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Comparison of Geopolymer Concrete Based On Strength and Cost with Concrete

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Abstract*: Geopolymer concrete an innovative material that is characterized by long chains or networks of inorganic molecules is a potential alternative to conventional Portland cement concrete for use in transportation infrastructure construction. It relies on minimally processed natural materials or industrial by products to significantly reduce its carbon footprint, while also being very resistant to many of the durability issues that can plague conventional concrete. However, the development of this material is still in its infancy, and a number of advancements are still needed. This briefly describes geopolymer concrete materials and explores some of their strengths, weaknesses, and potential applications. In this paper we discuss the strength and behaviour of geopolymer concrete.*

1. Geopolymer Concrete

Geopolymer materials represent an innovative technology that is generating considerable interest in the construction industry, particularly in light of the ongoing emphasis on sustainability. In contrast to Portland cement, most geopolymer systems rely on minimally processed natural materials or industrial by products to provide the binding agents. Since portland cement is responsible for upward of 85 percent of the energy and 90 percent of the carbon dioxide attributed to a typical ready-mixed concrete, the potential energy and carbon dioxide savings through the use of geopolymers can be considerable. Consequently, there is growing interest in geopolymer applications in transportation infrastructure.

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In the context of increased awareness regarding the ill effects of the over exploitation of natural resources, eco friendly technologies are to be developed for effective management of these resources. Concrete usage around the world is second only to water. Cement is conventionally used as the primary binder to produce concrete. The environmental problems associated with the production of cement are well known. The amount of the carbon dioxide released during the manufacture of cement due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of cement produced. Hence, it is imminent to find an alternative material to the existing most expensive most resource consuming Portland cement. OPC is extensively used in India due to its low cost and easy availability. Concrete can be cast in almost any desired shape, and once hardened, can become a structural (load bearing) element. On the other hand it also affects environment, also there are many negative influence of OPC.

2. Mix Design of Geopolymer Concrete

As there are no code provisions for the mix design of geopolymer concrete, the density of geo-polymer concrete is assumed as 2400 Kg/m3. The rest of the calculations are done by considering the density of concrete. The total volume occupied by fine and coarse aggregate is adopted as 77%. The alkaline liquid to fly ash and GGBS ratio is kept as 0.4. The ratio of sodium hydroxide to sodium silicate is kept as 2.5.The conventional method used in the making of normal concrete is adopted to prepare geopolymer concrete.

Table No. 1 Mix Design

Sample	Fly ash	GGBS	Sodium hydroxide	Sodium silicate	Fine Agg.	Coarse Agg.
M40	12.87	30.03	7.48	18.69	33.28	55.84
M60	14.85	34.56	8.58	21.57	40.69	64.54
M80	16.83	39.27	9.78	24.44	46.15	72.63
Distilled water: 10% of the total cementious material						

3. Experimental Result for Compression of Split tension Strength

It is seen that the compressive capacity is enhanced 33.06 % by replacing cement by fly ash and GGBS. As the grade of cement increases the Split tension capacity of normal concrete and geopolymer concrete is noted to be same. The Split tension strength of geopolymer concrete is directly proportional to the quantity of geo-polymer liquid and indirectly to fly ash content. The Split tension capacity of concrete is enhanced if the replacement of fly ash is reduced but the heat of hydration is increased at that scope.

Table No. 2 Comparison of Geopolymer Concrete to Controlled specimen with admixtures for Split Tension

Sample	M40	M60	M80
Geopolymer Concrete	3.97	4.87	6.72
Controlled specimen with admixture	2.97	3.26	5.55
Percentage Difference	25.19	33.06	17.41

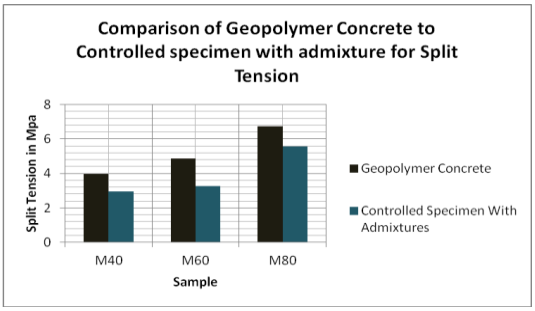
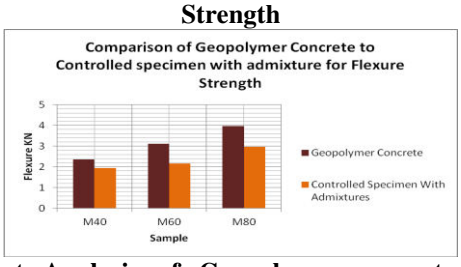


Fig No. 1 Comparison of Geopolymer Concrete to Controlled specimen with admixtures for Split Tension

Table No. 3 Comparison of Geopolymer Concrete to Controlled specimen with admixture for Flexure Strength

Sample	M40	M60	M80
Geopolymer Concrete	2.36	3.12	3.96
Controlled specimen with admixture	1.95	2.16	2.96
Percentage Difference	17.37	30.77	25.25

Fig No. 2 Comparison of Geopolymer Concrete to Controlled specimen with admixture for Flexure Strength



4. Cost Analysis of Geopolymer concrete and Controlled specimen with admixture

Table No. 4 Comparison of Geopolymer Concrete to Controlled specimen with admixture for Cost of Production.

Sample	Grade 40	Grade 60	Grade 80
Geopolymer Concrete	5163	5986	6780
Controlled specimen with admixture	3871	4441	4982
Percentage Difference	33.39	34.78	36.08

It is seen that the cost is enhanced 34.75 % by replacing cement by fly ash and GGBS. High resistance of geopolymer cements against aggressive environment is reported in many papers. The following ones are presented as examples. Fly ash-based geopolymer cement had been proved by many studies to provide better resistance against aggressive environment. A general fire resistance of geopolymer cements is reported. It was found that the fly ash based geopolymer displayed increase in strength after temperature exposure. In addition, the thermal

incompatibility between the geopolymer matrix and its aggregate components was the most likely cause of the strength loss in geopolymer concrete specimens at elevated temperatures. It can be proved by comparison of geopolymer concretes made with two different aggregates of distinctly different thermal expansion characteristics.

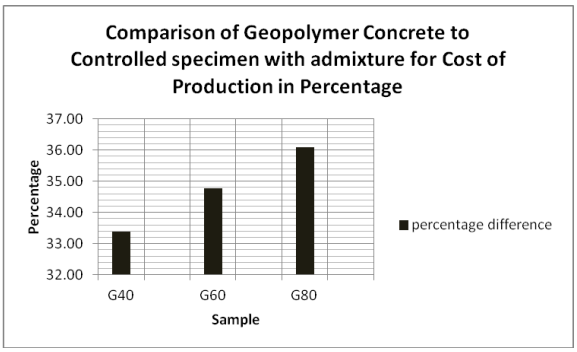


Fig No. 3 Comparison of Geopolymer Concrete to Controlled specimen with admixture for Cost of Production.

5. Conclusion

Geopolymer results from the reaction of a source material that is rich in silica and alumina with alkaline liquid. It is essentially cement free concrete. This material is being studied extensively and shows promise as a greener substitute for ordinary Portland cement concrete in some applications. Research is shifting from the chemistry domain to engineering applications and commercial production of geopolymer concrete. It has been found that geopolymer concrete has good engineering properties with a reduced global warming potential resulting from the total replacement of ordinary Portland cement. The results from studies on mix design development to enhance workability and strength of geopolymer concrete. The influence of factors such as, curing temperature and regime, aggregate shape, strengths, moisture content, preparation and grading, on workability and strength are presented.

Based on the results obtained in the experimental investigation, the following conclusions are drawn.

- The test results states that the chemical composition of Geopolymer liquid will help in increasing the strength of concrete with full replacement of cement and partial replacement of fly ash. The strength of the Concrete is directly proportional to the combination proportion of geopolymer liquid and fly ash.
- Increase in cost is seen by 2.9% to 6.67% with increases the grade of concrete but it depends upon manufacturing replacements of material and not need water curing.
- In comparison of the Geopolymer concrete with the controlled specimen with admixtures mix compression strength was increased by 13.64%, Split tension strength was increased by 33.06 %, and Flexure strength was increased by 30.77%.
- In comparison of the Geopolymer concrete with the controlled specimen with admixtures mix the cost of production per meter cube of concrete differ by 34.75%.
- The geopolymer concrete gained strength within 24 hours at ambient temperature without water curing.
- The necessity of heat curing of concrete was eliminated by incorporating GGBS and fly ash in a concrete mix.
- The strength of geopolymer concrete was increased with increase in percentage of GGBS in a mix.

6. References

1. Ana María Aguirre-Guerrero, Rafael Andrés Robayo-Salazar, Ruby Mejía de Gutiérrez," A Novel Geopolymer Application: Coatings To Protect Reinforced Concrete Against Corrosion", Applied Clay Science, 2016
2. B. Vijaya Rangan, "Geopolymer Concrete For Environmental Protection", Future Concrete.
3. G.B. Maranan, A.C. Manalo, B. Benmokrane, W. Karunasena, P. Mendis, "Evaluation Of The Flexural Strength And Serviceability Of Geopolymer Concrete Beams Reinforced With Glass-Fibre-Reinforced Polymer (GFRP) Bars" Engineering Structures, Vol. 101, Pp. 529–541, 2015.
4. Iftekhair Ibnul Bashar, U. Johnson Alengaram, Mohd Zamin Jumaat, Azizul Islam, Helen Santhi, Afia Sharmin, "Engineering Properties And Fracture Behaviour Of High Volume Palm Oil Fuel Ash Based Fibre Reinforced Geopolymer Concrete", Construction and Building Materials, Vol. 111, Pp. 286–297, 2016.
5. L.Krishnan, S.Karthikeyan, S.Nathiya, K. Suganya, "Geopolymer Concrete An Eco-Friendly Construction Material", IJRET: International Journal of Research in Engineering and Technology.
6. M.S.H. Khan, Arnaud Castel, A. Akbarnezhad, Stephen J. Foster, Marc Smith, "Utilisation Of Steel Furnace Slag Coarse Aggregate In A Low Calcium Fly Ash Geopolymer Concrete", Cement and Concrete Research, Vol.0 89, Pp. 220–229, 2016.
7. Pradip Nath, Prabir Kumar Sarker,"Flexural Strength And Elastic Modulus Of Ambient-Cured Blended Low-Calcium Fly Ash Geopolymer Concrete", Construction and Building Materials, 2016.
8. Sara Rios, Catarina Ramos, António Viana da Fonseca, Nuno Cruz and Carlos Rodrigues," Colombian Soil Stabilized With Geopolymers

For Low Cost Roads" Procedia Engineering, Vol. 143, Pp. 1392–1400, 2016.

9. Vinh Duy Cao, Shima Pilehvar, et. al ," Microencapsulated Phase Change Materials For Enhancing The Thermal Performance Of Portland Cement Concrete And Geopolymer Concrete For Passive Building Applications" Energy Conversion and Management, Vol. 133, Pp. 56–66, 2017.
10. Xiaochun Fan , Mingzhong Zhang," Experimental Study On Flexural Behaviour Of Inorganic Polymer Concrete Beams Reinforced With Basalt Rebar", Composites, Vol. 93 Pp. 174-183, 2016.