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"The Effect of Ground Granulated Blast Furnace Slag As On Alternative Cement Replacement Material In Concrete After 28 Days Strength"

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Abstract – *Concrete is a mixture of cement , fine aggregate , coarse aggregate and water , concrete plays a vital role in the development of infrastructure. The utilization of supplementary cementation material is well accepted , since it leads to several possible improvement in the concrete composites, as well as the overall economy. This paper present an experimental investigation carried out to study the effect of ground granulated blast furnace slag (GGBFS) On strength development of mortar and the optimum use of slag in mortar. Cement was partially replaced with seven percentage (40%, 42%, 44%, 46%,48%,50%) of slag by weight . Ordinary Portland cement (OPC) mortar was also prepared as reference mortar. A total of 42 cube and briquet mortar specimens were cast and compressive as well as tensile strength of the mortar specimens were determined at curing age of 7, 14 and 28 days.*

I. INTRODUCTION

1.1 Introduction to Ground Granulated Blast Furnace Slag

1.1.1 Ground Granulated Blast Furnace Slag

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. Ground -granulated blast furnace is highly cementitious and high in CSH (calcium silicate hydrates) which is a strength enhancing compound which increases the strength, durability and appearance of the concrete.

PROPERTIES OF GGBS

Ground Granulated Blast furnace Slag (GGBS) GGBS is obtained from local available industries. It is obtained by burning molten Iron slag from a blast furnace in water or steam to produce a glassy, granular product which is dried and grounded into a fine powder. The ground granulated blast furnace slag (GGBFS) is a by-product of iron manufacturing which when added to concrete improves its properties such as workability, strength and durability. This material is obtained by the heating of iron ore, limestone and coke at a temperature about 1500 degree Celsius. The process is carried out in a blast furnace. The formation of GGBFS is not direct. The by-product of iron manufacturing is a molten slag and molten iron. The molten slag consists of alumina and silica, also with the certain amount of oxides .This slag is later granulated by cooling it. For this, it is allowed to pass through a high-pressure water get. This result in quenching of the particles which results in granules of size lesser than 5mm in diameter. The main constituents of blast furnace slag are CaO, SiO2, Al2O3 and MgO. These are the minerals that are found in most of the cementitious substances.

Composition of Ground Granulated Blast Furnace Slag (GGBFS)
The difference in mineralogical composition in GGBFS compared to Portland cement is shown in the table below.

Mineral	GGBFS	Portland Cement
CaO	30-50%	55-66%
SiO2	28-40%	20-24%
Al2O3	8-24%	0-8%
MgO	1-18%	5%

Another significant difference in GGBFS is that some of the metals within it have not undergone complete oxidation. This change will be reflected in the structural formation in concrete when compared with Portland cement.
Advantages Ground Granulated Blast Furnace Slag (GGBFS)

- GGBFS in concrete increases the strength and durability of the concrete structure.
- It reduces voids in concrete hence reducing permeability
- GGBFS gives a workable mix.
- The structure made of GGBFS constituents help in increasing sulphate attack resistance.
- The penetration of chloride can be decreased.
- The heat of hydration is less compared to conventional mix hydration.
- The alkali-silica reaction is resisted highly.
- These make the concrete more chemically stable
- Gives good surface finish and improves aesthetics
- The colour is more even and light.
- Lower chances of efflorescence
- The maintenance and repair cost of structures are reduced thus increasing the life cycle of concrete structures.
- Unlike cement, GGBFS does not produce carbon dioxide, sulphur dioxide or nitrogen oxides.

Ground Granulated blast furnace slag is a waste product of steel production industry. The mixture of limestone, iron ore and coke are entered in the kiln. Consequential melted slag hangs over the melted iron at 15000C to 16000C temperature. Melted slag contains about 35% to 45% silicon dioxide (SiO2) and Calcium oxide about 45%. The chemical composition of molten slag as nearly the same as that of ordinary Portland cement (OPC). When the melted iron is removed then the melted slag, which contains siliceous aluminous scum is rapidly submerged in liquid, resulting in the creation of glassy granulate. The glassy granulated is dehydrated and then crushed into the required size . This grounded slag is known as ground granulated blast furnace slag. The little amount of extra energy is required to produce Ground Granulated blast furnace slag as compared to the energy required to produce cement. Ground granulated blast is co-environmental construction material. Caron dioxide emission can be controlled up to some extent by substitution of cement by Ground granulated blast furnace slag. GGBFS improve the impermeability of concrete and improved resistance to corrosion and sulfate attacks. Due to these properties of GGBFS concrete, the service duration of assembly is increased, and maintenance charge is decreased. Substitution of cement by a high percentage of co-environmental GGBFS leads to concrete which not only utilized waste materials but also protects natural resource and energy depletion .

Applications
GGBS is used to make durable concrete structures in combination with ordinary portland cement and/or other Pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years.[2]
Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete.
Concrete made with GGBS cement sets more slowly than concrete made with ordinary Portland cement,

depending on the amount of GGBS in the cementitious material, but also continues to gain strength over a longer period in production conditions. This results in lower heat of hydration and lower temperature rises, and makes avoiding cold joints easier, but may also affect construction schedules where quick setting is required.
Use of GGBS significantly reduces the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress — reducing the risk of reinforcement corrosion — and provides higher resistance to attacks by sulfate and other chemicals.

How GGBS cement is used

GGBS cement can be added to concrete in the concrete manufacturer's batching plant, along with Portland cement, aggregates and water. The normal ratios of aggregates and water to cementitious material in the mix remain unchanged. GGBS is used as a direct replacement for Portland cement, on a one-to-one basis by weight. Replacement levels for GGBS vary from 30% to up to 85%. Typically 40 to 50% is used in most instances.
The use of GGBS in addition to Portland cement in concrete in Europe is covered in the concrete standard EN 206:2013. This standard establishes two categories of additions to concrete along with ordinary Portland cement: nearly inert additions (Type I) and pozzolanic or latent hydraulic additions (Type II). GGBS cement falls in the latter category. As GGBS cement is slightly less expensive than Portland cement, concrete made with GGBS cement will be similarly priced to that made with ordinary Portland cement.
It is used partially as per mix ratio.

II- LITERATURE REVIEW

(a) S.k. Sirajuddin, T.Venkat Das In the present study an investigation is made on properties of concrete by partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS) and the fine aggregate with Quarry Dust (QD). GGBS is the by-product of iron and steel industry which is produced in large quantities as a solid waste. It is highly cementitious. Quarry Dust is a byproduct of the crushing process which is a concentrated material to use especially as fine aggregates. The replacement percentages of cement with GGBS are 20%, 40% and 60% by weight and fine aggregate with QD are 25%, 50% and 75% by weight. These combinations of materials were used to study compressive strength, spilt tensile strength and flexural strength tests and the results obtained were compared with the control concrete. It is observed that the optimum replacement percentages of GGBS and QD are 40% and 50% respectively.

(b) Sheikibrahim k, Sathish S Now a days more cementitious waste materials are produced by the many industries like iron industries (GGBS), coal industries (FLY ASH), paper industries (PAPER ASH) etc. Cement is the most important material in the construction sector. But the cement production from the industries affects the environment, due to emission of CO2 and greenhouse effect. This paper mainly focus on the strength of the concrete by determining the compressive strength and tensile strength of the concrete by various replacement of Fly ash and GGBS. The test results shows that strength increasing with the increase of fly ash and GGBS up to optimum value beyond which strength value start decreasing with further addition of fly ash and GGBS.

(c) Dr.M.G.R. University The utilization of supplementary cementation materials is well accepted, since it leads to several possible improvements in the concrete compo sites, as well as the overall economy. The present paper is an effort to quantify the strength of ground granulated blast furnace slag (GGBS) at various replacement levels an devaluate its efficiencies in concrete. Cement with GGBS replacement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, cost savings, environmental and socio-economic benefits. This research evaluates the strength and strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of ground granulated blast furnace slag for M35 grade of concrete at different ages. From this study, it can be concluded that, since the grain size of GGBS is less than that of ordinary Portland cement, its strength at early ages is low, but it continues to gain strength over a long period. The optimum GGBFS replacement as cementation material is characterized by high compressive strength, low heat of hydration, resistance to chemical attack, better workability, good durability and cost-effectiveness.

(d) Md. Aftabur Rahman This paper presents an experimental investigation carried out to study the effects of Ground Granulated Blast Furnace Slag (GGBFS) on strength development of mortar and the optimum use of slag in mortar. Cement was partially replaced with seven percentages (10%, 20%, 30%, 40%, 50%, 60% and 70%) of slag by weight. Ordinary Portland cement (OPC) mortar was also prepared as reference mortar. A total of 400 cube and briquet mortar specimens were cast and compressive as well as tensile strength of the mortar specimens were determined at curing age of 3, 7, 14, 28, 60, 90 and 180 days. Test results show that strength increases with the increase of slag up to an optimum value, beyond which, strength values start decreasing with further addition of slag. Among the seven slag mortars, the optimum amount of cement replacement is about 40%, which provides 19% higher compressive strength and 25% higher tensile strength as compared to OPC mortar.

(e) J. Prasad In the present study, the effect of curing procedure on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag is studied. The compressive strength development of cement mortar incorporating 20, 40 and 60 percent replacement of GGBFS for different types of sand and strength development of concrete with 20, 40 and 60 percent replacement of GGBFS on two grades of concrete is investigated. The compressive strength of cement mortar and concrete obtained at the ages of 3, 7, 28, 56, 90, 150 and 180 days. Tests results show that the incorporating 20% and 40% GGBFS is highly significant to increase the compressive strength of mortar after 28 days and 150 days respectively. The magnitude of compressive strength of mortar for standard sand is higher than the magnitude of river sand. Incorporating 60% BFS replacement is showing lower strength at all ages and water-cement ratio for both types of sand. The compressive strength of OPC concrete shows higher strength as compare to the GGBFS based concrete for all percent replacement and at all ages. Incorporating 40% GGBFS is highly significant to increase the compressive strength of concrete after 56 days than the 20 and 60% replacement. Among GGBFS based concrete 40% replacement is found to be optimum. Keywords: Blast furnace slag; compressive strength; cement mortar; concrete; curing; time.

(f) S.k.Sirajuddin : In the present study an investigation is made on properties of concrete by partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS) and the fine aggregate with Quarry Dust (QD). GGBS is the by-product of iron and steel industry which is produced in large quantities as a solid waste. It is highly cementitious . Quarry Dust is a by product of the crushing process which is a concentrated material to use especially as fine aggregates. The replacement percentages of cement with GGBS are 20%, 40% and 60% by weight and fine aggregate with QD are 25%, 50% and 75% by weight. These combinations of materials were used to study compressive strength, spilt tensile strength and flexural strength tests and the results obtained were compared with the control concrete. It is observed that the optimum replacement percentages of GGBS and QD are 40% and 50% respectively. Index Terms: GGBS, Quarry Dust, Compressive strength, Spilt tensile strength and Flexural strength.

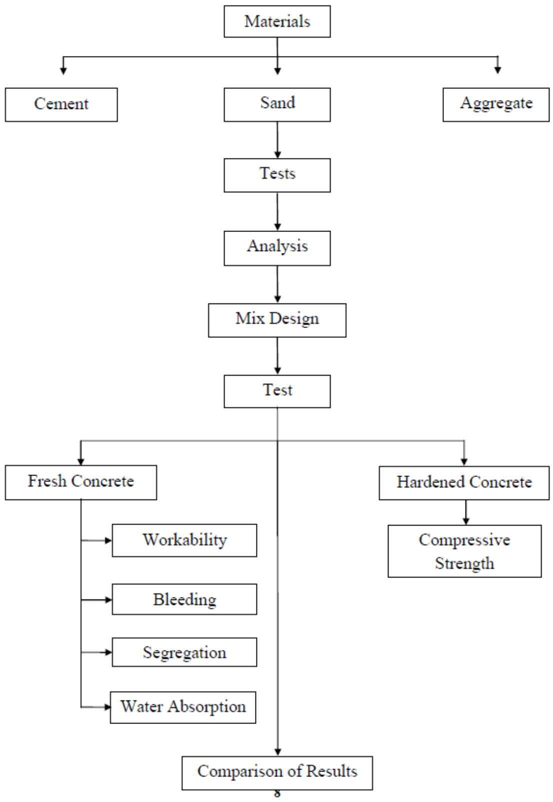
PROBLEM IDENTIFICATION

In the present study an investigation is made on properties of concrete by partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS) . GGBS is the by-product of iron and steel industry which is produced in large quantities as a solid waste. It is highly cementitious. The replacement percentages of cement with GGBS are 20%, 40% and 60% by weight .And it is mentioned that replacement of 40%-50% with GGBS gives the best result in compressive strength after 28 days. But it can further be optimized with the very sharp and by 40%,42%,44%,46%,48%,50% by weight of cement and then approximate % of GGBS. characteristics compressive strength after 28 days is analyzed and then it is compared with conventional normal concrete strength

III- OBJECTIVE OF THE STUDY

The main objective of this research work is to determine the characteristic compressive strength of concrete by compaction with normal concrete to the concrete with GGBS practically with cement , Also the study is made on the stream of some concrete properties namely workability , segregation , bleeding , shrinkage, permeability and compression is been made with normal mix concrete i.e (without any admixture) properties.

IV- METHODOLOGY



V-RESULT AND DISCUSSION

5.1.1 **Properties of cement:**

Ordinary Portland cement confirming IS 8112:1989 was used thought the work. Cement used was dry and free from lump with SG = 3.35

PROPERTIES	RESULT
Fineness modulus	2%
Specific gravity	3.35
Consistency	28%
Initial setting time	32min
Final setting time	600min

Table no. 1 Properties of fine aggregate

The fine aggregate used in this work was clean river sand and maximum size is 4.75 mm. Sieve analysis confirms to zone-II (according to IS: 383-1970).

PROPERTIES	RESULT
Zone	II
Water absorption	1.1%
Fineness modulus	2.86
Specific gravity	2.66

Table no. 2 Properties of coarse aggregate

Machine crushed aggregate of 20mm size is used. And it is separated by sieving size passing from 40mm and retain on 20mm.

PROPERTIES	RESULT
Size of C.A	20mm
Water absorption	0.8%
Fineness modulus	7.2
Specific gravity	2.79

Table no. 3 Properties of GGBS

Property of GGBS

Sr. No	**Property**	**Value**
1	Specific gravity	**2.9**
2	Colour	Off White
3	Bulk Density	1000-1100 kg/m^3 (loose) 1200-1300 kg/m^3 (vibrated)
4	Fineness Modulus	>350m^2/kg

5.1.2 WORKABILITY TEST
SLUMP TEST

Reference : IS CODE 1199-1959,IS CODE 456-2000
Apparatus : Mould in the form of frustum of a cone, tamping rod, tray, measuring scale.

Theory : This is the method of testing consistency of concrete in field or in laboratory. The slump test is done where the nominal maximum size of the aggregate does not exceed 38mm. The height of slump formed at the given water/cement ratio is check for the need and final result of workability from IS 456-2000. Slump recorded in terms of milli-meter and any slump which collapse or shear off laterally give incorrect result, so repeat with other sample. If, in the repeat the result is same then shear slump is recorded.

Procedure :

1. The mould should be cleaned and placed in a non-absorbent flat surface. The mould should be filled with concrete in four layers with tampering for 25 times. 2. After the top surface is levelled the mould should be removed immediately by raising it slowly and carefully in vertical direction. 3. This allow the concrete to form the slump and it is measured by the difference in height between the mould and that of the height point of specimen being tested. 4. This test is carried out at a place which h is free from vibration and within a period of two minute after sampling. 5. Now, the recorded reading is check from IS CODE 456-2000 to know for which purpose the concrete can be used.

Result : The slump value in mm = 40 (0% GGBS)
The slump value in mm = 46(40%GGBS)
The slump value in mm = 46.2 (42% GGBS)
The slump value in mm = 46.7 (44% GGBS)
The slump value in mm = 48(46% GGBS)
The slump value in mm = 47.3(48% GGBS)
The slump value in mm = 47(50% GGGB)

Table No. 3 : Compression test on different percentage of GGBS added to concrete

Sr..No	GradeOf Concrete	% Replacement (MD)	Characteristics Compressive Strength after 28 Days (N/mm^2)		
			7 Days	14 Days	28 Days
1	M20	0%	12.62	17.69	21.37
2	M20	40%	12.50	18.56	19.24
3	M20	42%	11.99	17.68	20.48
4	M20	44%	13.31	18.44	20.49
5	M20	46%	18.92	26.19	29.11
6	M20	48%	18.11	24.86	28.08
7	M20	50%	18.63	25.80	28.67

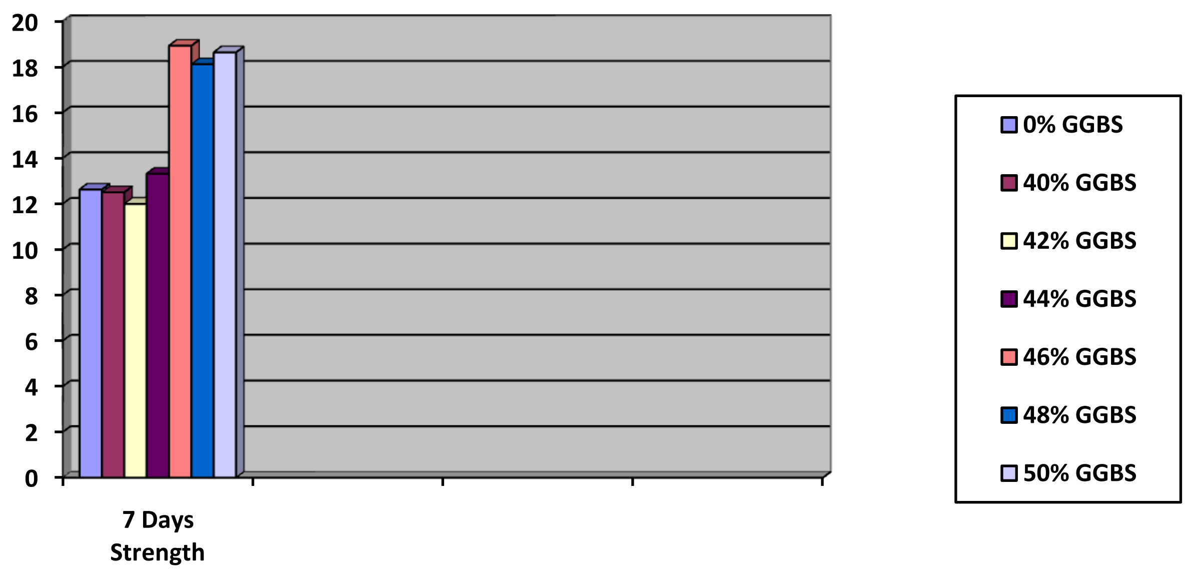


Fig : 1 Graphical representation of 7Days Compressive strength with different % replacement of GGBS

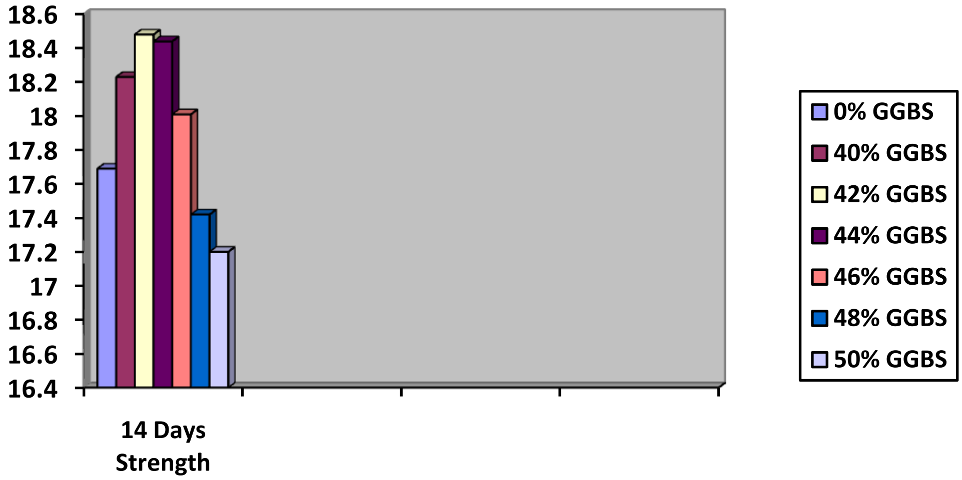


Fig :2 Graphical representation of 14 Days Compressive strength with different % replacement of GGBS

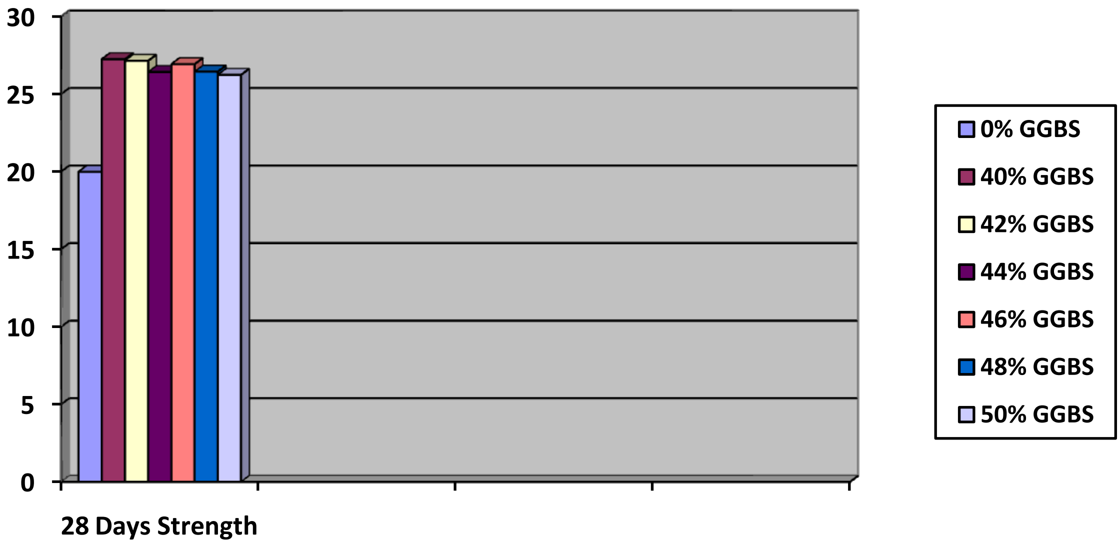


Fig: 3 -Graphical representation of 28 Days Compressive strength with different % replacement of GGBS

The graphical representation above fig:14 says that when 46% replacement of GGBS is done then it will give the highest growth rate of Compressive strength after 7 days i.e. 18.92 N/mm^2 , Minimum strength rate growth is achieved when 0% replacement of GGBS is done .Again when 14 days strength is compared fig:15 the highest strength growth is in 46% replacement and lowest in 0% replacement of GGBS.fig:16 28 Days strength is maximum when 40% replacement of GGBS is made .So here replacement of GGBS with cement is worthy upto some extent and limit.

Future Scope Of Work

As we concluded that GGBS can be replaced by cement upto some % but for the future scholer I may suggest for 100% replacement with GGBS and some other admixture so that the cost of cement can be reduced even more

REFERENCES

[1]*https://www.researchgate.net/publication/284899064Strength_and_Durability_Studies_on_GGBS_Concrete*

[2] *https://www.researchgate.net/publication/329754518*

[3] *https://en.wikipedia.org/wiki/Ground_granulated_blast-furnace_slag*

[4] *https://doi.org/10.12989/acc.2016.4.4.283*

[5] *www.elsevier.com/locate/cscm Sustainable concrete with high volume GGBFS to build Masdar City in the UAE Mohamed Elchalakani*

[6]*ttps://www.researchgate.net/publication/305501367STRENGTH BEHAVIOR OF MORTAR USING SLAG AS PARTIAL REPLACEMENT OF CEMENT Md. Moinul Islam*

[7] *The Effect of Ground Granulated Blast Furnace Slag as an alternative cement replacement material in Concrete after 28 days Strength*

[8] *Jordan Journal of Civil Engineering, Volume 8, No. 3, 2014 - 263 - © 2014 JUST. All Rights Reserved. Sustainable Studies on Concrete with GGBS As a Replacement Material in Cement S. Arivalagan*

[9] *www.ijirset.com Vol. 6, Issue 4, April 2017 Copyright to IJIRSET DOI:10.15680/IJIRSET.2017.0604229 5966 An Experimental Study on Cement Replacement by GGBS in Concrete P Lakshmaiah Chowdary*

[10] *International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019 Experimental Investigation on Properties of Concrete by Partial Replacement of Cement with GGBS and Fine Aggregate with Quarry Dust*

[11] *International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.88 Volume 6 Issue IV, April 2018- Available at www.ijraset.com ©IJRASET (UGC Approved Journal): All Rights are Reserved 3266 Utilization of GGBS and Steel Slag for Betterment of High Strength Concrete - Review Naitik Joshi*

[12] *www.internationaljournalssrg.org ISSN: 2348 – 8352 Strength and Durability Studies on GGBS Concrete Santosh Kumar Karri1*

[13] ***www.ijemr.ne t****ISSN (ONLINE): 2250-0758, ISSN (PRINT): 2394-6962Study and Analysis of Strength of GGBS Concrete Sunil Bhagwan Yamgar*

[14] *E. Condren & S. Pavía. (2007). A comparative study of the moisture transfer properties and durability of PC and GGBS mortars. International Conference on Concrete Platform. M I Russell and PA M Basheer Eds. Queen's University, Belfast, 469-478. Available at: http://www.tara.tcd.ie/bitstream/handle/2262/12843/SPCP 2007*

[15] *IJSR - INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH GGBS as Partial Replacement of OPC in Cement Concrete – An Experimental Study| Issue : 11 | November 2013 ISSN No 2277 – 817*

[16] *Effect of Ground Granulated Blast Furnace Slag as Partial Cement Replacement on Strength and Durability of Concrete: A Review Rajesh Kr. Pandey e-ISSN: 2395 -0056 Volume: 03 Issue: 02 | Feb-2016 www.irjet.net p-ISSN: 2395-0072*

[17] *Venu Malagavelli et. al. ―High performance concrete with GGBS and robo sand‖ International Journal of Engineering Science and TechnologyVol. 2(10), 2010, 5107-5113*

[18] *O'Connell, Martin, McNally, Ciaran, & Richardson, Mark G. (2012). Experimental Investigation on Strength of High Performance Concrete with GGBS and Crusher Sand. Construction and Building Materials, 27(1), 368–374.*

[19] *Mahesh Patel, P. S. Rao, & T. N. Patel. (2013). Experimental investigation on strength of high performance concrete with GGBS and crusher sand. Indian Journal of Research, 3(4), 114-116.*

[20] *Mr. Bennet Jose Mathew, Mr. M Sudhakar, & Dr. C Natarajan. (2013). Strength, economic and sustainability characteristics of coal ash– GGBS based geopolymer concrete. International Journal of Computational Engineering Research, 3(1), 207-212.*

[21] *Elsayed, A.A. (2011). "Influence of Silica Fume, Fly Ash, Super Pozz and High Slag Cement on Water Permeability and Strength of Concrete". Jordan Journal of Civil Engineering , 5 (2), 245-257.*