# Review paper - EFFECT OF ELEVATED TEMPERATURE ON CONCRETE WITH GROUND GRANULATED BLAST FURNACE SLAG AS A PARTIAL REPLACEMENT OF CEMENT

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***Abstract*— Ground granulated blast furnace slag (GGBFS) has been widely utilized as ingredients in concrete due to the advantages of economic, technical and environmental benefits of this material. This paper presents the review on effects of elevated temperatures on properties of concrete. The objective of this paper is to investigate the effect of elevated temperature on mechanical properties such as compressive strength, splitting tensile strength and flexural strength of concrete with GGBFS as a mineral admixture and investigate most suitable combination.**

***Index Terms*—Ground Granulated Blast Furnace Slag (GGBFS), Steel Fiber.**

## 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 a temperature of about 1500°C to 1600°C. The molten slag has a composition of 30% to 40% silicon dioxide (SiO2) and approximately 40% CaO, which is close to the chemical composition of Portland cement. 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.

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 is turn reduces the consumption of cement.

## II. OBJECTIVES

The aim of work is to investigate the effect of elevated temperature on concrete with partial replacement of cement by GGBFS with 1% of steel fiber

The objectives are:

1. To investigate the effect of elevated temperature on conventional concrete and concrete with

GGBFS as a Mineral admixtures with 1% steel fiber.

2. To investigate the effect of elevated temperature on compressive strength, flexural strength and tensile strength of conventional and concrete with GGBFS as Mineral admixture.

3. To investigate most suitable combination.

## III. LITERATURE REVIEW

**Long T. Phan and Nicholas Carino J. (Feb. 2002)** In this paper they investigate the Mechanical properties of high strength concrete exposed to elevated temperatures were measured by heating 100mmx200mm cylinders at 50°C / minute to temperature from 100°C to 600°C. Heating was carried out with and without a sustained stress, and properties were measured at elevated temperatures as well as after cooling to room temperature. The compressive strength ranging from 51 to 98 MPa were used. The mixtures contained silica fume. For exposure to 450°C, the relative strength loss was highest for the residual property test condition. The values of w/c or the presence of silica fume affected the results. Results indicate that losses in relative strength due to high temperature exposure. The presence of silica fume does not appear to have a significant effect.

**Chi-Sun Poon and Yuk-Lung Wong (2003)** They carried out an experimental investigation to evaluate the performance of metakaolin (MK) concrete at elevated temperatures up to 800°C and the rate of heating is 2.5°C/min. Eight normal and high strength concrete (HSC) mixes incorporating 0%, 5%, 10% and 20% MK were prepared. The size of specimen was used (0.1x0.1x0.1)m for cube and (0.1 x 0.2)m for cylinder. The residual compressive strength, chloride-ion penetration, porosity and average pore sizes were measured and compared with silica fume (SF), fly ash (FA) and pure ordinary Portland cement (OPC) concretes. It was found that after an increase in compressive strength at 200°C, the MK concrete suffered a more severe loss of compressive strength than the corresponding SF, FA and OPC concretes at higher temperatures. Explosive spalling was observed in both normal and high strength MK concretes and the frequency increased with higher MK contents.

**Persson. B. (2004)** He made a comparison between the performance of vibrated concrete and self compacting concrete (SCC) under elevated temperature. Cylinders and columns were tested by Compressive loading with high temperature. The size of cylinder and column uses is (0.1x0.2) m and (2x0.2x0.2) m. Polypropylene fibers were used to avoid the spalling of concrete. Rate of heating was maintained at 240°C and 480°C per hour. Specimens were heated in the temperature range of 20°C to 800°C and specimens were slowly cooled upto room temperature at a rate of 60°C/hr and tested. It was observed from the test results that explosive spalling took place for columns with SCC but not for columns with vibrated concrete. It was also found that fire spalling mainly depended on the stress in the concrete and w/c ratio. Lower elastic modulus at fire temperature was observed in SCC than in vibrated concrete.

**M. S. Morsy, S. H. Alsayed and M. Aqel(2009)** An experimental investigation was conducted to evaluate the influence of elevated temperatures on the mechanical properties and physical properties of silica flour concrete. The OPC were partially replaced by 0, 5, 10, 15 and 20% of silica flour. The hardened concrete was thermally treated at 100˚c, 200˚c, 400˚c, 600˚c and 800˚c for 2 hours. The studied silica flour has a very positive effect on the strength after thermal treatment at 400˚C for 2 hours. Based on the mechanical and physical properties of silica flour concrete, it was observed that 20% silica flour concrete was generally more favorable than 5%, 10% and 15%, and thus can be used in structural elements exposed to elevated temperature up to 400˚C.

**Q. Sobia and S. Ahmad (2013)** This research study focused on Thin high performance cementitious composites (THPCC) based on High Alumina cement (HAC) replaced by 60%, 70%, 80% and 85% of ground granulated blast furnace slag (GGBS). Samples were evaluated by the measurement of their mechanical strength (28 & 56 days of curing) after exposed to 400°C, 600°C and 28°C of room temperature for comparison and corroborated by their microstructure study. Results showed that among all mixtures, the mix containing only HAC showed the highest compressive strength after exposed to 600°C as compared to other mixtures. However, the tensile strength of THPCC made of HAC and 60% GGBS content was comparable to the THPCC with HAC only after exposed to 600°C. Field emission scanning electron microscopy (FESEM) images of THPCC accompanying Energy Dispersive X-ray (EDX) microanalysis revealed that the microstructure deteriorated considerably after exposure to elevated temperatures which led to the decrease in mechanical strength.

**Reshma Rughooputh and Jaylina Rana (2014)** This research work investigates the effects of partial replacement of OPC by GGBS on various properties of concrete including compressive strength, splitting tensile strength, flexure strength, modulus of elasticity, drying shrinkage and initial surface absorption. Cement was partially replaced by 30 % and 50 % of GGBS by weight and test was performed at 7 and 28 days. It was found that GGBS in concrete leads to lower early compressive strength but latter gain higher compressive strength. Flexural strength of test specimens increased by 22% and 24%, tensile strength increased by 12% and 17% for 30% and 50% replacement respectively. Drying shrinkage increased by 3% and 4%. Static modulus of elasticity increases by 5% and 13%. He also observed that the initial surface absorption decreases as the GGBS content increases because GGBS decreases the permeability of concrete. Based on the results the optimum mix was the one with 50% GGBS.

**S. O. Osuji and U. Ukeme (July 2015)** This study investigates the effects of elevated temperatures on the compressive strength of Grade 40 concrete. A total of thirty cube specimens were cast, cured in water at ambient temperature in the laboratory and subjected to various temperature regimes before testing. A concrete mix of 1:1:3 (cement: fine aggregates: coarse aggregates) with water content ratio of 0.44, fine aggregates lying in zone 2 of sieve tests as well as course aggregate of maximum size 12.5mm was designed. Specimens cured for 7 and 28 days were subjected to compressive loading tests at room and elevated temperature of 24°C, 100°C, 150°C, 200°C, 250°C and 300°C at one hour duration. The result indicated 14.49%, 25%, 51%, 35.51% and 43.88% decrease in compressive strength at the earlier quoted temperatures respectively. At an elevated temperature of 300°C a peak decrease of 53.47% in compressive strength was observed.

**Santosh Kumar Karriet and P. Markandeya Raju (Oct. 2015)** This paper shown the research on Strength and Durability of GGBS Concrete. They selected 30%, 40% and 50% as cement replacement with GGBS and cured the specimens of M20 and M40 grade of concrete for 28 and 90 days. He found that the workability of concrete increases with the increase in GGBS Percentages. He also observed that the maximum compressive strength, split tensile strength and flexural strength is achieved at 40% cement replacement for both M20 and M40 grade concrete, beyond which the strength decreases slightly.

**Yue Li and Miaoke Wu (2017**) This paper aims to illuminate the effects of elevated temperature on mechanical properties of fiber rein-forced plastic (FRP) strengthened concrete glued by modified epoxy resin (MER) adhesive. Tensile strength, flexural strength and interface bonding properties of FRP-MER-concrete (C30 and C50) were measured after exposure to 80°C, 160°C and 240°C for 1.5 h and 3 h, respectively. Microstructures of the interface were analyzed by scanning electron microscope (SEM). From the test results, It was found that the most distinct decrease in strength is observed in specimens, which are exposed to 240°C for 3 h. The strength decreases by 30.54% and 34.02% for C30 and C50 specimens, respectively. It was also found that the ultimate tensile strength and strain of MER-FRP and bonding strength of FRP-concrete interface gradually decrease as exposure temperature and time increase. The ultimate capacity of FRP-strengthened concrete gradually decreases. The loss rates of ultimate capacity and fracture energy of high-strength specimens are greater than those of low-strength specimens.

**Xianjun Tan and Weizhong Chen (2017)** This study investigates the influence of high temperature on the properties of foamed concrete, four densities of foamed concrete (300 $kg/m^3$, 450 $kg/m^3$, 600 $kg/m^3$ and 800 $kg/m^3$) were taken into account in a series of tests. The change laws of appearance, mass, compressive strength and elastic module at ambient temperature and after undergoing different high temperatures (200°C, 400°C and 600°C) were presented. The results indicate that the appearances for all of four different densities were different. The cracks to be observed at the higher densities foamed concretes (i.e., 800 kg/m$^3$ and 600 kg/m$^3$). However, the pore connectivity and surface spalling phenomenon are easier to be observed at lower densities foamed concretes (i.e. 300 kg/m$^3$ and 450 kg/m$^3$). With temperature increasing, the density, compressive strength and elastic modulus became lower and lower for all samples

## IV. CONCLUSION

From literature review it was found that from temperature ranging from 400°C to 800°C the concrete shows deficiency in the physical properties and it was also found that the strength of concrete can be modified by using GGBFS as Mineral admixture.

**REFERENCES**


[1]. Long T. Phan and Nicholas Carino J., "Effects of test Conditions and Mixture proportions on Behavior of High Strength concrete Exposed to High Temperatures" ACI Materials Journal, January-February 2002 PP 54-62

[2]. Chi-Sun Poon, Salman Azhar, Mike Anson and Yuk-Lung Wong., "Performance of metakaolin concrete at elevated temperatures"Cement and Concrete Composites, pp 83-89, 2003

[3]. Persson. B., "Fire resistance of self-compacting concrete SCC",Materials and Structures, 37, November 2004, pp 575-584.

[4]. M. S. Morsy, S. H. Alsayed and M. Aqel, Effect of Elevated Temperature on Mechanical Properties and Microstructure of Silica Flour Concrete.(2009)

[5]. Q. Sobia, A. Shyzleen, M. S. Hamidah, I. Azmi, S. F. A. Rafeeqi, and S. Ahmad "Post Elevated Temperature Effect on the Strength and Microstructure of Thin High Performance Cementitious Composites (THPCC)"World Academy of Science, Engineering and Technology International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol:7, No:2, 2013

[6]. Reshma Rughooputh and Jaylina Rana, "Partial Replacement of Cement by Ground Granulated Blast Furnace Slag in Concrete" Journal of Emerging Trends in Engineering and Applied Sciences(JETEAS), Vol. 5, Issue 5, 2014, pp. 340-343, ISSN: 2141-7016

[7]. S. O. Osujiand U. Ukeme, "EFFECTS OF ELEVATED TEMPERATURE ON COMPRESSIVE STRENGTH OF CONCRETE" Nigerian Journal of Technology (NIJOTECH) Vol. 34 No. 3, July 2015, pp. 472 – 477

[8]. Santosh Kumar Karriet, G.V. Rama Rao and P. Markandeya Raju, "Strength and Duribility Studies on GGBS Concrete"International Journal of Civil Engineering(SSRG-IJCE), Vol. 2, Issue 10, October 2015, pp. 34-41, ISSN: 2348-8352

[9]. Yue Li, Xiongfei Liu and Miaoke Wu "Mechanical properties of FRP-strengthened concrete at elevated temperature" Construction and Building Materials 134 (2017) 424–432

[10]. Xianjun Tan, Weizhong Chen, Jiuhong Wang, Diansen Yang, Xianyin Qi, Yongshang Ma,Xu Wang, Shaosen Ma, Changjun Li "Influence of high temperature on the residual physical and mechanical properties of foamed concrete" Construction and Building Materials 135 (2017) 203–211