Feasibility Analysis of use of Bagasse Ash for the Production of Geo Polymer Concrete

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***Abstract*— Geo polymer is a amalgam of waste products with alkaline solution to form useful product. A Geo polymer Concrete is characterized by its ecofriendly nature. This paper is intended to understand the use of bagasse ash in Geo polymer Concrete.**

Bagasse ash is a by-product from sugarcane industry , which is widely available in the world. Moreover , the use of bagasse ash is more environmental friendly which reduces the final cost of Geo polymer Concrete. Bagasse ash is a rich in silicate and alumina, hence react with alkaline solution to produce aluminosilicate gel which will bind the fine and coarse aggregate in a suitable manner, which also provide good resistance against adverse conditions.

An attempt has been made to check the possibility of reuse of bagasse ash in Geo polymer Concrete by investigating compressive strength of M25 grade plain concrete and flexural behavior of RC member for 25 and 30 percent replacement by bagasse ash.

Keyword: Bagasse ash, Geo polymer Concrete, Alkaline solution, Air curing.

I. INTRODUCTION

The cement is one of the extensively using material in construction industry. With infrastructure development growing and housing sector booming, the demand for cement is also bound to increase. However, the cement industry is extremely energy intensive and consumes about 4GJ per tonne of energy. After thermal power plants and iron and steel sector, the Indian cement industry is third largest user of coal in the country. Production of one tonne of cement requires about two tonnes of raw materials (shale and limestone) and releases 0.87 tonnes (≈1 tonne) of carbon di-oxide, 3 kg of nitrogen oxide, an air contaminant that contributes ground level smog and 0.4 kg of PM_{10} (particulate matter of size 10 µm), an air borne particulate matter that is harmful to the respiratory track when inhaled. The global release of CO_2 from all the sources is estimated at 23 billion tonnes a year and the Portland cement production accounts for about 7%of total CO_2 emission. The cement industry has been making significant progress in reducing CO_2 emissions through improvements in process technology and enhancement in process efficiency, but further improvements are limited because CO2 production is inherent to the basic process of calcinations of limestone. Mining of limestone has impact on land use patterns, local water regimes and ambient air quality and thus remains as one of the principal reasons for the high environmental impact of industry. Dust emissions during cement manufacturing have long been accepted as one of the main issues facing the industry.

The cement industry does not fit the contemporary picture of a sustainable industry because it uses raw materials and energy that are non-renewable; extracts its raw materials by mining and manufactures a product that cannot be recycled. Through waste management, by utilizing the waste by-products from thermal power plants, fertilizers unit and steel factories, energy used in the production can be considerably reduced. This cuts energy bills raw material cost as well as greenhouse gas emission. In the process it can turn abundantly available waste into valuable products, such Geo polymer concretes.

'Geo polymer concretes (GPC) are inorganic polymer composites, which are prospective concretes with the potential to form a substantial elements of an environmentally sustainable construction by replacing/supplementing the conventional concretes. GPC have high strength, with good resistance to chloride penetration, acid attack, etc. These are commonly formed by alkali activation of industrial aluminosilicate waste material such fly ash and ground granulated blast furnace slag, and have a very small greenhouse footprint when compared to traditional concretes.

II. LITERATURE REVIEW

M. I. Abdul Aleem et al made an attempt to find out an optimum mix for Geo polymer concrete and they have casted concrete cubes of size 150 x 150 x150 mm and cured under steam curing for 24 hours. The compressive strength was found out at 7 days and 28 days results are compared. The optimum mix is fly ash: fine aggregate: coarse aggregate (1:1.5:3.3) with a solution (NaOH and Na2SiO3combined together) to fly ash ratio of 0.35. High and early strength was obtained in the Geo polymer concrete mix.

Mahadeshwaran C. K et.al studied the variation of strength for different grades of Geo polymer concrete by varying the molarities of Sodium hydroxide. Different molarities of NaOH (3M, 5M, 7M) are taken to prepare different mixes and cured in the ambient temperature. GPC mix formulations with compressive strength ranging from15 to 52 MPa have been developed. The specimens are tested for their compressive strength at the age of 7 and 28 days. The compressive strength of GPC increased with increasing concentration of NaOH. The GPC produced for different combination of FA and GGBS are able to produce structural concrete of higher grade by self-curing only

T. V. Srinivasmurthy et.al have replaced fully OPC by GGBS and alkaline liquids are used as the binding materials. They have casted cubes, cylinder and prisms to determine the strength properties. The curing is carried out in oven at 65º C and carried out the tests. The results are compares with conventional concrete. Thus higher the concentration of NaOH and higher the ratio of NaOH to Na2SiO3 higher is the compressive strength of GGBS based GPC. To improve the workability addition Naphthalene sulphonate based super plasticizer of about 4% of the binding material (GGBS) mass is used. The test results shows the use of GGBS based GPC the compressive, split, flexural strength increased by 13.82%, 18.23%, 30.19% as compared to conventional concrete.

III. MATERIALS

The properties of the following materials were determined as listed below

Ground Granulated Blast Furnace Slag (GGBS):

It is a by-product of the steel industries blast furnace slag is defined as "The non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with ironin a blast furnace. The percentage of GGBS passing through 45 micro meter IS sieve was found to be 97% and specific gravity 2.7.

Bagasse Ash(BA):

It is a by-product of sugarcane industry, it is collected and pass through 150µm IS sieve. Its specific gravity found to be 0.32.

Sodium Hydroxide(NaOH):

Sodium hydroxide flakes used in this investigation is of commercial grade with 97% purity.

Sodium Silicate Solution(Na_2SiO_3):

Sodium silicate solution flakes used in this investigation is of commercial grade with 97% purity.

*Fine Aggregate (*FA): M-SAND:

Manufactured sand confirms **GRADE-II** from sieve analysis test. With specific gravity 2.56 is fineness modulus found to be 2.55 its loose density found to be 1620.kg/m^3 and its dry compacted density was found to be 1842 kg/m^3.

Coarse Aggregate (CA):

Coarse aggregate used is of 10mm down sized and its specific gravity was found to be 2.77. It also passed the test of aggregate impact value and aggregate crushing value.

A. *PHYSICAL ANALYSIS OF BAGASSE ASH*

Mineralogical analysis of bagasse ash was carried out by EDX analysis, its results shows fallowing fig 1. (a), (b), (c) .

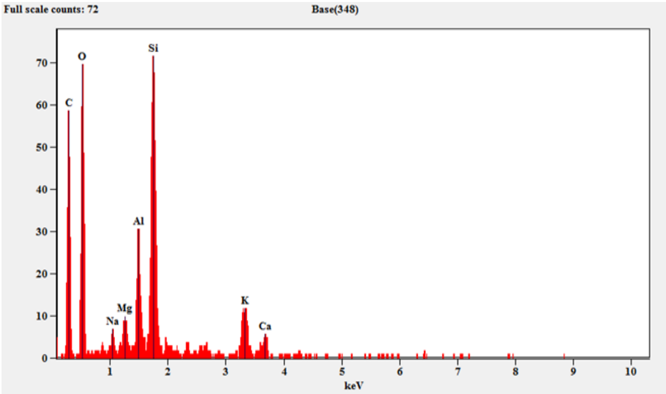
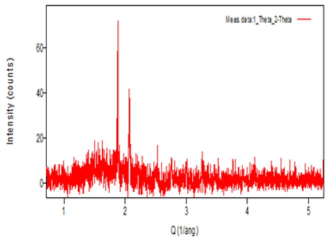


Fig 1(a). EDX analysis result



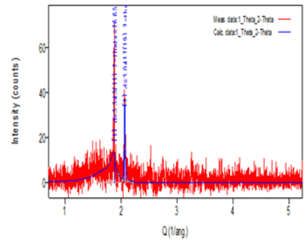


Fig 1(b). XRD analysis results Fig 1.(c)

Element Line	Weight %	Weight % Error	Atom %
C K	52.51	± 2.00	63.18
O K	32.25	± 2.33	29.13
Na K	1.05	± 0.25	0.66
Mg K	1.25	± 0.15	0.74
Al K	2.83	± 0.20	1.52
Si K	7.19	± 0.41	3.70
Si L	---	---	---
K K	1.99	± 0.37	0.74
K L	---	---	---
Ca K	0.93	± 0.18	0.33
Ca L	---	---	---
Total	100.00		100.00

Table 1.Chemical composition of Bagasse ash

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IV. METHODOLOGY

MIX DESIGN

There is no particular code which governs the mix design of Geo polymer concrete. In the present study, Rangan method guidelines were followed to calculate the quantity of different constituent material required to cast concrete specimens. Quantity of materials required for M25 grade of Geo polymer concrete were calculated with 25% and 30% of replacement by Bagasse ash.

A. Preparation of Materials

When Bagasse ash brought from the industry, it was passed through the 150µm IS sieve and then used for the replacement in concrete.

NaOH solution of required molarity was prepared. In this study 5M concentration was adopted and the solution was kept for 24 hours. Na_2SiO_3 and NaOH solutions were mixed in suitable proportion in order to obtain the gel .

Fig 2. Mixing of NaOH and Na_2SiO_3

B. Batching, Mixing and Casting

In this study, weigh batching was adopted. CA and FA were weighed to an accuracy of 0.5g. On a water tight platform CA, FA, GGBS and BA were mixed thoroughly. Then NaOH and Na_2SiO_3 mixture was added to the mix fallowed by water and continued mixing process until obtaining a good workable concrete mix. After performing the suitable workability test, the concrete mix. After performing the suitable workability test, the molds were filled with mix and get vibrated on table vibrator. After 24 hours remolded the specimens and kept to air curing for 28dsays i.e.., no water curing is necessary. Entire specimens were tested in the laboratory of NIE Mysore.

Fig 3(a). Weigh batching

Fig 3(b). Mixing of materials

C. Compressive Strength Test

Compressive strength is one of the important property of concrete which forms a basic property for analysis and calculations . For this test, cubes of dimension 150x150x150mm were casted and cured. These cubes were tested on Compressive testing machine as per IS 516-1959. Failure load was noted. Three cubes were tested for each test period and their average was reported

Fig 4(a). Testing of Cube

Fig 4(b). Failure of cube

D. Flexural Strength of Rc Beam

Flexural strength is one measure of the tensile strength of concrete. It is measured by loading a RC beam of size 150 x150x1100mm on Universal Testing Machine as per IS 516-1959. Failure load was noted.

Fig 5. Casting of RC beam

E. Trial Mix of M25 Grade Geo Polymer Concrete

The GPC mix designed used in this study was based on Rangan method for M25 grade of concrete. The alkaline to binder ratio is taken as 2.5and molarity of sodium hydroxide is taken as 5M. While rest of the component are varied according to the requirements of optimization method.A sample calculations for a mix design using Rangan method is shown in Table 2 and 3.

MIX PROPOTION FOR ONE METER CUBE OF GPC OF 25% BUGASSE ASH	
Sodium silicate solution	192.85 kg
Sodium hydroxide solution	77.14 kg
Extra water required	118.8 kg
GGBS	337.50 kg
Bagasse ash	112.50 kg
Fine aggregate(M-Sand)	774.55 kg
Coarse aggregate	1047.6 kg

Table 2.For 25% replacement by bagasse ash

MIX PROPOTION FOR ONE METER CUBE OF GPC OF 30% BUGASSE ASH	
Sodium silicate solution	180 kg
Sodium hydroxide solution	90 kg
Extra water required	259 kg
GGBS	315 kg
Bagasse ash	135 kg
Fine aggregate(M-Sand)	774.55 kg
Coarse aggregate	1047.6 kg

Table 3.For 30% replacement by bagasse ash

F. *Comparison of Density of Gpc Concrete with OPC Concrete*

GPC with Bagasse ash concrete mix

	1	2	3	4	5	6
Cube weight (kg)	7.760	7.652	7.615	7.625	7.765	7.682

Table 4.Weight of GPC mix cube

OPC concrete mix

	1	2	3	4	5	6
Cube weight (kg)	8.415	8.385	8.430	8.445	8.405	8.515

Table 5.Weight of OPC mix cube

Density of concrete mix= weight / volume

For GPC mix :Average weight= 7.683 kg

Volume of cube = 3.375×10^{-3} m^3

.`. Density= 7.683 / 3.375×10^{-3} kg/ m^3

= 2276.44 kg/ m^3

For OPC mix : Average weight= 8.432 kg

.`. Density=8.432 / 3.375×10^{-3} kg/ m^3

=2498.37 kg/ m^3

V. EXPERIMENTAL RESULTS

Compressive Strength of Cubes

Below table is showing the results obtained from compressive strength testing at 7 days curing.

Table 6. Compressive strength in cubes for 7 days curing M25 grade (Room Temperature)

% of Replacement by Bagasse ash	Trial No	Time of testing	Weight of cubes (Kg)	Compressive strength (N/mm^2)	Avg. Compressive Strength (N/mm^2)
25%	1.	7 days	7.652	26.22	26.66
	2.	7 days	7.760	27.11	
30%	1.	7 days	7.900	28.00	28.22
	2.	7 days	8.024	28.44	

A. *Flexural Strength of Rc Beam*

Grade Of Concrete	Mix Combination	Alkaline Ratio	Flexural Strength N/Mm^2	Flexural Strength As Per Is 456 N/Mm^2
M25	0% Bagasse ash	1:2.5	3.40	3.5
	25% Bagasse ash	1:2.5	3.87	

Table 7: Flexural strength of RC beam at 28 days

VI. CONCLUTIONS

- This investigation has enhanced the use of Bagasse ash as partial replacement for GGBS in Geo polymer concrete.
- GPC with bagasse ash concrete achieves about more than 95% of compressive strength at 7 days
- This investigation also evident for good flexural strength of RC beam.
- Density of this GPC mix is lesser than normal mix and hence self-weight of the member can be reduced.
- The utilization of bagasse ash in concrete solves the problem of its disposal thus keeping the environment free from pollution.

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