Effect of Geopolymer on the Unconfined Compressive Strength Value of Clay Soil

Shailja Joshi
Assistant Professor,
Dept of Civil Engineering, Quantum University,

Sandeep Gupta
Assistant Professor,
Dept. Of Civil Engineering G.B.P.U.A &T, Pantnagar,

Bhuvan Chandra Bhatt
Assistant Professor,
Dept of Civil Engineering, Quantum University,

***Abstract*:- Weak soils are encountered in many regions, which lack adequate stiffness and strength to resist the loading due to construction project. Soil improvement is a technique for amendment of these geo-materials. Two common method of soil improvement of soil mechanical and chemical stabilization .commonly mechanical procedures include the compaction and earth reinforcement. In the recent years treatment with geopolymer as a chemical stabilization technique has been widely investigate to earth improvement. Many experimental studies were conduct on the behaviour of soil stabilized with the geopolymer. Their results indicate that employing geopolymer improved the resistant behaviours of stabilized soils.**

Keyword: Geopolymer, fly ash, stabilization

1. INTRODUCTION:

In cement stabilized soils, the stabilization mechanisms are associated with hydration and pozzolanic reactions. When lime is mixed with clayey soils, the clay particles become closer and the soil is stabilized through flocculation and pozzolanic reactions. A major issue with conventional soil stabilizers (i.e., OPC and lime) is that their production processes are energy intensive and emit a large quantity of CO2. For instance, approximately one ton of CO2 is emitted for the production of one ton of cement. Furthermore, the raw materials readily available for cement production are being over-consumed. Therefore, civil engineering industry is always searching for new, viable sustainable alternatives to replace Portland cement as soil stabilizers.

2. REVIEW OF LITERATURE:

Cristelo *et al.* (2013) studied the role of calcium content in alkaline activation of fly ash used to stabilise soft soil. Alkaline activation of fly ash is also known as Geopolymerisation. The soil used in this study was marl contains high calcium carbonate content. Soil consist of plastic limit 19.7%, liquid limit 51.9%, OMC 18%, MDD 20.8 kN/m^3 and UCS 60 – 100 kPa. Two types of fly ash class C fly ash (high calcium content) and class F(low calcium content) were used which obtained from pulp and paper company & a thermoelectric plant respectively. Soils mixed with lime and with cement were also tested separately. For activation of fly ash, sodium-based alkaline activator was used which was a mixture of sodium silicate solution to sodium hydroxide solution. The ratio of sodium silicate to sodium hydroxide by mass was 2:1 while activators to fly ash ratio were 2:1 and 4:1. UCS samples were prepared and test performed after 1, 4 and 12 weeks of curing.

He *et al*. (2013) investigated mechanical properties and microstructure of soil stabilized by geopolymer. For the precursor two industrial waste, red mud (RM) and rice husk ash (RHA) at varying percentage were used. RM is the major waste produced by the alumina refining industry while RHA is produced by burning of rice husk. Geopolymerization reaction was initiated by dry mixing of RHA and RM with sodium hydroxide solution. This study was carried out into four sets of test samples. In test samples A, the solution to solid ratio weight ratio was kept 1.2. UCS was performed with RHA to RM weight ratio 0.4 and 4 molar sodium hydroxide solution after curing of 14, 21, 28, 35, 42, and 49 days. In test samples B, three weight ratios 0.3, 0.4, 0.5 and 0.6 of RHA and RM was taken at constant sodium hydroxide solution. In test sample C, three concentrations 2 Molar, 4 Molar and 6 Molar of sodium hydroxide taken at the curing of 60 days but other parameters were constant.

Mozumder and Laskar (2015) studied the unconfined compressive strength (UCS) test of geopolymer stabilized clay soil by an artificial neural network (ANN). For the Geopolymerization, source materials were fly ash (FA), Ground Granulated blast furnace slag (GGBS) and blend of GGBS and fly ash. Amount of source materials were varied as 4% to 50% for GGBS, 4% to 20% for FA-GGBS blends and fly ash. The molar concentration of alkali solution (M) used were 4 molar, 8 molar, 10 molar, 12 molar and 14.5 molar. Ratios of alkali solution to binder were varied from 0.45 to 0.85 for geopolymer synthesis. Samples were compacted at a consistency of plastic limit with a tempting rod to remove air voids.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

3. EXPERIMENTAL PROGRAME:

3.1 MATERIAL USED:

3.1.1 SOIL: The soil used in present work is taken from Shaktifarm Sitarganj, Udham Singh Nagar (Uttarakhand). Before collecting it, the topmost layer of the soil was removed by the spade up to 0.5 m depth. The soil was air-dried and pulverised for laboratory test purpose. Fig. 3.1 shows the pulverised soil sample.

3.1.2 FLY ASH: In the present study fly, ash was collected from Century Pulp and Paper Mill situated at Lalkuan, Nainital (Uttarakhand). The fly ash used in this study was class F fly ash.

3.1.3 ALKALI ACTIVATOR SOLUTION: for alkali activator solution 6 Molar sodium hydroxide Solution and 1 Molar Sodium Silicate Solution is used.

3.2 LABORATORY EXPERIMENTATION

Native soil sample were prepared for determination of physical and Geotechnical characteristics of the soil. The soil was mixed with three different percentages of fly ash (FA) as 15 %, 25% and 35% by dry weight of soil sample. Soil was mixed with geopolymer binder (fly ash and alkali solution) and treated soil samples were prepared. Fly ash treated soil samples were mixed with for alkali activator solution 6 Molar sodium hydroxide Solution and 1 Molar Sodium Silicate Solution (L_1). Table 1 presents the various geotechnical properties of the soil.

Table 1 Geotechnical Properties of Soil

S.No.	Parameters	Results
1.	Grain Size Distribution	
	Gravel Size Fraction (%)	0%
	Sand Size Fraction (%)	7.27%
	Silt Size Fraction (%)	78.73%
	Clay Size Fraction (%)	14%
2.	Soil Classification Based on IS Code	CL
3.	Unconfined Compressive Strength (kN/m^2)	
	0 Days	109.12
	7 Days	160.05
	14 Days	180.0
	28 Days	205.10

4. RESULT AND DISCUSSION:

Unconfined compressive strength (UCS) test is defined as the load per unit area at which a cylindrical specimen of soil will fail in the axial compression test. The UCS tests were conducted on soil added with different percentage of fly ash and alkali solution. The samples were tested for UCS on Helco hydraulic testing machine at strain rate of 1.25% mm/min after 0, 7, 14 and 28 days of curing. The stress-strain behaviour recorded during the UCS test. For soil and geopolymer mix UCS values were presented in Table 2

S.No.	Mix	Unconfined Compressive Strength (kN/m^2)			
		0 Days	7 Days	14 Days	28 Days
1	Soil+ 15%FA+ 10% 6 Molar SH Solution + 1 Molar SS Solution	135.27	308.15	346.12	410.52
2	Soil+ 15%FA+ 15% 6 Molar SH Solution + 1 Molar SS Solution	138.60	326.16	380.28	480.12
3	Soil + 25% FA+ 10% 6 Molar SH Solution + 1 Molar SS Solution	188.93	390.10	450.70	520.50
4	Soil + 25% FA+ 15% 6 Molar SH Solution + 1 Molar SS Solution	192.12	410.12	470.20	594.50
5	Soil + 35% FA + 10% 6 Molar SH Solution + 1 Molar SS Solution	118.16	218.16	298.12	344.26
6	Soil +35% FA+ 15% 6 Molar SH Solution + 1 Molar SS Solution	120.12	250.20	310.10	380.51

5. CONCLUSIONS:

- The study shows that the addition of geopolymer binder (fly ash (FA) and alkali solution containing sodium hydroxide and sodium silicate improves the engineering properties of soil.
- The unconfined compressive strength of the treated soil samples found to vary with the concentration of activator solution in fly ash based geopolymer.
- On increase in fly ash content, sodium hydroxide concentration and alkali solution percentage in the geopolymeric system improves the UCS but when they are excessive of the optimal value UCS decreases due to the precipitation at a very early stage before the poly- condensation process in geopolymer.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

REFERENCES

[1] **Cristelo, N., Glendinning, S., Fernandes, L. and Pinto, A.T., 2013.** "Effects of Alkaline-Activated Fly Ash and Portland Cement on Soft Soil Stabilisation". *Acta Geotechnica*, *8*(4), pp.395-405.

[2] **Das, S.K. and Yudhbir, 2005.** "Geotechanical Characteristic of Some Indian Fly Ashes", Journal of Materials in Civil Engineering, 17(5), 544-552.

[3] **Davidovits, J., 1994.** "Geopolymers: Man-Made Rock Geosynthesis and the Resulting Development of Very Early High Strength Cement". *Journal of Materials education*, *16*, pp.91-91.

[4] **Dhadse, S., Kumari, P. and Bhagia, L.J., 2008**. "Fly Ash Characterization, Utilization and Government Initiatives in India A Review". *Journal of Scientific and Industrial Research, Vol. 67, January 2008.*

[5] **He, J., Jie, Y., Zhang, J., Yu, Y. and Zhang, G., 2013.** "Synthesis and characterization of red mud and rice husk ash-based geopolymer composites". *Cement and Concrete Composites*, *37*, pp.108-118.