International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

EFFECT OF USE OF GGBS ON CHARACTERISTICS OF CEMENT CONCRETE

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Abstract - *In modern construction concrete is very expensive and popular material where cement is the main composite. Every year we are producing billion tones of concrete. Production of cement is responsible for too much of CO_2 production, in other words it is also responsible for global warming. Mostly India is facing the problem of pollution. Researchers have did a great job and found many ways to replace cement. For making geopolymer concrete by products of different industries may be used like. Flyash, rice husk. In this investigation geopolymer concrete is prepared with GGBS. GGBS is a byproduct of steel industry. It holds the coarse and fine aggregates in the matrix.*

In this investigation geopolymer concrete is prepared with GGBS and advantages and disadvantages are also investigated. Alkaline activator 8M, 10M, 2M & 16M are taken here. The proportion of Activator is 1.2.5. All cubes are prepared and curing is done at room temperature. Curing is done with ordinary water starting after 24hrs. Workability of the geopolymer green concrete was not good. So adding of plasticizer is a good decision adopted Specimen are tested for compressive strength, flexure strength & split tensile strength test. All the tests are performed at the age of standard period as per guided by is for concrete other than GPC. Unit weight of GPC was assumed as 2400 kg/m^3. There are some limitations to fully replace the cement with GPC. But engineers are ready with this and res archers have open their hands to to save the environment. We considered it as an Eco friendly way for the concrete making. Various properties are discussed with different age of concrete. It was an observation that it has good results over other concrete. GGBS is a good replacement of cement and it will help in reducing the production of CO_2. As a result of this global warming can be reduced. Our study is to test either we can get the strength of M45 grade.

Key Words: GPC, GGBS, Flyash, Rice husk

1. INTRODUCTION

In this present era, the concrete is one of the widely used construction material due to its durability and economy. India uses tonnes of ready-mixed concrete each year. It is in Streets, Buildings, Highways, Bridges, tunnels, Dams, Railway. It was an average that 3 tonnes of concrete is used by each person on earth. CO_2 leads to global warming and it has a major part of Green house gases. Contribution of CO_2 is 65% and out of this 7% is only from cement industry. India, China & USA generally consuming most of concrete produced. It was estimated that cement manufacturing was raising 2.5% annually by the production large amount of CO_2 is released. It was an estimate that around 1ton of CO_2 is produced in Production of 1ton of cement.

On the other hand plenty of materials are available with which cement can be replaced. It is helping a lot in reduction of emission of CO_2. Fly ash, slag, rise husk, GGBS are the things which are used for replacement. This concrete prepared is known as Geopolymer concrete. GPC is considered now complete replacement of cement. A lot of studies has been carried out by researcher that use of GGBS in Geopolymer concrete has improved the strength properties but its excess amount may reduce its strength. However, it has a history since 1940 but it is not so common till now.

1.1 INTRODUCTION TO GGBS AND GGBS BASED GEOPOLYMER CONCRETE

GGBS is generally produced during the production of steel. Generally limestone, iron ore, coke are put into a kiln for the production of iron. At a temperature of 1600^{o}C slag is produced approximately 40% lime (CaO) & 30-40% SiO_2 it is cementitious in nature. It hydrates like cement. It can also resist some chemical attacks. Molten iron is removed and slag contains residue have siliceous and aluminous properties. Now molten iron slag in water produces granulate slag. Rapid cooling is done to get granulated Slag. It is then dried and ground into fine powder to get GGBS. It was first introduced by Joseph Davidovits. In the year 1972 as an alternative of OPC

GGBS having specific gravity around 2.6, average size of particles 4.75mm & white in colour. It is an admixture given azs per IS 456:2000. it contains different ingredients. Aluminium Oxide, calcium Oxide, Magnesium Oxide, Silica, Manganese Oxide, Sulphur, Iron Oxide. It has a specific area of 400-600 m^2/kg. In this Alkali – Silicate reaction can be very detrimental to the stability of concrete

We are using GGBS to replace the cement. Alkaline Activator Solution with Source material helps in Binding of aggregates. For the preparation of mixture uses of IS Code methods Re adopted. In this study, 75% volume is occupied by Aggregates. Silicon and Aluminum are activated by sodium hydroxide and sodium silicate solution. Geopolymer concrete have a good strength and it is quite suitable for various works such as Rigid pavements, buildings etc. GGBS have all the properties of cement. Its Role for rigid pavement is studied in this thesis.

1.2 ADVANTAGES OF GEOPOLYMER CONCRETE

There are several advantages of GPC with GGBS. These make our curiosity to study about this. Some of them are presented as:

- A good alternate of OPC based concrete.
- It is helpful in reduction of CO_2 from cement industries.
- It has good strength properties.
- Curing can be done at room temperature & in oven.
- It can be considered as Eco friendly concrete.
- It will helpful to save the natural resources.
- It doesn't crack under sunlight like OPC.

2. OBJECTIVE OF THE STUDY

We have lack of study for Geopolymer concrete with GGBS for Rigid pavements. All the literature which we found, tested the strength and behaviour of concrete with fly ash, Glass, Red Mud, Foundry Sand. But the study with GGBS is Limited. All studies are done to check and find different parameters. Our study is to check the suitability of GPC with GGBS for rigid pavements. The following objectives are considered for the present study:

- To study the engineering properties of GPC with GGBS.
- To develop a mix without OPC.
- To know the effect of GGBS based GPC on environment.
- To know the suitability of GPC for Rigid Pavements.
- To identify the technique for preparation of workable mix.

3. MATERIALS USED AND METHODOLOGY

The material used for making concrete were GGBS as source material aggregates (CA+FA),Alkaline solution, Admixtures and potable water.

3.1 GROUND GRANULATED BLAST FURNANCE SLAG (GGBS)

It is a byproduct of steel industry and it includes all the constituents that an OPC has but the concentration is different. GGBS on GPC increases the strength of the concrete and it also makes the concrete curable at room temp. Table 1 and Table 2 shows the chemical composition and physical properties of GGBS.

Table 3.1: *Chemical Composition of GGBS*

Material (%)	Quantity present	IS requirement
CaO	0.31	5.5
Sio_2	5.89	17.0
Al_2O_3	0.25	5.0
Glassy Content	95.59	<85.0

Table 3.2: Physical Properties of GGBS

Test performed	**Result**	**Method**	**Colour -** Off-White
fineness	3.12	IS 1727-1967	
Specific gravity	2.86	IS 1727-1967	**Sp. Gravity = 2.9**

3.2 AGGREGATES

The aggregates are the most important constituent of the concrete and it provides good compressive strength to concrete. For our experiment work we used coarse and fine aggregates. The experimental investigations made on the aggregates are as below:

Fine Aggregates

Naturally available sand collect from New Delhi is used as fine aggregate in the present work. The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. Hence used as a fine aggregate in concrete. As per IS: 383 the sand falls under zone 2.

Table 3: Physical properties of fine aggregates

S.No.	**Physical properties of fine aggregates**	
1.	Specific gravity	2.56
2.	FM	3.16

Coarse Aggregates

Coarse aggregate is available from New Delhi is used as coarse aggregate in the present work. 10mm and 20mm sized aggregates are used.

Table 4: Physical properties of 10mm &20mm Aggregates

S.No.	**Properties**	**10mm Result**	**20mm Result**
1.	Type	Crushed	Crushed
2.	Max. Size	10	20
3.	Specific Gravity	2.62	2.69
4.	FM	1.25	1.97

3.3 ALKALINE ACTIVATOR

It is one of the important materials for making geopolymer concrete. It generally makes the environment of high pH. It also helps to accelerate the reactions. There are many chemicals which are used as alkaline activator. Generally all the activators are used in a requirement ratio. Some of the alkaline activator solution are NaOH, KOH, NA_2SiO_3,K_2SiO_3. We have these alkaline activator solutions but for our investigation we have used the Sodium Hydroxide and Sodium Silicate.

3.4 SODIUM HYDROXIDE & SODIUM SILICATE

In this investigation commercial grade is adopted 97%-99% pure. Generally Sodium Hydroxide was available in the form of pellets, flakes. All these things are used to male the solution of required molarity. for example solution with concentration 10M is considered as 10x40=400 grams of NaOH solids in the solution of 1 liter.

If we talk about The sodium silicate, this is available in solution form and it was 98% pure. These solutions are taken in different fractions with sodium hydroxide to make good Alkaline Activator Solution.

Table 3.8: *Sodium Hydroxide Properties*

S.No.	Properties	Amount
1.	Na_2CO_3 By mass	0.32
2.	NaOH by mass(%)	99.52
3.	NaCl(%)	0.12

Table 6: Sodium Silicate Properties

S.No.	Characteristics	Actual Value	Specified Value
1.	Color	Light gray	Clean
2.	Water	55.36%	55-57%
3.	Density	51.76	51-54
4.	SiO_2	31.2%	30-33
5.	Na_2O	14.23	13-15
6.	Total Solids	44.56	44%min

3.4 AAS

It has a vital role in the reaction. Silica and alumina present in the mix helps in binding. We are using 10M to prepare solution10x40= 400 Grams. It is prepared in 1L of water to prepare a solution of 1.32 in 1 kg of solution= 400/1.32=303.033 Grams. AAS sodium silicate was mixed with the sodium hydroxide solution. Sodium silicate helps to increase the reaction. We prepared the solution5urs before the cube casting. But the recommendation was 3-24 hours before casting.

Fig 1: Preparation of AAS Carefully

3.5 SAMPLE PREPARATION

For primary study we are using hand mixing process. All the materials weighted and mixed carefully. After this AAS were mixed but it was not workable hence, to increase the work ability we adopted to add some more amount of water. When the mix was uniform we filled the cubes carefully. Every care has been taken to fill the cubes such as cleaning, compaction and vibration. To avoid the voids problem vibration is done and sample was filled in the three layers. All the cubes were prepared at room temperature. After 24 hours of casting molds were opened. Application of water is done on samples. After that they were placed for 7 days open to sky in sunlight.

4. ANALYSIS AND RESULTS

4.1 COMPRESSIVE STRENGTH

We have tested the compressive strength of GPC on different molarity. Compressive strength has been tested on different curing ages. It is tested on 3days, 7days and 28days. The average compressive strength is plotted below.

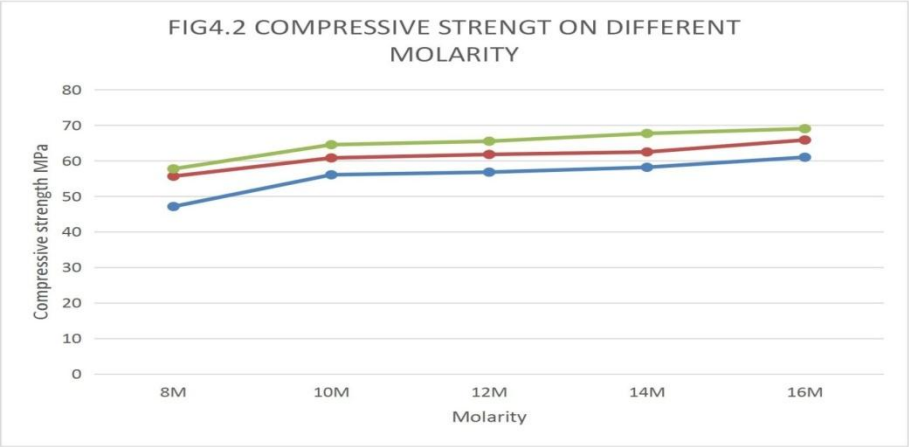

Fig 2: Compressive Strength on Different Molarity

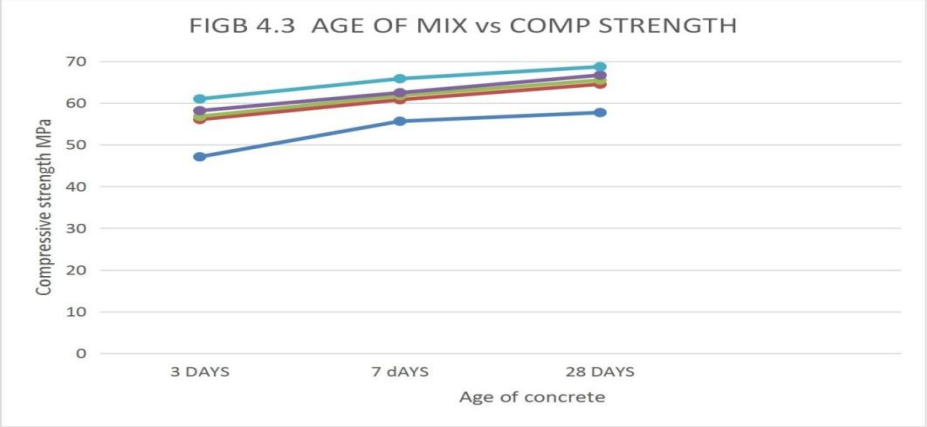

Fig 3: Age of Mix Vs Compressive Strength

4.2 SPLIT TENSILE STRENGTH

We have plotted the investigation results for the tensile strength for the GPC. Split tensile strength has been tested on 3days, 7 days and 28 days. The different values of split tensile strength have been plotted below.

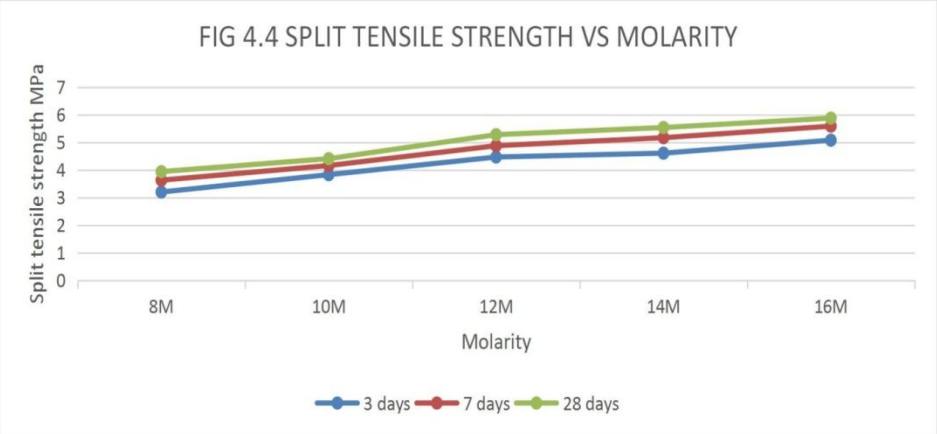

Fig 4: Split Tensile Strength Vs Molarity

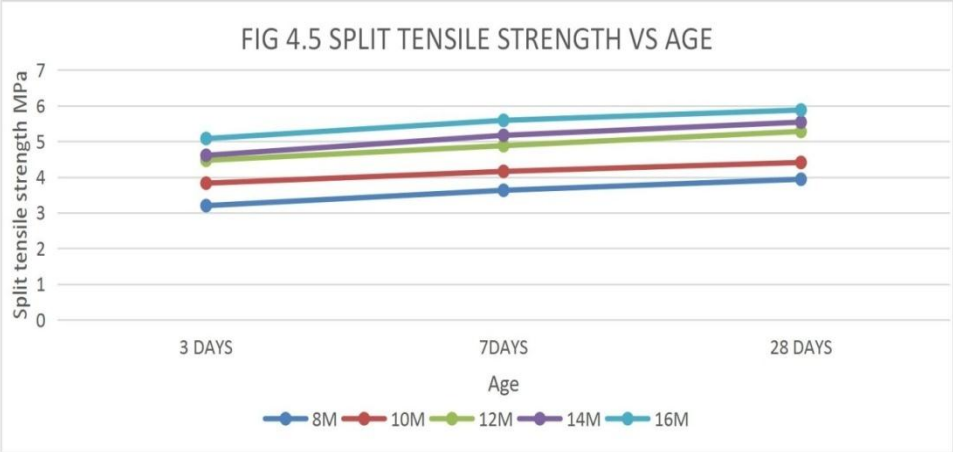

Fig 5: Split Tensile Strength Vs Age

4.3 FLEXURAL TENSILE STRENGTH

We have plotted the investigation results for the tensile strength for the GPC. Split tensile strength has been tested on 3days, 7 days and 28 days. The different values of split tensile strength have been plotted below.

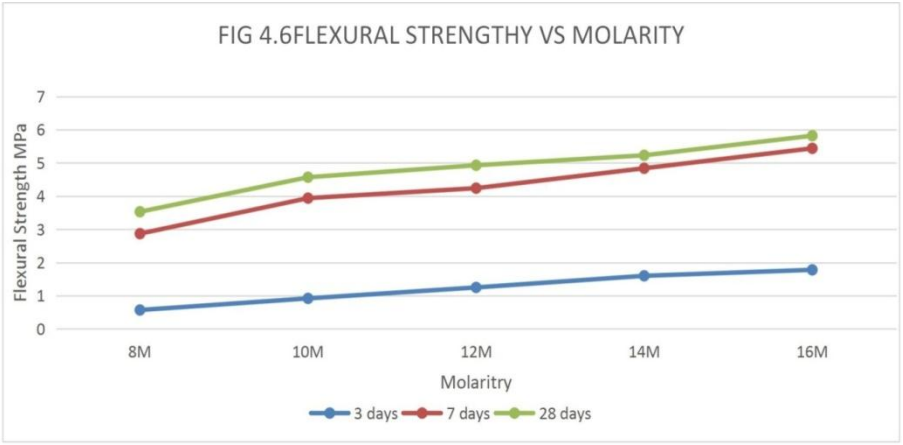

Fig 6: Flexural Strength Vs Molaity

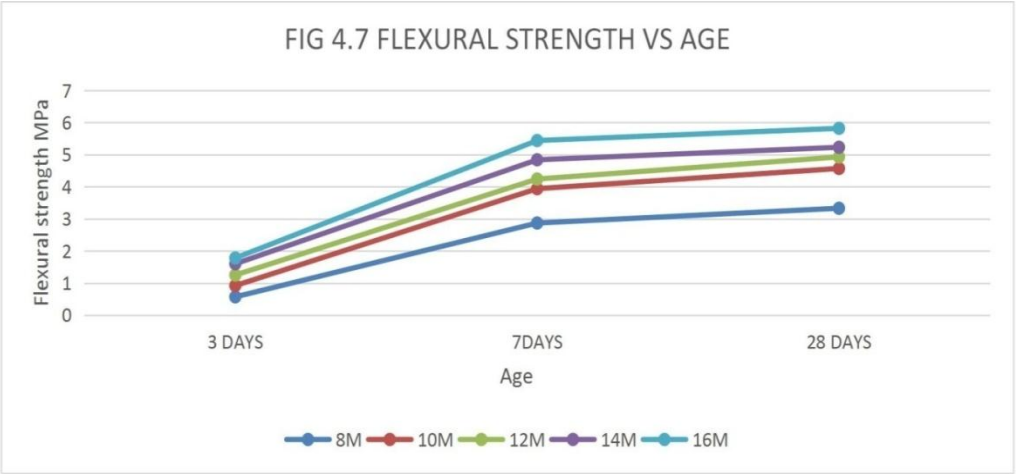

Fig 7: Flexural Strength Vs Age

5. CONCLUSIONS

The influence of replacement of cement by GGBS has been studied. Based on the experimental work conducted, the following conclusions are drawn.

- The Compressive strength we found in 8M is 81.62% at 3 days of 28 days strength and at 7 days it is 96.39% of 28 day's strength while in 10M, 3 days strength is 86.85 % of 28 days and 7 days strength is 94.32 % also for the 3 days strength of 12M, 14M, 16M are 81.20%,85.29%,88.35%. Further the strength of 7 days concrete is 95.27%, 92.28%, 95 % of the 28 days strength. We found the maximum strength in 16M.
- The split tensile strength we found in 8M is 81% at 3 days of 28 days strength and at 7 days it is 92% of 28 days strength. In 10M 3 days strength is 86% of 28 days and 7 days strength is 94 % of 28 days strength. Also for the 3 days strength of 12M, 14M, 16M are 84%, 83%, 86%. Further the strength of 7 days concrete is 92%, 93%, 95 % of the 28 days strength.
- The Flexural strength we found in 8M is 16% at 3 days of 28 days strength and at 7 days it is 81% of 28 day's strength. In 10M 3 days strength is20.13% of 28 days and 7 days strength is 86.21 % of 28 days strength. Also for the 3 days strength of 12M, 14M, 16M are 25.40%, 33%, 32.07%. Further the strength of 7 days concrete is 86.03%, 92%, 93.04% of the 28 days strength respectively.
- The concrete has good compressive strength but we found a poor flexural strength for 8M and 10M. For making of road pavements min flexural strength requirement is 45 Kg/cm^2. But the strength we found is very less than this in 8M and 10M. So we do not recommend the concrete to be used for pavements directly. We need to improve the flexural strength for better use in pavements. It can be used for local streets and parking areas where VDF is very less.bur for the 12M-16M we suggest this can be used for pavement construction but some more studies like durability and soundness need to be analyzed.

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