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EXPERIMENTAL INVESTIGATION ON FLEXURAL BEHAVIOR OF GEOPOLYMER CONCRETE

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ABSTRACT

Inorganic polymer concrete (geopolymer) is a rising class of cementitious material in which bond is supplanted by flyash, one of the bottomless modern results on earth. Eight trial mixes are prepared for M30 grade concrete with 100% replacement of cement with ASTM class F flyash. In this project, NaOH of 12M and 14M are used as the alkali activator solutions in four different percentages viz., 0.4%, 0.45, 0.50% and 0.55% of flyash. Natural river sand and coarse aggregates of 20 mm maximum size are used for all the geopolymer concrete specimens. The optimum percentage of alkali activator solutions is arrived by conducting the tests for compressive strength, split tensile strength and flexural strength on the geopolymer concrete specimens. From the experimental results, it is observed that there is no significant variation in strength properties of geopolymer concrete mixes when compared to that of the normal concrete. Geopolymer concrete with 0.4% of alkaline solution of 14M is found to be the optimum mix proportion and its compressive strength is improved by 7% than that of conventional concrete specimen. The experimental investigation on the flexural behavior of geopolymer concrete beams are carried out by conducting two point load tests on three beams of size 1000mm $\times$ 100mm $\times$ 200mm. From the flexural tests, it is observed that there is no significant variation in the flexural behavior of geopolymer and conventional concrete. Therefore geopolymer concrete can be used in the place of conventional concrete with cement and thus provides the solution for both the disposal problem of fly-ash from the thermal industries and pollution threat for the environment due to Carbon-di-oxide emission during the cement production.

Keywords: flyash, geopolymer, alkali activator solution

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1. INTRODUCTION

Construction is one of the quickly developing fields around the world. According to the present world insights, consistently around 260,00,00,000 Tons of Cement is required. This amount will be expanded by 25% inside a traverse of an additional 10 years. Since the Lime stone is the principle source material for the conventional Portland concrete an intense lack of limestone may come following 25 to 50 years. More finished while creating one ton of bond, around one ton of carbon di oxide will be transmitted to the air, which is a noteworthy danger for nature. Notwithstanding the above gigantic amount of vitality is additionally required for the creation of bond. Consequently it is most fundamental to locate an option folio. The Cement creation produced carbon di oxide, which dirties the climate. The Thermal Industry creates a waste called flyash which is basically dumped on the earth, involves larges territories. The waste water from the Chemical Industries is released into the ground which sullies ground water. By creating Geopolymer Concrete all the previously mentioned issues might be fathomed by Re-organizing them. Squander Fly Ash from Thermal Industry + Waste water from Chemical Refineries = Geo polymer concrete. Since Geopolymer concrete doesn't utilize any bond, the generation of concrete should be diminished and subsequently the contamination of air by the emanation of carbon di oxide might likewise be limited.

2. GEOPOLYMER CONCRETE

The name geopolymer was framed by a French Professor Davidovits in 1978 to speak to a wide scope of materials portrayed by systems of inorganic atoms. The geopolymers rely upon thermally actuated normal materials like Meta kaolinite or modern results like fly powder or slag to give a wellspring of silicon (Si) and alumina (Al). These Silicon and Aluminum is broken down in an antacid actuating arrangement and therefore polymerizes into sub-atomic chains and turn into the folio. The response of Fly Ash with a fluid arrangement containing Sodium Hydroxide and Sodium Silicate in their mass proportion, brings about a material with three-dimensional polymeric chain and ring structure comprising of Si-O-Al-O bonds.

Water is not engaged with the substance response of Geopolymer concrete and rather water is ousted amid curing and consequent drying. This is as opposed to the hydration responses that happen when Portland bond is blended with water, which create the essential hydration items calcium silicate hydrate and calcium hydroxide. This distinction significantly affects the mechanical and compound properties of the subsequent geopolymer concrete, and furthermore renders it more impervious to warm, alkali–aggregate reactivity and different sorts of synthetic assault

On account of geopolymers produced using fly fiery remains, the part of calcium in these frameworks is essential, since its quality can bring about glimmer setting and consequently should be precisely controlled. The source material is blended with an initiating arrangement that gives the alkalinity (sodium hydroxide or potassium hydroxide are regularly utilized) expected to free the Si and Al and conceivably with an extra wellspring of silica (sodium silicate is most usually utilized).

The temperature amid curing is vital, and relying on the source materials and initiating arrangement, warm frequently should be connected to encourage polymerization, albeit a few frameworks have been created that are intended to be cured at room temperature

3. PROPERTIES OF GEOPOLYMER CONCRETE

The superior properties of Geopolymer concrete, based on Prof. B. Vijaya Rangan and Hardijito, are

- Sets at room temperature
- Non - toxic, bleed free
- Long working life before stiffening
- Impermeable
- Higher resistance to heat and resist all inorganic solvents
- Higher compressive strength

Compressive strength of Geopolymer concrete is high contrasted with the customary Portland bond concrete. Geopolymer concrete likewise demonstrated high early quality. The compressive strength of Geopolymer concrete is around 1.5 times more than that of the compressive strength with the common Portland bond concrete, for a similar blend. Essentially the Geopolymer Concrete demonstrated great workability as of the standard Portland Cement Concrete.

4. LITERATURE REVIEW

Benny Joseph and George Mathew (2011) contemplated the impact of total substance on the building properties of geopolymer concrete. Impact of different parameters on building properties of geopolymer cement, for example, curing temperature, time of curing, proportion of sodium silicate to sodium hydroxide, proportion of soluble base to fly powder and molarity of sodium hydroxide are likewise talked about in this paper. In view of the investigation did, it could be reasoned that a geopolymer concrete with appropriate proportioning of aggregate total substance and proportion of fine total to add up to total, alongside the ideal estimations of different parameters, can have preferred building properties over the comparing properties of conventional bond concrete.

M.I. Abdul Aleem and P.D. Arumairaj (2012) considered that Geopolymer concrete uses a substitute material including fly cinder as restricting material set up of bond. This fly fiery remains responds with soluble arrangement (e.g., NaOH) and Sodium Silicate (Na_2SiO_3) to shape a gel which ties the fine and coarse totals. Since Geopolymer concrete is the developing field, the rules from the Bureau of Indian Standards are yet to be detailed. An endeavor has been made to discover an ideal blend for the Geopolymer concrete. Solid 3D shapes of size 150 x 150 x 150 mm were arranged and cured under steam curing for 24 hours. The compressive quality was discovered at 7 days and 28 days. The outcomes are thought about. The ideal blend is Flyash: Fine aggregate: Coarse total (1:1.5:3.3) with an answer (NaoH& Na_2SiO_3 consolidated together) to fly fiery remains proportion of 0.35. High and early quality was acquired in the Geopolymer solid blend.

Raijiwala D.B. and Patil H. S (2011) considered the distinctive properties of Geopolymer solid utilizing this fly slag and alternate fixings locally accessible in Gujarat. Potassium Hydroxide and sodium Hydroxide arrangement were utilized as soluble base activators in various blend extents. The genuine compressive quality of the solid relies upon different parameters, for example, the proportion of the activator answer for fly slag, profound quality of the basic arrangement, proportion of the activator chemicals, curing temperature and so on.

The part of Portland concrete is supplanted by low calcium fly powder. Geopolymer is an inorganic alumino-Hydroxide polymer orchestrated from prevalently silicon (Si) and alumina (Al) materials of geographical beginning or side-effect materials, for example, fly fiery remains. The term Geopolymer was acquainted with speak to the mineral polymers coming about because of geochemistry. The procedure includes achemical response under exceedingly soluble conditions on Si-Al minerals, yielding polymeric Si-O-Al-O securities in undefined shape.

S. V. Joshi and M. S. Kadu (2012) contemplated the Fly slag with blend of antacids like sodium hydroxide and sodium silicate can deliver restricting material relying on the attributes of these fixings. The likelihood of eco-accommodating utilization of locally accessible fly-fiery remains with economically accessible salts in the advancement of viable folio and the impact of different parameters on the compressive quality of geo-polymer concrete is investigated in the present paper. The lab examinations under surrounding and broiler dry curing conditions proposed that locally accessible low calcium fly-fiery debris is appropriate for advancement of geo-polymer concrete and the compressive quality of geo-polymer concrete is an element of mass proportion of basic fluid to fly-cinder, mass proportion of sodium silicate to sodium hydroxide and molar grouping of sodium hydroxide.

5. MATERIALS

5.1 FLY FIERY DEBRIS (FLY ASH):

Fly fiery debris is one of the deposits created in ignition, and involves fine particles that ascent with the pipe gasses. In a mechanical setting, fly fiery remains as a rule alludes to powder created amid ignition of coal. Fly fiery remains is by and large caught by electrostatic precipitators or other molecule filtration hardware's before the pipe gasses come to the stacks of coal-let go control plants.

The sorts and relative measures of incombustible issue in the coal decide the concoction sythesis of fly cinder. The compound sythesis is for the most part made out of the oxides of silicon (SiO2), aluminum (Al2O3), press (Fe2O3), and calcium (CaO). Magnesium, potassium, sodium, titanium, and sulfur are additionally present in a lesser sums. The sort of coal utilized decides the substance structure of the subsequent fly fiery remains. The ignition of sub-bituminous coal contains more calcium and less iron than fly powder from bituminous coal. The physical and concoction attributes rely upon the burning strategies, coal source and molecule shape.

The compound pieces of different fly powder demonstrate a wide range, showing that there is a wide variety in the coal utilized as a part of energy plants everywhere throughout the world. Fly slag that outcomes from consuming sub-bituminous coals is alluded as ASTM Class C fly fiery debris or high-calcium fly cinder, as it regularly contains more than 20 percent of CaO. Then again, fly powder from the bituminous and anthracite coals is alluded as ASTM Class F fly cinder or low-calcium fly fiery remains. It comprises of basically an alumino silicate glass, and has under 10 percent of CaO. The shade of fly fiery debris can be tan to dull dim, contingent on the synthetic and mineral constituents. For the present work class – F fly fiery debris has been utilized.

5.2. ALKALINE SOLUTION:

A blend of sodium silicate arrangement and sodium hydroxide arrangement was picked as the soluble fluid. Sodium-based arrangements were picked in light of the fact that they were less expensive than Potassium-based arrangements. The sodium hydroxide solids were business review in pellets frame with 97% virtue and sodium silicate arrangement of 0.1N was gotten from an organization in Coimbatore. The sodium hydroxide (NaOH) arrangement was set up by dissolving the pellets in refined water. Planning of NaOH arrangement brought about discharge of warmth of 60'C. The mass of NaOH solids in an answer changed relying upon the centralization of the arrangement communicated as far as molar, M. For our work 12 M and 14 M NaOH arrangement is utilized. Since the atomic mass of NaOH is 40, for 12M arrangement, 480 grams (40 x 12) of NaOH pellets and for 14M arrangement, 560 grams (40 x 14) was blended with one liter of water.

A structure of Na2O=14.7%, SiO2=29.4% and water=55.9% by mass was utilized as a part of all tests.

5.3. AGGREGATES:

Aggregate imparts greater volume stability and durability to concrete. The aggregate is used primarily for the purpose of providing bulk to concrete.

5.4. FINE AGGREGATES:

Fine aggregates by and large comprise of normal sand or pulverized stone with most particles going through a 4.75 mm sieve. The most important function of the fine aggregate is to assist in providing workability and uniformity in mixture. The fine aggregate also assists the polymer to hold the coarse aggregates in suspension. This action promotes plasticity in the mixture and prevents the possible segregation of paste and coarse aggregates.

5.5. COARSE AGGREGATES:

Coarse aggregates are any particles greater than 4.75 mm, but generally range between 10 mm to 40 mm in size. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Coarse aggregates provide strength, toughness and hardness to concrete. Presence of coarse aggregate increases the resistance of concrete to freezing and thawing, provides chemical stability and increases resistance to abrasion.

5.6. TRIAL MIX RATIOS OF GEOPOLYMER CONCRETE MIXTURES:

Concrete mixture design process is vast and generally based on performance criteria. Geopolymer is a type of amorphous alumino-silicate product that exhibits the ideal properties of rock forming elements, i.e. hardness, chemical stability and longevity. Geopolymer binders are used together with aggregates to produce geopolymer concretes. Hence trial and error method is opted for mixing these type of concrete. According to the journals referred, the alkaline solution used for the geopolymer concrete are recommended in the range of 0.2 to 0.5. As geopolymer concrete has good binding properties the alkaline liquid values are recommended as above. The geopolymer concrete mix proportions are arrived from the data obtained from the journals

Table 1 Trail Mix Ratio

Trial Mix Ratio		Alkaline liquid	Flyash	Fine aggregate	Coarse aggregate
12M solution	GPC-1	0.55	1	1.75	2.75
		194 litre/m^3	353 kg/m^3	718 kg/m^3	1125 kg/m^3
	GPC-2	0.50	1	1.95	3.06
		183 litre/m^3	365 kg/m^3	714 kg/m^3	1120 kg/m^3
	GPC-3	0.45	1	1.89	2.95
		172 litre/m^3	383 kg/m^3	724 kg/m^3	1134 kg/m^3

	GPC-4	0.40	1	1.82	2.85
		158 litre/m^3	395 kg/m^3	721 kg/m^3	1129 kg/m^3
14M solution	GPC-5	0.55	1	1.75	2.75
		195 litre/m^3	355 kg/m^3	716 kg/m^3	1121 kg/m^3
	GPC-6	0.50	1	1.96	3.07
		184 litre/m^3	367 kg/m^3	721 kg/m^3	1129 kg/m^3
	GPC-7	0.45	1	1.89	2.95
		172 litre/m^3	383 kg/m^3	724 kg/m^3	1134 kg/m^3
	GPC-8	0.40	1	1.82	2.85
		157 litre/m^3	394 kg/m^3	718 kg/m^3	1125 kg/m^3

6. EXPERIMENTAL WORKS

6.1. SPECIFIC GRAVITY OF FINE AGGREGATE:

In concrete technology, specific gravity of aggregates is made use of in design calculations of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is additionally required in figuring the compacting factor regarding the workability measurements.. Similarly, specific gravity of aggregate is required to be considered when we deal with light weight and heavy weight concrete. Normal specific gravity of the stones differs from 2.6 to 2.8.

Specific gravity of Fine aggregate = 2.61

6.2. SIEVE ANALYSIS:

This is the name given to the operation of dividing a sample of aggregate into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation. A convenient system of expressing the gradation of aggregate is one which the consecutive sieve openings are constantly doubled, such as 10 mm, 20 mm, 40 mm etc. Under such a system, employing a logarithmic scale, lines can be spaced at equal intervals to represent the successive sizes. The aggregates used for marking concrete are normally of the maximum size 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 600 micron and 150 micron. The aggregate fraction from 80 mm to 4.75 mm is termed as coarse aggregate and those fractions from 4075 mm to 150 micron are termed as fine aggregate. The size 4.75 mm is a common fraction appearing both in coarse aggregate and fine aggregate (C.A. and F.A). Grading pattern of a sample of C.A or F.A. is assessed by sieving a sample successively through the entire sieves mounted one over the other in order of size, with larger sieve on the top. The material retained on each sieve after shaking, represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above. Sieving can be done either manually or mechanically. In the manual operation the sieve is shaken giving movements in all possible direction to give chance to all particles for passing through the sieve. Operation should be continued till such time that almost no particle is all possible direction, and as such it is more systematic and efficient than hand-sieving.

From the sieve analysis the particle size distribution in a sample of aggregate is found out. In this connection a tern known as "Fineness Modulus" (F.M.) is being used. F.M. is a ready index of coarseness or fineness of the material. Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves ranging from 80 mm to 150 mm and dividing this sum by an arbitrary number 100. Many a time, fine aggregates are designated as coarse sand, medium sand and fine sand. These classifications do not give precise meaning. What the supplier terms as fine sand may be really medium or even coarse sand. To avoid this ambiguity fineness modulus could be used as a yard stick to indicate the fineness of sand.

The following limits may be taken as guidance:

Fine sand: Fineness Modulus: 2.2 - 2.6

Medium sand: F.M.: 2.6 - 2.9

Coarse sand: F.M.: 2.9 - 3.2

Fineness modulus of fine aggregate = F/100 = 3.63

Fineness modulus of fine aggregate = 3.63 (As per IS 393:1970, grading of aggregates falls in zone II)

Specific gravity of Coarse aggregate = 2.73

6.3. SIEVE ANALYSIS FOR COARSE AGGREGATE:

Weight properly 5000 grams of coarse aggregate and it on a typical set of sieves of 63mm,50mm,40mm,25mm,16mm,12.5mm,10mm,4.75mm and pan. Grading the pattern of c.a is assessed by sieving a sample in turn through the complete sieves mounted one over the order on order of size, with larger sieve on the highest. the fabric maintained on every sieve when shaking, represents the fraction of aggregates coarser than the sieve in question and finer than the sieve higher than. Sieve will be done by manually or automatically.

In manual operation the sieves is jolted giving movements all told attainable directions to administer probability to any or all particles for passing through the sieve. From the sieve analysis, the particles size distribution in a very sample of coarse aggregates is got wind.

Fineness modulus of Coarse aggregate = 4.936

7. COMPRESSIVE STRENGTH

Since the largest nominal size of the aggregate does not exceed 20 mm, the cube specimens of the size 15 x 15 x 15 cm were used for compressive strength test. Three specimens designated with suffixes a, b and c were casted for each mix proportion and the average value of the test results were used for interpretation. All the cubes were weighed before testing. The compressive strength was calculated from the load required at failure.

7.1. SPLIT TENSILE STRENGTH

The test was carried out by placing a cylindrical specimen placed horizontally between the loading platens of a compression testing machine and the load was applied until failure of the cylinder. This method was preferred because of its simplicity and splitting test is believed to be closer to the true tensile strength of concrete. In order to reduce the magnitude of the high compressive stress near the points of application of the load, narrow strips of plywood were placed between the specimen and the loading platens of the testing machine. Three specimens were casted for each mix proportion and the average value of the test results were used for the study. All the cylinders were weighed before testing.

8. FLEXURAL BEHAVIOUR OF GEOPOLYMER R.C BEAMS

To study the flexural behaviour, totally three reinforced concrete beams (2 Geopolymer R.C beams and 1 conventional R.C beam) of size 1000 mm x 100 mm x 200 mm were casted. 4 numbers of 12 mm diameter Fe 415 grade steel bars were provided as longitudinal reinforcement and 8 mm diameter stirrups are provided at 150 mm spacing centre to centre. Figure – 1 shows the reinforcement details of the beams.

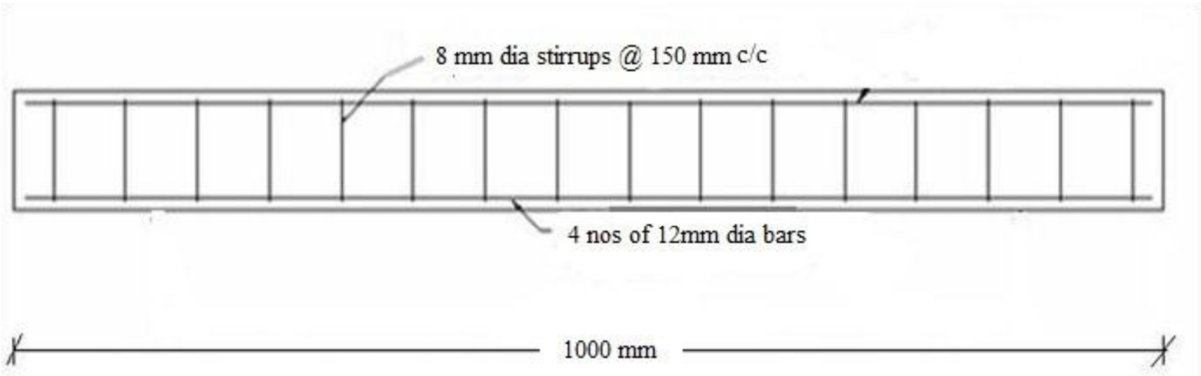

Figure 1 Reinforcement details

Steel beam moulds were oiled and were properly aligned to exact dimension on the concrete platform. Reinforcement cage was placed inside the mould and cover blocks were used to maintain proper cover. After pouring the fresh concrete into the mould, the concrete surface was levelled and finished using a trowel. After 48 hrs of casting, the specimen is kept without disturbance until it attains a hardened state. After the removal of beam moulds, the specimens were put for steam curing. Periodic check on temperature was done in order to assure proper curing of specimens.

The beams were simply supported and subjected to two point loading. A load cell was used to apply the load. The dial gauges were fixed at the centre of the beam and under the load points to record the deflection of the beam during test. The deflection of the beams at mid span and under the load points was measured. At every loading stage, cracks appearing on the surfaces were marked. Dial gauge readings for every 5kN load increment was noted. The beam was loaded up to failure. Figure – 2 shows the experimental setup of the beams.

Figure 2 Experimental setups of geopolymer beams

9. RESULTS AND DISCUSSION

The results of the compressive strength test obtained at 7 days and 28 days are presented in the table 2. A comparative plot for average compressive strength is shown in Chart.1. The average strength of GPC-4 and GPC-8 were higher than conventional mix at 7 days and 28 days. GPC-4 and GPC-8 showed a little higher compressive strength, while the GPC-3 mix has a near equal value to the compressive strength of conventional concrete mix.

Table 2 Compressive Strength Results for Cubes

Curing Period	7 days		28 days	
Specimen No.	Weight in kg	Stress in MPa	Weight in kg	Stress in MPa
GPC - 1a	8.114	20.84	7.961	27.6
GPC - 1b	7.956	17.68	8.131	23.95
GPC - 1c	8.086	18.66	7.905	22
GPC - 2a	8.096	19.28	8.016	23.95
GPC - 2b	8.117	19.68	8.236	27.51
GPC - 2c	7.984	20.57	8.032	26
GPC - 3a	8.145	19.28	8.105	30.71
GPC - 3b	8.192	24.26	8.014	32.53
GPC - 3c	8.235	26.44	8.148	28.22
GPC - 4a	7.985	25.82	8.158	33.24
GPC - 4b	8.043	26.71	8.219	33.42
GPC - 4c	7.936	27.55	7.994	31.55
GPC - 5a	8.129	12.75	7.944	18.4
GPC - 5b	7.925	15.37	7.541	20.26
GPC - 5c	8.024	13.64	8.144	18.35
GPC - 6a	8.312	16.26	8.092	22
GPC - 6b	8.212	13.7	8.02	24.4
GPC - 6c	7.979	18.75	7.892	19.33
GPC - 7a	8.01	21.64	8.01	23.24
GPC - 7b	7.541	22.26	8.02	29.95
GPC - 7c	8.092	18.93	7.892	26.57
GPC - 8a	8.26	26.57	8.021	33.38
GPC - 8b	8.183	26.04	7.994	33.35
GPC - 8c	8.254	27.68	8.421	34
CC - a	8.54	23.51	8.487	31.15
CC - b	8.26	25.2	8.325	29.64
CC - c	8.551	21.86	8.568	31.77

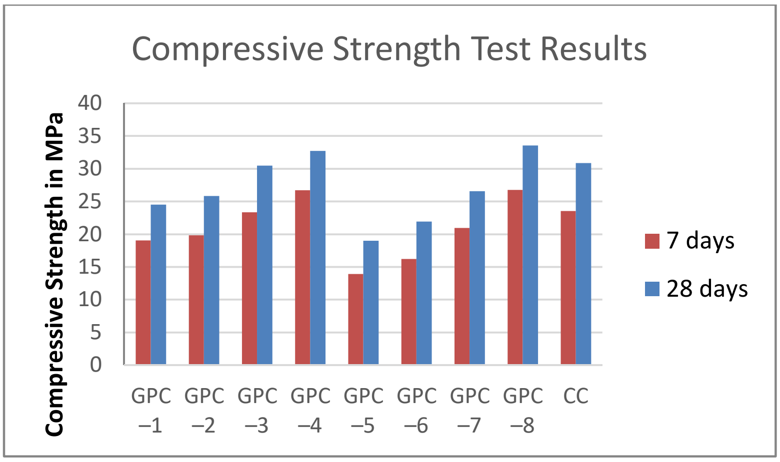

Figure 1 Comparison of Compressive Strength of 12 M and 14 M Concentration Specimens at 7 days and 28 days with conventional M30 cube

Table 3 Tensile Strength Results for Cylinders

Curing Period	**7 days**		**28 days curing**	
Specimen No	**Weight in kg**	**Stress in MPa**	**Weight in kg**	**Stress in MPa**
GPC - 1a	3.820	2.67	3.854	3.055
GPC - 1b	3.452	2.38	4.211	3.75
GPC - 1c	3.956	2.06	3.981	2.92
GPC - 2a	3.758	2.51	4.142	2.67
GPC - 2b	4.125	2.92	4.058	3.88
GPC - 2c	4.085	2.8	4.225	3.53
GPC - 3a	4.226	3.24	3.854	3.24
GPC - 3b	3.982	3.055	4.211	3.97
GPC - 3c	3.885	3.469	3.981	2.99
GPC - 4a	4.058	3.501	4.278	3.15
GPC - 4b	4.227	2.89	4.103	3.66
GPC - 4c	4.102	3.69	4.01	3.78
GPC - 5a	3.875	2.57	4.237	3.08
GPC - 5b	3.971	2.73	3.844	3.27
GPC - 5c	4.081	2.48	4.312	2.8
GPC - 6a	4.121	3.02	3.958	3.24
GPC - 6b	3.971	2.38	3.778	3.62
GPC - 6c	4.081	3.24	3.997	2.99
GPC - 7a	3.869	3.15	4.218	3.85
GPC - 7b	4.113	3.4	3.952	3.37
GPC - 7c	3.988	3.05	4.146	3.75
GPC - 8a	4.215	3.75	4.189	4.04
GPC - 8b	3.962	3.34	3.998	3.85

GPC - 8c	4.025	3.66	4.036	4.26
CC - a	4.025	3.24	4.015	3.88
CC - b	4.128	3.46	3.991	3.66
CC - c	4.237	3.08	4.241	4.07

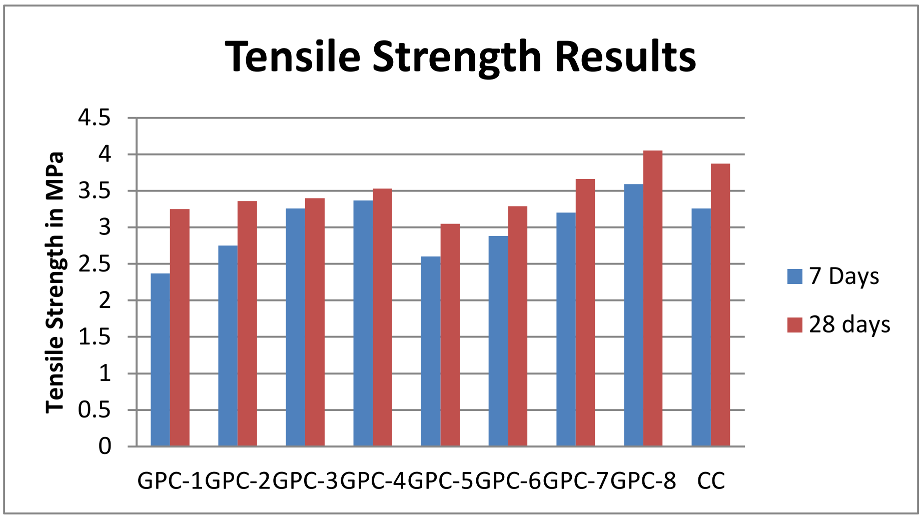

Figure 2 Comparison of Split Tensile Strength Results for Selected Mix Ratios of Beams with M30 Mix Ratio

The tensile strength of GPC-3,GPC-4,GPC-7 and GPC-8 are nearly equal or more than the tensile strength of the specimen with conventional concrete at 7 days but the 28 days tensile strength of GPC-8 only was more than the tensile strength of the specimen with conventional concrete.

The compressive and tensile strengths at 7 days of GPC-3, GPC-4 and GPC-8 are comparatively higher than results of conventional mix. This suggests a higher early strength is possible with Geopolymer concrete. For flexural strength GPC-4 and GPC-8 mixes only are used to compare with the conventional concrete mix. Geopolymer concrete specimens with strength less than the specimens with conventional mix also had lesser weight compared with the specimens of conventional mix.

Table 4 Load Deflection Behaviour for GPC – 4 Beam

LOAD (kN)	**DEFLECTION (mm)**		
	L/3	**L/2**	**2L/3**
0	0	0	0
5	0.249	0.658	0.518
15	0.745	0.897	0.854
20	1.072	1.256	1.21
25	1.362	1.75	1.535
30	1.668	2.06	1.891
35	1.872	2.26	2.11
40	2.154	2.45	2.34
45	2.378	2.77	2.65
50	2.553	3.01	2.84
55	2.798	3.15	3.1

60	3.008	3.35	3.325
65	3.414	3.57	3.771
70	3.564	4.24	3.977
75	4.065	5	4.25
80	4.531	6.37	5.893
85	5.727	7.85	5.956
90	7.107	9.45	7.658
95	8.425	12.85	9.547
100.11	9.758	14.09	10.22

Table 5 Load Deflection Behaviour for GPC – 8 Beam

LOAD (kN)	**DEFLECTION (mm)**		
	L/3	**L/2**	**2L/3**
0	0	0	0
5	0.413	0.62	0.363
15	0.657	0.798	0.605
20	1.056	1.125	0.973
25	1.298	1.45	1.208
30	1.447	1.79	1.35
35	1.675	2.35	1.583
40	1.896	2.56	1.805
45	2.073	2.97	1.979
50	2.238	3.26	2.147
55	2.547	3.78	2.47
60	2.851	4.02	2.808
65	3.21	4.56	3.06
70	3.589	4.78	3.455
75	4.025	5.22	4.35
80	5.05	5.89	5.36
85	5.85	6.58	6.11
90	6.54	7.68	7.45
95	7.45	9.54	8.36
100	8.56	11.5	9.44
105	10.45	12.65	11.25
110.26	12.22	14.55	12.65

Table 6 Load Deflection behaviour for M30 Beam

LOAD (kN)	**DEFLECTION (mm)**		
	L/3	**L/2**	**2L/3**
0	0	0	0
5	0.224	0.486	0.481
15	0.662	0.925	0.673
20	0.85	0.987	0.885
25	1.053	1.289	1.105
30	1.306	1.468	1.386

35	1.421	1.689	1.506
40	1.655	1.895	1.754
45	1.857	2.164	1.963
50	2.082	2.395	2.197
55	2.262	2.65	2.386
60	2.588	2.958	2.703
65	3.058	3.57	3.256
70	3.447	4.25	3.987
75	4.016	4.98	4.548
80	4.756	6.22	5.758
85	5.828	7.95	6.872
90	7.869	10.25	8.126
92.5	9.256	12.85	9.759

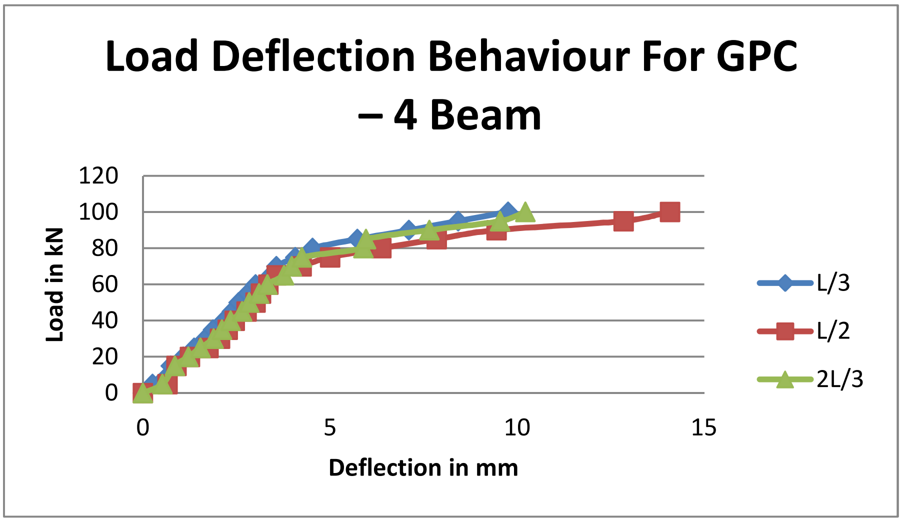

Figure 3 Load Deflection Behaviour for GPC – 4 Beam

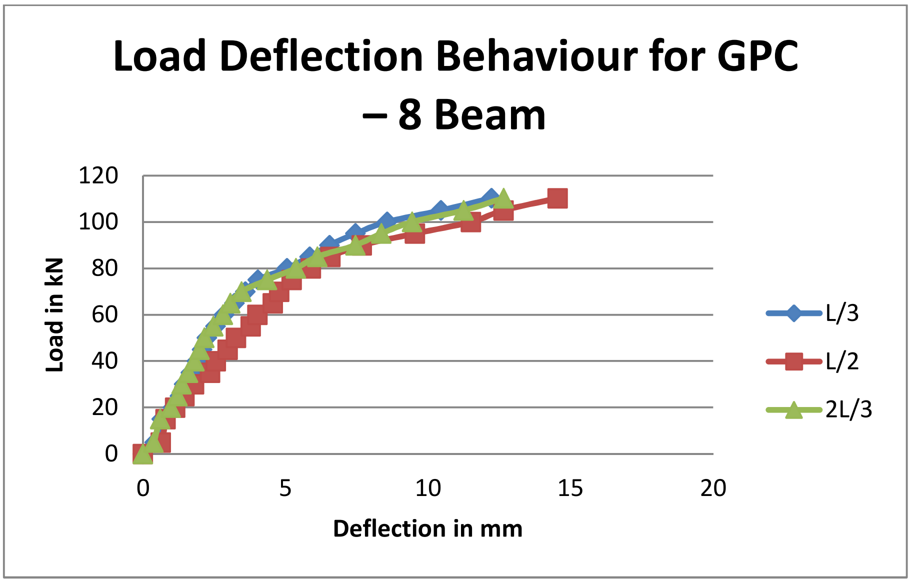

Figure 4 Load Deflection Behaviour for GPC – 8 Beam

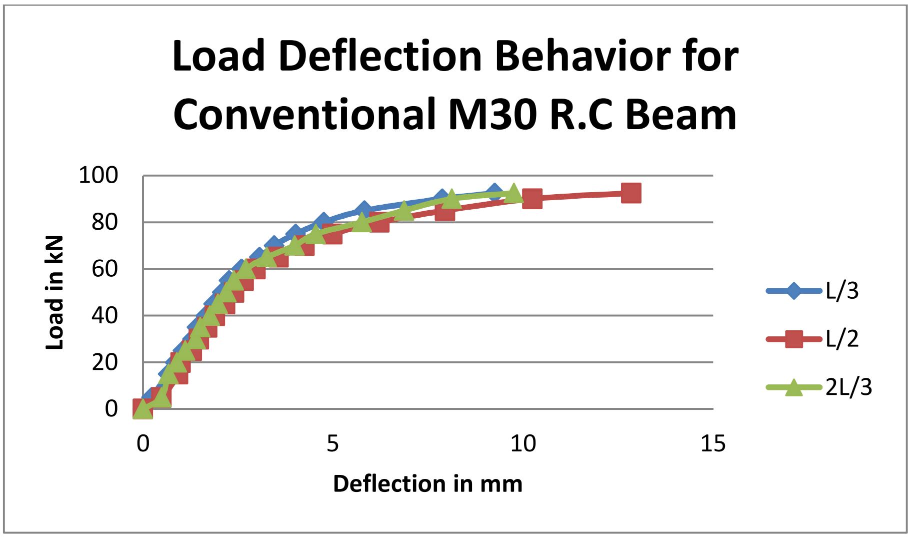

Figure 5 Load Deflection Behaviour for Conventional R.C Beam

The results of the flexural strength tests at 28 days is shown in table 4 to table 6 and a plot of deflection at various loads is shown in chart 3. to chart 5. for GPC-4, GPC-8 and conventional concrete respectively. From the plot of mid-span deflections as shown in chart 6. it can be observed that the flexural strength of the GPC-4 and GPC-8 are more than the conventional beam. The ductility of the GPC-8 is also more compared to the conventional beam.

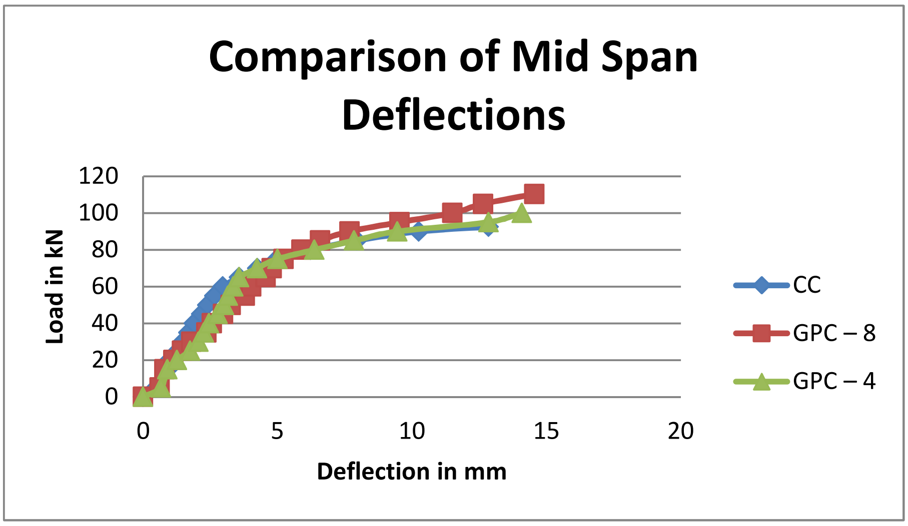

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Figure 6 Comparison of Mid Span Deflections of Geopolymer Beams with Conventional Concrete Beams

10. CONCLUSION

Flexural behaviour of Geopolymer concrete beams has an increase in the load carrying capacity compared to the conventional M30 mix by 19.2%. From the results its inferred that using higher percent of flyash and lower percent of alkali activator solution as a cement replacement can obtain higher strength. During the experiments its observed that user-friendly Geopolymer concrete can be used under conditions similar to those suitable for ordinary Portland cement concrete. The strength results at 7 days suggests the high early strength of Geopolymer Concrete can be effectively used in the precast industries, so that huge production is possible in short duration and the breakage during transportation shall also be minimized.

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