Review on Properties of Concrete Incorporating PVA & Basalt Fibre with Partial Replacement of Cement by GGBFS

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ABSTRACT

This paper focuses on the mechanical properties of concrete incorporating mixture of PVA and Basalt fibres with partial replacement of cement by GGBFS. Total thirty two (32) mixes of concrete were prepared including two control mixes, Thirty mixes were containing cement replacement by GGBFS as 10 to 50% and mixture of Basalt fibre 1%, 2% and 3% by volume with PVA fibre 0.25% by volume for M30 and M50 grade of concrete respectively. The mechanical properties investigated in current study include compressive strength, splitting tensile strength and flexural strength (modulus of rupture) and also study on durability.

Keyword:- *Geo – polymer concrete; Fibre reinforced concrete; GGBFS; PVA Fibre; Basalt Fibre; Mechanical properties of concrete.*

1. INTRODUCTION

Ordinary portland cement concrete is a mixture of cement, aggregates and water. Concrete is the most frequently used construction material. The world wide consumption of cement was expected to be about 4100000 million tons (U.S. Geological Survey, Mineral Commodity Summaries, January 2016) [1]. Due to increase in infrastructure developments, the demand for concrete would increase in the future.

The manufacture of portland cement release carbon dioxide (CO_2) that is a significant contributor of the greenhouse gas emissions to environment. The cement manufacturing industry contributes about 5% to global anthropogenic CO_2 emissions, making the cement industry an important sector for CO_2 emission mitigation strategies. In order to address the environmental effect associated with portland cement, there is a need to use other binders to make concrete.

Several efforts had been taken to decrease the use of portland cement in concrete in order to reduce CO_2 emission. These include the utilization of supplementary cementing materials such as fly ash, silica fume, metakaolin, granulated blast furnace slag, rice husk and the development of alternative binders to portland cement.

To reproduce environmental friendly concrete, ours has been replace the cement with the industrial by products such as fly ash, ground granulated blast furnace slag etc. In this respect, the new of technology geo-polymer concrete is a promising technology.

In this respect, the geo-polymer technology proposed by davidovits shows promise for concrete industry as an alternative binder to the portland cement. In term of global warming, the geo-polymer technology could significantly reduce the CO_2 emission to the environment caused by the cement industries.

Geopolymer concrete has highly desirable structural engineering properties, which can lead to significant environmental and economic benefits. Its use is, however, limited by concerns regarding an increased brittleness compared to OPC concrete. Cementitious materials are generally brittle in behaviour and are inherently weak in resisting tensile forces. Low amounts of tensile force can cause a sudden failure which is usually caused by the proliferation of cracks. The addition of fibres to cementitious materials works on a similar theory whereby fibres act to transmit tensile forces across a crack. Fibres in particular have gained popularity in recent years for use in concrete, mainly owing to their low price and excellent characteristics, but also because they reduce the shrinkage, and improve cracking resistance and toughness of plain concrete.

2. MATERIAL SELECTION OF PROJECT

2.1 Ground Granulated Blast Furnace Slag (GGBFS):

The GGBFS could be a by-product of the iron producing business. Iron ore, coke and stone are insert the chamber and also the ensuing ore, coke and limestone put in the chamber and also the ensuing liquefied scum oats higher than the melting iron at a temperature of regarding 1600 ºC to 1700°C. The soften scum incorporates a compound of regarding four-hundredth to five hundredth SiO_2 and regarding hour CaO, that is near the chemical composition of hydraulic cement. Once the liquefied iron ore taped of, the stay liquefied scum, that consists of in the main oxide and aluminous residue is then water quenched quickly, leading to the formation of a glassy granulate. The assembly of geo-polymer concrete is administered exploitation the traditional concrete technology strategies. The GGBFS primarily based geo-polymer concrete consists seventy fifth to eightieth by mass of mixture, that is certain by a geo-polymer paste fashioned by the reaction of the element and metallic element along with the GGBS and also the alkaline liquid created of hydrated oxide and soluble glass answer with addition of super plasticizer. This glassy granulate is dried and ground to the specified size and this can be referred to as ground granulated blast furnace slag (GGBFS).

The examine the utilization of GGBFS primarily based geo-polymer concrete has increase because of the environment sustain possibility of mistreatment subordinate in nursing industrial waste on type helpful material. Analysis and industry terms area unit exacted concerning the new direct of a concrete made of industrial by product this might scale back the matter of eliminate these materials.

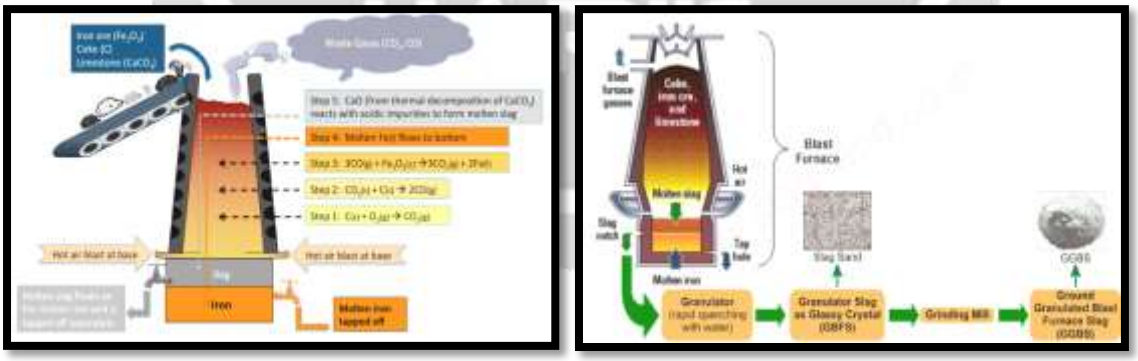

Figure 1: Process of GGBFS Manufacturing [2**]**

The GGBFS used powder form in this research work which are replacement with cement in the concrete mix and to determine the properties of GGBFS.

Figure 2: GGBFS

Table 1: Chemical Properties of GGBFS

Sr. No.	Characteristic	Test Report (%)
1	SiO_2	35.47
2	CaO	35.89
3	MgO	8.06
4	Fe_2O_3	2.41
5	Al_2O_3	14.27
6	Loss on Ignition	0.70
7	Insoluble Residue	0.52
8	MnO	0.34
9	Alkalies	0.20
10	Sulphide Sulphur as SO_3	1.58

2.2 Fibre:

Fibre - reinforced concrete is concrete that uses other materials mix in with the still liquid cement to reinforce the concrete structure. These fibres assist to make the concrete stronger. There are two types of fibre - reinforced concrete: natural fibres (Such as plant, animal and mineral) man – made fibre (Such as synthetic (mineral and polymer), semi – synthetic and regenerated).

Main determinant of economic efficiency of modern construction projects is time of their accomplishment. In this case, the traditional steel - concrete construction system is quite slow process and does not allow creating light, spatial elements. So the weight of steel-concrete elements and slow and time consuming process of their creation has negative effect on economic characteristics of the construction procedure. Chopped fiber concrete reinforcement is the most effective method to improve negative characteristics of plain concrete elements in modern construction that was actively accomplished in the world, especially during the last decade. Chopper fiber reinforced concretes have sharply improving parameter of strength, stability, impact resistance, freeze resistance and waterproofing.

The fibres used chopped form in this research work which is randomly distributed in the concrete mix and to determine the properties of these fibres.

Figure 3: PVA Fibre

Table 2: Properties of Polyvinyl Alcohol Fibre

Sr. No.	Test Description	PVA Fibre
1	Diameter	14 µm
2	Length	12 mm
3	Color	White
4	Specific Gravity	1.29 g/cm^3
5	Density	1.25 g/cm^3
6	Tensile Strength	1495 MPa
7	Elastic Modulus	41.7 GPa
8	Elongation of Break	7 %

Figure 4: Basalt Fibre

Table 4: Properties of Basalt Fibre

Sr. No.	Test Description	Basalt Fibre
1	Diameter	18 µm
2	Length	22 mm
3	Color	Light Brown
4	Specific Gravity	2.75 g/cm^3
5	Density	2.63 g/cm^3
6	Tensile Strength	3450 MPa
7	Elastic Modulus	79 GPa
8	Elongation of Break	3.1 %

3. LITERATURE REVIEW

In the past number of research and development has been done on Geo-polymer concrete and FRC has to a substantial and increasing number of publications of all types. Those research papers are useful for new research in combination of these both. In this chapter those considered most relevant to the current study are reviewed and summarized here.

R. Rughooputh and J. Rana examined that the effect of partially replaced ordinary portland cement (OPC) by ground granulated blast furnace slag (GGBFS) on the properties of concrete including compressive strength, tensile strength and flexural strength and it's content of 0%, 30% & 50% replacement with cement in each mixes. Compressive strength increase of 50% content of GGBFS replaced was about 6.25% and 2.50% compared to mix sample Normal Concrete and 30% content of GGBFS replaced respectively. Splitting tensile strength increase of 50% content of GGBFS replaced was about 14.29% and 4.08% compared to mix sample Normal Concrete and 30% content of GGBFS replaced respectively. Flexural strength increase of 50% content of GGBFS replaced was about 20.48% and 2.41% compared to mix sample Normal Concrete and 30% content of GGBFS replaced respectively. Finally It's conclude that the strength improvement increase with increasing GGBFS content [3].

Gengying Li and Xiaohua Zhao invested influence of combination of fly ash (FA) and ground granulated blast furnace slag (GGBFS) on the properties of high strength concrete. Evaluate strength potential of Normal Concrete, 40% content of Fly Ash & 15% & 25% content of GGBFS & Fly Ash respectively (Indicate – NC, FA40 & G15FA25). Compressive strength increase of G15FA25 was about 2.00% and 16.11% compared to mix sample NC & FA40 respectively. Finally It's conclude that the strength improvement was greater using GGBFS than Fly Ash [4].

Amin Noushini, Bijan Samali and Kirk Vessalas investigated the effect of uncoated polyvinyl alcohol (PVA) fibre addition on mechanical properties of fibre reinforced concrete (FRC) has been investigated in that study. PVA fibre two geometric lengths (6 mm and 12 mm) with aspect ratio of 428 and 857 respectively were utilized. Fly ash was also used as partial replacement of portland cement in all mixes. Based on total concrete volume, two fibre fraction of 0.25% and 0.50% were evaluated for their mechanical properties. When 0.25% fibre volume, Compressive strength, Splitting tensile strength & Flexural strength increase of 6 mm length fibre was about 10.45% and 3.73% & 24.49% and 4.08% & 17.65% and 1.47% compared to mix sample Normal Concrete and 12 mm length fibre respectively. When 0.50% fibre volume, Compressive strength, Splitting tensile strength & Flexural strength increase of 6 mm length fibre was about 2.44% and 4.88% & 11.90% and 2.38% & 11.11% and 1.59% compared to mix sample Normal Concrete and 12 mm length fibre respectively. Finally It's conclude that the strength

improvement was greater using shorter 6 mm PVA fibre than with 12 mm PVA fibre (In that experiments optimum result – 0.25% fibre volume add in concrete) [5].

A. Noushini, B. Samali and K. Vessalas examined that assesses the performance of using uncoated polyvinyl alcohol (PVA) fibres of two geometric lengths (6 mm and 12 mm) in concrete. Based on total concrete volume, 3 fibre fraction of 0.25%, 0.50% and 1.00% were evaluated for their effect on fresh and hardened properties of PVA fibre reinforced concrete (FRCs). When 0.25% fibre volume, Compressive strength increase of 6 mm length fibre was about 14.18% and 3.73% compared to mix sample Normal Concrete and 12 mm length fibre respectively. When 0.50% fibre volume, Compressive strength increase of 6 mm length fibre was about 9.45% and 7.88% compared to mix sample Normal Concrete and 12 mm length fibre respectively. When 1.00% fibre volume, Compressive strength decrease was about 69.12% compared to mix sample Normal Concrete. Finally It's conclude that the strength improvement was greater using shorter 6 mm PVA fibre than with 12 mm PVA fibre (In that experiments optimum result – 0.25% fibre volume add in concrete) and strength gain rate from 7 to 28 days is almost double for FRCs compared to the normal concrete. It can be concluded that PVA fibres help with improving the compressive strength in later ages [6].

John Branston, Sreekanta Das, Sara Y. Kenno and Craig Taylor investigated the two different length of copped basalt fibre were used: 36 mm and 50 mm at fibre content of 4 kg/m^3, 8 kg/m^3 and 12 kg/m^3in enhancing the mechanical behavior of concrete. When used 4 kg/m^3, Compressive strength & Splitting tensile strength increase of 50 mm length fibre was about 1.33% and 10.93% & 7.95% and 0.23% compared to mix sample Normal Concrete and 36 mm length fibre respectively. When used 8 kg/m^3, Compressive strength increase of 36 mm length fibre was about 4.05% and 1.37% compared to mix sample Normal Concrete and 50 mm length fibre respectively. Splitting tensile strength increase of 50 mm length fibre was about 17.18% and 3.89% compared to mix sample Normal Concrete and 36 mm length fibre respectively. When used 12 kg/m^3, Compressive strength & Splitting tensile strength increase of 50 mm length fibre was about 2.02% and 2.20% & 20.74% and 3.52% compared to mix sample Normal Concrete and 36 mm length fibre respectively. Finally It's conclude that the strength improvement was greater using longer 50 mm basalt fibre than with 36 mm basalt fibre [7].

Ahmet B. Kizilkanat, Nihat Kabay, Veysel Akyuncu, Swaptik Chowdhury and Abdullah H. Akca examined that comparatively analyze the application of basalt and glass fibers as fiber reinforcement in high strength concrete. The two different fibre were used: basalt fibre & glass fibre content of 0.25%, 0.50%, 0.75% and 1.00%. Compressive strength increase of BF1 fibre was about 7.46% and 1.00% compared to mix sample Normal Concrete and GF1 respectively [7]. Splitting tensile strength increase of BF1 fibre was about 33.33% and 22.22% compared to mix sample Normal Concrete and GF1 respectively. Flexural strength increase of BF1 fibre was about 28.57% and 7.14% compared to mix sample Normal Concrete and GF1 respectively. Finally It's conclude that the addition of BF and GF in the concrete mix decreased the workability of concrete. However GFRC showed lower slump values when compared to BFRC and basalt fibre give high strength compared to glass fibre as well as its strength increase with increase fibre dosages (In that experiments optimum result – 1% fibre volume add in concrete) [8].

Tehmina Ayub, Nasir Shafiq and M. Fadhil Nuruddin investigated influence of addition of 1%, 2% and 3% basalt fibre volume fraction in three different mixes of high performance concrete (HPC) is investigated. The 1st mix was prepared by using 100% cement and other two mixes were prepared by replacing 10% cement content with silica fume and locally produced met kaolin (Indicate – P, S, M). When add fibre volume in series P, the compressive strength increase of mix sample "P2" was about 3.19%, 0.87% and -13.95% compared to mix sample "P0", "P1" and "P3" respectively. Splitting tensile strength increase of mix sample "P3" was about 14.07%, 11.11% and 8.62% compared to mix sample "P0", "P1" and "P2" respectively. When add fibre volume in series S, the compressive strength increase of mix sample "S2" was about 1.82%, 1.27% and -19.92% compared to mix sample "S0", "S1" and "S3" respectively. Splitting tensile strength increase of mix sample "S3" was about 20.15%, 19.08% and 18.90% compared to mix sample "S0", "S1" and "S2" respectively. When add fibre volume in series M, the compressive strength increase of mix sample "M2" was about 1.62%, 0.04% and -4.09% compared to mix sample "M0", "M1" and "M3" respectively. Splitting tensile strength increase of mix sample "M3" was about 36.24%, 30.78% and 22.53% compared to mix sample "M0", "M1" and "M2 respectively. Finally conclude that In each series of three series of HPFRC (P, S & M) the optimum compressive strength at 2% basalt fibre volume in series M than series S and optimum splitting tensile strength at 3% basalt fibre volume in series S than series M [9].

In the context based on GGBFS conclude that the effect of GGBFS partial replacement with cement in concrete was investigate to show increment in result compared to normal concrete up to 50% replacement than after shown

decrement in result [3-4]. In the context based on PVA and Basalt fibre conclude that the effect of these fibres addition in concrete separately or/and partial replacement of cement by other cementitious material in concrete was investigate to show increment in result compared to normal concrete up to some proportion (obtain optimum result of PVA fibre – 0.25% and Basalt fibre – increase with basalt fibre volume) on mechanical properties of concrete [5-6]. PVA fibre strength improvement was using shorter fibre other than longer length fibre. Basalt fibre found that to be increase with the increasing fibre volume and strength improvement was using longer fibre other than shorter length fibre [7-9].

4. CONCLUSION

In the context of concrete, It's intense work to making concrete such as eco-friendly and high compressive strength also high tensile and flexural strength than normal concrete. Current research is focused in lead to significant environmental and economic benefits also high compressive strength or high strength in all stage. By my proposed scheme, we can achieve eco-friendly, high compressive, tensile and flexural strength concrete. My future work comprise the implementation of proposed scheme, I expect that my effort will be helpful to the making this type of concrete.

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