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Experimental Investigation on Alkali Activated Rice Husk Ash Based Concrete

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Abstract: Concrete made up of cement, aggregates, water & additives is the world's most consumed construction material since it is found to be more versatile, durable and reliable. Concrete is the second most consumed material after water which required large quantities of Portland cement. The production of Ordinary Portland Cement (OPC) causes havoc to the environment due to the emission of CO 2 as well mining also results in unrecoverable loss to nature. Estimated carbon emissions from cement production in 1994 were 307 MtC. Hence, it is the need of hour to find an alternative material to the existing most expensive cement-concrete. Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic molecules. Fly Ash, a by-product of coal obtained from the thermal power plant and Ricehusk ash a by product obtained from milling process of rice is plenty available worldwide. Fly ash rich in silica and alumina on reacting with alkaline solution produce aluminosilicate gel that act as the binding material for the concrete. It is an excellent alternative construction material to plain cement concrete without using any amount of ordinary Portland cement. Geopolymer concrete shows a greener substitute for ordinary Portland cement concrete in some applications. This paper briefly reviews the structural properties of Ricehusk ash based Geopolymer concrete and its applications.

INTRODUCTION

Concrete is the world’s most versatile, durable and reliable construction material. Large quantities of Portland cement are required for concrete. The consumption of Ordinary Portland Cement (OPC) causes pollution to the environment due to the emission of CO2. Geopolymer concrete was introduced to reduce environmental pollution that causes by production of Portland cement.

In 1978, Professor Joseph Davidovits introduced the development of mineral binders with an amorphous structure, named geopolymers. Davidovits (1988; 1994) proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term ‘Geopolymer’ to represent these binders. This was a class of solid materials, produced by the reaction of an alumino silicate powder and an alkaline liquid. The initial goal for the research done on these geopolymers was to find a more fire resistant binder material due to the high amount of fires in Europe at that time. This research led to the material being used as coatings for the fire protection of cruise ships and thermal protect results in a low flexural strength. Brittleness of both concrete types is compensated by conventional steel reinforcement. Geopolymer concrete is an innovative construction material which shall be produced by the chemical action of inorganic molecules. Otherwise geopolymer is an inorganic alumino- hydroxide polymer synthesized from predominantly silicon (Si) and aluminium (Al) materials of geological origin or byproduct materials such as fly ash. The term Geopolymer was introduced to represent the mineral polymers resulting from geochemistry. The process involves a chemical reaction under highly alkaline conditions on Si-Al minerals, yielding polymeric Si-O-Al-O bonds in amorphous form. Due to its high mechanical properties combined with substantial chemical resistance (magnesium or sulphate attack), low shrinkage and creep and environment friendly nature (very less amount of CO2 production in comparison with OPC), it is a better construction material for future. It is well known that RHA can contain non-crystalline silica and that a highly reactive pozzolana is obtained when the rice-husk is burnt under controlled conditions. In other conditions a ‘‘residual

RHA'' is produced with a lower quality, usually presenting residual carbon (which increases the water demand) and part of the silica in crystalline state. However, the residual RHA can be improved by grinding it to an appropriated particle size, although this process comes with a considerable cost, as expected [5]. Both processes imply energy costs and strategies for selection and disposition.

Composition of Geopolymer Concrete

Following materials are required to produce this concrete:

Fly ash – A byproduct of thermal power plant

GGBS – A byproduct of steel plant

Fine aggregates and coarse aggregates as required for normal concrete.

Alkaline activator solution for GPCC as explained above. Catalytic liquid system is used as alkaline activator solution. It is a combination of solutions of alkali silicates and hydroxides, besides distilled water. The role of alkaline activator solution is to activate the geopolymeric source materials containing Si and Al such as fly ash and GGBS.

RICEHUSK ASH: Rice husk ash is a byproduct of the cultivation and processing of rice as a foodstuff. Between 20% and 25% of the rice paddy is an indigestible outer husk, which is removed and usually burnt (either in a local power plant, to create steam with which to parboil the rice itself, or in household stoves). Approximately 18% of these husks, when burnt, will become ash, therefore, the production of 1 ton of rice will result in roughly 45 kg (70 lbs) of RHA, which is rich in silica (95%), with a high surface area and substantial pozzolanic properties [11]. The exact amount of RHA produced, its chemical composition, and its crystalline content depends strongly on the burning temperatures and furnace design . Crystalline silica content in RHA is a particular concern, as crystalline silica is a potent inhalation hazard

RESEARCH SIGNIFICANCE

No research data on the behaviour of fly ash based geopolymer with partial replacement of fly ash by Ricehusk ash is cited at present. Geopolymer concrete with Ricehusk ash at optimum replacement was found be effective. This Research work provided satisfactory test results regarding the experimental investigation on reinforced geopolymer concrete.

METHODOLOGY

To carry out a literature survey on geopolymer concrete and ricehusk ash properties that can be feasible to use in concrete.

To compare the result of various percentage of ricehusk ash replacement in geopolymer concrete.

MATERIAL AND PROPERTIES

FLYASH

S.NO	DESCRIPTION	VALUE
1	CONSISTENCY	29%
2	INTIAL SETTING TIME	50 min
3	FINENESS	8%
4	SPECIFIC GRAVITY	2.2

GGBS

S.NO	DESCRIPTION	VALUE
1	CONSISTENCY	33%
2	INTIAL SETTING TIME	55 min
3	FINENESS	8%
4	SPECIFIC GRAVITY	2.85

RICEHUSK ASH

S.NO	DESCRIPTION	VALUE
1	CONSISTENCY	37%
2	INTIAL SETTING TIME	35min
3	FINENESS	7%
4	SPECIFIC GRAVITY	2.25

FINE AGGREGATE

S.NO	DESCRIPTION	VALUE
1	FINENESS	10%
2	SPECIFIC GRAVITY	2.53
3	BULK DENSITY	0.01573N/cm^3
4	WATER ABSORPTION	1.5%

COARSE AGGREGATE

S.NO	DESCRIPTION	VALUE
1	CRUSHING VALUE	19.6%
2	SPECIFIC GRAVITY	2.78
3	BULK DENSITY	0.0137N/cm^3
4	WATER ABSORPTION	0.8%
5	IMPACT VALUE	12.5%

MIX PROPORTION

FLYASH (Kg/m^3)	FINE AGGREGATE	COARSE AGGREGATE	ALKALINITY SOLUTION

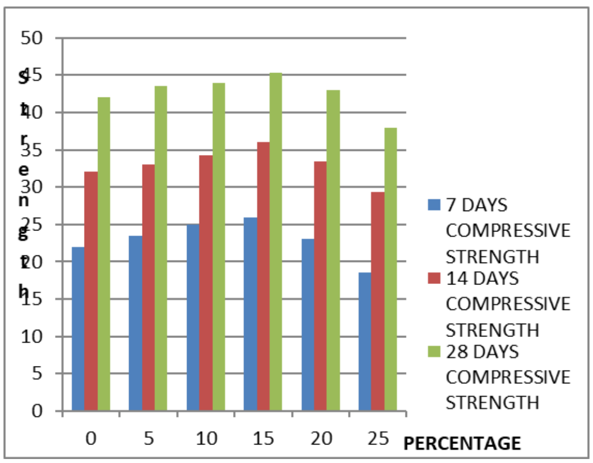
	(Kg/m^3)	(Kg/m^3)	(Kg/m^3)
425.7	562.6	1148.16	191.58
1	1.32	2.69	0.45

TEST RESULT AND DISCUSSION

COMPRESSIVE STRENGTH TEST:

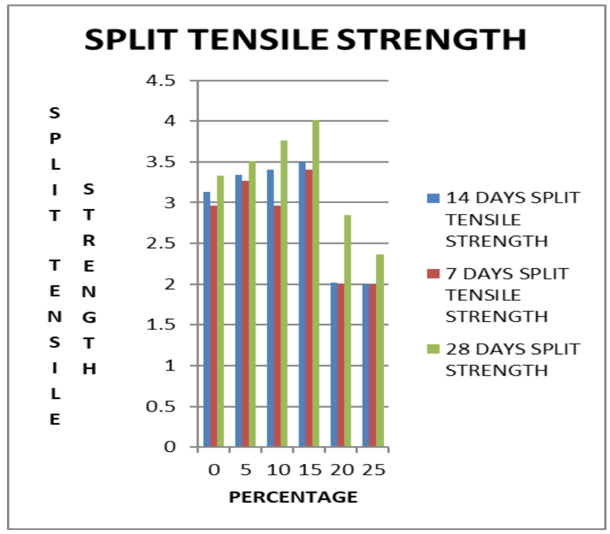
SIZE OF THE CUBE :100mm x 100mm x 100mm

Proportion	Compressive strength (N/mm$^{2)}$ for Ambient curing		
	7 days	14 days	28 days
0%	22	32	42
5%	23.5	33	43.5
10%	24.9	34.3	44
15%	25.9	36	45.3
20%	23.05	33.45	43
25%	18.6	29.40	38



SPLIT TENSILE STRENGTH

Proportion	Split tensile strength (N/mm$^{2)}$ for Ambient curing		
	7 days	14 days	28 days
0%	2.96	3.1	3.33
5%	3.27	3.34	3.51
10%	2.96	3.34	3.76
15%	3.4	3.5	4.01
20%	2.01	2.02	2.85
25%	2	2	2.36

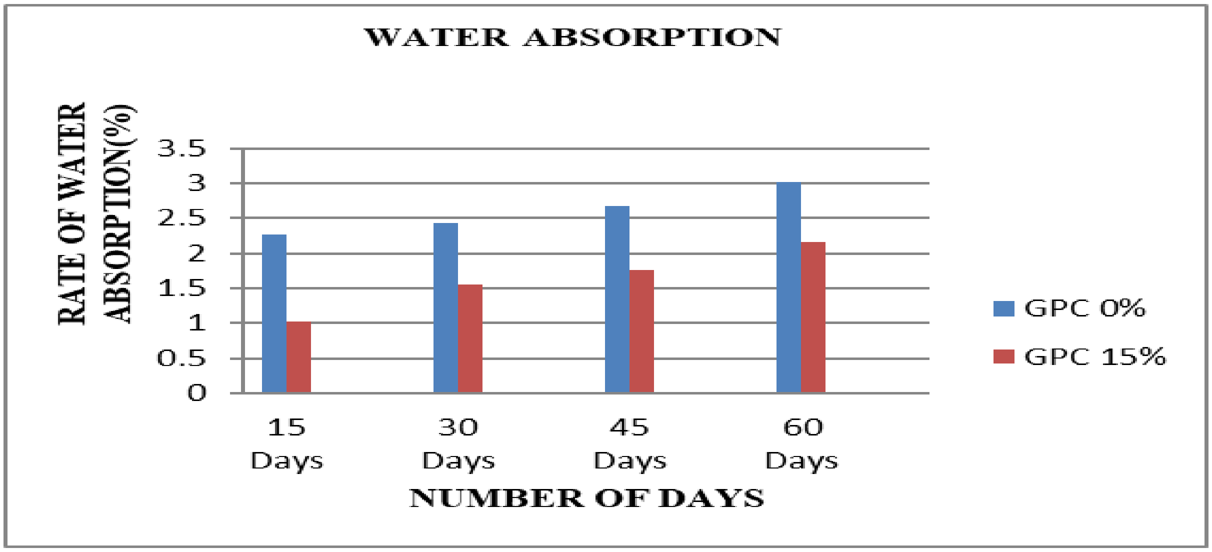


DURABILITY TEST

- WATER ABSORPTION TEST
- ACID RESISTANCE TEST
- SULPHATE RESISTANCE TEST
- CHLORIDE ATTACK TEST
- SORPTIVITY

WATER ABSORPTION TEST

DAYS	GPC 0%				GPC 15%			
	Dry weight (Kg)	Final weight (Kg)	Water absorption (%)	Avg (%)	Dry weight (Kg)	Final weight (Kg)	Water absorption (%)	Avg (%)
	2.524	2.58	2.22		2.430	2.456	1.07	
15 Days	2.536	2.595	2.33	2.27	2.438	2.462	0.99	1.03
	2.486	2.546	2.42		2.430	2.470	1.65	
30 Days	2.582	2.645	2.44	2.43	2.430	2.465	1.45	1.55
	2.552	2.619	2.63		2.440	2.481	1.69	
45 Days	2.578	2.648	2.72	2.67	2.424	2.468	1.82	1.75
	2.466	2.538	2.92		2.360	2.410	2.12	
60 Days	2.542	2.621	3.11	3.01	2.482	2.536	2.18	2.15



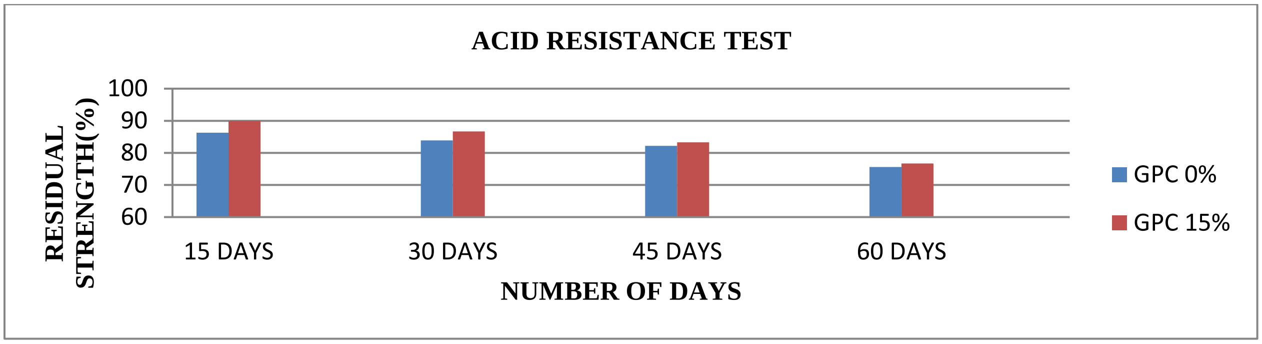
Acid resistance test

DAYS	GPC 0%				GPC 15%			
	Dry weight (Kg)	Final weight (Kg)	Increase in mass (%)	Avg (%)	Dry weight (Kg)	Final weight (Kg)	Increase in mass (%)	Avg (%)
	2.538	2.595	2.25		2.486	2.505	0.77	
15 Days	2.486	2.545	2.38	2.31	2.386	2.433	1.97	1.37
	2.768	2.830	2.24		2.466	2.498	1.30	
30 Days	2.546	2.610	2.52	2.38	2.428	2.466	1.57	1.43
	2.472	2.530	2.35		2.446	2.520	3.03	
45 Days	2.558	2.623	2.55	2.45	2.424	2.456	1.33	2.18
	2.602	2.675	2.81		2.424	2.478	2.23	
60 Days	2.582	2.655	2.83	2.82	2.452	2.512	2.45	2.34

Mass gain results in Acid resistance test

DAYS	SPECIMEN	COMPRESSIVE STRENGTH(Mpa)				
		INITIAL (Kg)	FINAL (Kg)	DECREASE IN STRENGTH(N/mm^2)	Avg (%)	RESIDUAL STRENGTH (N/mm^2)
15 DAYS	GPC 0%	42	37.5	10.72	13.6	86.31
		42	35	16.67		
		45.3	39.5	12.81		
	GPC 15%	45.3	42	7.29	10.0	89.95
		42	34.5	17.86		
30 DAYS	GPC 0%	42	36	14.29	16.0	83.93
		45.3	38.5	15.02		
	GPC 15%	45.3	40	11.7	13.3	86.64
		42	34	19.05		
45 DAYS	GPC 0%	42	35	16.67	17.8	82.14
		45.3	38	16.12		
	GPC 15%	45.3	37.5	17.22	16.6	83.33
		42	32	23.81		
60 DAYS	GPC 0%	42	31.5	25	24.4	75.6
		45.3	34.5	23.85		
	GPC 15%	45.3	35	22.74	23.2	76.71

Residual compressive strength in Acid resistance test



Residual compressive strength test for Acid resistance test

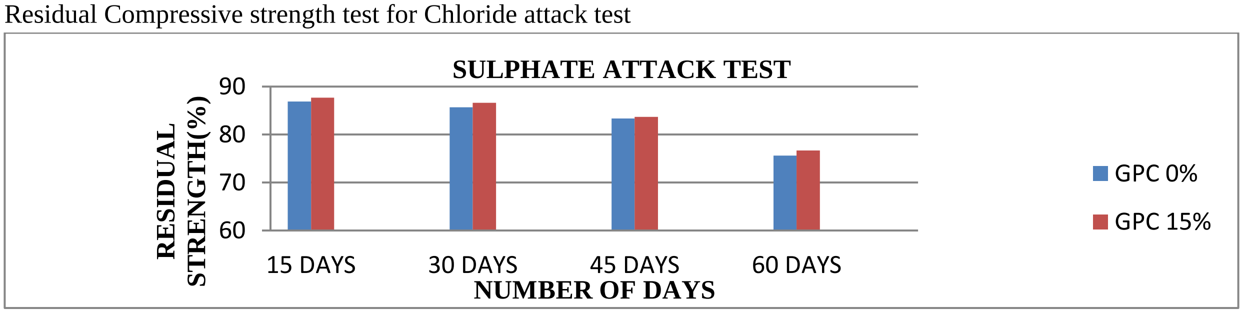
Chloride attack

DAYS	GPC 0%				GPC 15%			
	Dry weight (Kg)	Final weight (Kg)	Increase in mass (%)	Avg (%)	Dry weight (Kg)	Final weight (Kg)	Increase in mass (%)	Avg (%)
	2.558	2.588	1.18		2.46	2.52	2.44	
15 Days	2.518	2.603	3.38	2.28	2.554	2.565	0.44	1.44
	2.558	2.578	0.79		2.572	2.598	1.02	
30 Days	2.486	2.598	4.51	2.65	2.385	2.434	2.06	1.54
	2.518	2.546	1.12		2.458	2.472	0.57	
45 Days	2.474	2.588	4.61	2.86	2.432	2.498	2.72	1.65
	2.536	2.559	0.91		2.38	2.41	1.27	
60 Days	2.558	2.697	5.44	3.17	2.4	2.487	3.63	2.45

Mass gain results in Chloride attack test

AYS	SPECIMEN	COMPRESSIVE STRENGTH(Mpa)				
		INITIAL (Kg)	FINAL (Kg)	DECREASE IN STRENGTH(N/mm2)	Avg (%)	RESIDUAL STRENGTH (N/mm2)
15 DAYS	GPC 0%	42	37	11.91		
		42	35	16.67	14.29	85.71
	GPC 15%	45.3	40	11.7		
		45.3	41	9.5	10.6	89.4
30 DAYS	GPC 0%	42	34	19.05		
		42	36	14.29	16.67	83.33
	GPC 15%	45.3	38.3	15.46		
		45.3	39.5	12.81	14.13	85.87
45 DAYS	GPC 0%	42	33	21.43		
		42	36	14.29	17.86	82.14
	GPC 15%	45.3	37.45	17.33		
		45.3	37.3	17.67	17.5	82.5
60 DAYS	GPC 0%	42	33	21.43		
		42	31.5	25	23.21	76.79
	GPC 15%	45.3	33.45	26.16		
		45.3	36.5	19.43	22.79	77.21

Residual Compressive strength test for Chloride attack test



Residual compressive strength for Sulphate attack test

SORPTIVITY VALUE OF SPECIMENS @28DAYS

MIX	SPECIMEN 1	SPECIMEN 2	AVERAGE
GPC 0%	0.0403	0.0474	0.044
GPC 15%	0.0274	0.0265	0.03

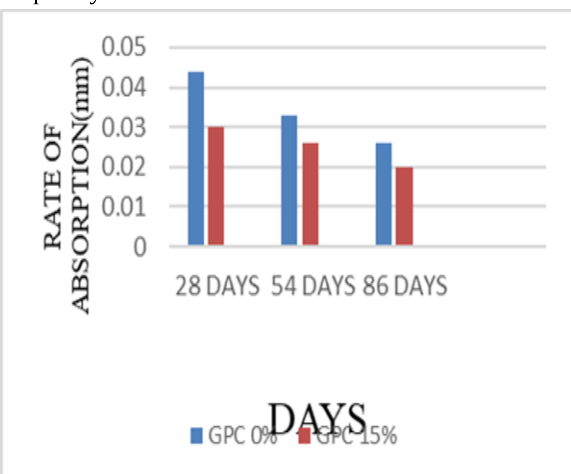
SORPTIVITY VALUE OF SPECIMENS @54DAYS

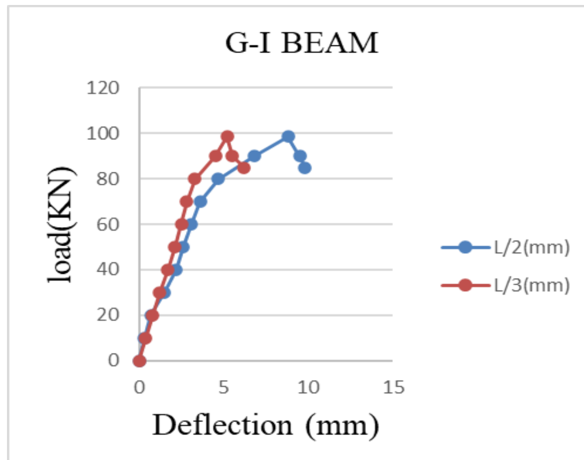
MIX	SPECIMEN 1	SPECIMEN 2	AVERAGE
GPC 0%	0.0327	0.0334	0.033
GPC 15%	0.0281	0.0241	0.026

SORPTIVITY VALUE OF SPECIMENS @54DAYS

MIX	SPECIMEN 1	SPECIMEN 2	AVERAGE
GPC 0%	0.023	0.0299	0.026
GPC 15%	0.02	0.026	0.02

sorptivity results





Load-Deflection of G-I beam

8.3 STRUCTURAL BEHAVIOUR TEST RESULTS ON REINFORCED GEOPOLYMER CONCERTE BEAM.

RESULTS OF 0% ADDED RHA REINFORCED GEOPOLYMER BEAM (G -I):

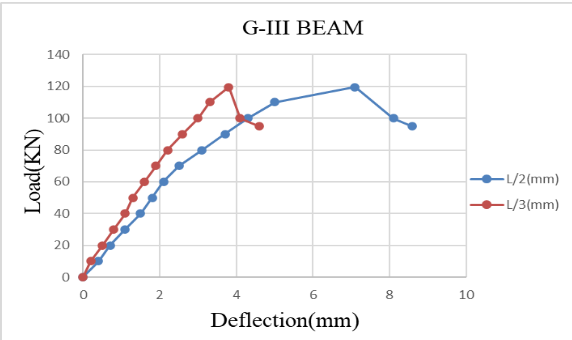
S.NO	LOAD (kN)	L/2 (mm)	L/3 (mm)	REMARKS
1	0	0	0	
2	10	0.3	0.4	
3	20	0.7	0.8	
4	30	1.5	1.2	
5	40	2.2	1.7	
6	50	2.6	2.1	
7	60	3.1	2.5	
8	70	3.6	2.8	
9	80	4.7	3.3	
10	90	6.8	4.5	
11	98.4	8.8	5.2	U.L
12	90	9.5	5.5	
13	85	9.8	6.2	

Table 8.22 Load-Deflection of G-I beam

RESULT OF15%ADDED RHA REINFORCED GEOPOLYMER BEAM (G-III):

S.NO	LOAD (KN)	L/2 (mm)	L/3 (mm)	REMAR KS
1	0	0	0	
2	10	0.4	0.2	
3	20	0.7	0.5	
4	30	1.1	0.8	
5	40	1.5	1.1	
6	50	1.8	1.3	
7	60	2.1	1.6	
8	70	2.5	1.9	
9	80	3.1	2.2	
10	90	3.7	2.6	
11	100	4.3	3	U.L
12	110	5	3.3	
13	119.5	7.1	3.8	
14	100	8.1	4.1	
15	95	8.6	4.6	

Table 8.24 Load –Deflection of G-III beam



Load –Deflection of G-III beam

CONCLUSION

- On adding 15% RHA to fly ash in geopolymer concrete, the Compressive strength increase over 8% when compared to control specimen.
- In durability test such as acid resistance, chloride attack, sulphate resistance test the GPC 15% specimen is found to have 2-3.04% higher compressive strength as compared to control specimen.
- In water absorption test, GPC 15% specimen shows rate of absorption of water 1.05% less than control specimen.
- Sorptivity results shows that concrete in which flyash is replaced by 15% of RHA was found to have 31% less capillary rise than control mix.

GPC 15% Specimen have superior compressive strength and flexural response. Failure pattern for both the reinforced concrete were similar

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