Utilization of Waste Materials (GGBS+FLY ASH)

R. B.Sheral

Assisant Professor
Dept. of Civil Engg.,
JSPM's Rajarshi Shahu College of Engineering
Pune, India

D. Sutar & P. Jagdane

Students
Dept. of Civil Engg.,
JSPM's Rajarshi Shahu College of Engineering
Pune, India

***Abstract*— Concrete is abundant manmade material in the world. One of the main ingredients in normal concrete mixture is Portland Cement (PC) depending on demand of PC the rate of cement increases day by day and it will affect cost of construction. However production of PC is also for increase in level of carbon-dioxide emission in environment. There is need to identify alternate material for cement. As fly ash & Granulated Blast Furnace Slag (GGBS) is waste product obtained by coal & steel industry respectively. Present work necessarily deals with the "Utilization of waste material in concrete".**

Total 45 tests were conducted with percentage variation of cement, GGBS & fly ash and test includes compressive strength test & Non-destructive test etc. It is observed from test results that partial and full replacement of cement with GGBS & fly ash is successfully possible whereas strength of geo-polymer concrete & conventional concrete shows similar behavior. Further it is noted that cost of geo-polymer concrete & conventional concrete is also nearly same.

***Keywords*— Geo-polymer, Fly ash, GGBS.**

I. INTRODUCTION

1.1 General

In order to create more sustainable world, Engineers and Scientist must need to develop and use a green building material. Waste material based concrete or Geo-polymer concrete is also much more durable than conventional concrete due to resistant to corrosion & it is also much stronger than conventional concrete.

In present work an attempt is made to study strength properties of waste material concrete based on GGBS & Fly ash. Use of conventional concrete is uneconomical in case of temporary structure as well as greater amount of CO_2 evolve from manufacturing process of cement which is adversely affect the environment. In order to fulfill its commitment to sustainable development of whole society, the concrete of tomorrow will not only be durable, but also should be developed to satisfy socio-economic need at the lowest environmental impact. The problem is related to environment & cost minimization but structural engineer will give solution by proper analyzing properties of concrete made by industrial waste material.

1.2 Materials:-

- Cement
- Fly ash
- Ground granulated blast furnace slag (GGBS)
- Superplasticizer
- Aggregates
  1) Fine Aggregate
  2) Coarse aggregate
- Chemicals
  1) Sodium Hydroxide
  2) Sodium Silicate

1.2.1 Fly ash:- Fly ash is a by-product of electric power generation that varies from source to source. This is one reason why Slag can be used in much larger amounts. Fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline), aluminium oxide (Al2O3) and calcium oxide (CaO) the main mineral compounds in coal-bearing rock strata. There are two types of fly ash (class f & class c). In this experiment, class F fly ash is used as binder material.

1.2.2 Ground Granulated Blast furnace Slag (GGBS):- GGBS is obtained by quenching molten iron blast furnace slag in water or Steam, to produce a glassy granular product that is then dried and ground into a fine powder. Silicate and aluminate impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag. In the case of pig iron production the flux consists mostly of a mixture of limestone and forsterite or in some cases dolomite.

Table1: Chemical composition of cement, fly ash & GGBS

Parameters	Formula	Cement (%)	Fly ash (%)	GGBS (%)
Lime	CaO	65	0.83	1.53
Silica	SiO_2	18	62.1	43.5
Alumina	Al_2O_3	7	27.44	12.5
Iron Oxide	FE_2O_3	4	4.57	1.3
Magnesia	MgO	2	0.55	1.5
Sulphur Trioxide	SO_3	3	0.4	-
Alkalies (Soda & Potash)	NA_2O & K_2O	1	0.04 & 1.17	0.9 & 0.6

*1.2.3 Superplasticizer:-*Superplasticizers are chemical admixtures used where well-dispersed particle suspension is

required. These polymers are used as dispersants to avoid particle segregation and to improve the flow characteristics of suspensions such as in concrete applications. This Investigation, a superplasticizer namely CONPLAST SP440 is used for geo-polymer concrete at low w/c ratio.

1.2.4 Chemicals:- In this present work chemical plays very important role. Sodium silicate and Sodium hydroxide liquid are obtained commercially from local suppliers.

(a)Sodium Hydroxide:-

It is an inorganic compound. It is a white solid and highly caustic metallic base and alkali salt of sodium which is available in pellets, flakes, granules, obtained from local suppliers and as prepared solution at a number of different concentrations Sodium hydroxide forms an approximately 50% (by weight)

These materials are available in aqueous solution and in solid form. The pure compositions are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities and it obtained from local suppliers The chemical composition of the sodium silicate solution was (Na2o=8%) , (Sio2=28%) and water 64% by mass.

II. LITERATURE REVIEW

2.1 Sunil. N. Manjunath, P. V. Sivapullaiah, M. Prasanna Kumar, In this paper the setting time of fly ash and the workability of mortar are examined with these replacements. In the present investigation, 25% and 50% of Cement (C) is replaced by fly ash; and 25%, 50%, 75% and 100% of Sand (S) by GGBS. Normal consistency and setting time increased with increasing replacement of cement with fly ash. The objectives of the research are to study effect of fly ash on cement and GGBS on sand. They are used in preparation of mortar with replacement materials. In this investigation, they are concluded that the normal consistency increases with increasing replacement of cement by fly ash along with increase in initial and final setting time and also use of CaCl2 effectively reduces the set time of all pastes.

2.2 Paras S.Pithadiya, Abhay V. Nakum, The objective of the present work is to study the effect of GGBS in fly ash based Geo-polymer concrete and to study the Effect of Oven Curing and Ambient room temperature curing on them. By replacing fly ash from 0 to 100% with GGBS and inspecting the Fresh Properties and Hardened Concrete properties at 7 days. They are concluded that with the variation in the parameters such as Na2SiO3/ NaOH Ratio, Molarity of NaOH, Curing temperature, Curing time makes the Variation in the Strength. Replacement of Fly ash by GGBS increases the Strength gradually without Oven curing provision and by using GGBS content can remove the problem of oven curing provision.

2.3 S. Arivalagan, The present paper is an effort to quantify the strength of ground granulated blast furnace slag (GGBS) at various replacement levels and evaluate its efficiencies in concrete. This research evaluates the strength and strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of GGBS for M35 grade of concrete at different ages. From this study, it can be concluded that, since the grain size of GGBS is less than that of ordinary portland cement, its strength at early ages is low, but it continues to gain strength over a long period and the degree of workability of concrete was normal with the addition of GGBS up to 40% replacement level for M35 grade concrete.

2.4 P. Vignesh, K. Vivek, In this paper an attempt is made to study strength properties of geo-polymer concrete using low calcium fly ash replacing with slag in 5 different percentages. Sodium silicate (103 kg/m3) and sodium hydroxide of 8M (41kg/m3) solutions were used as alkaline solution in all 5 different mixes. They concluded that the optimum replacement level of fly ash by GGBS in GPC will be carried out. Water absorption property is lesser than the nominal concrete and it can be achieved strength in a short time i.e. 70% of the compressive strength in first 4 hours of setting.

III. EXPERIMENTAL INVESTIGATION

3.1 Tests conducted

a) Compression test

b) Non-Destructive test

c) Rebound hammer

d) Ultrasonic pulse velocity

3.1.2 Rebound hammer Non-Destructive testing

Rebound hammer used to find out the compressive strength of concrete. The rebound is taken to be related to the compressive strength of the concrete. The rebound value is read from a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

3.1.3 UPV apparatus:

The ultrasonic pulse velocity (UPV) test instrument is used to examine the quality of concrete. It features online data acquisition, waveform analysis and full remote control of all transmission parameters. Along with the traditional transit time and pulse velocity measurement, the ultrasonic test equipment offers path length measurement, perpendicular crack depth measurement and surface velocity measurement. UPV tester is used for quality control and inspection of concrete. It measures the transit time of ultrasonic pulses through concrete for inspection of new and old structures, slabs, columns, walls, fire damaged areas, precast and pre-stressed beams, cylinders and other concrete forms.

3.1.4 Molarity:-

Amount concentration or substance concentration, is a measure of the concentration of a solute in a solution, or of

any chemical species, in terms of amount of substance in a given volume is called molar concentration or Molarity.

3.2 Testing of Material:-

The various test conducted on the material which is used in this experiment in order to find out quality, grading, before it is used in concrete mix.

The testing of various cementitious materials are as following.

Table 2: List of various tests conducted on materials

Sr.No	Type of Material	Type of test	Results
1	Cement	Fineness Test	277 m3/Kg
		Standard Consistency	30 %
		Setting Time Test	Initial = 158 minute
			Final = 258 minute
		Soundness test	0.78 mm
2	Aggregate	Crushing Test	12.15 %
		Grading Of Aggregate by Sive anlysis	Zone 2
		Flankiness & Elongation Test	5.43% & 4.47%
		Los Angels Abrassion Test	17.30%

3.3 Experimental Set-up :-

In this experiment, testing cube of conventional concrete and geo-polymer concrete were casted in various mix proportion. In mix design of geo-polymer concrete, the cement is partially as well as fully replaced by Ground Granulated Blast furnace Slag (GGBS) and Fly ash.

3.4 Test procedure:-

1) The material required for design of conventional concrete is taken and the properties of waste materials are checked thoroughly.
2) Design conventional concrete for M25 grade (1:2:4) according to Mix Design.
3) After that taking cubes of size of 150X150X150 mm. And casted concrete cubes as per. requirement with proper mixing, tamping and finishing
4) The cubes are kept in curing pond after 24 hrs and it kept in pond for further heat of hydration process. And then it was tested at the age of 3,7,28 days respectively by compression testing and NDT Test.
5) Then the Geo-polymer concrete cubes are casted with (GGBS 30%, Fly Ash 70%) as per above mixed design procedure with addition of Activated solution (sodium hydroxide 8M,sodium silicate) by weight of cementitious material used in mixed.
6) Then the cubes are tested at 3, 7 & 28 days respectively.
7) After that compared the result of compressive strength of conventional concrete with Geo-polymer concrete.

IV. RESULT AND DISCUSSION

4.1 Details of Test conducted

Table 3: Type of Test Conducted

Sr. no.	Name of Test	Size of Specimen (in mm)	No. Of Specimen
1	Compressive test	150x150x150	45
2	NDT Test		
	Rebound Hammer Test	150x150x150	45
	Ultrasonic Pulse Velocity	150x150x150	45
Total			135

4.2 Molarity:-

Amount concentration or substance concentration, is a measure of the concentration of a solute in a solution, or of any chemical species, in terms of amount of substance in a given volume is called molar concentration or Molarity.

4.3Test results

4.3.1Compressive strength Test (in N/mm2):-

Table 5: Compressive strength test results

Sr. No	Type of concrete	Duration in days		
		3	7	28
1	Conventional	11.49	19.22	26.20
2	Geo-polymer			
	GGBS=30% Fly ash=70%	12	20.04	29.26
	GGBS=40% Fly ash=60%	11.94	19.77	26.86
	GGBS=30% Fly ash=30% Cement=40%	12.22	14.94	26.70
	GGBS=50% Cement=50%	12.90	15.05	29.30

4.3.1.1 Overview of Compressive strength:-

Following chart shows compressive strength comparison of conventional concrete with fully and partially replaced geo-polymer concrete by compressive strength test. From graph it is observed that geo-polymer concrete gives greater strength than Conventional Concrete. However it shows that Geo-polymer is best alternative over a Conventional Concrete

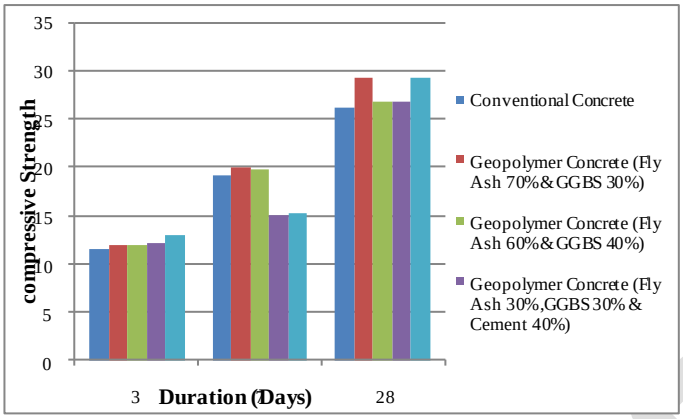

Fig1: Overview of compressive strength test comparison

4.3.2 Non Destructive Test:-

4.3.2.1Rebound Hammer Test (in N/mm^2):-

Table 6: Rebound hammer test results

Sr. No	Type of concrete	Duration in days		
		3	7	28
1	Conventional	5.206	16.74	28.08
2	Geo-polymer			
	GGBS=30% Fly ash=70%	3.407	17.64	30.68
	GGBS=40% Fly ash=60%	5.25	16.44	36.68
	GGBS=30% Fly ash=30% Cement=40%	7.904	17.10	34.13
	GGBS=50% Cement=50%	9.851	15.25	36.54

4.3.2.2 Overview of Non-Destructive Rebound Hammer Test:-
Following chart shows compressive strength comparison of conventional concrete with fully and partially replaced geo-polymer concrete by Non-destructive rebound hammer test. From this graph it is observed that compressive strength at 3 & 7 days of geo-polymer concrete of various proportions are less than conventional concrete, but at 28 day compressive strength is more than conventional concrete.

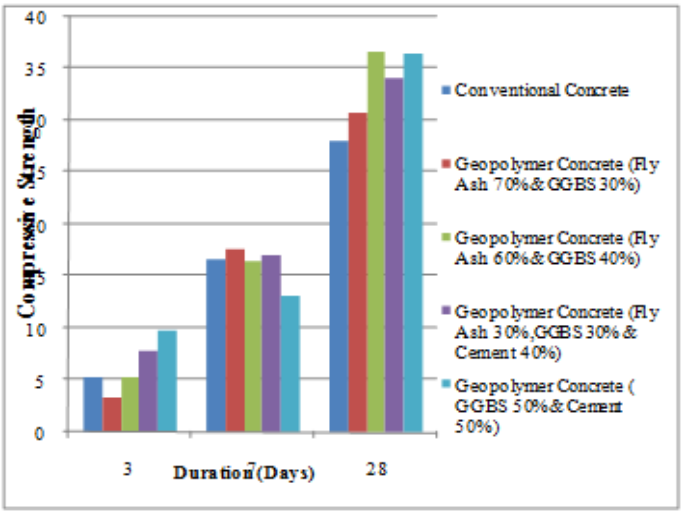

Fig 2: Overview of Non-destructive rebound hammer test comparison

4.3.2.3Result of Ultra Sonic Pulse Velocity:-

Cube No.	Distance (mm)	Time (µ.sec)	Velocity (km/sec)	Direction of probe	Concrete Quality	Duration (in days)
Conventional Concrete						
1	150	44.80	3.35	Direct	Medium	28
2	150	30.20	4.98	Direct	Excellent	
3	150	36.40	4.12	Direct	Good	
Fly Ash (70%), GGBS (30%)						
4	150	40.80	3.676	Direct	Good	28
5	150	42.40	3.53	Direct	Good	
6	150	40.20	3.73.	Direct	Good	
Fly Ash (60%), GGBS (40%)						
7	150	38.90	3.86	Direct	Good	28
8	150	41.40	3.62	Direct	Good	
9	150	39.80	3.96	Direct	Good	
Fly Ash (30%), GGBS (30%) , Cement (40%)						
10	150	40.20	3.73	Direct	Good	28
11	150	39.20	3.82	Direct	Good	
12	150	42.80	3.50	Direct	Good	
GGBS (50%) , Cement (50%)						
13	150	35.10	4.27	Direct	Good	28
14	150	36.90	4.06	Direct	Good	
15	150	34.90	4.29	Direct	Good	

4.3.2.4 Overview of Non-Destructive Ultra Sonic Pulse Velocity Test:-

The Non-Destructive Ultra Sonic Pulse Velocity Test defines the quality of Concrete based on velocity of pulse passes through the concrete specimen in interval of time. From the

test result it is observed that the quality of Geo-polymer concrete and Conventional is good. It proves that Geo-polymer can be used in quality work.

V. CONCLUSION

Based on experimental work carried out in present study, following conclusions are drawn

1) The compressive strength of conventional concrete and Geo-polymer concrete at 3, 7 & 28 days shows similar behaviour for partial replacement and full replacement of cement with GGBS & Fly ash.
2) Compressive strength observed from compressive strength test & Non-Destructive Rebound Hammer Test shows similar behaviour.
3) Quality of concrete tested from Non-Destructive ultra sonic pulse velocity test shows good performance for both geo-polymer concrete as well as conventional concrete.
4) Cost analysis is carried out to know economy of present work and it is observed that cost required for conventional concrete, geo-polymer concrete (fly ash 60% and GGBS 40%) & (fly ash 30%, GGBS 30% & cement 40%) is nearly same.

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