A REVIEW PAPER ON STRENGTH AND DURABILITY STUDIES ON GGBFS CONCRETE

Kamal Kumar[1], Akshay Pal[2], Ankush Singh[3] and Kartik Arya[4]

[1]*Ass.Professor,Civil Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh*

[2]*B.Tech Student, Civil Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh*

[3]*B.Tech Student, Civil Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh*

[4]*B.Tech Student, Civil Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh*

Abstract: *Concrete is probably the most extensively used construction material in the world with about six billion tones being produced every year. It is only next to water in terms of per-capita consumption. However, environmental sustainability is at stake both in terms of damage caused by the extraction of raw material and CO2 emission during cement manufacture. This brought pressures on researchers for the reduction of cement consumption by partial replacement of cement by supplementary materials. These materials may be naturally occurring, industrial wastes or byproducts that are less energy intensive. These materials (called pozzalonas) when combined with calcium hydroxide, exhibits cementetious properties. Most commonly used pozzalonas are fly ash, silica fume, metakaolin, ground granulated blast furnace slag (GGBFS). This needs to examine the admixtures performance when blended with concrete so as to ensure a reduced life cycle cost. The present paper focuses on investigating characteristics of M20 and M40 grade concrete with partial replacement of cement with ground granulated blast furnace slag (GGBFS) by replacing cement via 30%, 40%, 50%. The cubes, cylinders and prisms are tested for compressive strength, split tensile strength, flexural strength. Durability studies with sulphuric acid and hydrochloric acid were also conducted.*

Keywords: *GGBFS blended concrete, strength, cementetious properties*

1. Introduction :

Concrete is probably the most extensively used construction material in the world with about six billion tones being produced every year. It is only next to water in terms of percapita consumption. However, environmental sustainability is at stake both in terms of damage caused by the extraction of raw material and CO2 emission during cement manufacture. This brought pressures on researchers for the reduction of cement consumption by partial replacement of cement by supplementary materials. These materials may be naturally occurring, industrial wastes or by-products that are less energy intensive. These materials (called pozzalonas) when combined with calcium hydroxide, exhibits cementetious properties. Most commonly used pozzalonas are fly ash, silica fume, metakaolin, ground granulated blast furnace slag (GGBFS). This needs to examine the admixtures performance when blended with concrete so as to ensure a reduced life cycle cost.

There are competing reasons, in the long term, to extend the practice of partially replacing cement with waste by products and processed materials possessing pozzolanic properties. Lately some attention has been given to the use of natural pozzolans like GGBFS as a possible partial replacement for cement. Amongst the various methods used to improve the durability of concrete, and to achieve high performance concrete, the use of GGBFS is a relatively new approach, the chief problem is with its extreme finesse and high water requirement when mixed with Ordinary Portland cement. The present paper focuses on investigating characteristics of M20 and M40 grade concrete with partial replacement of cement with GGBFS by replacing cement via 30%, 40%, 50%. The cubes, cylinders and prisms are tested for compressive strength, split tensile strength, flexural strength. Durability studies with sulphuric acid and hydro chloric acid were also conducted. Numerous works have been done researchers across the globe and some of the important contributions are presented here.

2. Plan Of Experimentation

The Experimental investigation is planned as follows.

1. To find the properties of the materials such as cement, sand, coarse aggregate, water and GGBFS.

2. To obtain Mix proportions of OPC concrete for M20 and M40 by IS method (10262-2009).

3. To calculate the mix proportion with partial replacement such as 0%,30%, 40% and 50%of GGBFS with OPC.

4. To prepare the concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength and also cubes for durability studies in laboratory with 0%, 10%, 20% and 30% replacement of GGBFS with OPC for M20 and M40 grade concrete.

5. To cure the specimens for 28 days and 90 days.

6. To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength.

7. To evaluate the durability studies of M20 and M40 grade GGBS replacement concrete, with 1% and 5% concentrations of Hydro chloric acid (HCl) and Sulphuric acid (H2So4).

8. To evaluate and compare the results.

9. To check the economic viability of the usage of GGBFS, Keeping in view of the safety measures.

3. Properties Of Ingredients Of Concrete

The materials used in the experimental work namely cement, GGBFS, fine aggregate and coarse aggregate (20mm, 10mm) have been tested in laboratory for use in mix designs. The details are presented below.

Cement

Ordinary Portland cement of43 grade (Parashakthi) was used in this investigation. The properties of cement are as follows.

Specific gravity: 3.15 (Density bottle method)

Fineness test: 8% (Sieve test)

Initial setting time: 90 min. (Vicat's apparatus)

Final setting time: 3 hrs 30 min. (Vicat's apparatus)

Standard consistency: 33% (Vicats apparatus)

Fine Aggregate

Aggregates smaller than 4.75 mm and up to 0.075 mm are considered as fine aggregate. The properties of fine aggregate are as follows.

Specific gravity: 2.52 (Density bottle method)

Fineness modulus: 2.25 (Sieve analysis)

Water Absorption of Sand: 1.0%

Free (Surface) Moisture of Sand: Nil

Sieve Analysis of Fine Aggregate: Conforming to Zone III of table 4 of IS 383

Coarse Aggregates

Aggregates greater than 4.75 mm are considered as coarse aggregates. The properties of course aggregate are as follows.

Specific gravity: 2.71

Fineness modulus: 7.27

Water Absorption of 20 mm Aggregate: 0.5%

Free (Surface) Moisture of 20 mm Aggregate: Nil

LITERATURE REVIEW :

Venu Malagavelli et al. [1] studied on high performance concrete with GGBFS and robo sand nd concluded that the percentage increase of compressive strength of concrete is 11.06 and 17.6% at the age of 7 and 28 days by replacing 50% of cement with GGBFS and 25% of sand with ROBO sand.

Luo et al. [2] experimentally studied the chloride diffusion coefficient and the chloride binding capacity of Portland cement or blended cement made of Portland cement and 70 % GGBFS replacement with or without 5 % sulphate. They found that (i) chloride diffusion coefficient decreased; (ii) chloride ion binding capacity improved in samples of blended cement.

Clear [3] concluded that higher the proportion of GGBFS, the slower the early age strength development**.**

Oner and Akyuz [4] studied on optimum level of GGBFS on compressive strength of concreteand concluded that the optimum level of GGBFS content for maximizing strength is at about 55–59% of the total binder content.

Qian Jueshi and Shi Caijun [5] studied on high performance cementing materials from industrial slag and reviewed the recent progresses in the activation of latent cementitious properties of different slag. They opined that Alkali-activated slag, such as blast furnace slag, steel slag, copper slag and phosphorus slag should be a prime topic for construction materials researchers.

Ganesh Babu and Sree Rama Kumar [6] studied on efficiency of GGBFS in Concrete.

Wainwright [7] conducted Bleed tests in accordance with ASTM C232-92 on concretes in which up to 85% of the cement was replaced with ground granulated blastfurnace slag (GGBS) obtained from different sources. They observed that delaying the start of the bleed test 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 in bleed rate was similar for all mixes at about 45%.

Tamilarasan et al. [7] studied on Chloride diffusion of concrete on using GGBFS as a partial replacement material for cement and without and with Superplasticiser. The study results showed that, with the increase in percentage of GGBFS, the Chloride diffusion of concrete decreases. Also it is found that the Chloride diffusion in the M25 concrete is less than M20 concrete.

Soutsos et al. [8] studied on fast track construction with high-strength concrete mixes containing Ground Granulated Blast Furnace Slag. They showed that the existing maturity functions like the Nurse-Saul and the Arrhenius equation may not be suitable for GGBFS concretes.

Pavia and Condren [9] studied the durability of OPC versus GGBFS Concrete on Exposure to Silage Effluent. This research concluded that PC composites incorporating GGBFS are more durable than those made with PC alone in aggressive environments under the action of acids and salts such as those produced by silage.

Ashish kumar dash et al. [10] researched on different materials like rice husk ash, GGBFS, silica fume to obtain the desired needs.

Higgins[11] discussed on the effect of addition of a small percentage of calcium carbonate or calcium sulfate on the sulfate resistance of concrete containing GGBFS.

Pazhani and Jeyaraj [12] conducted experimental investigation to assess the durability parameters of high performance concrete with the industrial wastes.

Shariq Prasad et al. [13] studied 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 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.

Stanley [14] studied on the use of iron blast-furnace slag as a constituent of concrete, either as an aggregate or as a cementing material.

Hanifi Binici et al. [15] studied on blended cements containing corncob ash (CA) and GGBFS. They concluded that The CA and GGBFS containing cements, immersed in sulfate solution showed 15% lower average compressive strength than that of the control cement specimens at the end of 24 months. Greater resistances of blended cements against sodium sulfate were achieved with higher percentage of additives.

Puertas et al. [16] analyzed the behaviour of water glass- or NaOH-activated slag mortars after carbonation. The results obtained indicate that alkali-activated slag mortars were more intensely and deeply carbonated than Portland cement mortars.

Barnett et al. [17] studied on the strength development of mortars containing GGBFS and portland cement. They concluded that the early age strengthdevelopment of mixtures containing GGBFS is highly dependent on temperature.

Wang Ling et al. [18] studied the application of GGBFS in China.

An **Cheng, Ran Huang et al.** [19] investigated on the durability of GGBFS concretes and the corrosion behavior of reinforced concrete beams under various loading ratios.

Olorunsogo et al. [20] investigated the influence of particle size distribution (PSD) of GGBFS on the bleeding characteristics of slag cement mortars. The results showed that for the slag samples with similar size range distribution (i.e., having a constant slope, n), the bleeding capacity increased with increases in xo, except the 30% slag mixes, which were made to 0.35 w/c.

Huiwen Wan et. al. [21] investigated the geometric characteristics of different GGBFS, including particle size distribution (PSD), shape and their influences on cement properties. All the above results are based on the properties of ingredients used. The optimum % replacement may vary based on the properties of GGBS and ingredients used. The main objective of this paper is to study the strength and durability characteristics of GGBS concrete with locally available fine and course aggregate.

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