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STUDY ON THE BEHAVIOUR OF FLY ASH/SLAG BLENDED ALUMINA SILICATE CONCRETE UNDER AMBIENT CURING

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Abstract: Construction has been the most important human activity since ancient time. Concrete is widely used and reliable material for construction. Some of challenges in industry are global warming and insufficiency of construction material. One of the novel materials which replaces to conventional concrete is the Alumina Silicate Concrete. This research article outcomes the results of an experimental investigation on strength characteristics alumina silica concrete produced with Fly ash (Class – F Grade) and GGBS (Granulated Blast furnace Slag) and alkaline activators under ambient temperature. Fly ash was partially replaced by GGBS at different replacement levels from 0 to 50% with a standard concentration of 12M and the samples are cured at ambient temperature. The main parameters of the study are strength properties of Compressive strength test are also conducted. Alumina Silicate Concrete blended with fly ash and GGBS shows better results when compared to fly ash (100%) Alumina Silicate Concrete.

***Keywords* - Fly Ash, GGBS, Geopolymer concrete, Strength Parameters.**

I. Introduction

Concrete is the world's most versatile, durable and reliable construction material. It is one of the most widely used construction material, which is associated with Portland Cement. It is one of the leading components for making concrete. On the other hand, the demand for concrete increases rapidly daily due to the rapid increase of construction of various buildings in worldwide. Alumina silicate concrete or geopolymers has been emerging as a new material for better alternate material to cement in the Construction Industry. Geo-polymers produce the green environment and also possesses good characteristics same as that of cement considerably reducing low CO2 liberation. Geo-polymers are synthesized by mixing alkali oxides with alumina – silica materials. The material can be produced in temperature cured or in room temperature. The ingredients required for the manufacture geopolymers are clay/metakaolin. Studies are being undertaken recently by using the industrial waste materials and utilizing them.

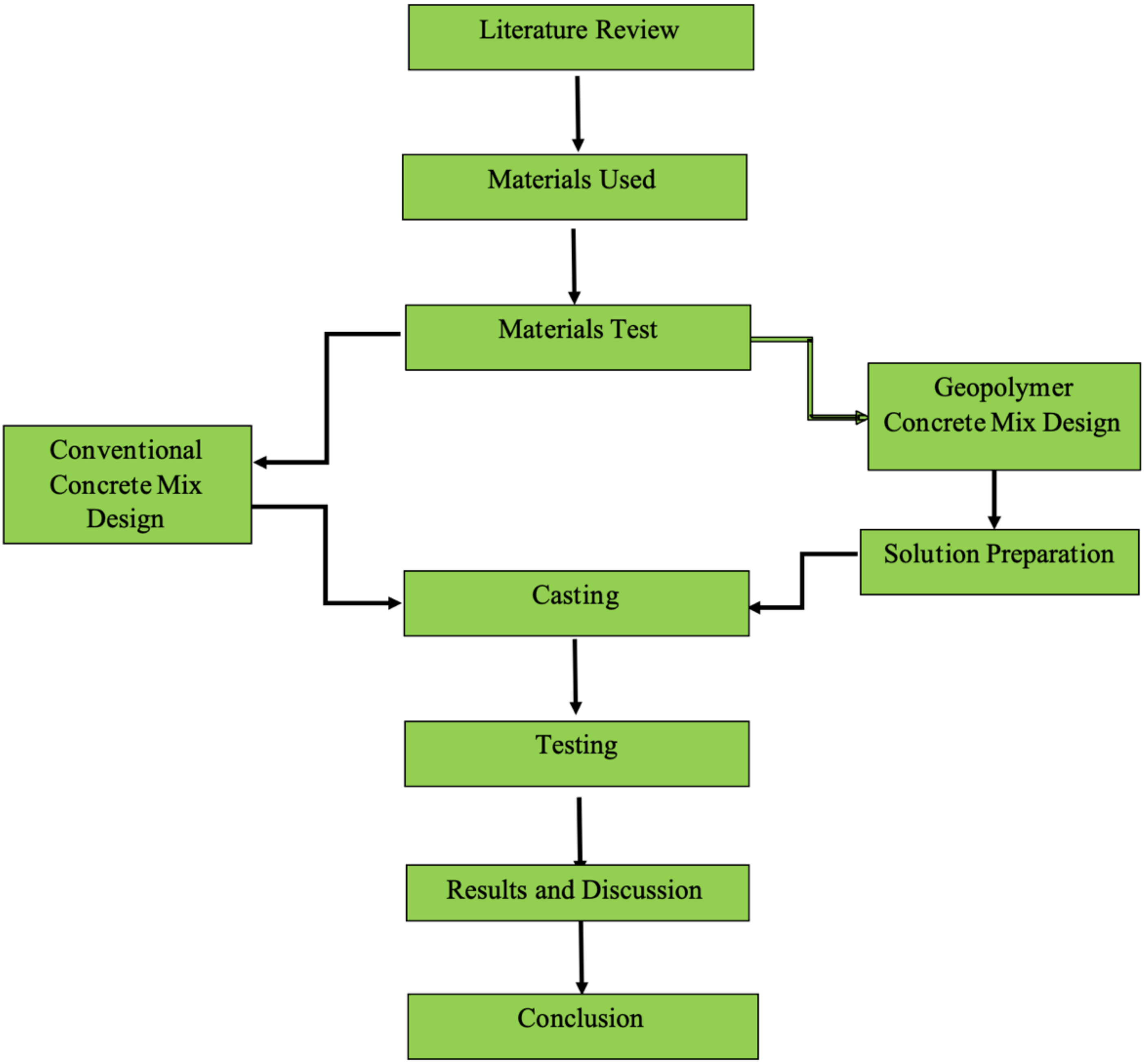
Pattanapong Topark-Ngarm et al., [21] stated that early strength high calcium geopolymer is being influenced by high curing temperature. E. Arioz et al., [7] observed that FTIR and XRD had shown the geo-polymeric structure successfully and in the SEM image, unreacted fly ash particles were seen. Neetu Singh et al., [18] concluded that geopolymer concrete possesses excellent mechanical and durability properties for aggressive environment when compared to Ordinary Portland Cement. André Miranda da Silva et al., [3] observed that sulfuric acid solution is more aggressive to geo-polymeric materials when compared to hydrochloric acid solution where large mass is lost. Shamsul Bashir et al., [32] noted that geopolymer concrete showed more resistance to sulphate when compared to conventional concrete. J. Guru Jawahar et.al., [8] observed that percentage of reduction in weight, compressive strength and pulse velocity values had decreased with increase in replacement of GGBS content during acid resistance tests. Ajay Takekar et.al., [2] observed that rate of gain of compressive strength, split tensile strength and flexural strength was rapid at 7 days curing period and the rate had reduced with age. They also observed that on increase in GGBS content, compressive strength, split tensile strength and flexural strength was also high due to the reason that GGBS achieves more strength. Ramamohana B et.al., [2] found out that the synthesis of GGBS and Fly ash in Geopolymer Binders had greater impact on engineering properties of geopolymer concrete and also 14 M gave best properties for GC when compared with different concentrations of NaOH solution. This research investigation studies the results of an experimental work on the strength characteristics and various durability parameters of geopolymer concrete produced with the blending of Fly Ash and GGBS.

The major applications of the geopolymer concrete are suitability for building pavements, retaining walls, tanks as well as precast concrete products like bridge decks, railway sleepers, electric power poles, parking tiles, for marine structures because of resistance capacity for chemical attacks and for waste containments. The advantages of using geopolymer over regular concrete are high compressive strength, it has rapid strength gain and cures quickly; tensile strength, it is less brittle than Portland concrete and can withstand more movement; resistant to heat and cold; chemical resistance; cutting the world's carbon; price of fly ash is low; fireproof; low permeability; eco-friendly and excellent properties within both acid and salt environments.

The aim of this research paper is to study the strength characteristics of fly ash and GGBS based geopolymer concrete under ambient curing, to study the durability properties of geopolymer concrete such as water absorption, sorptivity and rapid chloride ion penetration under ambient curing, to examine residual compressive strength of geopolymer concrete exposed to different environmental conditions such as chloride, and sulphate and to observe the changes in GPC exposed to different environment such as chloride and sulphate by conducting micro structural tests.

II. METHODOLOGY

The methodology used in this study contains study of materials, preliminary tests, concrete mix design, experimental investigation, comparing results and discussing them. The details are as follows,



III. MATERIALS

The materials used in this study are cement, fine aggregate, coarse aggregate, water, fly ash, ground granulated blast furnace slag, alkaline liquid, reinforcement steel bar, electrical strain gauge, metakaolin, and alumina silicate.

IV. PRELIMINARY TESTS

The specific gravity and water absorption tests, sieve analysis tests are done for both fine aggregate and coarse aggregate.

$$\text{Specific Gravity of Fine Aggregate} = \frac{D}{C-(A-B)} = 2.62$$

$$\text{Water Absorption of Fine Aggregate} = \frac{100(C-D)}{D} = 2.67\ \%$$

$$\text{Specific Gravity of Coarse Aggregate} = \frac{D}{C-(A-B)} = 2.74$$

$$\text{Water Absorption of Coarse Aggregate} = \frac{100(C-D)}{D} = 0.42\ \%$$

Table 4.1: Sieve Analysis of fine Aggregate

IS Sieve Size (mm)	Weight Retained (g)	% Retained	Cumulative Weight Retained	Cumulative % retained	Cumulative % Passing
10	0	0	0	0	100
4.75	0	0	0	0	100
2.36	176	17.6	176	17.6	82.4
1.18	221	22.1	397	39.7	60.3
600	151	15.1	548	54.8	45.2
300	159	15.9	707	70.7	29.3
150	135	13.5	842	84.2	15.8
PAN	158	15.8	1000	100	0
TOTAL	1000			367	

Therefore, the fineness Modulus of M-Sand = 3.67.

Table 4.2: Sieve Analysis of 20 mm Coarse Aggregate

IS Sieve Size (mm)	Weight Retained (g)	% Retained	Cumulative % Retained	Cumulative % Passing
16	13	0.43	0.43	99.57
12.5	181	6.03	6.46	93.54
10	1469	48.97	55.43	44.57
4.5	1326	44.2	99.63	0.37
PAN	11	0.37	100	
TOTAL	3000		261.95	

Therefore, the fineness Modulus of 20 mm Coarse Aggregate = 2.61.

V. MIX DESIGNATION

Table 5.1: Mix Designation

Sample No.	Coarse Aggregate %	Fine Aggregate %	Fly ash %	GGBS %
CC	100	100	0	0
GCA	100	100	100	0
GCB	100	100	90	10
GCC	100	100	80	20
GCD	100	100	70	30
GCE	100	100	60	40
GCF	100	100	50	50

Note:

1. 100% in the above table means total amount of material to be added as mentioned in the mix design.
2. 90% means, only 90% of the total amount of material mentioned in the mix design should be taken and the remaining 10% should be replaced by GGBS and so on.

VI. EXPERIMENTAL INVESTIGATION

In order to determine the workability of fresh concrete for conventional concrete, the slump test and compaction factor test were conducted as per IS1199:1959. For the case of hardened concrete, the controlled concrete is cast and cured for 28 days and the tests for hardened concrete such as compressive strength, split tensile strength and flexural strength are done.

Table 6.1: Description of Specimen

S.No.	Specimen	Size (mm)	No. of specimens
1	Cube	100 x 100 x 100	36
2	Cylinder	Diameter = 100 Height = 200	16
3	Beam	1200 x 150 x 150	3

Figure 1: Flexural Strength Test

Table 6.2: Flexural Strength Comparison

<table>
<tr><th>G1 – Cement Concrete</th><th>G2 – 100% Geopolymer</th><th>G3 – 80% Geopolymer & 20% Alumina Silicate</th></tr>
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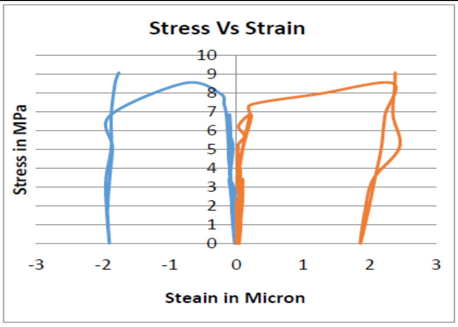
<td>
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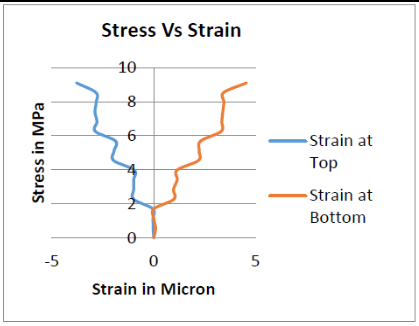
<td>
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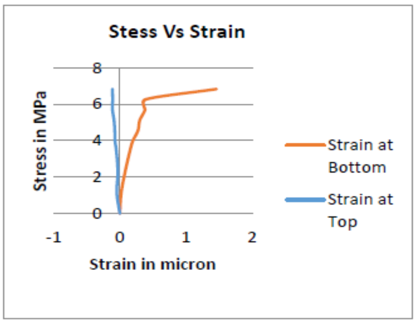
<td>
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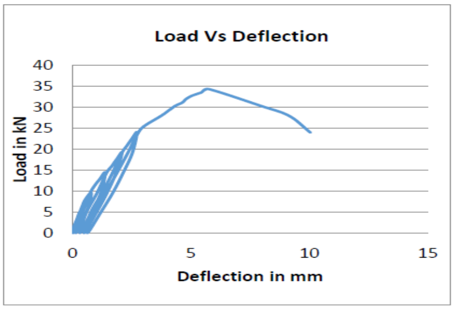
<td>
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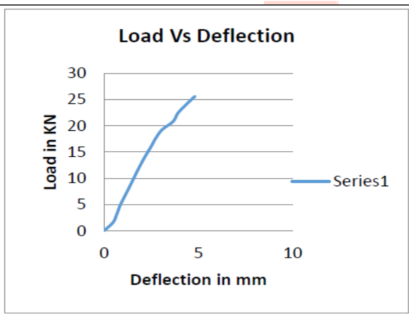
<td>
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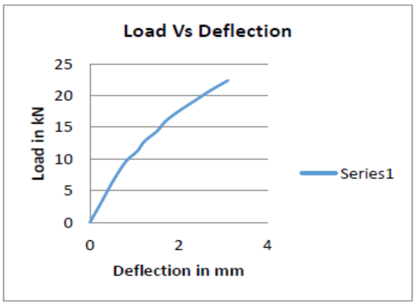
<td>
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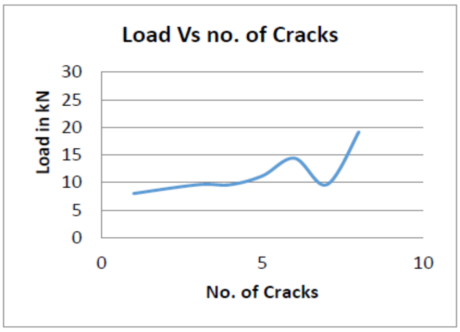
<td>
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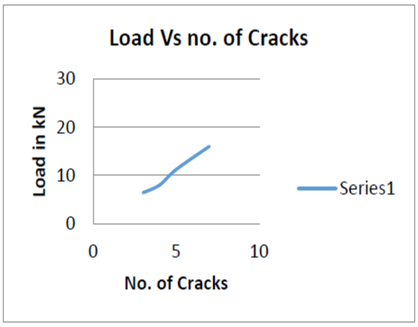
<td>
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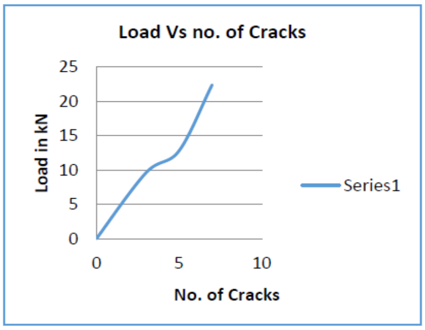
<td>
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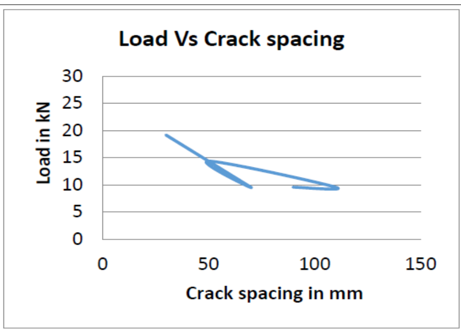
<td>
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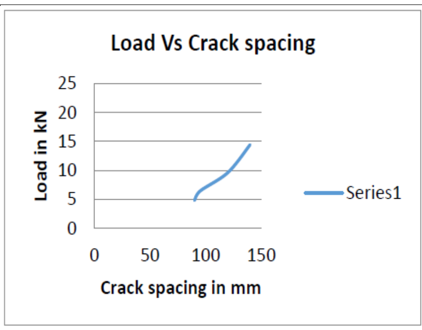
<td>
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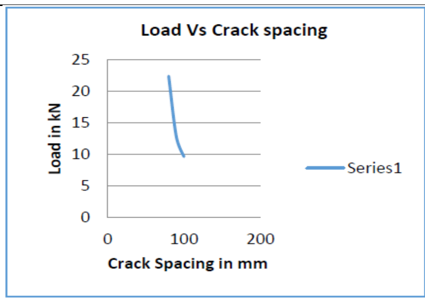
<td>
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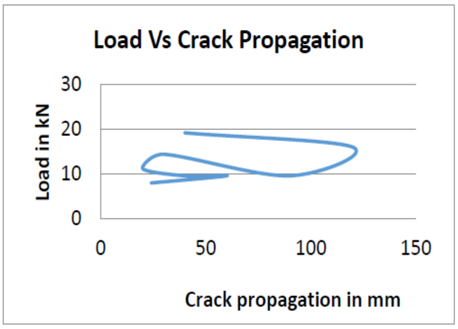

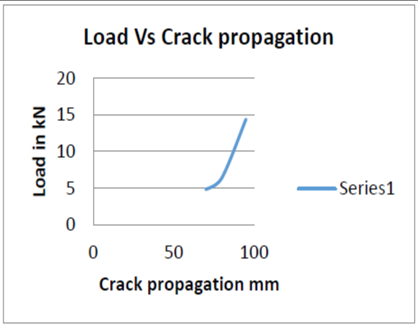

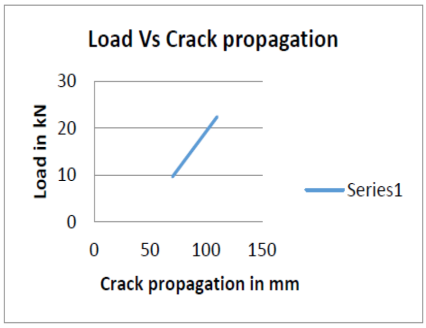

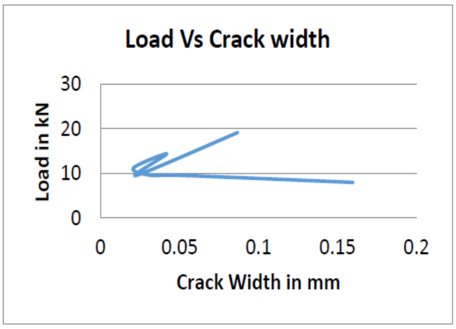

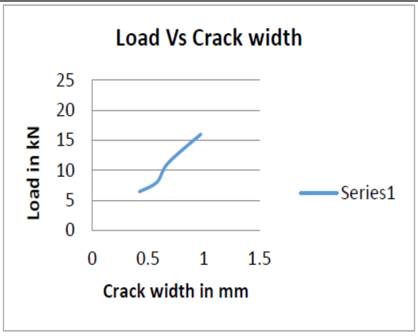

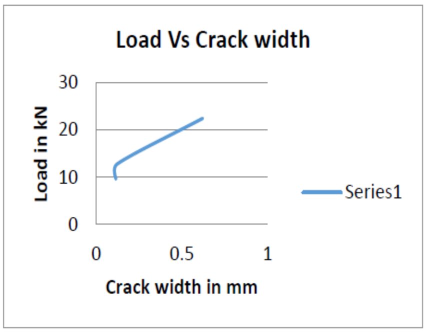

Table 6.3: Result Comparison

SPECIMEN	LOADING CONDITION	MODE OF FAILURE	ULTIMATE LOAD (KN)	MAXIMUM DEFLECTION (MM)
G1	Static	Shear cum flexure failure, shear crack reaches up to the top of the beam, flexural crack reaches up to 3/4th of the beam.	30.7	10.05
G2	Static	Shear failure	25.6	9.102
G3	Static	Shear failure, crushing of concrete in shear zone	22.4	7.964

VII. Conclusion

From the above Experimental Investigations, the following conclusions are made. The compressive strength of Geopolymer Concrete shows good results when compared to Conventional Concrete at 60 days at ambient curing. The partial replacement of 50% GGBS to Fly ash gives the optimum value. The compressive strength of Geopolymer concrete of 50% GGBS to Fly ash specimens exposed to sodium chloride and magnesium sulphate shows high compressive strength values when compared to Conventional Concrete specimens exposed to sodium chloride and magnesium sulphate at 60 days. There is an improvement in strength for the partial replacement levels of GGBS to Fly ash. The Split Tensile Strength of Geopolymer Concrete shows similar results when compared to Conventional Concrete at 28 days. The behaviour of Flexural Strength of Geopolymer Concrete is similar to Conventional Concrete from the observation of its test results. The Water Absorption of Geopolymer Concrete in par with the conventional concrete is the same. The partial replacement of 50% GGBS to Fly ash has high sorpitivity compared to other geopolymer concrete mixes. The partial replacement of 50% GGBS to Fly ash has less permeability and is less porous which results in high durability of the Geopolymer concrete. Therefore, Geopolymer concrete with partial replacement of 50% GGBS to Fly ash has high durability aspect compared to Conventional Concrete. The Geopolymer concrete with 50% Fly ash and 50% GGBS has very good concrete quality compared to other geopolymer concrete mixes.

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