CURVE RELATIONSHIP

Concrete belongs to a class of materials that can be called ‘Strain – softening’, indicating a reduction in stress beyond the peak value with an increase in the deformation (as against the strain hardening behaviour commonly exhibited by metals like steel). Figure 5.4.5 (b) shows different types of material behavior.

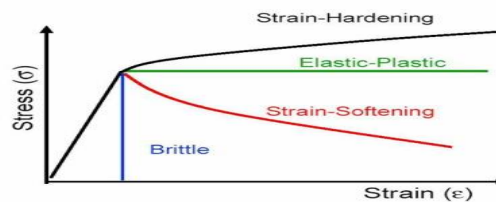


Fig 4.5(a) Different types of material behavior

## V. RESULTS AND DISCUSSIONS

### 5.1 COMPRESSIVE STRENGTH ON CUBES:

% of GGBS	Sample I	Sample II	Sample III	Avg. compressive strength in Mpa
0%	27.96	30.03	28.62	<b>28.87</b>
10%	31.62	29.96	30.08	<b>30.55</b>
20%	40.55	42.96	42.40	41.97
30%	35.11	37.87	33.98	<b>35.65</b>
40%	26.42	25.08	27.81	<b>26.43</b>
50%	23.09	24.76	25.82	<b>24.55</b>

TABLE: 5.1.1: Shows the characteristic compressive strength of the cubes for different percentages of GGBS of concrete cubes at the 28 days strength

% of steel slag	Compressive strength in Mpa			Avg. compressive strength in Mpa
	Sample I	Sample II	Sample III	
0%	27.96	30.03	28.62	<b>28.87</b>
10%	47.06	44.61	45.70	<b>45.61</b>
20%	<b>50.52</b>	<b>46.68</b>	<b>48.96</b>	<b>48.52</b>
30%	38.22	46.46	47.87	<b>44.183</b>
40%	34.30	47.02	45.69	<b>42.33</b>
50%	38.96	33.36	34.15	<b>35.49</b>

TABLE: 5.1.2: Shows the characteristic compressive strength of the cubes for different percentages of steel slag 28 days strength.

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Based on the results and discussion, it is clear that there is increase in strength of concrete and it advantageous. It has been observed using 20% of GGBS in concrete increases strength and 20% of steel slag increases strength individually.

Since 20% GGBS with replacement of cement increases the strength and 20% steel slag with replacement of coarse aggregate increases the strength.

We have casted cubes for testing combination with 20% of GGBS in replacement of cement and 20% steel slag in replacement of coarse aggregate and the results are below in Table 5.1.3.

% of GGBS replaced with cement	% of steel slag added replaced with CA	Age in days	Avg. compressive strength in Mpa
20%	20%	7 days	32.26
		14 days	41.15
		28 days	<b>51.77</b>

TABLE: 5.1.3: Shows the characteristic compressive strength of the cubes for 20% of steel slag and 20% of GGBS in concrete.

➤ The compressive strength of designed M<sub>20</sub> grade mix proportion with 20% steel slag and 20% GGBS is **51.77N/mm<sup>2</sup>**

s.no	% of materials added for concrete mixing	age in days	avg. compressive strength in mpa
1	conventional 0% steel slag+0% GGBS)	28 days	28.87
2	GGBS 20% (0% steel slag)	28 days	41.97
3	steel slag 20% (0% GGBS)	28 days	48.52
4	20% GGBS +20% steel slag	28 days	51.77

TABLE – 5.1.4: shows the comparison of characteristic compressive strength of designed M20grade various mix proportions.

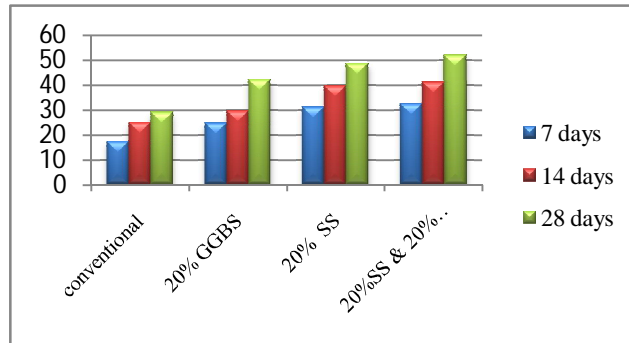
It is clear that the mix proportion of 20% steel slag and 20% GGBS have high compressive strength from the comparison.

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BAR CHART – 5.1: shows the compressive strength V/s various mix percentage.

### 5.2 TESTS ON CONCRETE CYLINDERS:

By observing the results on cubes and we have conducted the compressive strength and split tensile test on concrete cylinders and the results are as follows

S.No	% Of Materials Added For Concrete Mixing	Workability	Compression Mpa	Tensile Mpa
1	Conventional (0% Steel Slag+0% GGBS)	0.87	29.1	1.3915
2	GGBS 20% (0% Steel Slag)	0.85	42.29	1.6125
3	Steel Slag 20% (0% GGBS)	0.88	43.71	1.839
4	20% GGBS +20% Steel Slag	0.89	44.69	2.225

TABLE – 5.2.1: shows the results of characteristic compressive strength and split tensile strength of designed M20grade various mix proportions on concrete cylinders.

- The compressive strength of designed M20 grade mix proportion with 20% steel slag and 20% GGBS is 44.69N/mm<sup>2</sup>. The split tensile strength of M20grade mix proportion with 0% GGBS and 0% of steel slag is 2.225N/mm<sup>2</sup>.

It is clear that the mix proportion of 20% steel slag and 20% GGBS have high compressive strength and high split tensile strength from the comparison.

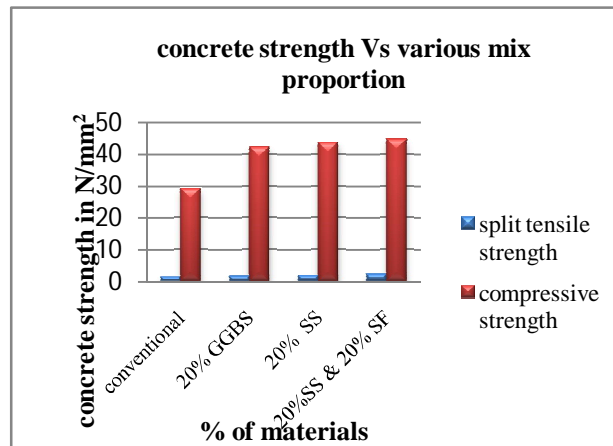


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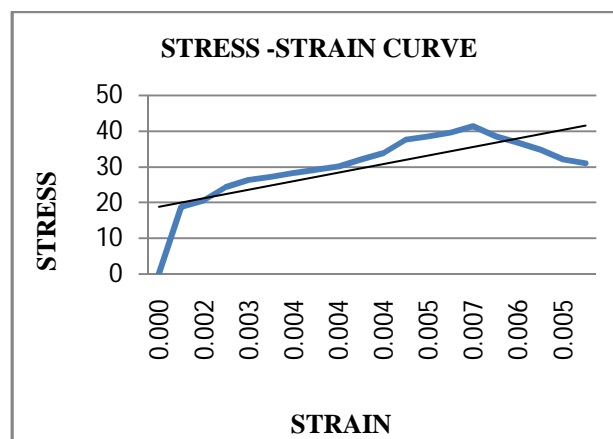
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**BAR CHART – 5.2.1:** shows the concrete strength V/s various mix percentages

### 6.2. STRESS-STRAIN RESULTS:

The relationship between stress and strain is important in understanding the basic elastic behaviour of concrete in hardened state which is useful in design of concrete Structures. From the values of stresses and strains, average stress-strain curve for each mix is plotted, taking the average values of the results.



**Graph 6.2.1:** shows the resultant curve for the stress-strain values for 20% steel slag +20% GGBS specimen

## VI. CONCLUSIONS

Based on the work carried out the following conclusion have been mentioned below:

1. It is clear that there is increase in strength of concrete and it advantageous. It has been observed using 20% of GGBS in concrete increases strength and 20% of steel slag increases strength individually.
2. combination with 20% of GGBS in replacement of cement and 20% steel slag in replacement of coarse aggregate results in increase in the strength of concrete cubes.

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3. From the results it is clear that the mix proportion of 20% steel slag and 20% GGBS have high compressive strength and high split tensile strength from the comparison.
4. By observing the stress-strain relationship of concrete cylinder we can clearly conclude that maximum load can be resisted by the cylinders casted using 20% steel slag and 20% GGBS.
5. Deformation in the cylinder is less in concrete made with 20% steel slag and 20% GGBS.
6. If we observe all the curves have nearly with similar shape and similar characteristic properties and the shape of curves are strain-softening material properties.
7. The only difference is that Curves of for 20% steel slag+20% GGBS concrete mixes have shown improved stress values for the same strain levels compared to that of other concrete mixes

Final conclusion is the 20% steel slag and 20% GGBS with partial replacement of coarse aggregate and partial replacement of cement has high compressive strength and high split tensile strength in concrete and high resistance than the other mixes of concrete and shows elastic plastic material characteristic property

### REFERENCES

1. Concrete technology by M.S. Shetty – S Chand & co; 2004
2. Concrete technology by A.M. Neville – Pearson publication
3. Certificate analyses of GGBS (Micro silica) properties by ASTRAA CHEMICALS, Chennai.
4. Influence of GGBS on concrete by Prof. Vishal & S. Ghutke & Prof. Pranita & S.Bhandari (IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 44-47).
5. Effect of GGBS on strength and durability Parameters of concrete by N. K. Amudhavalli, Jeena Mathew(International Journal of Engineering Sciences & Emerging Technologies, August 2012. ISSN: 2231 – 6604 Volume 3, Issue 1, pp: 28-35).
6. Effect of GGBS in Concrete by Vikas Srivastava, Alvin Harison, P. K. Mehta, Atul and Rakesh Kumar(International Journal of Innovative Research in Science, Engineering and Technology. An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 4, March 2014)
7. I.S: 10262 – 2009 : Recommended guide lines for concrete mix design
8. I.S: 2386 – 1963 : Test procedures of aggregates
9. I.S: 383 – 1970 : specification for coarse and fine aggregate from natural resources