GSJ: Volume 9, Issue 1, January 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

USING OF GGBS (GROUND GRANULATED BLAST FURNACE SLAG) AS A REPLACEMENT OF CEMENT FOR THE COMPRESSIVE STRENGTH OF THE CONCRETE.

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Abstract

Concrete is a mixture of cement, fine aggregate, Coarse aggregate and water. Cement is used as a binder, also called a binding material. Concrete plays a very important role in various types of structures (such as buildings, industries, bridges, roads, etc.). Cement is a very expensive material and is widely used. In the process of preparing cement in the factory, a large amount of carbon dioxide is released into the atmosphere, destroying the ozone layer, and is very harmful to human life. This Paper present the utilization of Industrial by product such as GGBS, which is produced, in large amount in steel industries. In this paper the GGBS is used in a concrete to replace with cement up to 30, so for the experimental procedure 36 sample is prepared for achieving 3000-psi strength is 0% (Control Sample), 20%, 25%, and 30% for 7days, 14days and 28days respectively. The average Compressive strength for Control sample is 2377.17psi, 2551.97psi and 3420.64psi for 7days, 14days and 28days respectively. The average compressive strength for 20% replacement is 1853.06psi, 2360psi and 3318.02psi for 7days, 14 days and 28days. The average compressive strength for 25% replacement is 1782.44psi, 2271.84psi and 3303.66psi for 7days, 14days and 28days respectively. The average compressive strength for 30% replacement is 1721.66psi, 2148.43psi and 3095.7psi for 7days, 14days and 28days respectively.

From this study, it is clear that to replace 30% GGBS we get the design strength and by increasing the GGBS amount beyond 30% the compressive strength is decreasing and so the structure feels unsafe by using GGBS beyond 30%.

Keywords –Compressive Strength, Concrete, GGBS, Replacement.

1. INTRODUCTION

1.1. History of GGBS

GGBS is not a new product. Since the middle of the 19th century, it has been proven worldwide.

Emil Landin (1824) first discover the GGBS cement. At initial stage the GGBS are used in lime, where lime had great importance of used in Germany and after that in 1880 the commercial use of GGBS in Portland Cement took great concentration.

In United State, the GGBS was used in 1896 for the first time, so from that period, all the Europe Countries used the GGBS with the certain amount of Blast Furnace, and Steel Industries and furthermore the Europe countries then used the GGBS in Construction Sector in all structure weather small or large. In 1914, GGBS was produced in Scotland. BS 146 was released in 1923, followed by BS 6699 for GGBS in 1986. It is Clear from the Statics analysis that in the UK, more than twenty lac tons of GGBS are used each year. GGBS is also broadly charity by the cement and concrete productions in interior Europe, currently using approximately 17.7 million tons per year.

Kishan lal jain (2016) work on GGBS as a partial replacement with cement to check the effect on strength of concrete. He used OPC 43-grade cement for experimental procedure, the additionally work he used GGBS which are varies from 5% to 25% at interval 0f 5% by total weight of OPC. The result he obtain is in term of performance of concrete mix is slump, compressive strength flexural strength and splitting tensile strength for 7 days and 28 days respectively

1.2. GGBS Production

In Blast Furnace the iron ore, limestone and coke are heated at a temperature of 1500°C iron are produced from this process and also GGBS are produced is a by product material.When iron ore, limestone and coke are burned in blast furnace, two material are produced during the buring process these material are: cast iron and slag. The slag is agiler and soars in the molten iron. The slag mainly contains silicate and alumina from the original iron ore, as well as some oxides from limestone. The granular slag is further processed by drying and then ground into a very fine powder, namely GGBS (granular blast furnace slag) cement and then granular slag is crushed in a rotary ball mill.

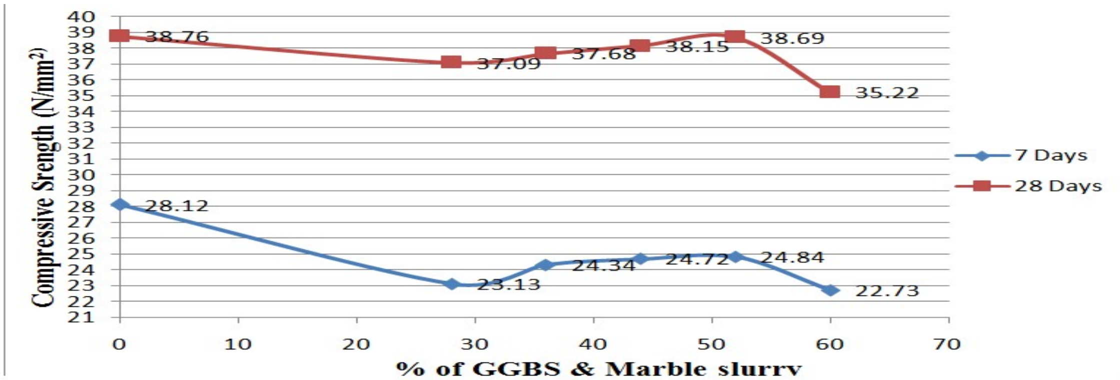
Figure 1: Production of GGBS in mill.

2. LITERATURE REVIEW

Er. Arvind Singh Gaur et al (2017), the working principle of this study is to use Marble slurry and GGBS as an admixture in concrete. As marble slurry is a byproduct, material of of marble industry which had a great composition of environmental pollution, whereas GGBS is obtain as byproduct of manufacturing of steel. In this study the fine powdered form of GGBS and Marble slurry are used in OPC 43-grade cement as a partial replacement. In this study, the binding material OPC 43 is replaced with GGBS up to 20% and Fine Aggregate Up to 40% with Marble slurry. This study investigates the performance of concrete mixture in terms of compressive strength of cube, flexural strength of beam and splitting strength of cylinder for 7 days and 28 days respectively. The experimental picture of his work are,

Fig 2: Marble slurry

Fig 3: Ground-granulated blast furnace



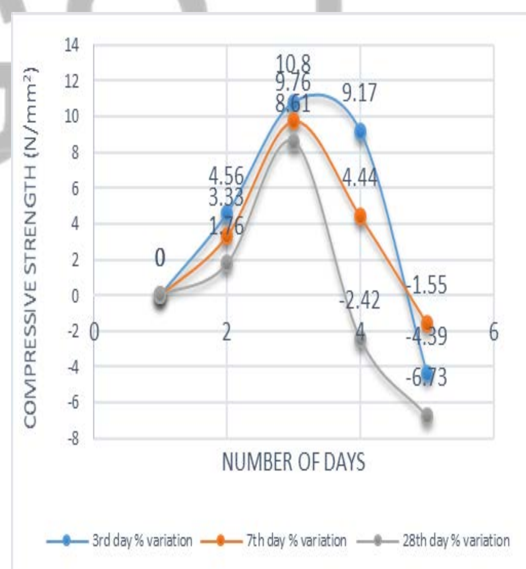
Graph 1. Shows that the compressive strength of OPC+GGBS(80+20)and Sand+MS(68+32) achieve maximum strength in 7 days and after that strength is decreasing, also compressive strength of OPC+GGBS(80+20) and Sand+MS(68+32) achieve maximum strength in 28 days.

S.P. Kanniyappan et al (2016), work on the properties of GGBS with cement and concluded the result that "The water movement in the GGBS mixture may be due to the strong and dense microstructure of the interface aggregate/binder transition zone, which may be the reason for the high resistance of the GGBS mixture in aggressive environments (such as oil wells). Silage. The mineral composition of GGBS cement paste (less aluminates and silicates than Portland cement) may help increase strength. As we have seen, GGBS can be a good substitute for concrete in some cases and can effectively work, but it cannot completely replace concrete. However, even if it is partially replaced, it can still bring great results to our engineers today and provide a greener approach to construction and sustainable development.

Fig 4: Showing that workability is more and pumping will be easy.

Praveen Kumar Gahlot et al (2020), He studied the method of partially replacing GGBS with cement to verify the compressive strength of the cube he prepared for the test, and concluded:

"By adding 20% of GGBS as a partial substitute for M30 cement and M35 concrete, This increases the compressive strength of concrete compared with the alternative concrete. Compared with the uncured cube, the compressive strength of the concrete cube after curing for 28 days is reduced to the level of M30 and M35 grade concrete cement instead of blast furnace slag (GGBS The 35% partial replacement of) is irreplaceable. It is also observed from the experimental work that in the first few days (7 days), the percentage increase in the compressive strength of the two grades of cemented conglomerate.



Graph 2: -Compressive strength M30 grade

Graph 3: -Compressive strength M35 grade

Graph number 2 and 3 shows us the compressive strength with number of days. As from graph it is clear that whenever the percentage of GGBS increasing the result goes toward (-ive), it means that it is less than the design strength.

3. MATERIAL USED FOR EXPERIMENTAL PROCEDURE

3.1. Fine Aggregate:

Lawrencepur sand Qibla Bandi Sand that are available in Abundance are used for the experimental procedure.

Figure 5: Lawrencepur sand used in experiment.

3.2. Cement:

The ordinary Portland cements of ASTM C 150 Type-I are used in the experimental procedures (Ordinary Portland Cement (DG brand - Grade 43).

3.3. Coarse aggregates:

The Coarse aggregates having size in the range of 9.5mm to 37.5 mm, and the coarse aggregate are angular in shape are used.

3.4. GGBS:

GGBS is obtain from the iron ore as a byproduct, and they have the cementing properties. In this paper we use GGBS as a partial replacement up to 30% with cement.

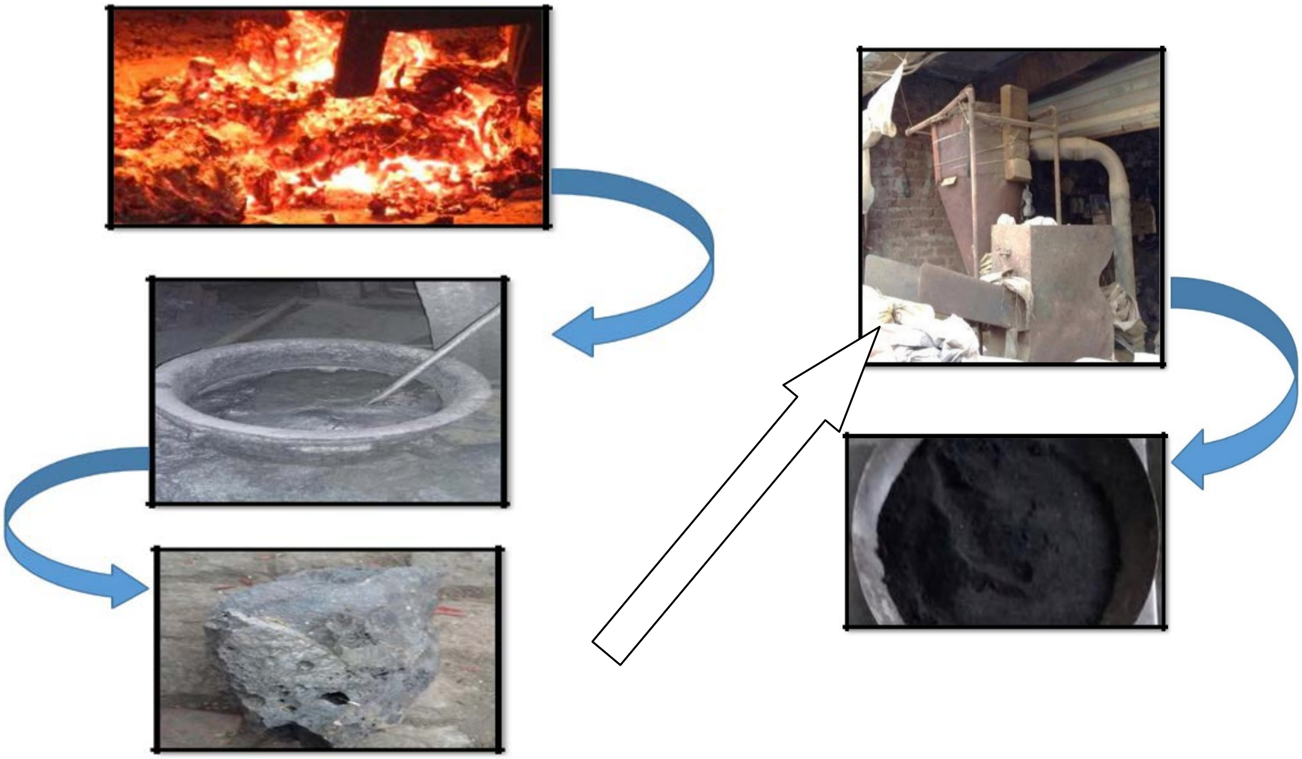


Figure 6: Process of GGBS Production

4. EXPERIMENTAL WORK

To achieve the study objectives, the following methodology is adopted.

4.1. Test On Fine Aggregate:

For to calculate the Specific gravity and water absorption test. It is performed on pycnometer apparatus according to (ASTM C68-30) standard. The result obtains from for Specific Gravity is 2.5 and for water, absorption is 2%.

Figure 7: Pycnometer filled up to full capacity **Figure 8:** Oven used for drying

Sieve analysis test was performed according to (ASTM C136-06) standard, from these analyses we obtain the gradation of Fine Aggregate. The Result obtain for fines modules is 2.45.

Figure 09: Mechanical Sieve Shaker for sieve analysis.

4.2. Test On Coarse Aggregate

The test performs for Specific gravity and water absorption test. It is done through pycnometer apparatus according to (ASTM C127-04) standard. The result obtains from for Specific Gravity is 2.61 and for water absorption is 0.8%.

Figure 10: Specific gravity of coarse aggregate.

4.3. GGBS

The size of GGBS, which we used in our project, was 63µm.

The Replacement of GGBS with Cement by weight are 20%, 25% and 30%.

Figure 11: Fine GGBS

4.4. Cylinder

We casted 36 GGBS concrete cylinders, Depth of cylinder is 12 inch and dia of cylinder is 6 inch

Figure 12: Cylinder Moulds

4.5. Required Mix Design

The determination of manipulative is to achieve the 21MPa strength in a stipulated minimum strength durability and to make the concrete in the most economical manner. The mix design value for to achieve the desired compressive strength is **1:2.28:3.28.**

ACI Mix Design Data	
Specified Strength = Fc′	21 Mpa
Required Slump	45mm
Maximum Size of Aggregates	19mm
Fineness Modulus of coarse Agg.	3.35
Fineness Modulus of fine Agg.	2.45
Density of Coarse Aggregates	1596.36 kg/m^3
Water Absorption for Coarse Aggregates	0.80%
Water Absorption for fine Aggregates	2%
Type	Non Air Entrained

Table 1: Data for concrete mix design

Figure 13: Proposed mix design mixing.

Figure 14: Final mixing of concrete

Figure 15: Discharging of concrete from mixer.

4.6. Workability

For workability the slump test is carried out for freshly concrete. The slump value value is calculated for control sample and for GGBS containing 20%, 25% and 30% GGBS replace with cement volume. For calculation the slump ASTM C143 procedure were followed. The result for slump of Control Sample, 20%, 25% and 30% replacement are under in the below table.

Figure 16: Compacting each layer of fresh concrete

Figure 17: Smooth finishing of top surface

Figure 18: Raising the cone

Figure 19: Measuring of Slump

4.7. Slump Test Result

Concrete	Slump Value (mm)
Control Sample	42
GGBS 20%	40
GGBS 25%	38
GGBS 30%	37

Table 2: Slump Values of Control and GGBS concrete.

5. RESULT AND DISCUSSION:

5.1. Compressive strength of concrete

For Compressive strength the Specimen (Cylinder) are placed in the Universal Testing Machine for to calculate the failure of the specimen, the Uniaxial loading are noted at the of cracks occur in the cylinder.

Figure 20: Concrete Cylinder under Testing

Result of cylinder under compressive strength

5.1.1. Control Sample

Table number 3 gives the test results of compressive strength at 7, 14 and 28 days which is 2377.1, 2551.97 and 3420.64 respectively for control sample. Its mean strength is increases from 7 days to 28 days, at 28 days' strength achieve maximum Strength.

Specimen #	7days (psi)	Average	14days (psi)	Average	28days (psi)	Average
1	2350.5		2517.64		3389.6	
2	2385.5	2377.17	2545.76	2551.97	3417.8	3420.64
3	2395.5		2592.5		3454.5	

Table 3: Results of Compressive Strength Cylinder on Control sample

5.1.2. Cement Replace with 20% GGBS

Table number 4 gives the result of compressive strength at 7, 14 and 28 days which is 1853.06, 2360 and 3318.02 respectively with 20% cement replacement. Its mean strength is increases from 7 days to 14 days and from 14 days to 28 days, at 28 days' strength achieve maximum Strength.

Specimen #	7days (psi)	Average	14days (psi)	Average	28days (psi)	Average

1	1830.7	1853.06	2375.9	2360	3175.5	3318.02
2	1850.2		2357.5		3581.5	
3	1878.3		2345.8		3493.2	

Table 4: Results of Compressive strength on 20% GGBS used

5.1.3. Cement Replace with 25% GGBS

Table number 5 gives the test results of compressive strength at 7, 14 and 28 days which is 1782.44, 2271.84 and 33.03.66 respectively with 25% cement replacement. Its mean strength is increases from 7 days up to 28 days, at 28 days' concrete achieve full strength, which is the maximum Strength.

Specimen #	7days (psi)	Average	14days (psi)	Average	28days (psi)	Average
1	1759.8	1782.44	2293.9	2271.84	3058.3	3303.66
2	1785.4		2369.5		3380	
3	1802.1		2252.1		3445.7	

Table 5: Results of Compressive strength on 25% GGBS used

5.1.4. Cement Replace with 30% GGBS

Table number 6 gives the test results of compressive strength at 7, 14 and 28 days which is 1721.66.44, 2128.43 and 3095.7 respectively with 30% GGBS replacement. Its mean strength is increases from 7 days up to 28 days, at 28 days' concrete achieve full strength in 28 days, which is the maximum Strength.

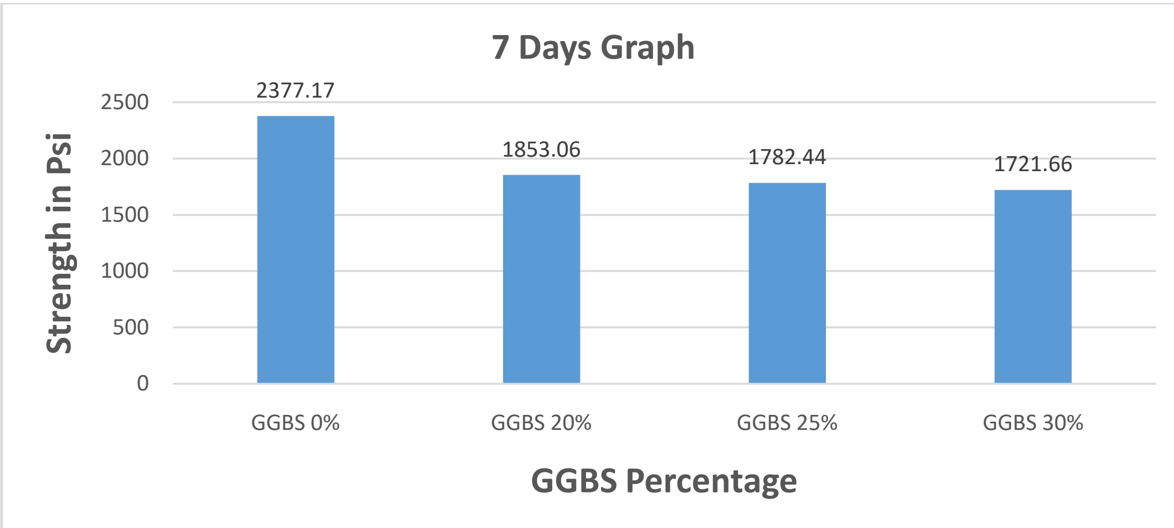
Specimen #	7days (psi)	Average	14days (psi)	Average	28days (psi)	Average
1	1699.5	1721.66	2175.7	2128.43	2870.7	3095.7
2	1725.3		2119.4		3238	
3	1740.2		2090.1		3178.4	

Table 6: Results of Compressive strength on 30% GGBS used

5.2. Graph of Compressive strength for 7, 14 and 28 days.

5.2.1. 7 days Bar chart for different percentages of GGBS.

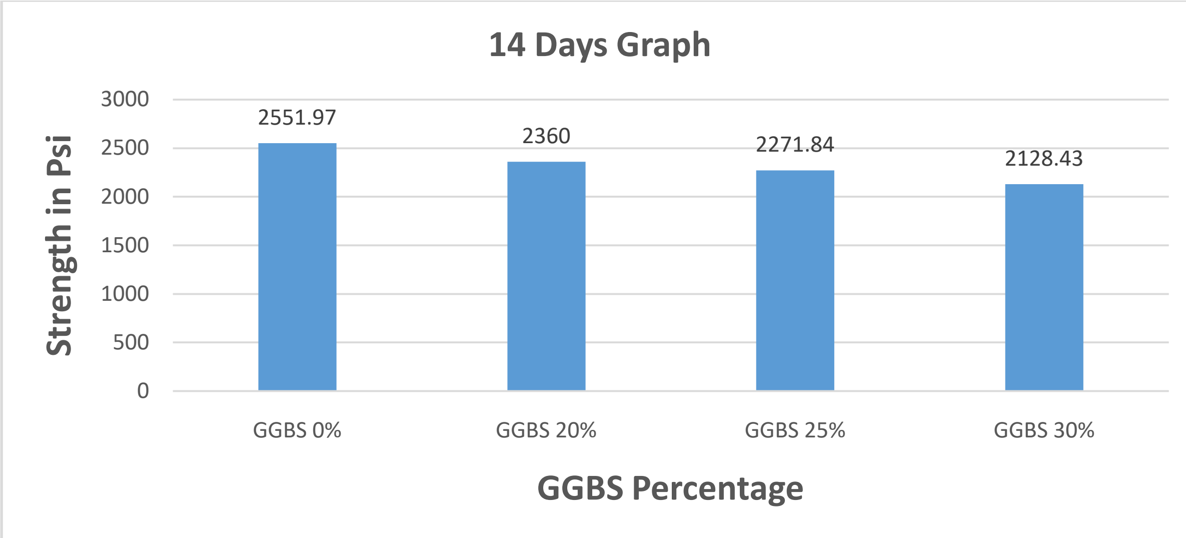
Graph number 4 shows that the compressive strength is decreases from conventional concrete up to replacement of 30 percent of GGBS, at 100 percent cement concrete achieve maximum strength at 7 days.



Graph 4: 7 days Bar chart for different percentages of GGBS.

5.2.2. 14 days Bar chart for different percentages of GGBS.

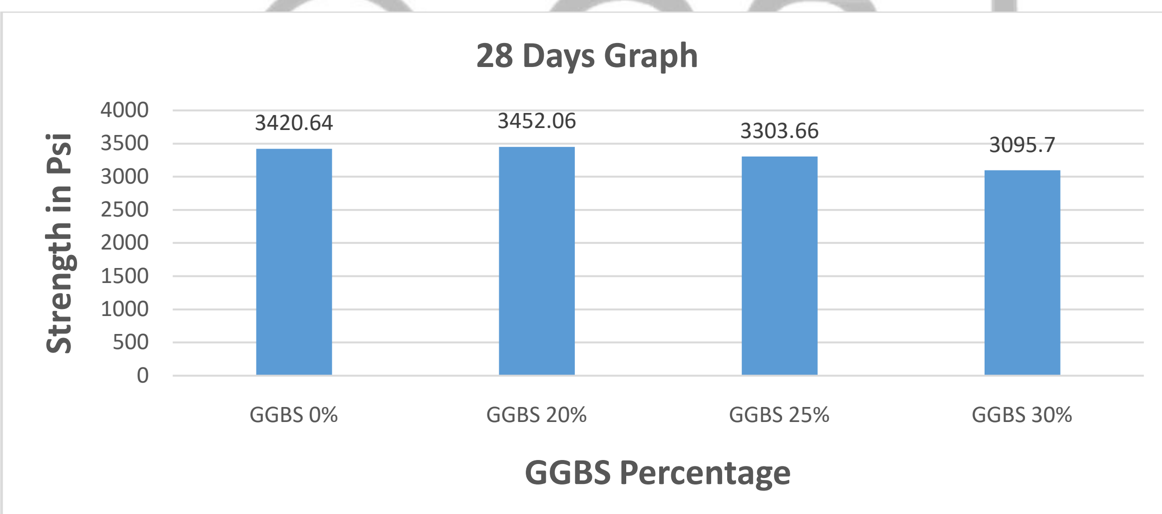
Graph number 5 shows that the compressive strength is decreases from conventional concrete up to replacement of 30 percent of GGBS, at 100 percent cement concrete achieve maximum strength at 14 days.



Graph 5: 14 days Bar chart for different percentages of GGBS.

5.2.3. 28 days Bar chart for different percentages of GGBS.

Graph number 6 shows that the compressive strength is increases from conventional concrete up to replacement of 20 percent of GGBS, and then again decreases onward, at 20 percent replacement of GGBS concrete achieve Maximum Strength at 28 days.



Graph 6: 28 days Bar chart for different percentages of GGBS.

6. CONCLUSION

The Conclusion of this Research paper can be summarized as

- The GGBS replacement with cement up to 30%, gives better result and within the purposes compressive strength.
- Max strength is achieved at 20% replacement.

- The optimum value of GGBS is 30%, which shows satisfactory result at 28 days, in accordance to the target strength of mix design 3000psi.
- As GGBS are cheaper than cement so by using GGBS in structure instead of cement, the structural became economical.

7. FUTURE RECOMMENDATION

- Below 20% Replacement of GGBS should be evaluated for mechanical strength.
- The GGBS concrete should be evaluated for different curing environment.
- The GGBS base concrete should be investigated for smaller particle size.

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