ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, Available at: www.paperpublications.org

Assessment of Water Absorption Capacity of Concrete with GGBS Replacement

[1]Mallikarjun Hulagabali, [2]Dr. R. Prabhakara, [3]Anand Hulagabali

[1]Former PG Student, Department of Civil Engineering, M.S. Ramaiah Institute of Technology, Bangalore
[2]Former Professor, Department of Civil Engineering, M.S. Ramaiah Institute of Technology, Bangalore
[3]PhD Scholar, Applied Mechanics Department, SVNIT, Surat

Abstract: **Concrete is a widely-used material in construction industry, because it has naturally and easily available ingredients like cement aggregate and water. Production of cement creates environmental problem like emission of CO_2 in the production process of cement. So, there is serious need to find ways and means to reduce CO_2 emission. To overcome this problem Ground Granulated Blast Furnace Slag (GGBS), which is a pozzolanic material can be used as a partial replacement to cement. The main components of GGBS are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1- 18%). In general, increase in CaO content of the slag increases slag basicity and therefore improves the compressive strength. As it is available from the literature, strength and durability are the two important mechanical properties to make reliable concrete. However, durability studies on medium and high strength concrete over different replacement levels of GGBS are limited. In the present study, GGBS was replaced with cement to obtain the influence of GGBS in normal and high strength concrete on durability properties. Comparisons were made with different percentage of replacements of GGBS for cement, which helped to arrive at the optimum percentage of replacement. Cement was replaced by GGBS at 0, 20, 30, 40 and 50% by weight of cement in conventional concrete and high strength concrete. Over 200 cubes and cylinders were casted, cured and tested for 28 and 56 days. Various durability tests were conducted on specimens and also water absorption test was conducted. Standard test procedure has been followed as per the codal provisions. Results were tabulated systematically, illustrative graphs were developed and the variation of durability properties is discussed in detail. It was observed from the investigation that as the percentage of GGBS increased, enhancement of durability properties was observed up to a certain level of percentage and further shown declination.**

Keywords: **Ground Granulated Blast Furnace Slag (GGBS), Water Absorption, High Strength Concrete.**

I. INTRODUCTION

Concrete is a widely-used material in construction industry, because it has naturally and easily available ingredients like cement aggregate and water. It has numerous applications because of its strength, ease of moulding and also cheap availability of its ingredients. Cement is one of the most important ingredients of concrete because of its binding properties. Increase in production of cement creates environmental problem like emission of CO_2 in the production process of cement [6]. One tonne of CO_2 is released to atmosphere when one tonne of OPC is manufactured which has very harmful effect on the environment. The emission of CO_2 depends upon the type of production processes, their efficiency; fuel used, yet concrete is a desirable construction material with relatively low embodied energy, very useful thermal mass and high potential durability [7]. so, there is serious need to find replacements for cement. To overcome this problem GGBS which is a pozzolanic material can be used as a partial replacement to cement. As GGBS is a waste from the iron industry and has chemical and physical properties like cement. So, it serves 2 purposes. 1. To replace cement partially. 2. To overcome the problem of disposal of GGBS.

From structural point of view, GGBS replacement reinforced lower heat of hydration, higher endurance and higher obstructed to sulphate and chloride intrusion when contrasted with normal ordinary concrete. On the farther hand, it also enriches to environmental resistance because it curtails the use of cement during the production of concrete. The main components of blast furnace slag are CaO (30-50%), SiO2 (28-38%), Al_2O_3 (8-24%), and MgO (1- 18%). In general, booming the CaO content of the slag terminates in raised slag basicity and a rise in compressive strength. GGBS is used to make reliable concrete structures. GGBS has been broadly used in Europe and progressively in Japan and Singapore for its Excellency in concrete durability, continuing the lifetime of buildings from fifty years to a hundred years' strength. [7]

II. LITERATURE REVIEW

S. Arivalagan (2014) studied on the sustainability aspect of GGBS in Concrete at different replacement levels. Research was done at different ages of concrete and its strength and strength efficiency factors of hardened concrete. Study was carried out on M35 grade concrete at 20, 30 and 40 % of GGBS replacement with cement. Different types of tests were conducted and analysed, later on the basis of results, conclusions were drawn. As the grain size of GGBS is lesser than ordinary Portland cement, concrete had lesser strength at early age but it continued to gain strength over a long period. The optimum replacement of GGBS was characterized by low heat of hydration, high compressive strength, resistance to chemical attack, better workability, good durability and cost-effectiveness. The optimum replacement was found out to be 40% of GGBS replacing the cement. **Hilal El-Hassan, Peiman Kianmehr (2017)** researched on the usage of GGBS in pervious concrete. From an economic standpoint, the Portland Cement Association (PCA) reported that concrete is in fact cheaper than asphalt based on initial and lifecycle maintenance costs given its superior durability. They performed different tests on pervious concrete with GGBS replacing cement by 50%. After the analysis of the results obtained, GGBS was found to be a very good alternative for cement, especially in porous concrete as GGBS is more sustainable paving solution, offering a reduction in heat island effect and electricity consumption while also alleviating carbon emissions. **Nan Su and Buquan Miao (2010)** proposed a new mix design method for medium strength flowing concrete (FC) with low cement content. The proposed method determined the packing factor (aggregate content) first, and then filled binding paste containing fly ash and GGBS into the voids between aggregates to make concrete workable and achieve required strength. Tests on slump, slump flow, and compressive strength were carried out and the results indicated that medium strength concrete can be produced successfully using this method. Concrete mixtures designed by using the proposed method required a small quantity of binder and is therefore very economical. **A. Andriya Annal, Priya Rachel (2016)** This investigation dealt with the development of high performance concrete when the cement and river sand were replaced by GGBS and Manufacture sand in various proportions. In this study 30%, 40% and 50% GGBS replaced with cement and 100% of manufactured sand replaced with the water cement ratio 0.38. This study mainly focused on the discussion of strength and workability characteristics of high performance concrete, when the cement was replaced by GGBS partially in various proportions, together with the replacement of river sand by M sand in various proportions. Compressive, split and flexural test were conducted on concrete specimens for strength analysis and for durability studies RCPT, Absorptivity and water permeability. Later they concluded based on the result of compressive strength at 14 days, the compressive strength increased by increase in percentage of GGBS. They also concluded that M sand could be used as one of the alternative material for river sand.

III. MATERIALS AND EXPERIMENTS

Characterization of materials is a very important stage in research work. Various materials were tested for their engineering properties and also mechanical properties.

CEMENT:

In the current investigation, Zuari 43 grade OPC conforming to IS 8112-2013 has been utilized. The physical properties of the cement were found to be as per IS 8112-2013 and has been mentioned below (Table 1.1).

FINE AGGREGATES:

Natural river sand is the most preferred choice as a fine aggregate material. It is mined from river beds and sand mining has disastrous environmental consequences. River sand is becoming scarce and its use needs to be stopped or reduced. Use of other alternatives to River sand has become necessary. Manufactured sand (M-sand) is proving to be a great alternative for river sand and has gained immense popularity in India in recent years. Specific gravity, bulk density and particle size distribution of M-sand is almost similar to River sand. The fine aggregates satisfied the specifications as per IS 383-1970.

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, Available at: www.paperpublications.org

Table 1: Requirements of cement properties as per IS 8112: 2013

Sl. No	Properties	Requirements as per IS 8112 : 2013
1	Fineness	Not more than 10%
2	Soundness	Not less than 10 mm
3	Initial Setting Time	Not less than 30 min
4	Final Setting Time	Not more than 600 min
5	3 days Compressive Strength	Not less than 23 N/mm^2
6	7 days Compressive Strength	Not less than 33 N/mm^2
7	28 days Compressive Strength	Not less than 43 N/mm^2

COARSE AGGREGATES:

Coarse aggregates are important to concrete as they play an important role in the attainment of strength in concrete. The strength of the concrete depends on the size and the grading of the coarse aggregates. Small sized coarse aggregates produce higher strength of concrete as the amount of stress concentrated around the aggregate particles is much lesser which is caused due the differences between the elastic moduli of the paste and aggregate. The coarse aggregates used in the current studies were found conforming to the codal provisions in IS 383-1970.

GGBS:

Ground granulated blast furnace slag used for the present investigation was borrowed from RMC Ready-mix India.

SUPER PLASTICIZER:

Conplast SP 430 which is commercially marketed by Fosroc Chemicals India Pvt Ltd was used as the super plasticizer in M60 grade High Strength Concrete.

WATER:

As per IS 456:2000 for both mixing and curing of concrete, potable water free from harmful salts was used.

MIX PROPORTION USED IN THE STUDY:

Based on the results observed from the trial mixes following mix proportions for HSC and MSC was adopted for the present investigation as shown below in table 1.2. Various mixes containing replacement of GGBS in different orders for HSC and MSC are shown in table 2.1 and table 2.2 below.

Table 2: Mix proportions of HSC and MSC

MATERIALS	MSC	HSC
Water binder ratio	0.4	0.29
Cement (kg/m^3)	420	504.21
Fine Aggregate (kg/m^3)	710	663.26
Coarse Aggregate(kg/m^3)	1123	1108.13
Water (kg/m^3)	168	146.28
Super plasticizer (kg/m^3)	-	7.563

As the grade of concrete increased the cement content also increased and water content in high strength concrete was decreased. Super plasticizer was used only in the M60 grade concrete and not in the medium strength concrete.

Table 3: Mix proportions of HSC with replacement of GGBS in different levels

Type of Mix	Binder (kg/m3)		Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)	Water Content (kg/m3)	Super Plasticizer (kg/m3)
	Cement	GGBS				
0% GGBS (control mix)	504.21	0	663.26	1108.13	146.28	7.563

20% GGBS	403.37	100.84	663.26	1108.13	146.28	7.563
30% GGBS	352.95	151.26	663.26	1108.13	146.28	7.563
40% GGBS	302.53	201.68	663.26	1108.13	146.28	7.563
50% GGBS	252.10	252.10	663.26	1108.13	146.28	7.563

It can be observed from the above table that only cement and GGBS content were varied and other materials i.e. fine aggregates, coarse aggregates, water and super plasticizer content was kept constant.

Table 4: Mix proportions of MSC with replacement of GGBS in different levels

Type of Mix	Binder (kg/m3)		Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)	Water Content (kg/m3)
	Cement	GGBS			
0% GGBS (control mix)	420	0	710	1123	168
20% GGBS	336	84	710	1123	168
30% GGBS	294	126	710	1123	168
40% GGBS	252	168	710	1123	168
50% GGBS	210	210	710	1123	168

Same procedure was followed like high strength concrete only variables were the cement and GGBS content like in the case of HSC.

IV. EXPERIMENTAL INVESTIGATION

Various tests were conducted on both fresh and hardened concrete. Tests included compressive strength, split tensile strength, fracture energy, flexural strength, modulus of elasticity, water absorption, sulphate attack and chloride attack.

SATURATED WATER ABSORPTION TEST:

The water absorption by immersion gives an estimation of the total (reachable) pore volume of the concrete. If the concrete has more pores that is less durable because if concrete is exposure to environment there is more deterioration takes in concrete. The pore structure of concrete is known to be of high importance for the durability of the material.

TEST PROCEDURE:

The test was conducted according to ASTM 642 on concrete specimens of 100mm dia and 50mm height, both MSC and HSC cubes were casted and cured for 28 days. After the curing of specimens were taken off from water and kept for surface dry. After surface dry the specimen then placed in oven at 105˚ C for 24 hours and weighed at regular intervals till constant mass, the weight taken as W1. Then the specimens are immersed in water after cooling to room temperature and measuring the gain in mass at regular intervals of 30 minutes duration. The procedure is repeated till constant mass is attained, the weight taken as W_2. Then the percentage water absorption is calculated using below equation.

Percentage weight loss = $\frac{W_1-W_2}{W_1} X\ 100$

where,

w_1 =initial weight of specimen in kg

w_2 =final weight of specimen after immersion in water in kg

V. RESULTS AND DISCUSSIONS

Discussions of results over benchmarking with literatures and validation of obtained data add value to work. Results from the experiments are discussed in this chapter.

Weights of samples after and before saturation for M40 grade concrete

ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, Available at: www.paperpublications.org

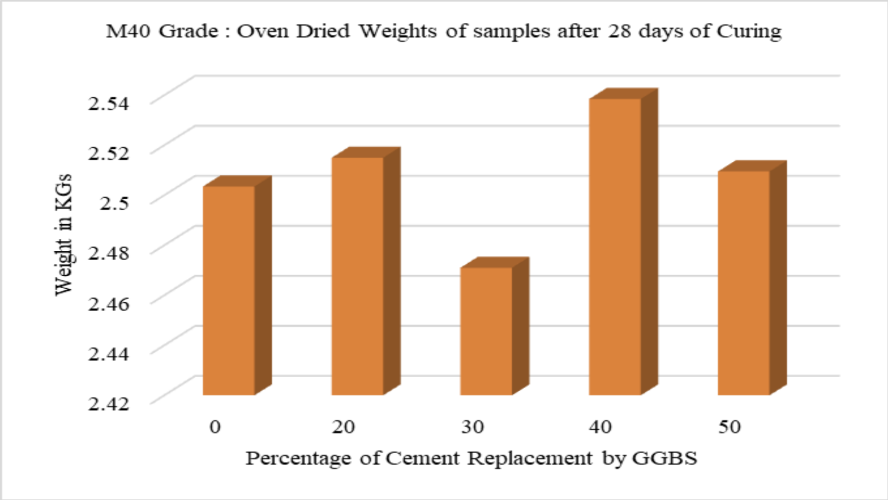

Fig 1: Oven Dried Weights of samples after 28 days of Curing (M40)

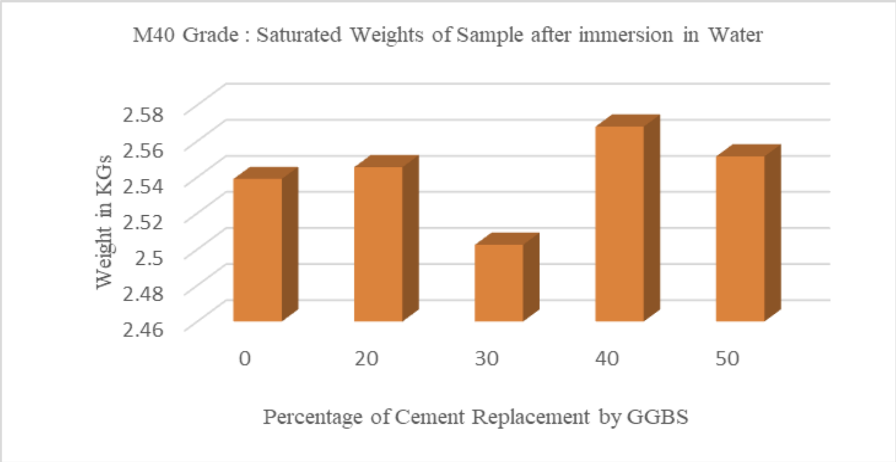

Fig 2: Saturated Weights of Sample after immersion in Water (M40)

Oven dried and saturated weights of concrete samples tested after 28 days of curing were found to be to be almost same with minor variations.

Weights of samples after and before saturation for M60 grade concrete

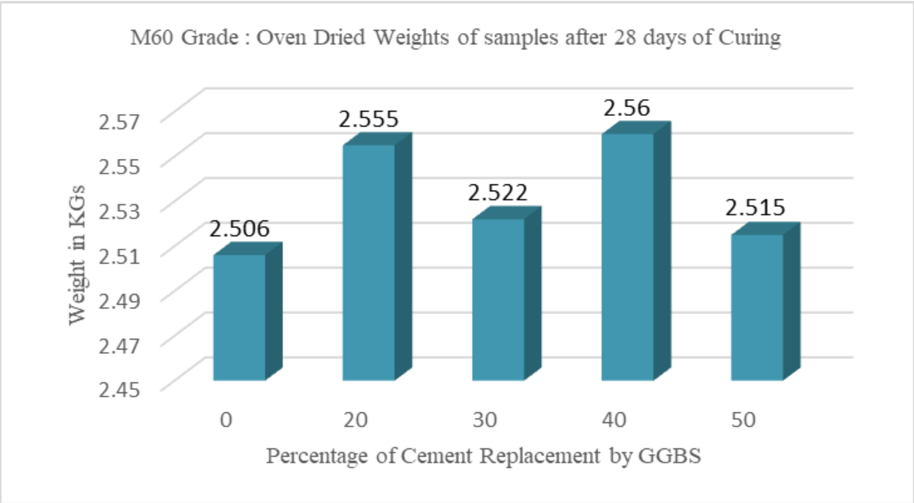

Fig 3: Oven Dried Weights of samples after 28 days of Curing (M60)

ISSN 2393-8471

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, Available at: www.paperpublications.org

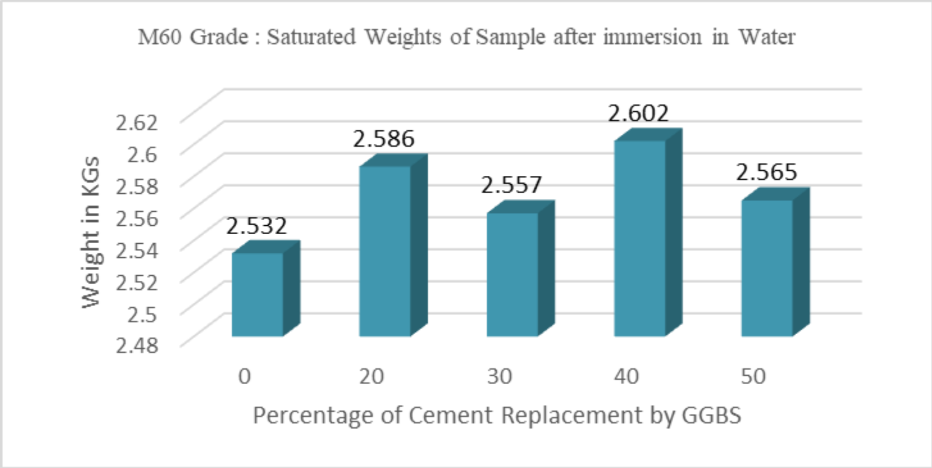

Fig 4: Saturated Weights of Sample after immersion in Water (M60)

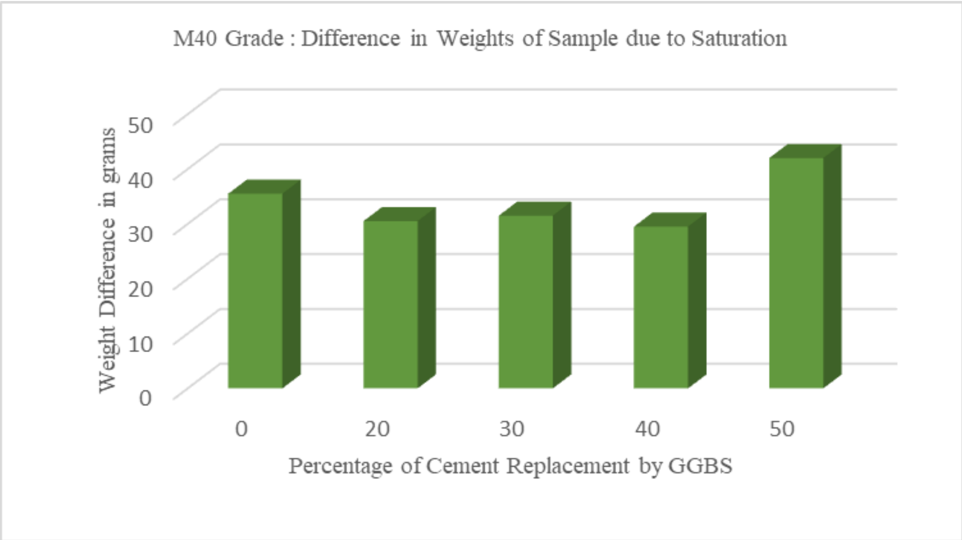

Fig 5: Difference in weight of samples due to saturation (M40)

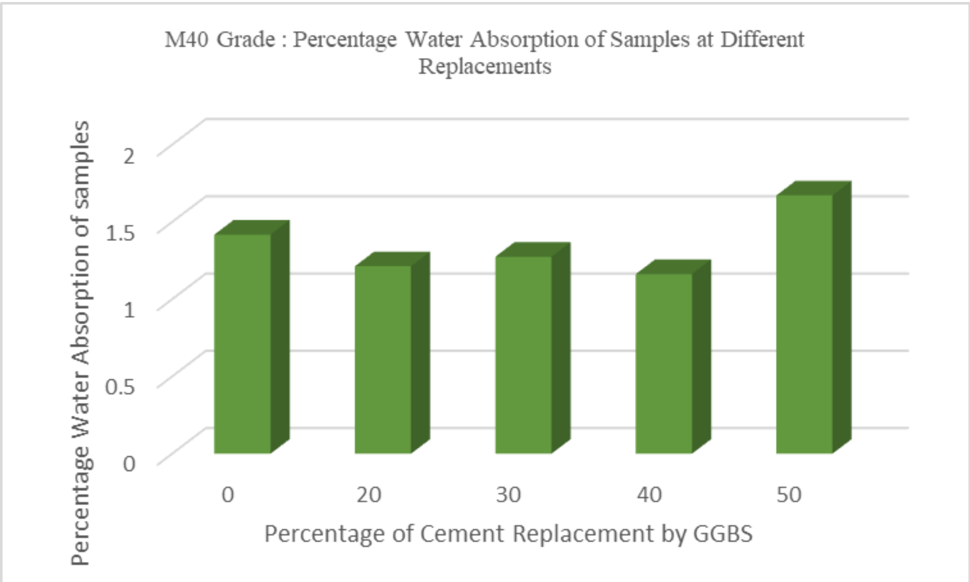

Fig 6: Percentage water absorption of samples at different replacements (M40)

ISSN 2393-8471
International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, Available at: www.paperpublications.org

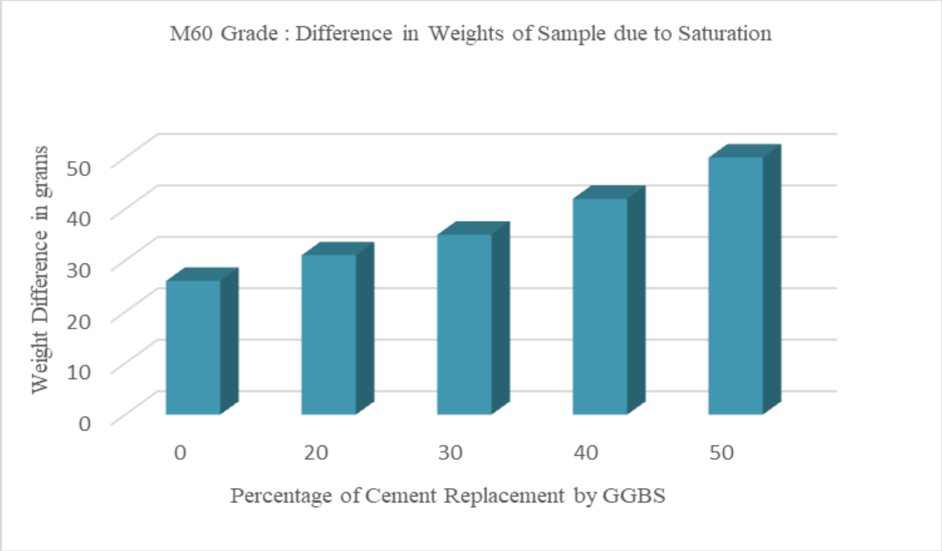

Fig 7: Difference in weight of samples due to saturation (M60)

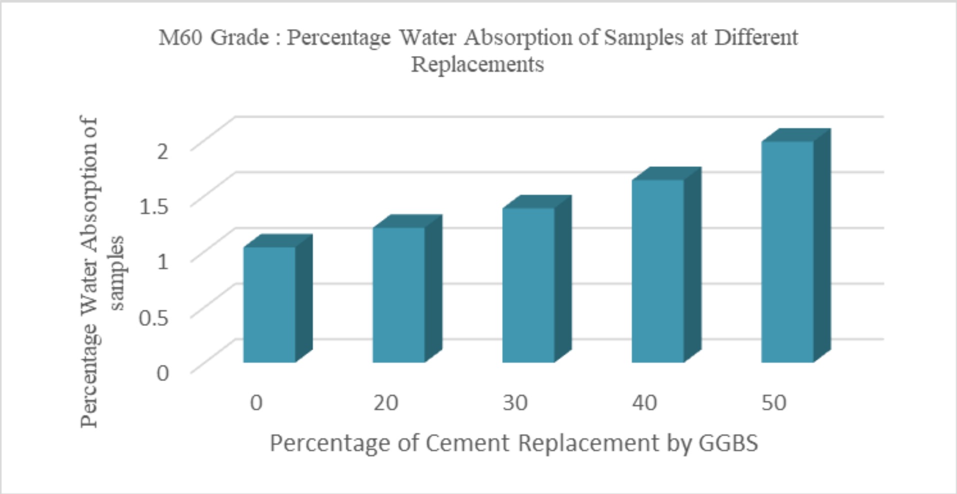

Fig 8: Percentage water absorption of samples at different replacements (M60)

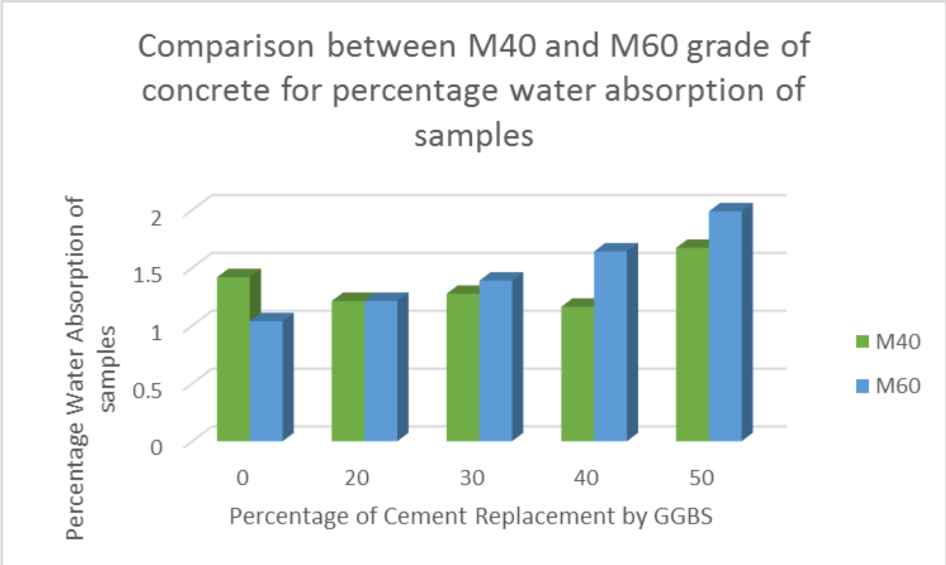

Fig 9: Comparison between M40 and M60 grades of concrete for percentage water absorption

International Journal of Recent Research in Civil and Mechanical Engineering (IJRRCME)
Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, Available at: www.paperpublications.org

VI. CONCLUSIONS

1. As the percentage of cement replacement of GGBS increased, percentage of weight reduction in both M40 and M60 grade concrete decreased.
2. The water absorption in M40 concrete did not vary too much for different percentages of replacement, whereas in case of M60 concrete there was noticeable increase in water absorption percentage as GGBS percentage was increased.
3. For 40% and 50% replacement levels, it was observed that there was no significant weight loss for high strength concrete.

REFERENCES

[1] Ajay Kumar Singh, (2016) "Strength and Durability Test of Fly Ash and GGBS Based Geopolymer Concrete" Int. Journal of Engineering Research and Application ISSN: 2248-9622, Vol. 6,Issue 8, (Part -1), pp.139-142 http://www.ijera.com/papers/Vol6_issue8/Part-%201/R0608011390142.pdf

[2] V.Nagendra, (2016) "Effect on strength properties of concrete by using GGBS by Partial Replacing cement with GGBS" International Journal of Recent Trends in Engineering & Research (IJRTER) ISSN: 2455-1457, Volume 02, Issue 08,

[3] Andriya Annal, Priya Rachel, (2016)"Experimental Study on Behaviour of High Performance Concrete using GGBS and M Sand" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 5 Issue 02 http://dx.doi.org/10.17577/IJERTV5IS020352

[4] T.H Patel, J M Shreeshaila, Prahlada V, (2016)"Experimental Study on Durability Properties of High Performance Self Compacting Concrete", International Journal of Innovative Research in Science, Engineering and Technology ISSN (Print): 2347-6710,Vol. 5, Issue 08 DOI:10.15680/IJIRSET.2016.0508107

[5] Aishwarya Asha,(2016) "Strength Characteristics of Concrete with Addition of Steel Fibre and Partial Replacement of Cement with Ground Granulated Blast Furnace Slag" International Journal of Engineering Science and Computing, ISSN 2321 3361DOI 10.4010/2016.1305

[6] Shankar Mishra, Pankaj Kumar Choudhary, Pawan Taneja, Naman Gupta, Manoj Olla, Kamlesh Saini (2016) "Studies on Utilisation of GGBS and Fly Ash to Make Green Concrete" SSRG International Journal of Civil Engineering (SSRG-IJCE), ISSN: 2348 – 8352volume 3 Issue 5 http://www.internationaljournalssrg.org/IJCE/2016/Volume3-Issue5/IJCE-V3I5P107.pdf

[7] Maria Rajesh Antonyamaladhas, Selvamony Chachithanantham and Anandkumar Ramaswamy, (2016) "Performance and Behaviour of Ground Granulated Blast Furnace Slag Imparted to Geopolymer Concrete Structural Elements and Analysed with ANSYS" Advances in Materials Science and Engineering Volume, Hindawi Publishing Corporation http://dx.doi.org/10.1155/2016/7023897

[8] C. S. Poon and L. Lam, (2006) "Compressive strength, chloride diffusivity and pore structure of High performance Metakaolin and silica fume concrete" Construction and Building Materials, 20 858–865 DOI: 10.1016/j.conbuildmat.2005.07.001

[9] Chaohua Jiang, Xiaobin Zhou, Guilan Tao,and DaChen, (2016), "Experimental Study on the Performance and Microstructure of Cementitious Materials Made with Dune Sand" Advances in Materials Science and Engineering Volume 2016 (2016), Article ID 2158706, 8 pages, Hindawi publishing http://dx.doi.org/10.1155/ 2016/2158706

[10] M. Saillio, V. Baroghel-Bouny and S. Pradelle "Various Durability Aspects of Cement Pastes and Concretes with Supplementary Cementitious Materials" Second International Conference on Concrete Sustainability ICCS16 Madrid 2016

[11] Matthieu Bergin, and Othman Omicron Metalssi "Changes in microstructure and pore structure of low-clinker cementitious materials during early stages of carbonation" DOI 10.4010/2016.1305 ISSN 2321 3361, 2016 IJESC

[12] Luca Bertolini and Maddalena Carsana "Corrosion of Steel in Concrete and Its Prevention in Aggressive Chloride-Bearing Environments" DOI 10.4010/2016.1305 ISSN 2321 3361, 2016 IJESC

[13] Wei-Chung Yei and Jiang-Jay Chang “Corrosion of Rebar Under Carbonation and Salt Environment” Second International Conference on Concrete Sustainability ICCS16 Madrid 2016

[14] M. Pavan Kumar, Y. Mahesh (2015) “The Behaviour of Concrete by Partial Replacement of Fine Aggregate with Copper Slag and Cement with GGBS” IOSR Journal of Mechanical and Civil Engineering, Volume 12, Issue 3 Ver 3, PP 51-56

[15] R. Prasanna Venkatesan, K.C. Pazhani (2015) “Strength and Durability Properties of Geopolymer Concrete made with GGBS and Black Rice Husk Rice” KSCE Journal of Civil Engineering, ISSN 1976-3808

[16] Kishan Lal Jain (2016) “To effect on strength properties of concrete of by using GGBS by Partial Replacing cement and addition of GGBS without replacing cement” SSRG International Journal of Civil Engineering (SSRG-IJCE) – volume 3 Issue 5ISSN: 2348 – 8352 pp 144-149 http://www.internationaljournalssrg.org/IJCE/2016/Volume3-Issue5/IJCE-V3I5P131.pdf

[17] A.I. Tamboli, Aishwarya Saha, Tejas Parakh, Nilesh Mane, Ashutosh Singh, Sufiyan Tamboli, (2016), “Strength Characteristics of Concrete with Addition of Steel Fibre and Partial Replacement of Cement with Ground Granulated Blast Furnace Slag”, International Journal of Engineering Science and Computing, ISSN 2321 336, Volume 6, Issue No. 05 DOI 10.4010/2016.1305

[18] T. Divya Bhavana, Etaveni Madhavi, (2016), “Strength and Workability Properties of Concrete Replaced by Quarry Dust and GGBS”, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 5 Issue 03 http://dx.doi.org/10.17577/IJERTV5IS030067

[19] Backus, J., McPolin, D. (2016). Effect of Cyclic Carbonation on Chloride Ingression in GGBS Concrete. ASCE, Journal of Materials in Civil Engineering. 10.1061/(ASCE)MT.1943-5533.0001529

[20] Deven Shinde, Mangesh chaudhari, Vaibhav Korgaonkar, Kunal Patil, Pritee Mistry, (2016), “Detail Study of High Performance Concrete using GGBS”, International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169, Volume: 4 Issue 4

[21] Christina Mary V. and Kishore C H, (2015) “Experimental Investigation on Strength and Durability Characteristics of High Performance Concrete Using GGBS And M Sand”, ARPN Journal of Engineering and Applied Sciences, VOL. 10, NO. 11 http://www.arpnjournals.com/jeas/research_papers/rp_2015/jeas_0615_2177.pdf

[22] Bureau of Indian Standards “Method of Tests for Aggregate for Concrete” IS: 2386-1963

[23] Bureau of Indian Standards “Ordinary Portland Cement 43 Grade – Specification” IS: 8112-2013

[24] Bureau of Indian Standards “Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete”, IS: 383-1970

[25] Bureau of Indian Standards “Plain and Reinforced Concrete – Code of Practice”, IS: 456-2000

[26] ASTM “Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars”, C 989-04

[27] American Concrete Institute “Guide for Selecting Proportions for High-Strength Concrete with Portland Cement and Fly Ash”, ACI 211.4R-93