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DESIGN AND PERFORMANCE ASSESSMENT OF GEO-POLYMER CONCRETE IN STRUCTURAL ELEMENTS

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Abstract:

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum. On the other hand, the abundant availability of flyash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete. So, one of the ways to produce environmental friendly concrete is to reduce the use of Ordinary Portland Cement byusing other forms of binders to make concrete. In geo-polymer concrete, the silicon and the aluminum in the low-calcium (Class F) fly ash react with an alkaline liquid that isa combination of sodium silicate and sodium hydroxide solutions to form the Geopolymer paste that binds the aggregates and other unreacted materials. Based on the previous studies and laboratory experience, it is found that the cost of geo-polymer concrete per cubic meter is approximately the same as that of Portland cement concrete. But on considering the impact of the possible carbon dioxide emission and cost of production of cement and the environmental advantage of utilization of fly ash,the geo-polymer concrete may prove to be economically and environmentally advantageous.

Key Words: Geo-Polymer, Framed Structure, Molarities & Strength

Introduction:

Davidovits coined the term "Geo-polymer to represent these binders. Geo-polymer concrete is concrete which does not utilize any Portland cement in its production. Geo-polymer concrete is being studied extensively and shows promise as a substitute to portal and cement concrete. Research is shifting from the chemistry domain to engineering applications and commercial production of geo-polymer concrete. The geo-polymer technology developed in the 1980s offers an attractive solution for this issue. Beam column a joint is a critical member in structural system and during earthquakes, structural elements must be able to dissipate a great amount of energy to ensure the structural integrity of the building to avoid collapse. The most critical region of the framed structure is the beam column joint, because of high shearing force acting and environmental effects .so in beam column joint portion increase the strength. In such situations geo polymer concrete become more applicable strength and environmental criteria. In the present study, the role of geo polymer concrete with various molarities of 8M, 10M, 12M, 14M, 16M in the behavior of geo polymer concrete beam column joints were studied under cyclic loading. The influence of geo polymer on the ultimate load, first crack load, deflection of beam column joints was studied.

Materials, Mixing & Casting:

Materials: There are two main constituents of Geopolymers, namely the source materials and the alkaline liquids. The source materials for Geopolymers (Al). These could be natural minerals such as kaolinite, clays, etc. Alternatively, by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc could be used as source materials. The choice of the source materials for making Geopolymers depends on factors such as availability, cost, type of application, and specific demand of the end users. The alkaline liquids are from soluble alkali metals that are usually sodium or potassium based. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate.

Fabrication of Reinforcement: Limit state method of design using IS 456:2000 was adopted for the design of beam and column separately and detailed as per IS13920:1993. The column consist of 4 numbers of 12 mm diameter bar and laterally tied with 8 mm diameter ties at a spacing of 50 mm c/c and the beam with 2 numbers of 16 mm diameter bar as tension reinforcement and 2 numbers of 12 mm diameter bar as compression reinforcement. Sufficient development length is provided in beam reinforcement and proper anchorage to column. The transverse reinforcement is provided with 8 mm diameter bars at 50 mm c/c near the joint at a length of 300 mm as per IS 13920:1993 and after that provide 100mm c/c throughout. The detailing of beam column joint shows the mould with reinforcement cage. To study the influence of fibers on the behavior of beam column joint in volume fraction of fiber was varied by keeping stirrup spacing constant. The detailing of beam column joint is given.

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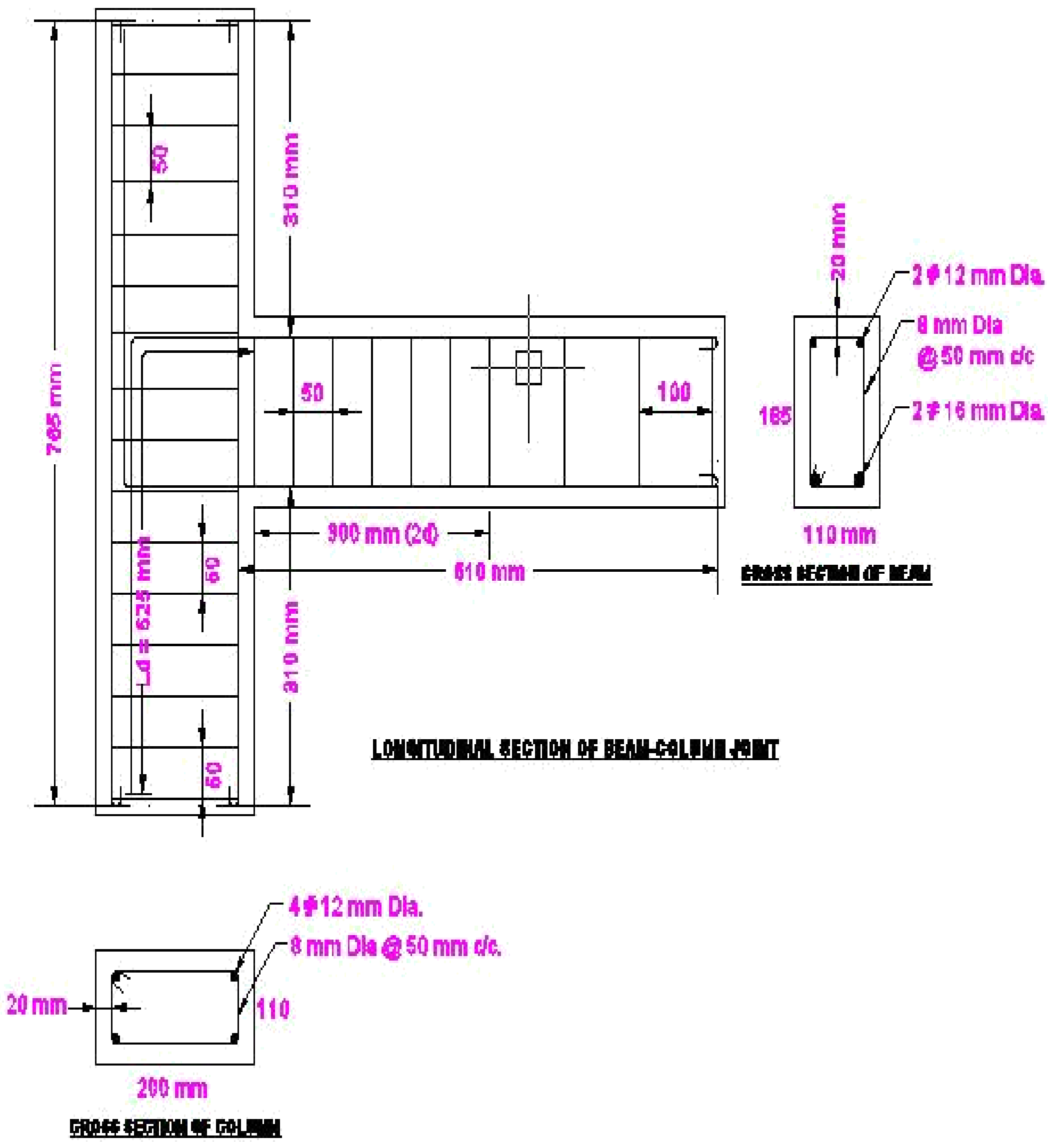

Figure 1: Fabrication of Reinforcement Details of Beam- Column Joint

Loading Arrangement: The prepared specimens were tested in a loading frame in our structural Engineering lab. The provisions were made for holding the column firmly in vertical position and also for the placing of dial gauge at various locations. A schematic representation of test set up is shown in Fig.4.6 and test set up for loading is shown in Fig..2

Figure 2: Loading arrangement of beam – column joint

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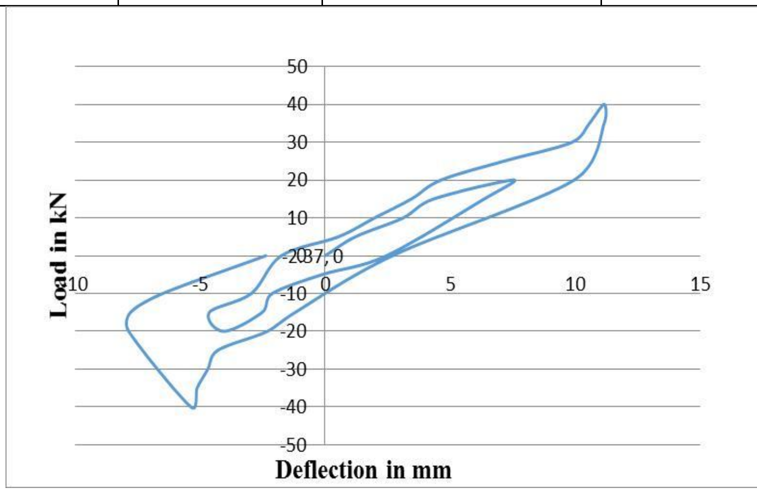
Load Deflection Behaviour: The deflection of the specimen in each increment of load was measured. The deformations due to the elastic rotation of the columns are deducted from the measure values at the tip of the beam so the deformation due to elastic behaviour of the joint is included in the corrected deformations, The typical load deflection curve for Conventional Concrete (CC) and geo-polymer specimens is shown

No. of Cycles	Load in kN	Max Deflection in mm (conventional)	
		Forward	Reverse
I	20	9.78	5.23
II	35	16.76	12.36
	40	-	-
III	30	-	-
	35	-	-



Load Deflection Curve:

No. of Cycles	Load in kN	Ductility factor(μ) (conventional)	
		Forward	Reverse
I	20	1.66	1.62
II	35	4.23	5.2
III	40		
	30	-	-
	35		

Ductility Factor-Conventional Concrete:

No of cycles	Load in kN	Ductility Factor(μ)							
		GP-2		GP-3		GP-4		GP-5	
		F	R	F	R	F	R	F	R
I	20	1.2	1.26	1.28	1.98	2.6	2.8	3.2	3.46
II	35	5.16	5.74	-	-	-	-	-	-
	40	-	-	3.86	5.24	4.2	5.2	4.8	5.0
III	30	-	-	4.0	-	-	-	5.2	-
	35	-	-	-	-	-	-	-	-
	40	-	-	-	-	6.9	-	-	-

First Crack Load and Ultimate Load: The geopolymer concrete specimens first crack load and ultimate load compared to conventional concrete. The addition of alkaline solution concentration increases the first crack load by 20% and 36% in geopolymer concrete and in conventional is 9.1% and 27.3% respectively. The conventional concrete beam column joint first crack was coming 15 kN and in geopolymer concrete firstcrack was appeard 20 kN .The geopolymer concrete beam column joint ultimate load was 40 kN and conventional concrete was 30 kN. This increase in first crack load and ultimate load may be due to the geopolymer stitching action in beam column joint which require more energy to propagate the crack.

Crack Pattern: The crack pattern of conventional and geopolymer beam column joint under cyclic loading .The crack pattern of GP2, GP3, GP4 and GP5 is given below,

Failure Pattern of GP

Conclusion:

A new class of geo-polymeric binders is obtained with full replacement of cement with industrial waste fly ash which in turn produced an economical and environmental friendly concrete with less consumption of energy resources and carbon dioxide emission. The main objective of the study was to explore the use of geo-polymer for beam column joint. From the experimental investigation, following conclusions have been drawn.

- ✓ Geo-polymer concrete to be a good alternative for normal concrete.
- ✓ Geo-polymer can improve all the properties of hardened concrete and the major influence was in the improvement of structural behavior.
- ✓ Geo-polymer concrete increased the compressive strength 30% compared to conventional concrete.
- ✓ The load deflection characteristics of geo-polymer reinforced beam column joint were better than conventional concrete. The geo-polymer specimens showed better performance under cyclic loading.
- ✓ In cyclic loading the increase in first crack load in geopolymer by addition of 12M, 14M and 16M of concentration are corresponding increase in conventional.
- ✓ The ultimate load of geopolymer increases by 32% compare to conventional concrete.
- ✓ In conventional specimen subjected to cyclic loading compare to in addition concentration of various molarities of NaOH increases the ductility factor. Geopolymer concrete increases the ductility factor to 1.6 times of the conventional mix.
- ✓ Under cyclic loading geo-polymer shows 3.17 times higher energy absorption capacity of conventional specimen.
- ✓ The geo-polymer concrete beam column joint shows higher stiffness.

References:

1. Anuar K. A., Ridzuan A. R. M. and Ismail S. (2011),"Strength Characteristic of Geopolymer Concrete Containing Recycled Concrete Aggregate," International Journal of Civil & Environmental Engineering IJCEE-IJENS, 11.01, pp .81-88
2. A.pimanmas and p. chaimahawan(2011), "CyclicShear Resistance of Expanded Beam Column Joint", Procedia Engineering vol-14, pp.1292–1299
3. Benny Joseph a, George Mathewb(2011),"Influenceof aggregate content on the behavior of fly ash based geopolymer concrete".
4. Cheng-Cheng Chen, Keng-Ta Lin (2009) ,"Behaviorand strength of steel reinforced concrete beam–column joints with two-side force inputs Constructional Steel Research" vol-65 ,pp.641–649
5. Fumio Kusuhara, Keikoazukawa (2004),"Tests of reinforced concrete interior beam-column joint sub assemblage with eccentric beams"