EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF GEOPOLYMER CONCRETE USING FOUNDRY SAND

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Abstract - *Geopolymer concrete is similar to conventional Portland cement concrete wherein Conventional Portland cement paste is replaced by geopolymer paste and the aggregate system basically remains the same. Usually Fly ash is used as a main binder material is Geopolymer concrete where as in this project GGBS (Ground Granulated Blast Furnace Slag) is used. Bagasse ash is used aa partial replacement for GGBS. Foundry sand from locally available foundries is used as fine aggregates. Alkaline solution used in this project is readily prepared and bought from a chemical company. The design mix used is M25 grade. This project, deals about the compressive strength, Split-tensile strength of various mix proportions of 0,5,10 and 15% of Bagasse ash for GGBS and their chemical compositions are analysed using XRD analysis. It is found that the replacement of GGBS with Bagasse ash gives reduction in strength for all proportions. Also found that, increase in the replacement of GGBS by Bagasse Ash gives decrease in the strength. The results show that Foundry sand can be replaced fully for fine aggregate in Geopolymer concrete.*

Keywords: ***GGBS, Geopolymer Concrete, Foundry sand, Bagasse Ash***

1. INTRODUCTION

The cement industry is one of the two largest producers of carbon dioxide (CO_2), creating up to % of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. The CO_2 produced for the manufacture of structural concrete (using ~14% cement) is estimated at 410 kg/m³ (~180 kg/ ton @ density of 2.3 g/cm³) (reduced to 290 kg/m³ with 30% fly ash replacement of cement). The CO_2 emission from the concrete production is directly proportional to the cement content used in the concrete mix.

Therefore, to reduce the pollution, it is necessary to reduce or replace the cement from concrete by other cementitious materials like Fly Ash, Ground Granulated Blast Furnace Slag, Metakaolin, silica fume etc., Geopolymers are gaining increased interest as binders with low carbon-di-oxide emission in comparison to Portland cement. Geopolymers also gain more engineering properties compared to cement. Use of cement globally adopted due to ease in operation, mechanical properties and low cost of production as compared to other construction materials. Production of Portland cement is increasing due to the increasing demand of construction industries. Therefore, the rate of production of carbon-di-oxide released to the atmosphere during the cement production of Portland cement is also increasing. Generally, for each ton Portland cement production, releases a ton of carbon di oxide in the atmosphere.

Geopolymer is an inorganic alumina silicate polymer synthesized from alkaline activation of various alumina - silicate materials of geological origin or by product materials like Fly ash, GGBS, metakaolin, etc., The polymerisation process involves a substantially fast chemical reaction of alumina silicate minerals under alkaline condition that results in a 3-D polymeric chain.

2. OBJECTIVE

- To study the mechanical properties of the geopolymer concrete under ambient curing.
- To study the characteristics of foundry sand as fine aggregate in Geopolymer concrete.
- To study the chemical compositions of the mixes with different proportions of Bagasse Ash.

3. MATERIALS

Table-1 Specific gravity

MATERIAL	QUANTITY (kg/m³)
GGBS	3.00
Bagasse ash	2.67
Foundry sand	2.5
Coarse Aggregate	2.7

Table-2 Sieve Analysis Result of Coarse Aggregate

IS Sieve No	Weight retained (g)	Cumulative weight	Cumulative percentage	Cumulative percentage
4.75 mm	0	0	0.00	100.00
2.36 mm	0	0	0.00	100.00

1.18 mm	58	58	11.60	88.40
700 microns	164	222	44.40	55.60
600 microns	90	312	62.40	37.60
300 microns	96	408	81.60	18.40
150 microns	74	482	96.40	3.60
Pan	14	496	99.20	0.80

The values obtained are conforming to Zone II as per IS 383:1970

Fineness modulus = sum of cumulative percentage retained / 100 **=** 2.73

Fineness Modulus = 2.73

4. MIX DESIGN

The following procedure is design mix for **M25** grade of Geo polymer concrete.

The following data are considered for mix design

Characteristic compressive

strength of GPC (f_{ck}) = 25 N/mm^2

Type of curing = Ambient Curing

Specific surface of GGBS = 385 m^2/kg

Solution to binder ratio = 0.55

Type of fine aggregate **(IS 383-1970)** = Foundry sand confirming to **ZONE IV**

The quantity of materials for 1m^3 are as follows

Table-3 Quantity of materials

MATERIAL	**QUANTITY (kg/m^3)**
Binder content	440
Fine aggregate	528.812
Coarse Aggregate	1282.18
Alkaline Solution	242
Solution to binder ratio	0.55

5. RESULT AND DISCUSSIONS

5.1 COMPRESSIVE STRENGTH

5.1.1 MIX -1 (CONTROL MIX)

In this mix proportion only GGBS is included. This mix is also called as control mix.

The quantity derived for 1m^3

Table-4 Mix proportion for Mix-1

	GGBS	**BAGASSE ASH**	**FOUNDRY SAND**	**COARSE AGGREGATE**	**ALKALINE SOLUTION**
QUANTITY	440	**-**	528.812	1282.18	242
PROPORTION	1		1.201	2.500	0.55

RESULTS OBTAINED

Table- 5 Compressive Strength for 100% GGBS at 7 days

LOAD (kN)	**SIZE (mm)**	**COMPRESSIVE STRENGTH (N/mm^2)**
725	150x150	32.20
705	150x150	31.33
759	150x150	33.73
AVERAGE		32.42

RESULTS OBTAINED

Table- 6 Compressive Strength of 100% GGBS at 28 days

LOAD (kN)	**SIZE (mm)**	**COMPRESSIVE STRENGTH (N/mm^2)**
930	150x150	41.33
924.3	150x150	41.08
941.3	150x150	39.77
AVERAGE		41.41

5.1.2 MIX -2

This mix is inclusive of 5% of bagasse ash with GGBS.

The quantity derived for 1m^3

Table- 7 Mix proportion for 5% Bagasse ash

	GGBS	BAGASSE ASH	FOUNDRY SAND	COARSE AGGREGATE	ALKALINE SOLUTION
QUANTITY	418	22	528.812	1282.18	242
PROPORTION	1		1.201	2.500	0.55

RESULTS OBTAINED

The following results are obtained at **7 days** of ambient curing

Table- 8 Compressive Strength of 5% Bagasse Ash at 7 days

SIZE (mm)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
150x150	643	28.57
150x150	740	32.80
150x150	641	28.48
AVERAGE		29.95

RESULTS OBTAINED

The following results are obtained at 28 **days** of ambient curing

Table- 9 Compressive Strength of 5% Bagasse Ash at 28 days

SIZE (mm)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
150x150	896	39.71
150x150	885	39.35
150x150	878	39.00
AVERAGE		39.37

5.1.3 Mix-3

This mix is inclusive of 10% of bagasse ash with GGBS.

The quantity derived for 1m³

Table-10 Mix proportion for 10% Bagasse ash

	GGBS (kg)	BAGASSE ASH (kg)	FOUNDRY SAND (kg)	COARSE AGGREGATE (kg)	ALKALINE SOLUTION (kg)
QUANTITY	396	44	528.812	1282.18	242
PROPORTION	1		1.201	2.500	0.55

RESULTS OBTAINED

The following results are obtained at **7 days** of ambient curing

Table- 11 Compressive Strength of 10% Bagasse Ash at 7 days

SIZE (mm)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
150x150	618	27.46
150x150	643	28.68
150x150	510	22.67
AVERAGE		26.93

RESULTS OBTAINED

The following results are obtained at **28 days** of ambient curing

Table-12 Compressive Strength of 10% Bagasse Ash at 28 day

SIZE (mm)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
150x150	768	34.68
150x150	720	32.00
150x150	672	29.86
AVERAGE		32.18

5.1.4 Mix-4

This mix is inclusive of 15% of bagasse ash with GGBS.

The quantity derived for 1m³

Table- 13 Mix proportion for 15% Bagasse ash

	GGBS (kg)	BAGASSE ASH (kg)	FOUNDRY SAND (kg)	COARSE AGGREGATE (kg)	ALKALINE SOLUTION (kg)
QUANTITY	374	66	528.81	1282.18	242
PROPORTION	1		1.201	2.500	0.55

RESULTS OBTAINED

The following results are obtained at **7 days** of ambient curing

Table-14 Compressive Strength of 15% Bagasse Ash at 7 days

SIZE (mm)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
150x150	513	22.80
150x150	579	25.73
150x150	622	27.67
AVERAGE		25.40

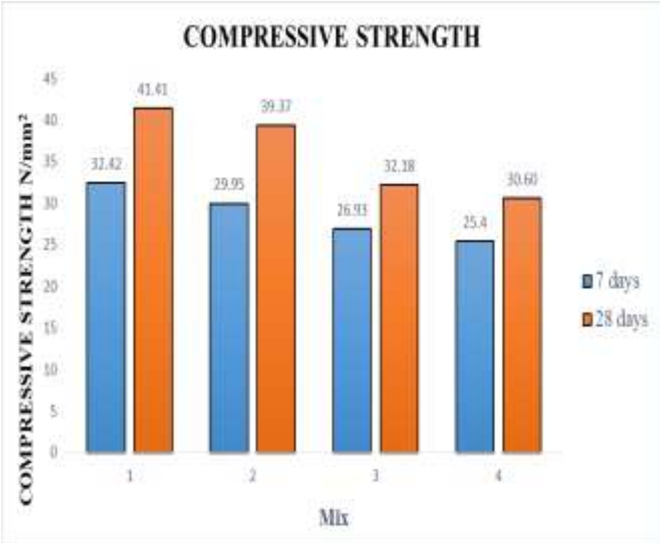
RESULTS OBTAINED

The following results are obtained at **28 days** of ambient curing

Table-15 Compressive Strength of 15% Bagasse Ash at 28 days

SIZE (mm)	LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
150x150	596	26.48
150x150	696	30.93
150x150	774	34.40
	AVERAGE	30.60

Graph – 1 Compressive Strength



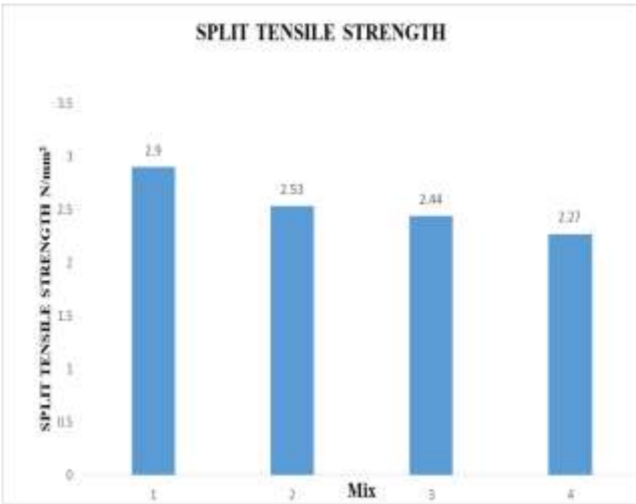
5.2 SPLIT- TENSILE STRNGTH

The following results are obtained at **7 days** of ambient curing

Table-16 Split Tensile Strength at 7days

MIX	LOAD (kN)	SPLIT TENSILE STRENGTH (N/mm²)
Mix-1	205	2.90
Mix-2	179.1	2.53
Mix-3	172.9	2.44
Mix-4	160.9	2.27

Graph – 2 Split Tensile Strength



6. XRD RESULTS

Based on the XRD results

- The chemical compound quartz (SiO_2) is commonly present in all the samples. Since the presence of this chemical compound the geopolymer concrete attains very high strength. The amount of quartz present in the samples are given below

Mix-1	Mix-2	Mix-3	Mix-4
38%	36%	37%	30%

- Since the bagasse ash has less Calcium content, it lacks in binding property and also it does not contribute sufficient enough for attaining strength. So, if the proportion of bagasse ash increases the strength decreases.
- As a filler material, it contributes towards achieving strength properties.
- Foundry sand is rich in chemical and mineral compounds; Therefore, it plays a major role in achieving the strength.

7. CONCLUSIONS

- The results show that the compressive strength of the partially added bagasse ash in all three mix proportions are decreases compared to the control mix. Therefore, if the proportion of the bagasse ash increases the strength decreases. In this project concrete workability is high. So, if the increase in alkaline solution workability increases and also the setting time decreases. But all the mixes are achieving the characteristic compressive strength.

- Based on XRD results, bagasse ash having less content of Calcium so, the strength of the mix which including of bagasse ash decreases.

- Foundry sand plays an important role in attaining the strength of geopolymer concrete and it can be replaced fully instead of fine aggregate.

8. REFERENCES

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