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Behavior of Geopolymer Concrete Columns Subjected to Biaxial Loading

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Abstract - *Column is compression member. It is mainly subjected to the axial forces but it carries moments also. The moments due to axial forces, uniaxial forces or biaxial loading. This study gives a look on biaxial loading of geopolymer concrete columns and conventional concrete columns. The behavioral comparison between geopolymer concrete columns and conventional concrete columns is shown. The 12 numbers of columns were casted. 6 numbers of geopolymer concrete and 6 numbers of conventional concrete the steel percentages is variation are 0.893%, 1.787%, 1.396%, 2.729%, 2.291% and 2.01%. The column size is 150X150X1000 mm. The columns were tested in loading frame. The eccentricity is kept constant i.e. 25mm in x-axis and 25mm in y axis. The testing of column is done. The load and deflection is recorded. The failure behavior of geopolymer column is similar to the conventional concrete column under biaxial loading. But geopolymer concrete columns behave well in compare to the conventional concrete columns. Geopolymer concrete columns taken load average 1.18 times the load taken by conventional concrete columns. The deflection is also noticed less in geopolymer concrete column than conventional concrete columns. Thus the geopolymer concrete columns resulted in good connection with the test results compare to the conventional concrete columns.*

Key Words: **Geopolymer concrete, Biaxial Loading of column**

1. INTRODUCTION

As per study, the production of 1ton cement realises same or bit lesser amount of carbon-di-oxide. It has seen that carbon-di-oxide content from cement industry is in high amount, which tends to global warming and also air pollution. To overcome this problem the new concrete is introduced is called Geopolymer Concrete. In Geopolymer concrete the binder materials from Ordinary Portland Cement is replaced by the by-products from the industries. There are many materials that can be replaced for Ordinary Portland Cement are Fly ash, Ground granulated blast furnace slag or clay also. The Geopolymer concrete mix has ingredients are Fine Agg., Coarse Agg., GGBS, Fly ash, Sodium Hydroxide, Sodium Silicate and Water. This study includes mix design of Geopolymer concrete, As well as biaxial loading of reinforced column of Portland cement concrete and Geopolymer concrete and also the comparison between the behaviour of OPC concrete and GPC concrete. Biaxial loading of concrete of column is the column having axial load acting in such a way that the load is eccentric about both the axis, in plane of column which produces the moment in both the direction x and y. The percentage of steel in all 6 columns are different, so this study incudes that the behaviour of the reinforced concrete columns with different percentages of steel are subjected to biaxial loading. And also the behavioural comparison between the Ordinary Portland Cement concrete columns and Geopolymer concrete columns. So after this experimental study, able to do mix design of geopolymer concrete and OPC concrete, Biaxial loading results of concrete column and comparison between the Geopolymer concrete column and Ordinary Portland cement concrete columns.

2 OBJECTIVES

The objectives of this experimental study are as follows,

- To study the fresh concrete properties of geopolymer concrete.
- To study the hardened concrete properties of geopolymer concrete.
- To study the behavior of geopolymer reinforced concrete columns subjected to biaxial loading.
- Comparison between the geopolymer concrete reinforced columns and ordinary Portland cement reinforced columns with different percentage s of the steel.

3 SUPPLEMENTARY PRODUCTS FOR CEMENT

3.1 FLY ASH

By-product of coal fire power station is called Fly ash. It is used for partial or fully replacement of cement in standard concrete mixes. It is aim to Geopolymer concrete to reinstate Ordinary Portland Cement with binder material. It is observed that more than billions of tons of fly ash is presently exhibit in the world with the rate of use is 20%. From the Coal Fire Power Station fly ash is accumulated all over the universe for concrete mix. The fine powder of fly ash is generated after it feeding in to the mills. Then the fine powder is blazed in boiler to generate steam required for

production of power. During this action, they form in shape of sphere of calcium silicate in nature.
There are two types of fly ash are available worldwide. Those types are depend on the content of calcium. Two types are,

- Class C- type fly ash
- Class F- type fly ash

If the percentage of calcium is less than 8% are called Class C- type fly ash. And if the percentage of calcium is more than 8% are called Class F- type fly ash.

3.2 GGBS

GGBS is also another by-product from the iron industries. Ground Granulated Blast Furnace slag is generally utilized to minimum heat hydration combat abrasion draining from ground water or resist other contrary environmental conditions. GGBS is produced during steel production, while iron ore, coke and flux are excited to melting point in blast furnace. After melting point process completed, remains of melting materials are gather and cooled rapidly. This melted material contains the flow of the aluminates and silicate of ore and coke ash which have been chemically fused to form blast furnace slag the slag is then cooled and ground furnace can be use.

Table -1: Mix Design of Conventional concrete

Cement	425 kg/m^3
Water	192 lit/m^3
Fine agg	588.53 kg/m^3
Coarse agg.	1235 kg/m^3

Table -2: Mix Design of Geopolymer concrete

Fine Agg	720 kg/m^3
Coarse Agg	1080 kg/m^3
Fly Ash	69 kg/m^3
GGBS	276 kg/m^3
Sodium Hydroxide	54 kg/m^3
Sodium Silicate	135 kg/m^3
Water	28.03 kg/m^3

4. METHODOLOGY

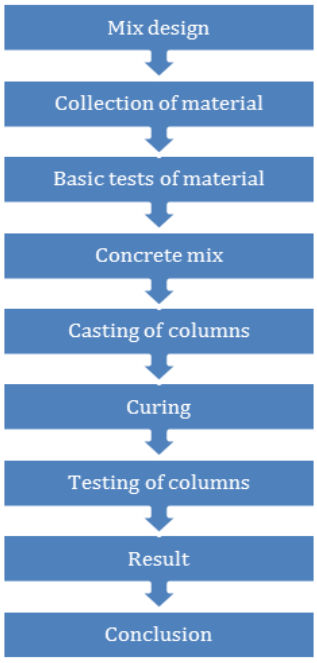

Chart -1: Methodology

5 TEST RESULTS OF BIAXIAL LOADING OF COLUMN

5.1 TEST COLUMN SPECIMENS

12 numbers of columns were tested for this experimental study. In those 12 numbers columns 6 columns are made up of conventional concrete and remaining 6 columns are made of geopolymer concrete. The column size is 150 X 150 X 1000 mm. The column numbers are for conventional concrete columns are NC1, NC2, NC3, NC4, NC5 and NC6 and the column numbers for geopolymer concrete columns are GC1, GC2, GC3, GC4, GC5 and GC6.

The percentage of the steel is varied. There are 6 numbers of percentages were used for casting of RC columns as follows,

Table -2: Mix Design of Geopolymer concrete

COLUMN	PERCENTAGES OF STEEL PROVIDED	REINFORCEMENT DETAILS
NC1& GC1	0.893%	4 numbers of 8 ø bars
NC2& GC2	1.787%	8 numbers of 8 ø bars
NC3& GC3	1.396%	4 numbers of 10 ø bars
NC4& GC4	2.792%	8 numbers of 10 ø bars
NC5& GC5	2.291%	4 numbers of 8 ø bars 4 numbers of 10 ø bars
NC6& GC6	2.01%	4 numbers of 12 ø bars

5.2 TEST RESULTS

COLUMN	% OF STEEL PROVEIDED	MAXIMUM LOAD	DEFLECTION AT MAXIMUM LOAD
NC1	0.893%	539	5.75
GC1	0.893%	582	5.25
NC2	1.787%	654	4.05
GC2	1.787%	719	3.6
NC3	1.396%	599	4.25
GC3	1.396%	669	4.8
NC4	2.792%	892	3.75
GC4	2.792%	964	3.30
NC5	2.291%	777	3.9
GC5	2.291%	852	3.55
NC6	2.01%	702	4.25
GC6	2.01%	789	3.8

5.3 COMPARISON OF RESULTS

The graphical comparison of test results for biaxial loading of columns of geopolymer concrete and conventional concrete columns with the respective percentages of steel provided.

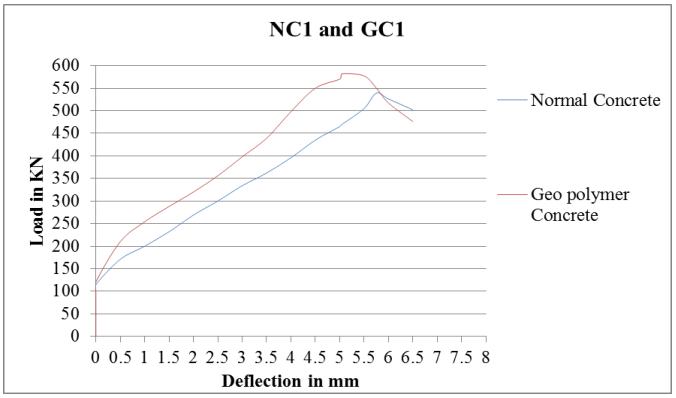

Chart -2: Comparison of NC1 and GC1

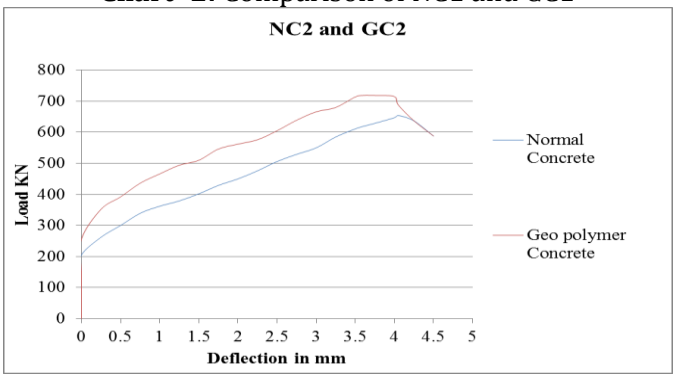

Chart -3: Comparison of NC2 and GC2

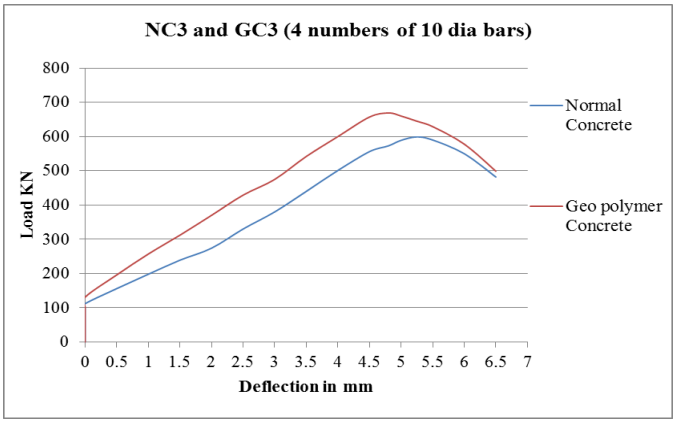

Chart -4: Comparison of NC3 and GC3

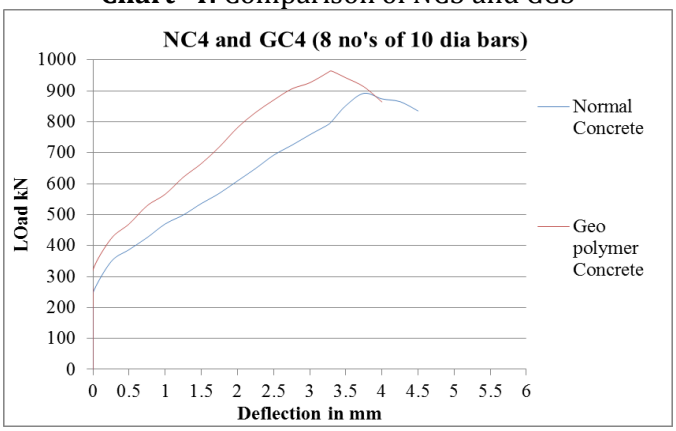

Chart -5: Comparison of NC4 and GC4

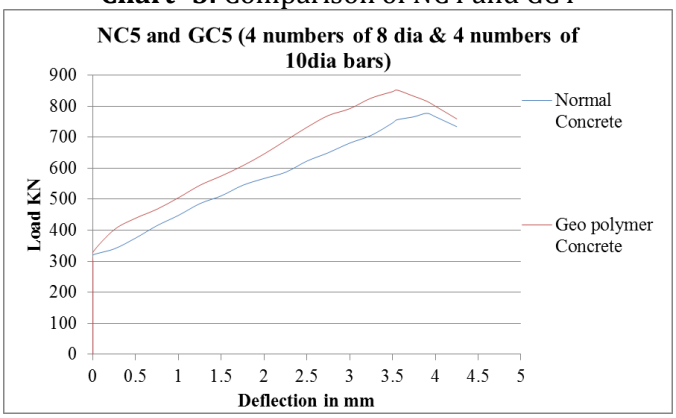

Chart -6: Comparison of NC5 and GC5

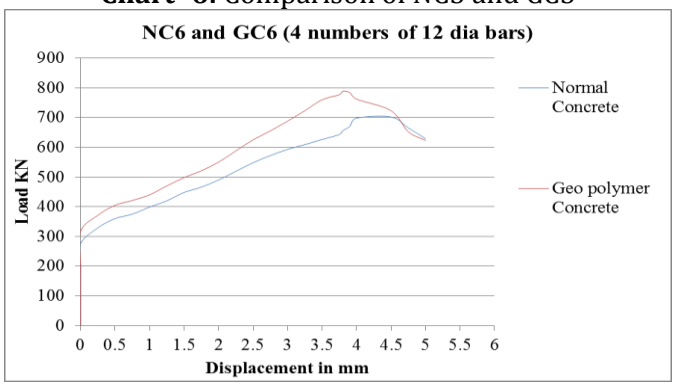

Chart -7: Comparison of NC6 and GC6

CONCLUSIONS

The comparative behavioral experimental study on the conventional concrete and geopolymer concrete has been done. Six numbers of conventional concrete columns and six numbers of geopolymer concrete columns were tested under biaxial loading with same eccentricity i.e. 25mm in x axis and 25mm in y axis. Six different percentages of steel for each column of geopolymer concrete columns and conventional concrete column has been studied.

The overall load-deflection and failure behavior of column is studied. After the testing of column it has highlighted that the load taken by geopolymer concrete column is more compared to conventional concrete. The failure behavior of geopolymer column is similar to the conventional concrete column under biaxial loading. But geopolymer concrete columns behave well in compare to the conventional concrete columns. Geopolymer concrete columns taken load average 1.18 times the load taken by conventional concrete columns. The deflection is also noticed less in geopolymer concrete column than conventional concrete columns. Thus the geopolymer concrete columns resulted in good connection with the test results compare to the conventional concrete columns.

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