"EFFECT OF GGBFS BASED CEMENTETIOUS MATERIAL BY PARTIAL REPLACEMENT OF FLY ASH AND SILICA FUME WITH ALKALINE SOLUTION"

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ABSTRACT

Pozzolanic material is successively replaced in certain percentage with cement and it also totally replaced by geopolymerization. Thus it is a need to develop sustainable alternatives to conventional concrete utilizing more eco-friendly materials. Geopolymer cements are innovative binders which can be produced by the chemical action of aluminosilicate materials are available worldwide. They are rich in silica and alumina reacting with alkaline solution and producing aluminosilicate gel that acts as the binding material for the concrete. Geopolymers are synthesized by polycondensation reaction of geopolymer binder and alkali polysilicates. So cement is totally replaced by pozzolanic material that is rich in silica and alumina like Flyash, Ground granulated blast furnace slag (GGBFS),Silica fume (SF),Metakeoline etc. can be possible. But this material canot be used directly alternative of cement because percentage of chemical composition of cement is different than waste. The main components of blast furnace slag are CaO (30-55%), SiO2 (22-36%), Al2O3 (6-22%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicaly and an increase in compressive strength. The MgO and Al2O3 content show the same trend up to 10-12% and 14%, respectively beyond which no further improvement can be obtained. Hence in pozzolanic material cementing power is developed with the help of sodium hydroxide mixed in sodium silicate. The laboratory investigations under ambient and oven dry curing conditions suggested that waste from iron or steel production i.e GGBS is suitable for development of geopolymer concrete; and the compressive strength of geo-polymer concrete is a function of mass ratio of alkaline liquid to GGBS, mass ratio of sodium silicate to sodium hydroxide and molar concentration of sodium hydroxide. The fixed ratio of sodium silicate to sodium hydroxide is 1.0 but the concentration of sodium hydroxide is varied from 6M to 14M and to get the greatest compressive strength from different concentration of NaOH. Activated liquid to GGBFS ratio is 0.32 by mass was maintained constant on the basis of maximum compressive strength of GGBFS with 12M NaOH and alkaline ratio is 1.The temperature of oven heating was maintained at 60, 80 ,90 ,100,120,140 °C for fixed 7 hours duration and tested 7 ,28,and 56 days after heating.

Keyword : - *Pozzolanic , GGBSF, Alkaline Solution, and Cementetious etc….*

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1. INTRODUCTION

Now a days production of Portland cement is increasing with the increasing demand of construction in world. Ultimately its effect on the rate of production of carbon dioxide released to the atmosphere is also increasing. Each ton of Portland cement releases a one tone of CO2 in the atmosphere. The cement industry contributes 7% of the total CO2 emission and this will increase rapidly due to the increase in the cement production (4). The manufacturing process involves burning of coal, fuel oils and petroleum coke for producing energy. But in recent years, natural gas and alternative fuels are used for energy production in the manufacture of cement globally(6). Due to these environmental issues, attempts been carried out to find alternative material in concrete. On the other side, some of the waste material from different industries like coal based thermal power plant, Iron manufacture or steel production, available abundantly but have disposal problem(9). Several hectors of valuable land is acquired by such industries for the disposal of west from it. In India more than 100 million tons of fly ash and GGBFS is produced annually out of which 20 – 24 % GGBFS is utilized either in concrete as a part replacement of cement or workability improving admixture or in stabilization of soil(10). There are environmental benefits in reducing the use of Portland cement in concrete, and using a cementitious material such as GGBFS, RHA, FA, SF, metakeoline, etc. as a partial substitute. „Geopolymer Concrete" (GPC) is a type of inorganic polymer composite, which has recently emerged as a prospective binding material based on novel utilization of engineering materials. It has the potential to form a substantial element of an environmentally sustainable construction industry by replacing/ supplementing the conventional concretes (Duxson et al., 2007). GPC can be designed as high strength concrete with good resistance to chloride penetration, acid attack. Sulphate attack,etc(11). The geo-polymeric concretes are commonly formed by alkali activation of industrial alumino silicate waste materials such as FA and GGBFS, and have very small footprints of greenhouse gases when compared to traditional concretes(12). Because of possible realization of even superior chemical and mechanical properties compared to Ordinary Portland cement (OPC) based concrete mixes, and higher cost effectiveness, GPC mixes based on GGBFS ,FA and silica flume are being discussed for their potential application in concrete industry including structural concreting, precast panels and ready-mixes (13).

1.1 Scope for study

Industrialization and uncontrolled exploitation of natural resources has lead to the formation of large quantity of industrial waste materials which pose problem of disposing such materials and environmental pollution. Fly ash from thermal projects, GGBFS from steel industries, Silica fume from production of silicon metal and quarry dust from granite quarries are examples of industrial waste materials disposing problems. These are to be recycled / reused properly instead of disposing them as waste materials. Considerable research is taking place throughout the world in developing suitable technologies for proper utilisation of these industrial waste materials. The main constituents of geopolymer are an alkaline liquid and source materials. The source materials should be rich in Silicon and Aluminium. They could be natural minerals such as a product of kaolin clay or by-product materials such as FA, SF, Sodium silicate, GGBFS, etc. Alkaline liquid is Sodium hydroxide solution. Geopolymer concrete can be produced using low-calcium fly ash obtained from thermal power plants where it is formed as a by-product of burning anthracite or bituminous coal. Coarse and fine aggregates used for making Portland cement concrete can also be used to make geopolymer concrete. Sodium hydroxide with 97%-98% purity in the form of flakes is commercially available which can be dissolved in water to have concentration in the range of 8 molar to 16 molar. Mass of NaOH required depends on the concentration required. NaOH solution with concentration of 8molar requires 8x40=320 grams of NaOH flakes per litre of water. In order to improve the workability of the geopolymer concrete, a water reducer super plasticizer or extra water may be added to the mixture. The constituent materials can be mixed thoroughly using appropriate method or approach to obtain geopolymer concrete of required consistency or slump.

2. METHODOLOGY

2.1 Materials used

1) Ground granulated blast furnace slag (GGBFS)
2) Fly ash
3) Silica Fume
4) Chemicals- Sodium hydroxide ,Sodium silicate
5) Superplasticizer
6) Fine aggregate
7) Coarse aggregate

2.2Combination of Pozzolanic materials.

In this project prepare geopolymer concrete by using varies pozzolanic material such as GGBFS, Fly ash and Silica flume in certain percentage as shown table no.3.1

Table 3.11 Different mix proportion of GGBFS, SF, and FA.

Sr.no	Mix proportion	Abbreviation
1	(100%)GGBFS+ NaOH+ Na2SiO3	M1
2	(80%)GGBFS+ (20%)FA+ NaOH+ Na2SiO3	M2
3	(70%)GGBFS+ (30%)FA+ NaOH+ Na2SiO3	M3

4	(80%)GGBFS+ (20%)SF+ NaOH+ Na2SiO3	M4
5	(70%)GGBFS+ (30%)SF+ NaOH+ Na2SiO3	M5
6	(60%)GGBFS+ (20%)SF+ (20%)FA+ NaOH+ Na2SiO3	M6
7	(50%)GGBFS+ (25%)SF+ (25%)FA+ NaOH+ Na2SiO3	M7

Table 3.10 Materials required for M30 grade geopolymer concrete.

Ingredients of GPC	GGBFS	NaOH	Na_2SiO_3	sand	Coarse Aggregate	total water (W/GPB)	Extra water
Quantity (kg/m^3)	405	70.88	70.88	83.13	1,268.66	108.35	29.46
Proportion	1	0.32		1.82	3.37	0.211	0.07

3.TEST RESULT AND DISSCURSSION

To check the suitability of geopolymer concrete following test are conducted on material.

3.1 Standard consistency

Standard consistency of a pozolanic material with varying percentage of GGBS, FA and SF was performed with the help of Vicat apparatus attached with needle in accordance with IS4031-PART4 1996. bar chart showing its variation is presented in figure 4.1.

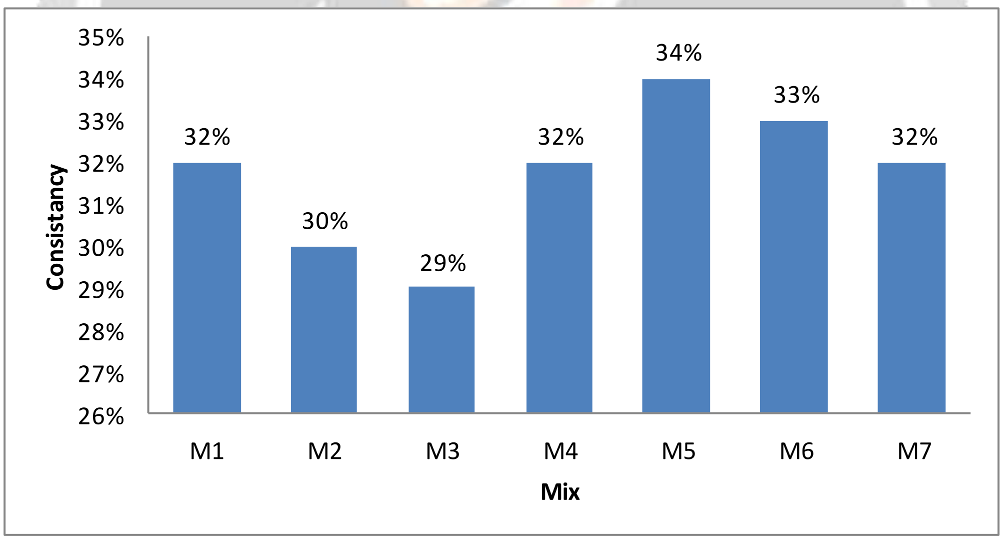

Fig 3.1 : Consistency of various mixes

3.2 Initial and Final setting time.

Initial Setting Time (IST) and Final Setting Time (FST) of a pozolanic material with varying percentage of GGBS,FA and SF was performed with the help of Vicat apparatus attached with needle in accordance with IS: 4031(Part V) -1996. and the result obtained is summerized in table 3.2 below and bar chart showing its variation is presented in figure 3.2.

Table 3.1 Initial and Final setting time of different mixes

Mix Proportion	IST in min	FST in min
M1	50	190
M2	55	200
M3	65	230
M4	45	180
M5	40	160
M6	60	190
M7	50	170

3.3 Compressive strength of GGBFS.

Compressive strength test of cement was determined by testing a cube of size 70.6mm in Compressive testing machine at uniform rate of loading as per IS: 4031(Part VI) -1988. The cube made up with mortar of standard sand and cement and water. The result obtained is summerized in table 3.2.

The compressive strength result for 7th,28th and 56th days of testing are shown in Figure 4.4. For 7th day of testing, 12 M NaOH solutions showed the highest compressive strength of 32.65 MPa. However, for the 28th and 56th days of testing, samples with 12 M NaOH solution produced highest compressive strength of 34.69 MPa and 35.71 MPa respectively, when activator concentration increased above 12 M, a lower rate of polymer formation was produced resulting in the decrease of strength.

Table -3.2 Effect of molarity of NaOH on strength of GGBFS with binder ratio 0.32

Molarity	Average compressive strength in MPa		
	7 Days	28 Day	56 Day
6M	20.40	22.44	22.44
8M	24.48	27.55	28.57
10M	29.56	30.61	31.63
12M	**32.65**	**34.69**	**35.71**
14M	31.63	32.65	32.65

3.3 Effect of oven curing on block.

After cheking compressive strength of GGBFS with different molarity, again casted 3 block of each mix by highest compressive strength of given molarity say 12M NaOH with binder ratio 0.32 and put in oven for 7 hours at different temperature starting from 60oC to 140oC and find out maximum compressive strength of GGBFS morter of respective temperature, result shown in table 3.3.

Table 3.3 Effect of temperature on strength of GGBFS with 12M NaOH

Temprature In ^{0}C	Average compressive strength in MPa		
	7 Day	28 Day	56 Day
60	17.34	18.36	20.40
80	22.44	23.46	24.48
100	30.61	32.65	33.36
120	**36.73**	**38.77**	**39.79**
130	35.71	36.73	36.73
140	32.65	34.69	33.36

4. CONCLUSIONS

The samples of geopolymer concrete for various proportions of GGBFS, Fly ash and Silica fume with varying concentration of alkaline solution were tested for compressive strength, Flexure strength and split tensile strength. The test result of geopolymer concrete depends on pozzolanic material used for preparation of concrete. Based on the results obtained in the experimental investigation, the following conclusions are noted.

1)Consistency of pozzolanic material gets increases with increasing fineness. If percentage of silica fume increases also increasing consistency due to silica fume is finer than the GGBFS and Fly ash.

2)Initial and final setting time get increasing with increases percentage of Fly ash and it will reduce with increasing silica fume.

3)Soundness of GGBFS is 2 mm but it will get reduce if fly ash is increases and soundness is increase with silica fume increases.

4)The strength of geopolymer mortar increases with increasing concentration of NaOH up to 12M and further increasing molarity of NaOH strength get reduce.

5)The strength of geopolymer mortar increases with increasing temperature up to 1200C and afterword increasing temperature strength get reduce.

6)The GGBFS based geopolymer concrete gained maximum strength within 7 days of 12M NaOH with 0.32 binder ratio and at 1200C oven temperature without water curing.

6. REFERENCES

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