COMPARATIVE ANALYSIS OF GEOPOLYMER CONCRETE OVER CONVENTIONAL CONCRETE

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Abstract - Concrete, a substance made of cement, aggregate, and water that is flexible, durable, and dependable, is the most often used material in the world. After water, conventional concrete is the substance that is used the most frequently, and it uses a lot of Portland cement. Mining has a negative impact on the environment, just as the manufacturing of Portland Cement (OPC) does due to the release of carbon dioxide. Finding a replacement for the current cement concrete is important because of the sharp growth in carbon emissions. Another material used in construction that is produced by chemically processing inorganic minerals is Geopolymer concrete. Throughout the world, fly ash is a by-product of thermal power plants' use of coal. An aluminosilicate gel that serves as a concrete binder is created when silica-rich fly ash and alumina are activated with an alkaline activator. It is one of the best building materials for ordinary concrete without the use of large quantities of Portland cement. In some applications, geopolymer concrete is a very friendly alternative to Portland cement concrete. This article reviews the properties and applications of geopolymer concrete.

Key Words: ordinary Portland cement, fly ash, GGBS, alkaline solution. Sodium Hydroxide.

1. INTRODUCTION-

Construction industry is fastly growing. Hence Demand of concrete is increasing rapidly and we need a substitute of cement to decrease CO2. Ordinary Portland Cement (OPC) is the primary binder utilised in concrete. In general, the 2.6 billion tonnes of cement produced annually around the world account for 7% of the carbon dioxide that contributes to environmental pollution and global warming [3]. The consumption of a lot of limestone is also necessary for cement manufacture. On the other side, burning coal produces vast amounts of fly ash, the majority of which end up in landfills and have an adverse effect on groundwater and surface waters.

Therefore, it is very important to use other pozzolanic materials it will use waste materials, decrease the negative impact of construction on the environment and increase the performance of good quality stone [2].

2. OUTLINE ON GEOPOLYMER CONCRETE

Concrete constructed from waste industrial products like fly ash and silica fume is known as Geopolymer concrete. Geopolymer concrete depends on the chemical reaction between alkali metal silicates and aluminosilicate minerals, as opposed to regular Portland cement, which depends on the hydration of calcium silicates. The production of Geopolymer concrete has a lower carbon footprint than traditional concrete, as it uses waste materials and does not require high- temperature kilns. Additionally, geopolymer concrete has several desirable properties, including high compressive strength, low permeability, and good fire resistance.

3.LITERATURE REVIEW

According to Dr. Mohd concluded that fly ash-based Geopolymer concrete is superior to regular concrete in terms of workability, exposure to hostile environments, exposure to high temperatures, and compressive strength. This is encouraging because it suggests that Geopolymer concrete could be a practical substitute for conventional concrete in many applications.

T. Narendra studied the topic "Study on the Geopolymer Concrete. The paper presents the different Conclusion. The Study tells us compressive strength of concrete increases after 7 days and flexural strength increases 40% after 7 to 8 days. Split tensile strength increases 50% after 7 days.

Dr. S. Elavenil studied the topic "Geopolymer concrete with self-compacting: A review". Its included various parameters such as different material needed for making strength, economic benefits of GPC concrete.

M. I. Abdul Aleem et al. studied the topic "Geopolymer concrete: A revaluation". This study takes into account a wide range of factors, such as the nature of Geopolymer concrete, its qualities, applications, and restrictions. The study found that because the chemicals used to manufacture Geopolymer concrete (GPC) can burn your skin, it is important to make this material cautiously. Therefore, it should be used with caution. [5].

4.MATERIALS

1.Fly Ash- This is one of the key components of Geopolymer Concrete. It is created when coal with high silica and alumina content is burned in power plants. These materials' high silica and alumina contents aid in reducing environmental impact.

2. Ground Granulated Blast Furnace Slag -Ground Granulated Blast Furnace Slag is a cementitious material mostly used in concrete as a by -Product of metal blasting.

3.Aggregates- The production of Geopolymer concrete uses both fine and coarse materials.

4.Alkaline Solution-In making of geopolymer concrete we need some reactive chemical which will help in making bond with silica and fly ash in order to polymerization.

In this we used Hydroxide of sodium and potassium.

5.EXPERIMENTAL RESULTS:

i. Compressive Strength

Dr. Marathe al. concentrated on the subject that "Review on strength and Durability studies on Geopolymer concrete". The composition of materials formed by geopolymers, many composites, has no effect on energy, the operation, technology and mechanics of geopolymer concrete in the new case were studied. This study concluded that GPC have more strength comparison to ordinary Portland cement. Hence we can use geopolymer concrete as substitute of Cement. [7]

Raghu Sharma et al reviewed that compressive strength of geopolymer concrete is 1.5 times higher than ordinary Portland cement.

ii. Workability

"B.Siva Konda Reddy" study that workability of geopolymer concrete is decreases with higher concentrations of sodium hydroxide solution . For a specified concentration of NaoH solution, we can see a very little increase in the compressive strength with time for the concrete. [18].

Chindaprasirt et al. (2007) investigated the workability and strength slightly higher in more fly ash Geopolymer. The authors conducted a series of experiment to determine the optimal mix design and the properties of the resulting Geopolymer. [12].

The study discovered that adding a superplasticizer will improve workability. However, adding more superplasticizer reduced the geopolymer's strength. The strength of the Geopolymer was also observed to diminish as the proportion of coarse particles in the mixture increased, according to the authors.

iii. Durability

"Rangan, B.V. stated that Geopolymer concrete is more resistant to heat, sulphate attack, water ingress &alkali aggregate reaction. The role of calcium in Geopolymer concrete made up of fly ash is very prominent since it may cause flash setting. Such structures with high durability can be adapted to marine environment" [16].

"K.Srinivas" told that thermally treated geopolymer concrete which is made with fly ash has low creep and exhibits very little dry shrinkage after one year at about 100 microtension. and shows very good resistance to sulphate attack [17].

"Dr.Chan"It proves fly ash-based geopolymers are more resistant to harsh environments. The creation of structures exposed to sea environments will therefore use this protective device. [10].

"Sathia" et al., derived that in case of geopolymers when put or react with acid, they lose 0.5% of their weight compared to bread in 3% sulfuric acid. [7].

iv. Benefits of Geopolymer

Neuosn A. Lloyd and Bron is a researcher who has written extensively on the economic benefits of geopolymer technology. In his research, he highlights the potential cost savings associated with using geopolymer technology in construction and infrastructure projects. [14]. One of the main economic benefits of geopolymer technology is its potential to decrease the amount of Portland cement used in construction. Reduced use of Portland cement, a significant source of greenhouse gas emissions, can lessen the environmental effect of construction projects. Additionally, Portland cement can be expensive, and using geopolymer technology instead can result in cost savings. [14]. Another economic benefit of geopolymer technology is its potential for use in the repair and maintenance of infrastructure. Geopolymers can be used to repair and strengthen concrete structures, such as bridges and buildings, at a lower cost than traditional repair methods. [14].

v. Necessity of Geopolymer Concrete

According to papers and journals from international research, geopolymer technology has the potential to address several environmental and economic challenges facing the construction industry.

One major challenge is the environmental impact of Conventional cement production. In making of Portland cement lots of carbon di oxide releases in atmosphere which cause greenhouse gas emission. Geopolymer technology can help to reduce the amount of Portland cement used in construction, thereby reducing carbon emissions associated with the construction industry.7 [3]. K. Srinivasan et al is a researcher who has written extensively on the use of geopolymer technology in construction. In his research, Srinivasan highlights the potential benefits of geopolymer technology for the construction industry, and argues that it is a necessary development for the future of construction. [11]. One of the main arguments made by Srinivasan is that geopolymer technology offers significant environmental benefits compared to traditional cement-based materials. [11]

vi. Applications

Ahmad L. Almutairi et al. mentioned that Geopolymer technology has a wider range of potential uses in the construction industry. Geopolymers can be used to replace the traditional Portland cement. It can be used to create high strength, durable concrete for use in building and infrastructure projects [5].

Overall, Geopolymer concrete can be used in every construction industry., cost-effective, and durable alternatives to traditional Portland cement-based materials. However, further research and development are needed to fully understandable the properties and potential applications of geopolymer materials, and to optimize their use in various construction and infrastructure projects. [15].

6. Challenges

The production of geopolymer materials can present some challenges, which need to be addressed in order to optimize the use of this technology in construction. Some of the challenges in making of geopolymer include.[3].

Chemicals, Raw material variability, Mixing and curing, Lack of standardizations are the main challenges in making of Geopolymer concrete. Need to careful from the chemicals used in it. [3].

7. COMPARISION IN BETWEEN STRENGTH OF GEOPOLYMER CONCRETE

Dr. Y. Nagvekaret reviewed the topic of conventional concrete and Geopolymer. Following tables are representing the exact data. Geopolymer materials' compressive strength typically rises over time, with noticeable improvements in strength seen between 7 and 28 days. This is due to the continued chemical reaction between the raw materials used to

Table 2: Compressive Strength after 3 days

Test Results after 3 days			
Serial Number	**Portland cement Concrete N/mm^2**	**Geopolymer (Water curing) N/mm^2**	**Geopolymer (steam curing) N/mm^2**
1	**9.15**	**5.67**	**15.0**

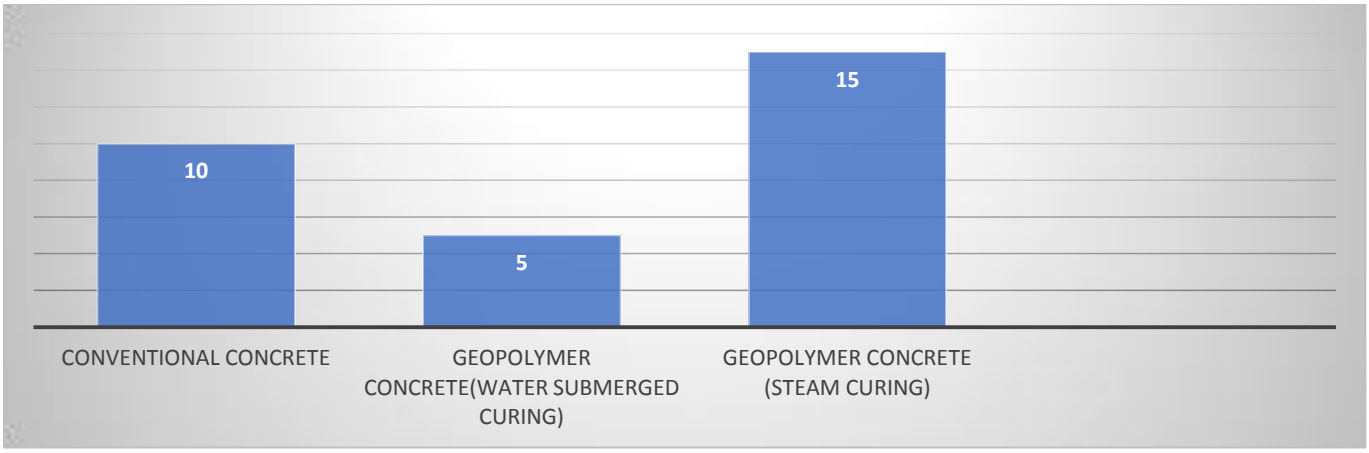

Figure 1. (Comparison after 3 days)

Table 2: Compressive Strength after 7 days

Test Results after 7 days			
Serial Number	**Portland cement Concrete N/mm^2**	**Geopolymer (Water curing) N/mm^2**	**Geopolymer (steam curing) N/mm^2**
1	**14.76**	**9.4**	**21.6**

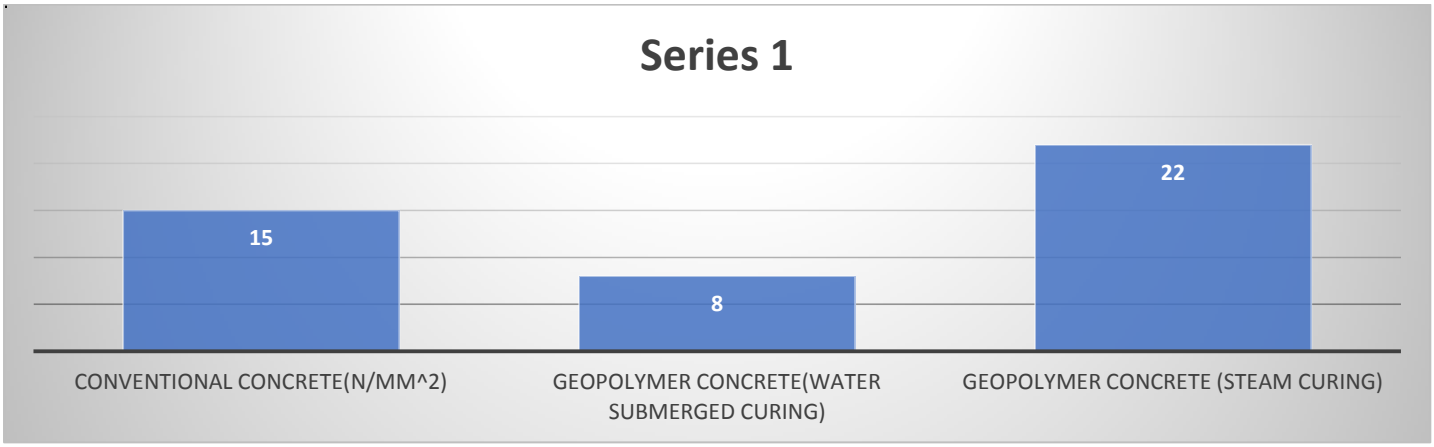

Figure 2: (Comparison after 7 days)

Table3. Compressive strength after 28 days

Test Results after 28 days(Compressive strength)			
Serial number	**Conventional Concrete (N/mm^2)**	**Geopolymer Concrete (Water submerged curing) N/mm^2**	**Geopolymer concrete (Steam Curing) (N/mm^2)**
1	**14.6**	**21.8**	**28.67**

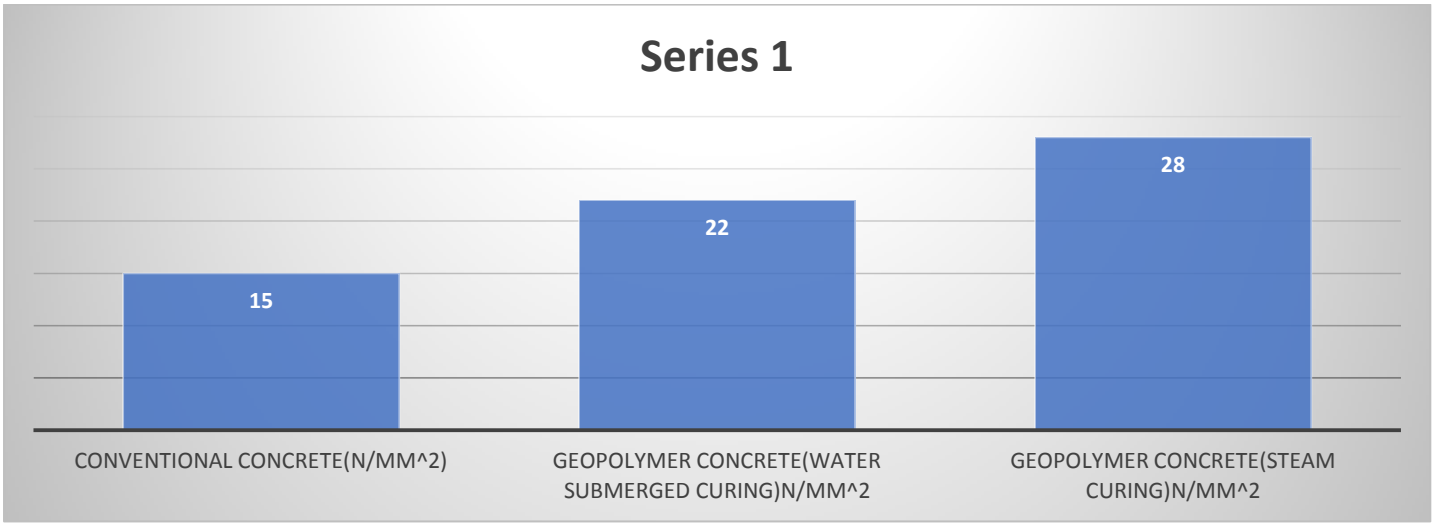

Figure 3: Comparison after 28 days

After study the data of experiment, the authors observed that conventional concrete have far better compressive strength compared to geopolymer green concrete in water immersion cure. However, during curing, geopolymer

concrete is 10% stronger than normal concrete. Therefore, chamber cure is a better choice for geopolymer concrete than water immersion cure.

8.Conclusion:

From many studies, it can be observed that Geopolymer concrete is better than ordinary concrete in strength and performance as it performs well in many aspects such as compressive strength, and when we observe it in corrosion conditions., retention and exposure to high pressure. Many study have already shown that it is corrosion resistive and also fire resistive. addition, the shrinkage rate is lower than concrete. Therefore, it can be inferred from this model that Geopolymer concrete will be a viable substitute for cement concrete in the future. Determining the advantages and disadvantages of geopolymer concrete should be investigated and analyzed by scientists.

Numerous studies have found that Geopolymer has greater compressive strength than traditional concrete but it is slightly difficult to get necessary material for geopolymer concrete. The emission of carbon di oxide due to production of geopolymer concrete is approx. negligible in comparison to ordinary Portland cement

Geopolymer can be used effectively in the precast industry due to its early strength feature, which enables large products to be obtained in a short time and reduces breaks during transportation. Geopolymer concrete can be used effectively in reinforced concrete column-column joints. In addition, geopolymer concrete should be used effectively in the construction of structures., fly ash should be used appropriately to avoid waste. Steam-cured geopolymer concrete provides better strength than water-immersion curing.it will be 10% stronger after chamber treatment. The government is taking steps to remove sodium silicate and sodium hydroxide solutions from chemical industry waste, thereby reducing the budget of alkaline solutions required for geopolymer concrete.

REFERENCES

1) **M. Mustafa Al. Bakri, Review on fly ash** based geopolymer concrete without cement, Journal of Engineering and Technology Research, Vol. 3(1), pp. 1-4, January 2011
2) B. Singh, Geopolymer concrete: A review of some recent developments, Construction and Building Materials 85, 78–90, 2015
3) B. Jindal, Geopolymer Concrete – A review, April 2015
4) Y. Nagvekar, D. Aarekar, P. Dalal and V. Kudke, Comparative study of conventional and green concrete, Volume 5 Issue V, May 2017
5) Ahmad L. Almutairi, Potential application of geopolymer concrete in construction-A review. December 2021
6) International Journal of Engineering Sciences & Emerging Technologies, Feb 2012.
7) S. Marathe, Mithanthaya, N. Bhavani, A Review on Strength and Durability Studies on Geopolymer Concrete, Vol. 5, Special Issue 9, May 2016
8) Bakharev T, "Thermal behavior of geopolymers prepared using class F fly ash and elevated temperature curing". Cement Concrete Res., 36: 1134-1147, 2006.
9) Bakharev T, Resistance of geopolymer materials to acid attack. Cement Concrete Res. 35: 658-670 2005
10) Chanh NV, Trung BD, Tuan DV, Recent research geopolymer concrete. The 3rd ACF International Conference –ACF/VCA 2008.
11) Kong DLY, Sanjayan JG, Damage behavior of geopolymer composites exposed to elevated temperature. Cement Concrete Compos. 30: 986-991, 2008. [12]
12) Chindaprasirt P, Chareerat T, Siricicatnanon V (2007). Workability and strength of coarse high calcium fly ash geopolymer. Cement Concrete Composites. 29: 224-229. [13]
13) Rangan B.V., "On the Development of Fly Ash Based Geopolymer Concrete", ACI Materials Journal, 2004[
14) Rangan B.V., "Studies on Fly Ash-Based Geopolymer Concrete, Malaysian Construction Research Journal, Vol. 3, 2008
15) Davidovits J., "Geopolymer Chemistry and Applications", Institute Geopolymer, Saint-Quentin, France, 2008

16) Rangan, B. V., "Low-Calcium, Fly-Ash-Based Geopolymer Concrete", Concrete Construction Engineering Handbook. Taylor and Francis Group, Boca Raton, FL, 2008.
17) Wallah, S. E., Rangan, B.V. (2006) "Low Calcium Fly Ash Based Geopolymer Concrete: Long Term Properties." Research Report GC2, Faculty of Engineering, Curtin University of Technology