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Structure and Behaviour of Geo Polymer Concrete Beams

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Abstract

The worldwide production of concrete is on the expansion to meet the expanding pace of construction. Since cement production adds to greenhouse gas emissions, it is imperative to create elective low-emission covers to lessen the carbon impression of concrete. Fly ash-based geopolymer is an elective cover that can possibly lessen the CO2 emission of concrete production. It has been appeared in changed examinations that the mechanical properties of geopolymer concrete are tantamount to those of conventional Portland cement (OPC) concrete. This paper clarifies the structure and conduct of geopolymer concrete beams.

Introduction

Research on geopolymer concrete is on-going to explain its mechanical properties and toughness. The mechanical properties of geopolymer concrete, including compressive strength, roundabout rigidity, modulus of versatility, and toxic substance proportion have been explored [1]. The outcomes showed that the modulus of flexibility expanded with expanding compressive strength and the toxin proportion was in the scope of 0.12 to 0.16. The conduct of the roundabout rigidity and the scope of breakdown under pressure conditions was fundamentally the same as that of Ordinary Portland Cement (OPC) concrete. The geopolymer concrete pressure strain bend showed a pinnacle strain in the reach 0.0024–0.0026. The mechanical properties of geopolymer concrete have been anticipated utilizing Australian Standards [2], which incorporate the modulus of versatility, poison proportion, compressive strength, parting elasticity, and flexural strength. The activator focus and sort of fly ash affected the nature of the mechanical properties of the geopolymer concrete and a portion of the prevalent mechanical properties, specifically the quick strength and little shrinkage [3]. The bond strength of geopolymer concrete was additionally higher than that of OPC concrete [4]. Geopolymer concrete utilized low calcium fly ash showing higher compressive strength when relieved under raised temperatures.

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The penetrability character and the modulus of versatility of the geopolymer concrete were profoundly reliant on the geopolymer concrete compressive strength. Geopolymer concrete shrinkage was little, around 100 micro-strains following one year. This worth was less than the OPC concrete shrinkage of 500 to 800 micro-strains. The increment in Sodium Hydroxide (NaOH) molarity prompts an abatement in chloride infiltration and decreased erosion in steel. Thus, the solidness of geopolymer concrete is superior to typical concrete, as it is impervious to sulfate and chloride and a carbonation climate. The component of polymerization from 28 days to 356 days has been concentrated with consequences of strength increment, diffusion coefficients decline, and reasonable gel production prompting denser microstructure. Other examination showed that geopolymer concrete offered preferable properties over ordinary concrete like quick strength improvement.

Structural Behaviour Reinforced Geo-polymer Concrete Beams

Structural behaviour of fly ash based geopolymer concrete beams were started by Sumajouw et al. An aggregate of six under-supported concrete beams with shifting reinforcement proportions (0.64–2.69%) were tried for flexural disappointment. The flexural load-conveying limit expanded with the expanded ductile reinforcement proportion, the test-to-expectation proportion were somewhere in the range of 0.98 and 1.28. In the examination by Sumajouw et al. sixteen built up geopolymer concrete beams (Figure. 1) with differing tractable reinforcement proportion (0.64–2.69%) and concrete compressive strength (37–76MPa) were tried.

Figure 1. Geopolymer concrete beams

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In various examinations, it was additionally detailed that under-supported fly ash-based geopolymer concrete beams acted likewise (first breaking load, break width, load-redirection relationship, flexural solidness, extreme burden and disappointment mode) as regular built up concrete beams exposed to flexural stacking. Though, Dattatreya et al. noticed lower post-top pliability of geopolymer concrete beams and this was by Yost et al. who found a more weak disappointment during concrete smashing contrasted with customary cement-based concrete. Interestingly, Jeyasehar et al. discovered higher first break load, midspan diversion and extreme burden just as more modest break width for the instance of supported geopolymer concrete beams when contrasted with ordinary cement-based concrete beams. Like the past examination in Sumajouw et al., Sumajouw et al. assessed the flexural load limit of the sixteen supported geopolymer concrete beams and the normal test-toprediction proportion was discovered to be 1.11. Taking into account that the beams were under-built up, the impact of the geopolymer concrete compressive strength was marginal.

Material and Methods

Fly ash class f [IS: 3812(part-1)].Ordinary Portland cement 53[IS:8112]. Coarse aggregate [IS: 383].Fine aggregate [IS:383].Chemical admixtures [IS:9103].sodium hydroxide pellets, alkaline activator is sodium hydroxide solution, GGBS, Water.

Fly ash

As per ASTM c-618, there are two types of classes a) class F, is generated by burning bituminous coal which contains calcium less than 10% b) class C, is generated by burning sub-bituminous coal which contains excess calcium (10%-40%), due to higher calcium content class c fly ash participate in both cementitious and pozzolanic reaction.

Chemical Characteristics of Indian Fly Ash (low lime fly ash)

The fly ash has higher concentration of silicon dioxide and aluminum oxide and lower contents of ferric oxide, as fly ash cannot react with water, which leads to longer life of concrete structure. Delay in heat of hydration helps in reduction in thermal cracks in concrete in turn improves microstructure and rheology.

Table 1. Fly ash Physical and Chemical Properties

S. No	Description	Values	Requirements
Physical Properties			

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1	Specific gravity	2.05	-
2	Fineness	333	320
3	SiO_2	62.92	35
4	Al_2O_3	30.96	-
5	SiO_2+ Al_2O_3+ Fe_2O_2	93.88	70
6	MgO	.74	5
7	Total sulphur as sulphur trioxide	0.23	3
8	Loss of ignition	0.59	5

NaoH: Sodium hydroxide, too known as lye and caustic soda, which is an inorganic compound with the formula NaOH. "It is a white solid ionic compound consisting of sodium cations Na+ and hydroxide anions OH−, sodium hydroxide is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemical burns. It is highly soluble in water, and readily absorbs moisture and carbon dioxide from the air, it forms a series of hydrates NaOH·nH2O". The monohydrate NaOH·H2O crystallizes from water solutions between 12.3 and 61.8 °C. "The commercially available sodium hydroxide is often this monohydrate, and published data may refer to it instead of the anhydrous compound". Sodium hydroxide is used in various cement mix plasticizers. "This helps homogenize cement mixes, preventing segregation of sands and cement, decreases the amount of water required in a mix and increases workability of the cement product, be it mortar, render or concrete".

Mix Proportion

The mix proportion is calculated according to Indian Standards IS:10262. Grade of concrete = G30, assumed standard deviation=5.0(according to table 1 of is 10262)

Stage 1:

$$f_m = f_{ck} + 1.65S$$

$$30+1.65(5.0)$$

$$f_m = 38.25\ N/mm^2$$

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Stage 2:

Assume water cement ratio as 0.45

Aggregate size = 20 mm

Maximum water content = 186 kg

Stage 3:

Water Content

Assuming slump value to be 100 mm corresponding increment in water is 6% and decreasing up to 30% for using superplasticizer

$186 + (\frac{6}{100})$ X $186 = 197.16\ kg$

Stage 4:

Cement Content

Cement Content = 360 kg

fly ash= 0.85 X360 = 306 *kg*

Ggbs = 0.15 X 360 = 54 *kg*

Stage 5:

Volume of Coarse Aggregate and Fine Aggregate

IS:10262 clauses 4.4, A-7 and B-7Nominal size of aggregate for zone II is 0.62 for 20 mm aggregate*This volume of aggregate is for w\c ratio 0.5* 0.50.4=0.1For every change of w\c ratio 0.05, the Coarse aggregate volume will change by 0.01 vice versatherefore, 0.1×0.01 0.05=0.02 Total volume of aggregate = 0.62+0.02 = 0.64, Coarse aggregate = 0.64, Fine aggregate = 1-CA= 0.36

Mass of Admixture

Volume of concrete = $1m^3$

Volume of (cement) = $\frac{360}{3.15}$ X $\frac{1}{1000} = 0.114\ m3$

Volume of water = 0.318 m^3

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Result

Volume ofadmixture: 2% of (cement)= 6.9 kg = 6.9/1.145 X 1/1000 = 0.006026

Volume of aggregate = (a-(b + c + d)) = (1-(0.114 + 0.138+0.006026)) = 0.741 m^3

Mass of coarse aggregate = e×vol of ca × sp gravity of ca

= 0.741×0.64×2.74=1308 kg

Mass of fine aggregate = e×vol of fa × sp gravity of fa

= 0.741×0.36×2.67=717 kg

Table 2. Final mass of ingredients

Ingredient	Mass(kg/m^3)
Fly ash + GGBS	360
Water	138
Coarse aggregate	1308
Fine aggregate	717
Admixture	6.9
w\c ratio	0.45

Therefore, the mix proportion for 0.45 w\c(G30) is 1: 2 : 3.6: 0.45

Fly ash + GGBS = 1, Fine aggregate = 2, Coarse aggregate = 3.6

Water content = 0.45

Most of the literature suggested that the solution and the pellets to be mixed prior to 24 hours before casting but in our investigation, we understood that 30 minutes is sufficient before casting (based on trail and error basis) if the solution is kept upon 30 minutes there was an increase in water content i.e., after 30 minutes for every delayed 10 to 15 minutes we have to add more amount of water to get the suitable workability that has to be placed in molds. Utmost care has to be taken while mixing the pellets into NaOH solution by stirring it continuously as the pellets will be settled at bottom if left still, as solution reacts with pellets and produce great amount of heat and vapors so wearing gloves is important. The solution then is transferred after 30 minutes to pan mixer where all the other ingredients like coarse aggregate, fine aggregate, flyash, GGBS, are placed before hand, then transferred to molds. After setting the GPC cubes are demoulded and a batch (6 cubes) is kept in oven for 24 hours at 60°C.

After 24 hours it is kept aside to cool down for one day and this period is called resting period. The other batch (6 cubes) are kept for ambient curing, Then the cubes are subjected to compression on 3,7,14 days and the results are tabulated and comparison is made between oven cured, ambient cured and conventional concrete.

Conclusion

The developments of flexural cracks are relatively less in geo polymer beams compared to conventional RCC beams. The failure occurred in the beams was in flexural mode and the cracks are generated from the tension zone to the compression zone. The compressive strength is greater than before due to decrease in porosity, as the fineness of fly ash is more in case of geopolymer concrete. The mix proportions, which are used to manufacture geopolymer and conventional concrete, are same.

References

1. M. Ratna srinivas1, Y. Himath Kumar2, B. Sarath Chandra Kumar, “Studies on Flexural Behavior of Geopolymer Concrete Beams with GGBS”, (IJRTE) ISSN: 2277-3878, Volume-7, Issue-6C2, April (2019).
2. N. Sai kiran1, Y. Himath Kumar2, B. Sarath Chandra Kumar, “Experimental Investigation on Reinforced Geopolymer Concrete Slabs”, (IJRTE) ISSN: 2277-3878, Volume-7, Issue6C2, April (2019).
3. Tatsuya Koumoto,Ph.D. “Production of High Compressive Strength Geopolymers Considering Fly Ash or Slag Chemical Composition”, ASCE journal. (2019).
4. Xin Ren and Lianyang Zhang, M.ASCE, “Experimental Study of Geopolymer ConcreteProduced from Waste Concrete”, 10.1061/(ASCE)MT.1943-5533.0002750.© (2019).
5. Xin Ren and Lianyang Zhang, “Experimental study of interfacial transition zones between geopolymer binder and recycled aggregate”,X. Ren, L. Zhang / Construction and Building Materials 167 749–756 (2018).

6. Kunal Kupwade-Patil, Ph.D.; and Erez N. Allouche, Ph.D., "Impact of Alkali Silica Reactio on Fly Ash-Based GeopolymerConcrete " ,X. Ren, L. Zhang / Construction and Building Materials 167 749–756. (2018).
7. Paulo H. R. Borges; Lucas F. Fonseca; Vitor A. Nunes; Tulio H. Panzera; and Carolina C. Martuscelli, "Andreasen Particle PackingMethod on the Development of Geopolymer Concrete for Civil Engineering", DOI: 10.1061/(ASCE) MT.19435533.0000838. American Society of Civil Engineers.(2014).
8. C. Antony Jeyasehar, G. Saravanan, M. Salahuddin and S.Thirugnanasambandam. "Development of fly ash based geopolymer precast concrete elements", ASIAN JOURNAL OF CIVIL ENGINEERING (BHRC) VOL. 14, NO. 4,605-615. (2013).
9. Naspuri Arun Raju, T. Suresh Kumar, International Journal of Innovative Technology and Exploring Engineering, Vol. 8 no. 11, pp: 3860-3864, (2019)
10. Srinivasa Reddy, V., Seshagiri Rao, M.V., Shrihari, S, "Appraisal of processing techniques for recycled aggregates in concrete", IJEAT, 8 (6), pp. 1661-1665, (2019).
11. Gunasekara, C.; Law, D.W.; Setunge, S. Long term permeation properties of different fly ash geopolymer concretes. Construct. Build. Mater. 2016, 124, 352–362
12. T. Narmadha, J. Gowrishankar, M. Ramkumar, and K. Vengatesan,"Cloud Data Center Based Dynamic Optimizing Replica Migration",J. Comput. Theor. Nanosci. 16, 576–579 (2019)
13. Zeng, S.; Wang, J. Characterization of mechanical and electric properties of geopolymers synthesized using four locally available fly ashes. Construct. Build. Mater. 2016, 121, 386–399.
14. Dattatreya, J.K.; Rajamane, N.P.; Sabitha, D.; Ambily, P.S.; Nataraja, M.C. Flexural behavior of reinforced geopolymer concrete beams. Int. J. Civ. Struct. Eng. 2011, 2, 138–159.
15. Mourougane, R.; Puttappa, C.G.; Sashidhar, C.; Muthu, K.U. Shear behavior of high strength GPC/TVC beams. Proc. Int. Conf. Adv. Arch. Civ. Eng. 2012, 21, 142.
16. Topark-Ngarm, P.; Chindaprasirt, P.; Sata, V. Setting time, strength, and bond of high-calcium fly ash geopolymer concrete. J. Mater. Civ. Eng. 2014, 27, 04014198.