A REVIEW PAPER ON PERFORMANCE AND EVALUATION OF GGBS CONCRETE WITH REFERENCE TO COMPRESSIVE AND FLEXURAL TENSILE STRENGTH

Yashraj Jadhav[1],Abhijeet Patil[2],Pratik patil[3],
Anupama Kadam[4],Pratik Meshram[5]
[1,2,3,4,5]Department of Civil Engineering,
Bharati Vidyapeeth, college of engineering, Kolhapur, (India)

ABSTRACT

The utilization of supplementary cementation materials is well accepted, since it leads to several possible improvements in the concrete composites, as well as the overall economy. The concept of project is an effort to quantify the strength of Ground granulated blast furnace slag (GGBS)at various replacement levels with cement and evaluate 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 and cost savings, environmental and socio-economic benefits. This project evaluates the strength and Strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of Ground granulated blast furnace slag for M20 grade of concrete at different ages. The optimum GGBS 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. This paper takes review of research papers on GGBS concrete so as to find scope of further research for UG level project.

Keywords:Compressive strength, flexural tensile strength, (GGBS), pozzolanicmaterial etc.

I. INTRODUCTION

Blast furnace slag is a by-product of iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace, and the resulting molten slag floats above the molten iron at temperature of about 1500°C to 1600°C. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). After the molten iron is tapped off, the remaining molten slag, which mainly consists of siliceous and aluminous residues is then rapidly water- quenched, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size which is known as ground granulated blast furnace slag (GGBS). The production of GGBS requires little additional energy compared with the energy required for the production of Portland cement. The replacement of Portland cement with GGBS will lead to a significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace as much as 80% of the Portland cement when used in concrete[1].GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced.High volume eco-friendly replacement slag leads to the development of concrete which not only, utilizes the industrial wastes but also saves significant natural resources and energy. This in turn reduces the consumption of cement.

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and or other pozzalonic 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.Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blastfurnace 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 cementations 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 sulphate and other chemicals.

APPLICATIONS OF GGBS CONCRETE:

- Greener And Stronger foundation.
- Controlling and reducing thermal cracking.
- Reducing heat of hydration.
- Long term strength development
- Increased resistance to acid peaty soils.
- Increased resistance to sulphates, and salt marine environment.

Major applications of GGBS CONCRETE for today are High ways, bridges and high rise structures.

II. LITERATURE REVIEW

GGBS concrete is a type of concrete in which a part of cement is replaced by ground granulated blast furnace slag, which is an industrial waste. As a result of its low environmental impacts, using GGBS can reduce significantly many of the environmental burdens associated with concrete. If concrete is mixed with ground granulated blast furnace slag as a partial replacement for Portland cement, it would provide environmental and economic benefits and the required workability, durability and strength necessary for the structures.

SANTOSH KUMAR KARRI ,G. V. RAMA RAO,P. MARKANDEYA RAJU(10 OCT 2015)[1]: This present paper focuses on investigating characteristics of M20 and M40 grade concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS) by replacing cement via 30%,40%,50%. The cubes,cylinder and prism are tested for compressive strength,split tensile strength, flexural strength, durability studies with sulphuric acid and hydrochloric acid were also conducted .from this paper workability of concrete increases with the increasing GGBS replacement level .the compressive strength of concrete increased when cement is replaced by GGBS for both M20 and M40 grade concrete. at 40% replacement of cement by GGBS the concrete attained maximum compressive strength. the split tensile strength of concrete is increased when cement is replaced with GGBS the split tensile strength is maximum at 40% of replacement .the flexural strength of concrete is also increased when the cement is replace by GGBS. At 40% replacement the flexural strength is maximum. The compressive strength values of acid effected concrete decreases on comparison with of normal concrete, but the effect of acid on concrete decreases with the increase of percentage of GGBS. at 40% replacement of GGBS the resistance power of concrete is more . The compressive strength values of GGBS concrete effected to HCL were greater than the GGBS concrete effected to H_2SO_4 the effect of HCL on strength of the concrete is lower than the effect of H_2SO_4 on strength of the cement

DR. SURESH AND K. NAGARAJU (2015)[2]: Investigating characteristics of concrete with partial replacement of cement with GGBS. This paper deals with GGBS, its advantages and disadvantages in using it in a concrete. Author carried out experiment on GGBS concrete by replacing it with OPC by 50%, 60%, 80% and 90%. It is observed that GGBS is good replacement to cement in some cases but it cannot replace cement completely but even though it replaces partially it gives very good result.

HOGAN AND MEUSEL[3]: AT 40%,50% found that upto 3 days of age strength contribution of slag mortar was low. However, strength similar to reference Portland cement was achieved in 7 days and higher strength thereafter.

A.ONER AND AKYUZ(JAN 2007)[4]: Onercalculated the optimum GGBS content to maximize the strength as 40%. When the curing period is extended the strength increases the reason is that the Pozolanic reaction is slow and the formation of calcium hydro oxide requires time. The compressive strength of GGBS concrete increases as GGBS content increases at optimum point after which the compressive strength decreases. The optimum level of GGBS content maximizing the strength is at about 55-59% of total binder content.

HUIWEN WAN(17 JULY 2003)[5]: Geometric characteristics of different GGBS including particle size distribution ,shape and their influence on cement properties GGBS with same surface area but made by different grinding techniques can have different performance . Even though the surface area of GGBS are same the geometric characteristics and the PDS (particle Distribution size) can be different due to different grinding techniques.

K. GANESH BABU&V.SREE RAMA KUMAR (30 MARCH 2000) [6]: This paper attempts to assess the cementations efficiency of GGBS in concrete at the various replacements in percentage at 28 days. In this paper the replacement levels in the concrete studied varied from 10% to 80% and the strength efficiencies at 28 days are calculated. The earlier proposed method for evaluating the efficiency of pozzolans like Fly ash and Silica fume was also found to be appropriate for the evaluation of GGBS .The overall strength efficiency factor (K) varied from 1.29 to 0.70 for percentage replacement levels varying from 10% to 80%. General efficiency factor (Ke) with a value of 0.9 at 28 days and percentage efficiency factor (Kp) varying from +0.39 to -0.20 for the replacement levels varying from 10% to 80% studied.

the strength ofconcrete varying from 20 to 100 Mpa with GGBS level varying from 10% to 80%. For obtaining equal strength I concrete it will be required that and additional 8.5% and 19.5% in total cementitous material at 50% and 65% cement replacement

P. J. WAINWRIGHT, N. REY[7]: The addition of slag at both levels of 55% and 85% resulted in an increase in workability from 15 mm slump (for the OPC mix) to between 20 and 40 mm for the slag mixes.slags from different sources were used which have similar physical and chemical properties have found little effect on bleeding. Slag used in this present study had a much less marked effect on bleeding than those produced 10 years ago.Replacement of cement with up to 55% GGBS increased the bleed capacity by 30% but had little effect on the bleed rate. Increasing the slag level to 85% had no further significant effect on bleeding. Delayingthe start of the bleed tests from 30 to 120 min reduced the bleed capacity of the OPC mix by more than 55% compared with 32% for the slag mixes. The reduction inbleed ratewassimilarfor allmixes at about 45%.

S.J. BARNETT, M.N. SOUTSOS[8]: All mortars gain strength more rapidly at higher temperatures and have a lower calculated ultimate strength. The early age strength is much more sensitive to temperature for higher levels of ground granulated blast-furnace slag.The early age strength development of mixtures containing ggbs is highly dependent on temperature. Under standard curing conditions, ggbs mortars gain strength more slowly thanportland cement mortars. However, at higher temperatures,strength gain is much more rapid and the improvement in earlyage strength is more significant at higher levels of ggbs. even a10 -C increase in curing temperature above standard curingtemperatureconsiderably accelerates the strength developmentof mortars containing high levels of ggbs and at 40 and50 -C, the strength of ggbs mortars is more or less equivalent tothat of portland cementmortar after 3 days .this increased temperature sensitivity of the strength gain inggbs mortars is reflected in their higher apparent activationenergies. the apparent activation energy increases approximatelylinearly with ggbs level. The Portland cement used inthis work has an apparent activation energy of 34 kJ/mol whilethis figure increases to 60 kJ/mol when a binder consisting of70% ggbs and 30% portland cement was used. these valuesare in broad agreement with values quoted in the literaturethe apparent activation energies obtained in this work arecurrently being used to predict concrete strength developmentunder variable temperature conditions. Initially, existingmodels,which generally have been based on portland cement hydration only, are being assessed for their suitability inmodelling strength development of concrete containing ggbs.

V.Nagendra, C. Sashidhar, S. M. Prasanna Kumar, N.Venkata Ramana[9]: In the present paper Ground Granulated Blast Furnace Slag (GGBS) is used asparticles of specific size, as replacement to cement. the GGBS is placed in the concrete mix with particles of various uniform sizes of 250µm, 125µm, 90µm, 45µm and 20µm.

The dosage of GGBS is varied from 10% to 40% at an increment of 10% for concrete to evaluate the compressive strength. As the particle size decreases, the strength increases for all replacements of cement with GGBS. Particle of size 20 µm, the strength is optimum, which is at 20% replacement level. the 28 day compressive strength is optimum at 20% replacement level and is obtained for 20micrometer particle size the percentage increase when compared with control mix for 20micrometer particle size is equal to 12%, whereas for 250 micrometer particle size it is slightly lowerthan the control mix. The addition of GGBS modifies the products and the pore structure in hardened cementationsmaterials and it results higher compressive strengths at all days. For 20 m particle size the strength is maximum at all days of testing, this is because more specificsurface area is available for the pozzolanic reaction.

Alaa M. Rashad , Dina M. Sadek[10]: In this paper possibility of improving compressive strength of high-volume GGBS (HVS) paste before and after being exposed to elevated temperatures using metakaolin (MK) in micro-size (mMK) has been investigated. portland cement(PC) has been partially substituted with GGBS at level of 70%, by weight to produce HVS paste. afterword, GGBS was partially substituted with mMK at levels ranging from 2% to 10% with an increment of 2%, by weight. after curing, the specimens were subjected to elevated temperatures ranging from 400 C to 1000 C with an interval of 200 C for 2 h. weight and compressive strength before and after being exposed to elevated temperatures have been thoroughly explored. the various decomposition phases formed were identified using X-ray diffraction (XRD) and thermo gravimetric (TGA) analyses. the morphology of the formed hydrates was studied using scanningelectron microscopy (SEM). the low compressive strength (especially at early ages) as well as the resistance of elevated temperatures of the neat HVS system can be modified and enhanced with the inclusion of mMK particles. mMK particles are much finer than GGBS particles as well as mMK has higher content of Al_2O_3, which led to much higher pozzolanic activity. consequently the compressive strength increased. the compressive strengthincreased with increasing mMK content consequently showed less porosity compared to the neat HVS. theincrement in mMK content significantly affects weight loss after heat treatments the higher the mMK content the higher the weight loss. at 400 C, the neat HVS paste residual strength canbe increased by 6.47%, 10.17%, 13.29%, 16.39% and 22.72% with the inclusion of 2%, 4%, 6%, 8% and 10% mMK, respectively. at 600 C, the 2%, 4%,6%, 8% and 10% mMK blends exhibited approximately 1.1, 1.15, 1.2, 1.27 and 1.35 times greater residual strength than that of the neat HVS paste (mMK0).

III. SCOPE OF STUDIES

Experimental work conducted as part of this study included: producing appropriate powder aggregate in the laboratory, mixing trial batches to determine appropriate mix proportions under laboratory condition, testing hardened samples to determine which mix proportions and manufacturing method provided good properties for GGBS concrete, and establishing basic material properties. In this workability, tensile strength and compressive strength is determined. In this kind of concrete, the compressive strength can reach to more than normal concrete depending on the curing type and the manufacturing process. Also, the effect of confinement on the ultimate compressive strength is evaluated.

The result obtained from the previous studies is for 10%, 20%, 30%, 40%, 50%. We observed that the strength up to 40% goes on increasing and from 50% GGBS strength reduces.[1]

Following are the results of previous studies:

Table no.1-Compressive strengthand Flexural Tensile Strength [1]

Sr. No.	%OF GGBS	Compressive Strength (N/mm^2)		Flexural Tensile Strength(N/mm^2)	
		28 days	90 days	28 days	90 days
1.	0	33.3	46.2	5.21	6.51
2.	30	35	50.11	5.60	7.05
3.	40	36.42	52.49	5.82	7.77
4.	50	32.2	48.12	5.3	6.8

With due reference to results mentioned in table no.1 and 2, there is a need to check the maximum percentage of GGBS replacement which provides highest results for workability, compressive and flexural tensile strength.

IV.METHODOLGY

The stated goal of the GGBS concrete material characterization study is to determine the compressive and flexural strength of GGBS concrete with the intent of using GGBS concrete. The curing treatment applied to concrete which is always important is even more important in the case of GGBS concrete.

4.1 Batching

Amount of quantity of the material such as cement, fine aggregates , coarse aggregates, GGBS, water is done.

4.2 Mixing

Thorough mixing of material is done and is very essential for the production of uniform concrete until the mass of the concrete becomes homogeneous and uniform in colour with a proper consistency.The mixing is done by replacing cement by GGBS with percentage of 0%, 30%, 40%&50%

4.3 Casting

After mixing of the material moulds are prepared and are casted in the cube of size 150mm x 150mm x 150mm**.**

4.4 Curing

Curingis done so as to reduce heat of hydration developed by cement in concrete. Good curing practice is done so as to make the concrete of good and inferior quality.

4.5 Testing

The various tests conducted on GGBS concrete can be classified into Workability Testing, compressive strength testing and flexural strength Testing. The workability test to be carried out is Slump cone test, Compaction factor test. The strength tests to be carried out are compressive strength, flexural toughness, shrinkage and creep.

4.5.1 Strength Test

Compression test: The compression test is used to determine the hardness of cubicle specimens of concrete. The strength of a concrete specimen depends upon cement, aggregates, bond, w/c ratio, curing temperature & age & size of specimen. Mix design is the major factor controlling the strength of concrete. Cubes of size 15cm x 15cm x15 cm will be cast. The specimen should be given sufficient time for hardening (approx. 24 h) and then it should be cured for 7, 28 days. After that, it should be loaded in the compression testing machine &tested for maximum load. Compressive strength should be calculated by dividing maximumLoad by the cross- sectional area.

Flexural strength test: The concrete prism specimens was placed in the machine in a such a manner that the load was applied to the upper most surface as cast in the mould , along two lines spaced 13.33 cm apart. The axis of the specimen was carefully aligned with the axis of the loading device.the load was applied through to similar steel rollers,38mm in diameter,mounted at the third points of the supporting span i.e spaced at 13.33 cm centre to centre. the load was applied without shock and increased continuously at the rate of 180kg/per min until the specimenfailed the test result for flexural strength are presented in Table -2 for 0%, 30%,40% and 50% of GGBS concrete for M20 grades of concrete at room temperature for 7 and 28 day respectively.

V. CONCLUSIONS

The following conclusions can be drawn from this literature review:

1.Increase in GGBS replacement levelworkability of concrete also increases.

2.At 40% replacement of the cement by GGBS the concrete gives maximum compressive strength for M20 grade concrete.

3. When the cement is replaced 40% by GGBS theflexural strength is maximum.

4. By experiential analysis, the maximum value of replacement of GGBS can be worked out, which provides highest results of workability, compressive strength and flexural strength.

REFRENCES

[1]Santosh Kumar Karri, G.V.Rama Rao,P.Markandeya Raju, "Strength and Durability Studies on GGBS Concrete"SSRGInternational Journal of Civil Engineering (SSRG-IJCE), volume 2, Issue 10, October 2015.

[2] D.Suresh and K.Nagaraju,"Ground Granulated Blast Slag (GGBS) In Concrete- A Review", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X Volume 12, Issue 4 Ver.VI (Jul. - Aug. 2015), PP 76-82.

[3] Hogan and Mesuel,"Durability of concretes containing ground granulated blast furnace slag (GGBS)" , Department International Journal of Concrete Structures and Materials, April 29, 2013.

[4] A.Oner, S.Akyuz,"An experimental study on optimum usage ofGGBS forthe compressive strength of concrete Cement &Concrete Composites" 29, (2007) 505–514.

[5] Huiwen Wan et. al. "Analysis of geometric characteristics ofGGBS particles and their influences on cement properties,Cement and Concrete Research" 34, January 2004, 133-137.

[6] K.Ganesh Babu,V.Sree, Rama Kumar,"Performance of GGBS incementitious composites" Sixth NCB International Seminar on Cementand Building Materials, New Delhi, India (1998) XIII-76.

[7] P.J. Wainwright , N. Rey," The influence of ground granulated blastfurnace slag (GGBS)additions and time delay on the bleeding of concrete" School of Civil Engineering, University of Leeds, Leeds LS2 9JT, UK
Scott Wilson Scotland Ltd., 6 Park Circus, Glasgow G3 6AX, UK.

[8] S.J. Barnett, M.N. Soutsos, S.G. Millard, J.H. Bungey," Strength development of mortars containing ground granulatedblast-furnace slag: Effect of curing temperature anddetermination of apparent activation energies"Department of Civil Engineering, University of Liverpool, Brownlow Street, Liverpool, L69 3GQ, UKReceived 9 February 2005; accepted 7 November 2005.

[9]V.Nagendra1, C. Sashidhar, S. M. Prasanna Kumar, N.Venkata Ramana,"Particle Size Effect of Ground Granulated Blast Furnace Slag (GGBS)in Cement Concrete" Civil Engineering Department, Nagarjuna College of Engineering and Technology, Bangalore, Karnataka,India.

[10] Alaa M. Rashad , Dina M. Sadek,"An investigation on Portland cement replaced by high-volumeGGBS pastes modified with micro-sized metakaolin subjectedto elevated temperatures" Building Materials Research and Quality Control Institute, Housing & Building National Research Center, HBRC, Cairo, Egypt Received 23 April 2016; accepted 22 October 2016.