

An Experimental Study on Cement Replacement by GGBS in Concrete

P Lakshmaiah Chowdary ¹, S Khaja Khutubuddin ², B Vinayaka ³, D Saikiran ⁴, Y Induja ⁵, Y Narasappa ⁶

Associate Professor, Department of Civil Engineering, BITS Engineering College, Alur Road, Adoni, A.P, India¹

B. Tech, Department of Civil Engineering, BITS Engineering College, Alur Road, Adoni, A.P, India²

B. Tech, Department of Civil Engineering, BITS Engineering College, Alur Road, Adoni, A.P, India³

B. Tech, Department of Civil Engineering, BITS Engineering College, Alur Road, Adoni, A.P, India⁴

B. Tech, Department of Civil Engineering, BITS Engineering College, Alur Road, Adoni, A.P, India⁵

B. Tech, Department of Civil Engineering, BITS Engineering College, Alur Road, Adoni, A.P, India⁶

ABSTRACT: Concrete may be used for some special purpose for which special properties are more important than those commonly considered. Sometimes, it may be of great importance to enhance one of the ordinary properties. There is extensive evidence to show that concrete materials and concrete structures all over the world are deteriorating at a rapid rate and that we are unable to ensure their long-term durable service life performance. It is becoming increasingly apparent that some human activities and development practices are negatively affecting the well-being of the planet and putting future generations at risk. Public agencies are recognizing the paramount importance of adopting more “Sustainable” practices and products those that preserve or enhance economic, environmental, and social well-being in designing, constructing, and maintaining public infrastructure. The most important objective of this study is to evaluate the possibility of usage of GGBS (Ground Granulated Blast Furnace Slag) in concrete. The researches will also focus on the potentiality of hybrid blending by GGBS. The latter mineral incineration could reduce the demands for fossil and electrical, required for producing mono-blends with GGBS. The development of a sound technology requires investigating effects exerted by the mineral admixture on the strength of the cementitious materials. Replacement percentage has to be varied to that end and different accounts of mixing water have to be considered. Strength should be recorded at early age and in the more mature state of material. This project represents the results of an experimental investigations carried out to find the suitability of GGBS in production of concrete. In this experimental study the effect of GGBS on strength of referral concrete M20 was made using 43 Grade PPC and the other mixes were prepared by replacing part of PPC with GGBS. The replacement levels were 10%, 20%, 30%, 40% (by weight of cement) for GGBS. Test results indicate that use of replacement cement by GGBS in concrete has improved performance of concrete up to 10% to 30%.

KEYWORDS: GGBS, Cement, CA & FA, Compressive Strength, Tensile Strength.

I. INTRODUCTION

Concrete is a very strong and versatile mould able construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

It could be justifiably argued that since the late 1800s onwards, when consistent mass produced Portland cement became readily available, that the world that we live in has been transformed by the design and construction of all sorts of concrete structures; the list is large: dams, bridges, skyscrapers, water and sewerage systems, public buildings, schools, hospitals, shopping centres, airport and rail termini, ports, factories and sporting stadia, houses, foundations,

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

cast beams, floor slabs, walls and stair units, monuments, art and landscape projects; from the good, to the bad and the down-right ugly. Even boat hulls have been made in cast concrete.

On its own, concrete has excellent resistance to compression (crushing), but is very poor in tension (stretching). To give it good load bearing capability when under tension, it has to be reinforced with steel bars (rebar), polymer strands or fibres. Bars and strands can be tensioned during casting of pre-cast concrete structures such as floor and bridge beams. When the concrete has set, the tension is released and the reinforcement tries to pull back to its original length, but can't, as it is now bound into the set concrete. It thus imparts a pulling force which gives the cast structure great strength.

II. LITERATURE REVIEW

Fulton (1974), Rajamane et al. (1998) investigated the workability of concrete containing GGBS in greater detail and suggested that the cementitious matrix containing GGBS exhibited greater workability due to the increased paste content and increased cohesiveness of the paste. Meusel and Rose (1982) reported that the water demand for normal concrete is generally 3 to 5 percent lower than concrete with GGBS for trial mixture proportioning studies.

Wu and Roy (1982) reported that the amount of high-range water reducing admixtures required to produce flowing concrete is usually 25 percent less than that used in concretes containing non GGBS. They also found that pastes containing GGBS exhibits different rheological properties compared to paste of Portland cements alone. Their results indicate a better particle dispersion and higher fluidity of the pastes and mortars, both with and without water reducing admixtures.

Scali et al. (1987) reported that the water demand of concrete containing silica fume increases with increasing amount of silica fume at the stage of fresh concrete. Osborne (1989) reported the test results of slump, veebee time and compaction factor for concrete containing zero, 40 and 70 percent GGBS and concluded that when the percentage of GGBS is increased, the workability properties is reduced.

Hogan and Meusal (1981) conducted experiments on development of strength and durability properties on concrete and reported that the compressive and flexural strength-gain characteristics of concrete containing GGBS can vary over a wide range. When compared to Portland cement concrete, use of GGBS typically results in reduced strength at early ages (1 to 3 days) and increased strength at later ages (7 days and beyond).

Newman John and Choo (2003) recorded that GGBS is a very reactive pozzolana. In the presence of water, it reacts with calcium hydroxide to produce stable, insoluble cementitious hydrates. This pozzolanic reaction reduces the permeability and porosity of cement paste making it stronger and significantly more durable. The use of GGBS as a partial replacement for cement in suitably designed concrete mixes improves acid resistance, sulphate resistance and freeze and thaw resistance. And it also increases the resistance to the penetration of chloride ions and eliminates alkali-silica reaction.

III. MATERIALS USED

In the present investigation materials used are

1. Portland Pozzolana Cement 43 grade PPC (fly ash based).
2. GGBS (Ground Granulated Blast Furnace Slag).
3. GGBS as partial replacement to cement.
4. Naturally available River sand as fine aggregate.
5. Crushed Granite as coarse aggregate of size not greater than 20 mm.
6. Water MATERIAL PROPERTIES.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

IV.MATERIAL PROPERTIES

- Portland Pozzolana Cement (PPC 43 grade) conforming to IS: 1489 (1991) is used in this work. The properties of used cement were

TYPE	PPC 43 GRADE (BHARATHI)
Normal Consistency	33%
Specific Gravity	2.85

- GGBS brought from JSW Cement plant having specific gravity 2.91
- The physical properties of fine aggregate (river sand) were.

Physical properties of FA

Property	Test results
Specific gravity	2.60
Water absorption	1%
Density (kg/m ³)	1727

Sieve Analysis details of FA

IS sieve designation	% of FA Passed	Zone 2
4.75 mm	98	90-100
2.36 mm	94.5	75-100
1.18 mm	84	75-90
600 μ	52.5	35-59
300 μ	23.5	8-30
150 μ	10.5	0-10

- The physical properties of Coarse aggregate (Crushed granite) were

Physical Properties of CA

Property	Test results
Specific gravity	2.74
Water absorption	0.8%
Density (kg/m ³)	1675

V.MIX PROPORTIONING

The mix design was carried out based on draft code IS: 10262:2009. In this present work M₂₀ grade concrete was considered. For the present investigation, mix design for M₂₀ grade of concrete was carried out using the above coarse aggregate, fine aggregate, and the binder. The proportion of the materials by weight was 1:1.65:2.84 (cement: fine aggregate: coarse aggregate) with w/c ratio 0.53. The cement constituent was subsequently replaced with percentage of GGBS (by mass). The percentage of cement was 0%, 10%, 20%, 30% and 40%. Taking previous studies into consideration, work was carried out to know the mechanical properties of concrete using Ground Granulated Blast Furnace Slag represented by GGBS as M mix as cement replacing sustainable cementitious material. The study includes investigation of the compressive strength, split tensile strength, elasticity modulus of concrete and the compressive strength of cement for percentage replacement of cement by GGBS. In this study the cement were replaced to an extent of 40% varying the percentage of GGBS by different proportions as shown in the table below;

The Grade of concrete (mix) chosen for the study was M₂₀

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

% of Replacement of cement

Group Mix	% of GGBS	% of Cement
M0	0	100
M1	10	90
M2	20	80
M3	30	70
M4	40	60

Mix proportion of concrete with GGBS

Ingredients	Mixes				
	C (0%)	M1 (10%)	M2 (20%)	M3 (30%)	M4 (40%)
Cement (kg/m ³)	397	357.3	317.6	277.9	238.2
GGBS (kg/m ³)	-	39.7	79.4	119.1	158.8
Water (kg/m ³)	213	213	213	213	213
FA(kg/m ³)	656.82	656.82	656.82	656.82	656.82
CA (kg/m ³)	1129.36	1129.36	1129.36	1129.36	1129.36

VI. TESTING PROCEDURES

(a) Fresh Properties

Workability is the ability of a fresh (plastic) concrete mix to fill the form/mold properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), Cementitious content and age (level of hydration and can be modified by adding chemical admixtures, like Super plasticizer. Raising the water content of adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and/or segregation of aggregates (when the cement and aggregates start to separate), with the resulting concrete having reduced quality. The use of an aggregate with an undesirable gradation can result in a very harsh mix design with a very low slump, which cannot be readily made more workable by addition of reasonable amounts of water. There are many tests which are conducted to check the quality of concrete.

Slump test – workability:

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199-1959 is followed. The apparatus used for doing slump test are Slump cone and tamping rod. Workability can be measured by the concrete slump test, a simplistic measure of the plasticity of fresh batch of concrete following the ASTM C 143 or EN 12350-2 test standards. Slump is normally measured by filling an "Abrams cone" with a sample from a fresh batch of concrete. The cone is placed with the wide end down onto a level, non-absorptive surface. It is then filled in three layers of equal volume, with each layer being tamped with a steel rod in order to consolidate the layer. When the cone is carefully lifted off, the enclosed material will slump a certain amount due to gravity. A relatively dry sample will slump very little, having a slump value of one or two inches (25 or 50mm). A relatively wet concrete sample may slump as much as eight inches. Workability can also be measured by using the flow table test.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Workability Test Details

Mix Designation	GGBS %	CF	Slump value (cm)
C	0	98.1	25
M1	10	98.4	24
M2	20	99.5	23
M3	30	99.5	22
M4	40	99.5	21

(b) TESTS ON HARDENED CONCRETE:

COMPRESSION TEST:

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc.

Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommend concrete cylinder or concrete cube as the standard specimen for the test. American Society for Testing Materials ASTM C39/C39M provides Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

Compressive strength of Cubes

MIX	F_{CK} (N/mm ²) at 7 days	F_{CK} (N/mm ²) at 28 days
C	19.77	25.77
GGBS (10%)	13.88	21.22
GGBS (20%)	15.55	22.77
GGBS (30%)	19.99	36.00
GGBS (40%)	17.22	29.67

Test results of compressive strength of cylinders

MIX	F_{CK} (N/mm ²) at 7 days	F_{CK} (N/mm ²) at 28 days
C	14.82	20.93
GGBS (10%)	12.26	17.82
GGBS (20%)	16.45	22.07
GGBS (30%)	17.05	22.92
GGBS (40%)	18.92	26.60

SPLIT TENSILE STRENGTH:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength 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.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

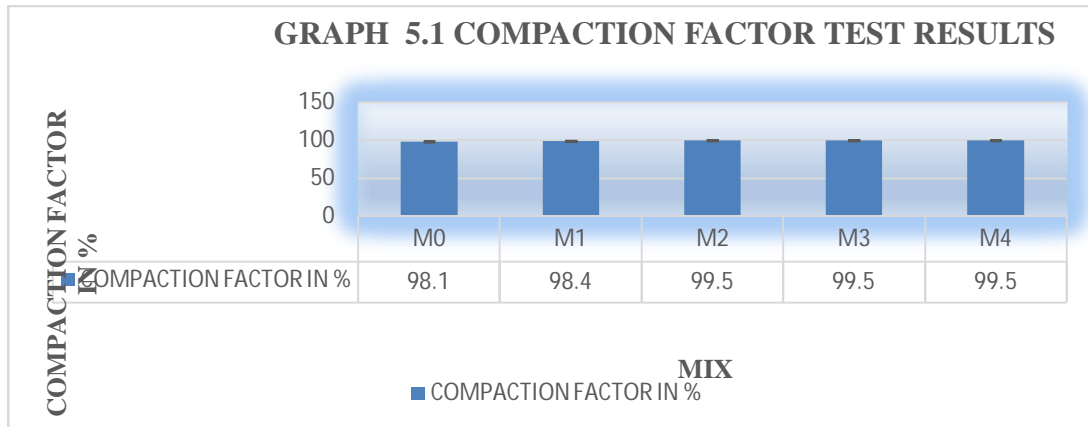
Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

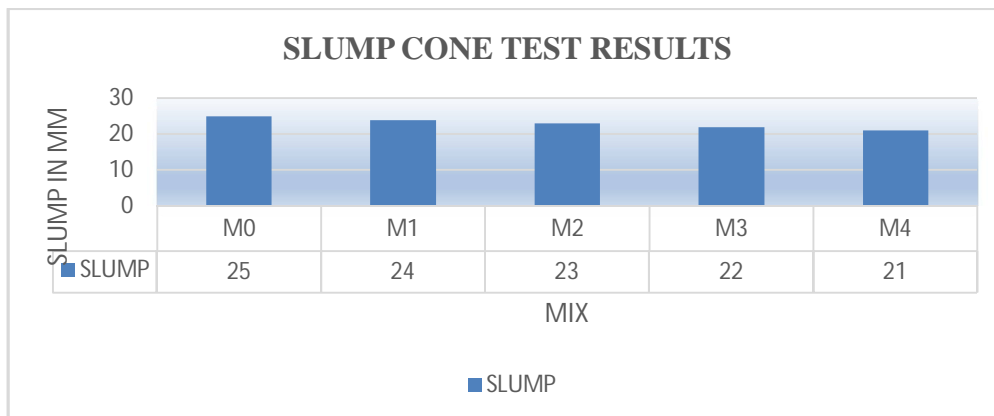
Test results of Split Tensile Strength of cylinders

MIX	Split Tensile Strength (N/mm ²) at 7 days	Split Tensile Strength (N/mm ²) at 28 days
C	0.45	2.83
GGBS (10%)	1.23	1.84
GGBS (20%)	0.88	1.98
GGBS (30%)	1.41	2.62
GGBS (40%)	1.37	2.62

GRAPH 5.1 COMPACTION FACTOR TEST RESULTS



SLUMP CONE TEST RESULTS

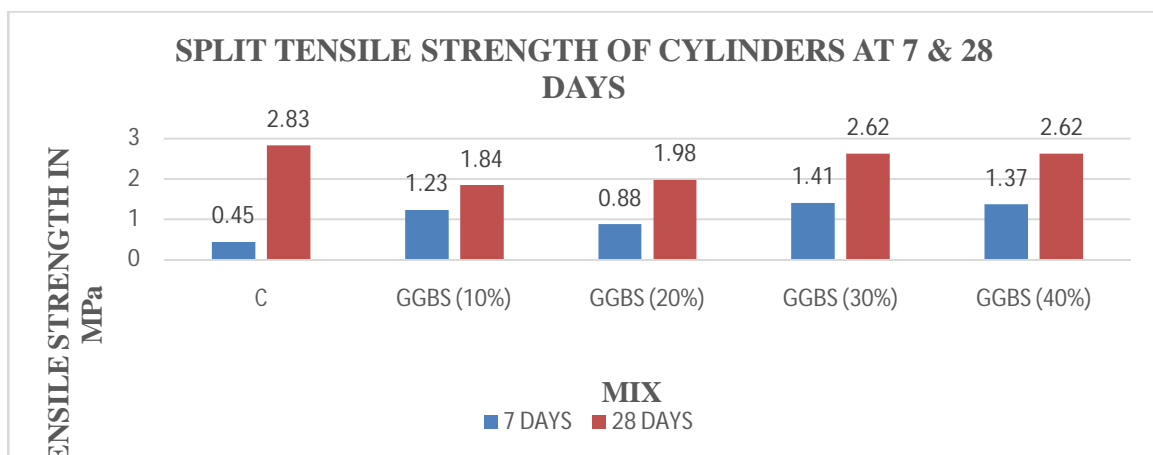
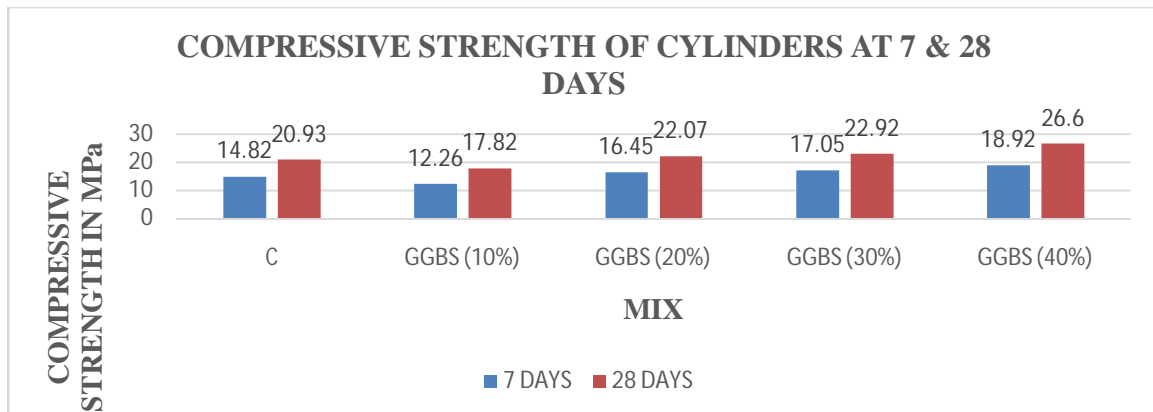
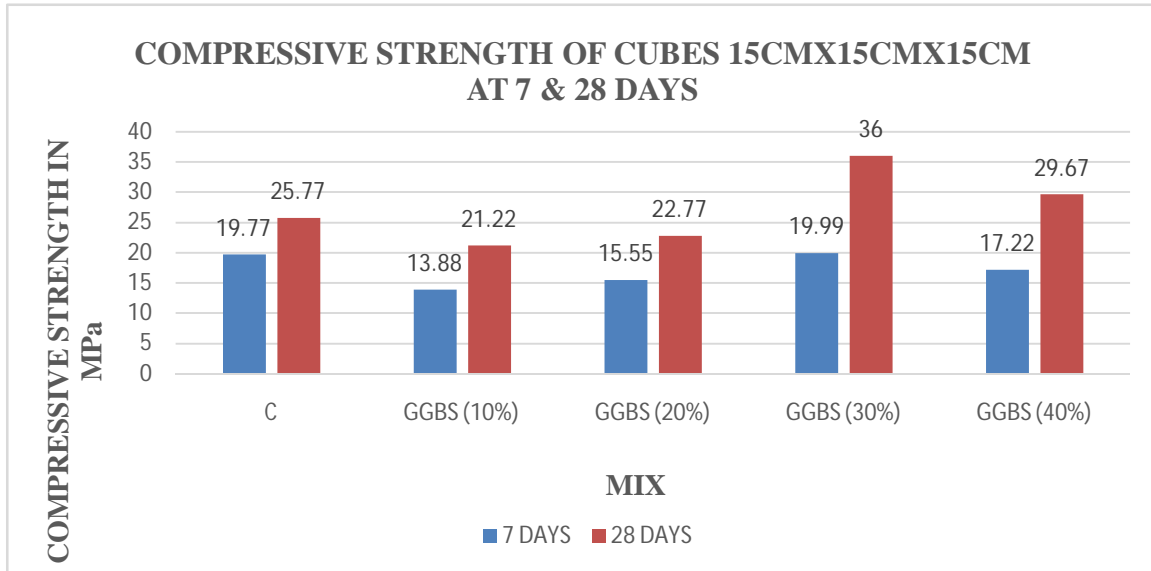


International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

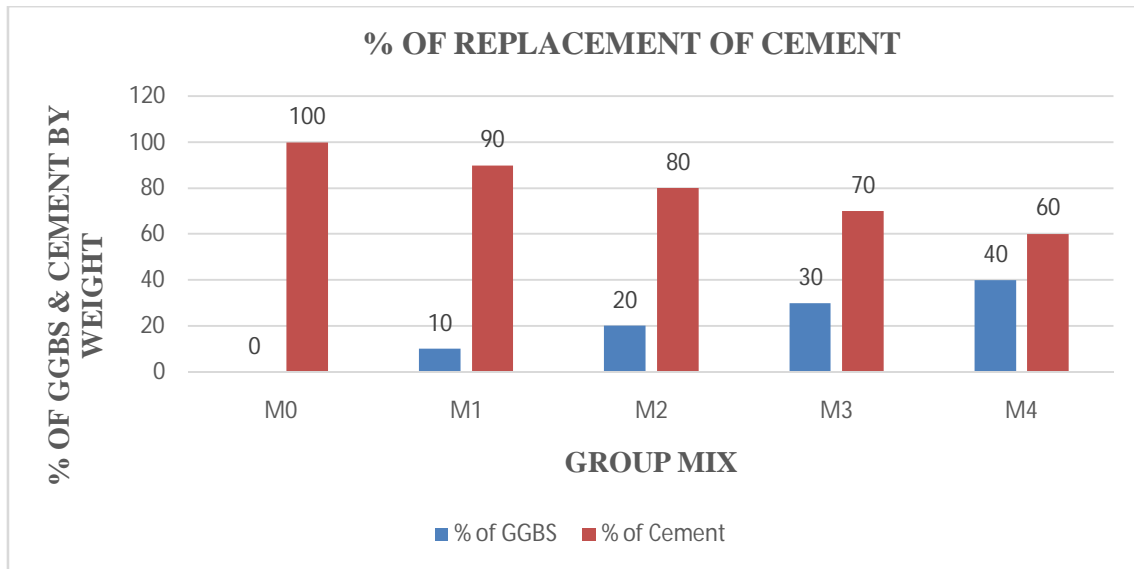


International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017



VII. CONCLUSION

1. Foremost objective of this study is thus realization of sound technology providing significant economic benefits. Additionally, sustainability is promotion.
2. The usage of GGBS in concrete is highly improves the strength, the results carried out the strength in 28 days.
3. GGBS mix reduces the workability.
4. From the above results, it can be concluded that GGBS can be effectively used in concrete.
5. The inclusion of GGBS has desirable effect on concrete mechanical properties which is comparable to normal concrete.
6. The usage of GGBS in concrete as cement replacement materials will lessen the CO₂ is being emitted during its manufacture and acts as an eco-friendly material reducing the Greenhouse effect.
7. Incorporation of these types of mineral admixtures in cement helps in making it more economical.

REFERENCES

1. Ground granulated blast-furnace slag - Wikipedia, the free encyclopedia
2. http://www.ukcsma.co.uk/what_is_ggbs.html
3. http://www.ecocem.ie/technical_working.htm
4. <http://ggbsreviewgroup.blogspot.in/>
5. <http://www.vcem-global.com/technical.html>
6. Venu Malagavelliet.al./International Journal of Engineering Science and Technology Vol. 2(10), 2010, 5107511.
7. European Journal of Scientific Research ISSN 1450-216X Vol.88 No-1 October, 2012, pp.155163@Euro journals Publishing, Inc. 2012 <http://www.europeanjournalof scientific research.com>.
8. Civil and Marine Company. "Frequently Asked Questions". Retrieved 2007-01-24.
9. EnGro Corporation Ltd. "Ground Granulated Blast furnace Slag (GGBS)". Archived from the original on 2007-01-22. Retrieved 2007-01-24.
10. Construct Ireland. "Ground Granulated Blast furnace Slag (GGBS)". Retrieved 2008-02-21.
11. Ecocem. "Ground Granulated Blast furnace Slag (GGBS)". Retrieved 2013-05-27.
12. U.S. Federal Highway Administration. "Ground Granulated Blast-Furnace Slag". Archived from the original on 2007-01-22. Retrieved 2007-01-24. http://shodhganga.inflibnet.ac.in/bitstream/10603/31527/7/07_chapter2.pdf.
13. "Concrete Technology Theory and Practice" by M. S. Shetty.
14. "CONCRETE TECHNOLOGY" by M L Gambhir.
15. "Properties of Concrete" by A.M. Neville.
16. IS: 456-2000 code of practice for plain and reinforced concrete.
17. SP: 23-1982 hand book on concrete mixes.
18. IS: 10262-2009 Indian standards recommended guidelines for concrete mix design.
19. IS: 516-1959 Indian standards methods of tests for strength of concrete.
20. IS: 383-1970 specifications for coarse aggregate and fine aggregate.