A STATISTICAL REVIEW OF SOIL STABILIZATION USING GEOPOLYMERS

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Abstract—
The process of altering or increasing a soil's physical characteristics such that it satisfies the requirements for a variety of engineering uses is known as soil stabilization. Globally, the use of stabilized soil is increasing at a higher rate because ising economically lowlow-costd effective in pavement design. In Indihe soil stabilization using Geopolymers proves to be very effective because of the nature and type of roads in plain, hilly and mountainous regions. The common techniques used in stabilizing the soil includes mechanical and chemical (Geopolymerization). Chemical method is widely used, approved and cost effective in terms of the materials and chemicals. Several studies on the stabilization of soil using geopolymer have been undertaken over the past several years to evaluate and analyse the results to see whether qualities are improving or not. This paper's goal is to review the many activities undertaken to stabilise soil using the Geopolymerization strategy, an attempt is made by me to verify and analyze the mechanical and durable properties of research work to determine the most feasible composition and design mix.

Keywords— Stabilization; Geopolymerization; cost-effective; design mix; durable

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1 INTRODUCTION

By adding and combining various elements to the soil, soil stabilization is a strategy for improving the soil's physical characteristics. In essence, it is a technique for raising the soil's shear strength characteristics, which raises the soil's bearing potential. When the soil beneath the basis for building cannot support the structural load, it is usually necessary. A soil stabilization technique is a corrective action that lessens the soil mass's permeability and compressibility and increases its shear strength, which aids in reducing the settlement of structures. Shear strength, compressive strength, and overall soil carrying capacity are all increased by stabilization.

In the field of road construction, gravel and soil are used as the main components for the construction of pavement which does not bear good engineering properties for load bearing capacity. So, for that purpose, Geopolymer based materials (cement, lime, fly ash, bitumen, or a combination of these) are added in the soil mix for enhancing its physical properties. In the domain of civil engineering, common and widely accessible soils like organic soils and soft clays can now be used, and stabilization techniques can enhance their qualities. Over the years, it was been confirmed that stabilization of soil using Geopolymer has proven to be effective in strengthening the physical properties of soil for utilization in civil engineering field.

Low-strength soil layers are much of the time experienced in street development, and they essentially affect different periods of development plan. Use of clayey soil is one more basic issue in structural designing. Clayey soil is a global problem that presents challenges for property owners, construction projects, and structural designers. Clayey soils are considered to be a possible constant danger capable of wreaking havoc on building design. Furthermore, structures developed on clayey soils have caused huge harm because of the clayey soil's unwanted and unusual qualities. To balance out soil, the most well-known or regular methodology was by eliminating the delicate soil first. More significant materials, for example, squashed rock, will supplant delicate soil. Different scientists tracked down one more technique to experience this issue since the expense engaged with supplanting the materials was generally high. Soil adjustment refers to the mechanical and compound adjustment alteration of at least one soil property. The majority of analysts thought about increasing the dirt's compressive strength in order to improve the designing properties. According to ASTM D 4609 standard, "soil adjustment" refers to any physical, chemical, or combination of those procedures used to improve particular characteristics of ordinary soil so that it satisfies design requirements.

Adding admixtures to such sort of subgrade utilizing fly debris, Silica gel, GGBS along with chemicals is a feasible strategy. This would make the required changes in the designing attributes. The objective of this paper is to stabilize the soil using Geopolymer.

There are mainly three methods of stabilizing the soil for engineering requirements:

1. **Mechanical Stabilization:** It consists of a physical process of stabilizing by tampering or compacting by means of machineries such as rollers or rammers. This method is largely used for compacting sub base and base courses. This method of stabilization can also be achieved by removing or adding soils of different types so that soil particle distribution is effectively achieved.

2. **Chemical Stabilization:** Through a chemical reaction between the soil's constituents and the stabilizer in use, soil can be stabilized. Cement, lime, fly ash, rice husk ash, sodium hydroxide, and other substances can be employed as stabilizers. This technique increases the strength and longevity of base and sub base courses and can be applied to many pavement types.

3. **Polymer Stabilization:** It basically refers to the addition of polymers for improving soil properties. Polymers have a tendency to increase the Soil strength through their interaction with clayey particles existing in the soil. Bio polymers and synthetic polymers are used widely for soil stabilization process. Biopolymers are eco-friendly as they are derived from plants and microbes while as synthetic polymers are derived from petroleum and other products. Nylon, Epoxy and other products.

4. **Subgrade:** It is a compacted natural soil which is responsible for providing the support to the layers above it. This layer possesses the highest load bearing capacity and uniformly supports all the loads acting on it.

1,1 Geopolymers:
Geopolymers are the inorganic materials which are obtained from the Geopolymerization reaction between raw materials contacting rich amount of silica and alumina and sodium hydroxide and sodium silicate. The aluminosilicate materials are produced or obtained naturally (rice husk ash, metakaolin) or through the industrial processes (fly ash, rice husk ash). Over the years, Due to their ability to improve the physical characteristics of cement and soil, Geopolymers have proven useful in the building industry. The increase in compressive strength is significantly aided by the calcium present in fly ash. The ions of calcium provide a faster reaction and results in quick hardening of geopolymer in shorter curing time. Most of the researches conducted in past revealed that in the concentration of fly ash based Geopolymer, NaOH plays an important role.

1.2 Geopolymerization (Process):
Geopolymerization is the procedure by which aluminosilicate materials are transformed into covalently bonded 3D system consisting of [━Si━O━Al━O━]n. It basically refers to the synthesis of raw materials which are chemically integrated. Vicious cementitious slurry is formed by the result of Geopolymerization reaction and upon hardening a compact and durable geopolymeric material is formed. Inorganic compounds are created as a result of the process, which involves the reaction of source materials with reactive silica and alumina (fly ash) and an alkaline activator solution (sodium hydroxide and sodium silicate). Higher silicate content is produced due to addition of sodium silicate in sodium hydroxide solution and faster polymerization is attained due to formation of gel.

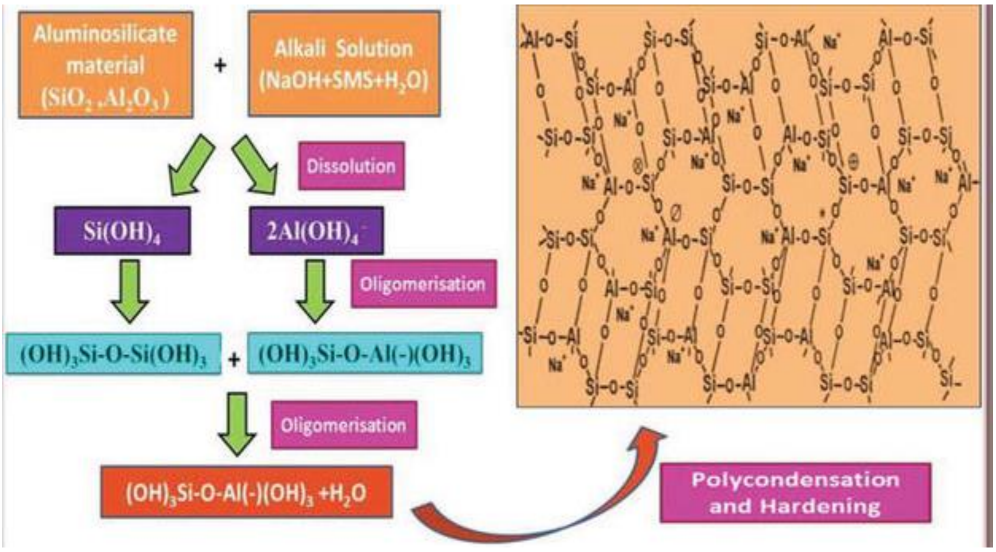


Figure 1 Geopolymerization Process

1.3Applications Of Geopolymers In Soil Stabilization:

- Addition of geopolymer based material enhances the property of expansive or normal soil so that such soil can be utilized for engineering purposes.
- Strength of expansive soils gets improved by the use of geopolymer.
- Provides high mechanical strength and durability.
- Improves the load bearing capacity of soil.
- The addition of geopolymer to the surface of the soil has boosted the soil's compressive and shear strengths.
- Addition of geopolymer based material enhances the property of expansive or normal soil so that such soil can be utilized for engineering purposes.

2. MATERIAL AND METHODOLOGY

MATERIALS TO BE USED:

- Soil (S1, S2)
- Water
- Fly Ash
- Rice Husk Ash
- Sodium Hydroxide (Caustic Soda)
- Sodium Silicate
- Silica gel

2.2 Conventional Methods

2.2.1 Soil Stabilization Using Fly Ash:
A substance called fly ash is increasingly being used for soil aeration as well as a concrete alternative in heavy mixtures. Since fly debris is a pozzolan, it can bind to soil minerals and make the soil stable at any place, which can reduce soil swelling and shrinkage and increase soil strength.

The expansion of fly debris is one method for settling soil.

2.2.2Soil Stabilization Using Rice Husk Ash (RHA):

RHA is created by burning rice husk basically a by-product. Its application as a soil stabilizer is an environmentally favorable substitute for final disposal. RHA is not self-cementitious; hence cements must be formed by adding a hydraulic binder like lime or sodium silicate in order to increase the strength of soil.

The Strength of Soils after Fly Ash and Rice Husk Ash Stabilization

The ability of soil to withstand pressure without collapsing determines how strong it is. A soil's solidarity can be determined by how well it can withstand common and shear tensions. The rate of soil strength ascent may be influenced by additional factors in addition to the fundamental reaction products produced. An increase in soil strength could result from the inclusion of synthetic components that speed up or slow down the soil. Utilizing solid wastes for soil stabilization, such as rice husk ash and fly ash, lowers the cost of chemical stabilization.

3. DATA COLLECTION

Table 1 : Unconfined Compressive Strength (UCS):

No.	Author	Raw Material	Design Mix/ Methodology (%)	Curing (days, at room temp.)
1	Kumar. A	FA, Soil, Lime, fibre	FA: 15; Lime: 8; Fibre: 1.5	7, 28
2	Murmu. A. L	FA, BCS	FA: 5, 10, 20	7, 14, 28
3	Puppala. A	FA, Soil, Fibre	FA: 5, 10, 15; Fibre: 0.3, 0.6, 0.9	7
4	Renjith. R	FA, Soil, lime	FA: 15, Lime: 2	28
5	Sabat. A. K	FA, Soil, Q.D	FA & Qd: 45	4

Table 2 : California Bearing ratio (CBR):

No.	Author	Raw Material	Design Mix/ Methodology (%)	Curing (days, at room temp.)
1	Dungca. J. R	Fly Ash, Soil	FA: 10,20,30	7, 28
2	Brooks. R. M	Fly Ash, Soil,CWA	FA: 25; CWA: 0-12	28
3	Murmu. A. L	Fly Ash, BCS	FA: 5,10,15,20	7,14, 28
4	Renjith. R	Fly Ash, Soil, lime	FA: 15, Lime: 2	28
5	Sabat. A. K	Fly Ash, Soil, Q. D	FA: 0-25; Qd: 0-50	4

Table 3 Dry Density (Dd):

No.	Author	Raw Material	Design Mix/ Methodology (%)	Curing (days, at room temp.)
1	Misra. A	Class C Fly Ash, Soil	FA: 10,15,20	7
2	Nath. B. D	Fly Ash, Soil	FA: 10, 15	7
3	Murmu. A. L	Fly Ash, BCS	FA: 5,10,15,20	7, 14, 28
4	Kumar. A	Fly Ash, Soil, lime	FA: 15, Lime: 2	7, 14, 28
5	Sabat. A. K	Fly Ash, Soil, Q. D	FA-Qd mixture: 15, 30, 45, 60	4

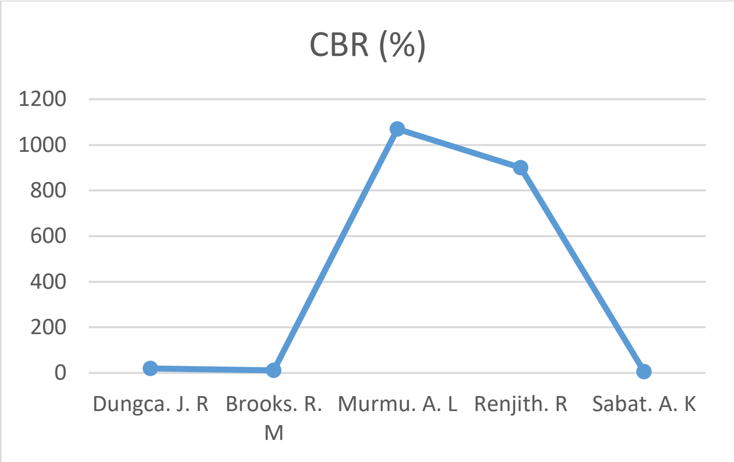
Table 4 : Optimum Moisture Content (OMC):

No.	Author	Raw Material	Design Mix/ Methodology (%)	Curing (days, at room temp.)
1	Jose. J	Fly Ash, Bentonite, Exp. Soil	FA: 10,15	7
2	Mahvash. S	FA, Sandy Soil, OPC	FA: 5, 10, 15, 20	7, 28
3	Murmu. A. L	Fly Ash, BCS	FA: 5,10,15,20	7, 14, 28
4	Kumar. A	Fly Ash, Soil, lime	FA: 5-20; Lime: 2-8	7, 14, 28
5	Sabat. A. K	Fly Ash, Soil, Q. D	FA-Qd mixture: 15, 30, 45, 60	4

Table 5: Potential of Hydrogen (pH):

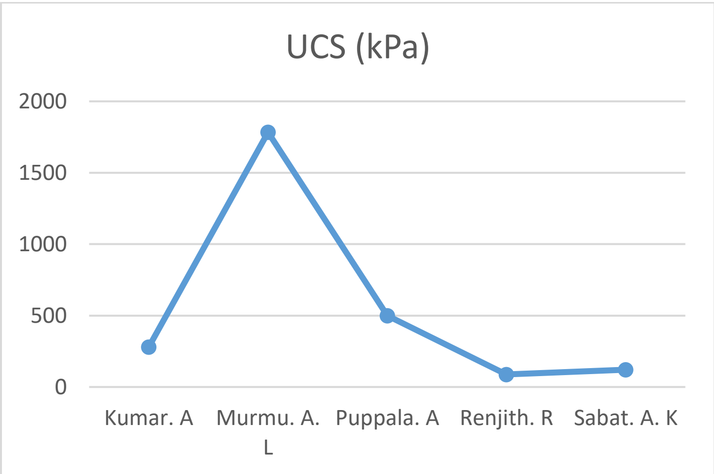
No.	Author	Raw Material	Design Mix/ Methodology (%)	Curing (days, at room temp.)
1	Nath. B. D	Soil, Fly Ash	FA: 10,15,20	7
2	Ghadir. P	Fly Ash, cement	FA: 5,10,15	1, 7, 28
3	Sharma. R. K	Fly Ash, Lime. C&D waste	FA: 5, 10, 15	7, 28

4. DATA ANALYSIS AND RESULT AND DISCUSSION



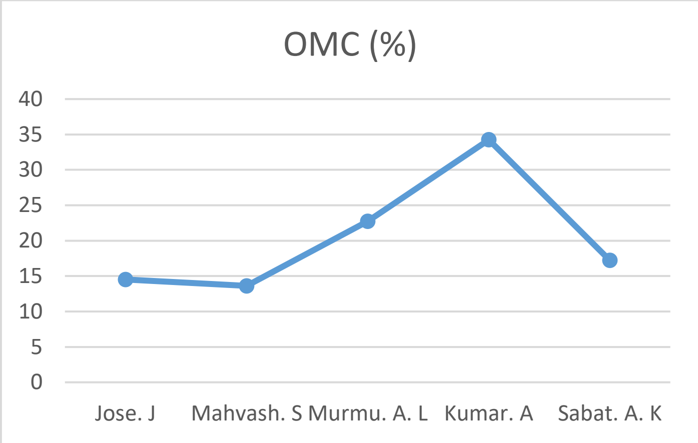
Graph 1

1) For CBR:
Based on previous studies of stabilizing soil using Geopolymer, the value of CBR is highest as conducted by Murmu. A. L and Renjith. R with a design mix of, Fly Ash content 10-20 (%) and 15% respectively. Also, addition of 5% lime in case of study conducted by Renjith. R. The lowest value of CBR is indicated by Sabat. A. K, by adding quarry dust with varying content of Fly Ash for only 4 days of curing.



Graph 2

2) For UCS:
Based on previous studies, it is clearly observed that the value of UCS is highest as observed by Murmu. A. L with a design mix of adding Fly Ash in varying proportion of 10, 15, 20 for a curing period of 7, 14, 28.
The lowest is in case of, study conducted by Sabat. A. K because the main reason is the period of curing for just 4 days.

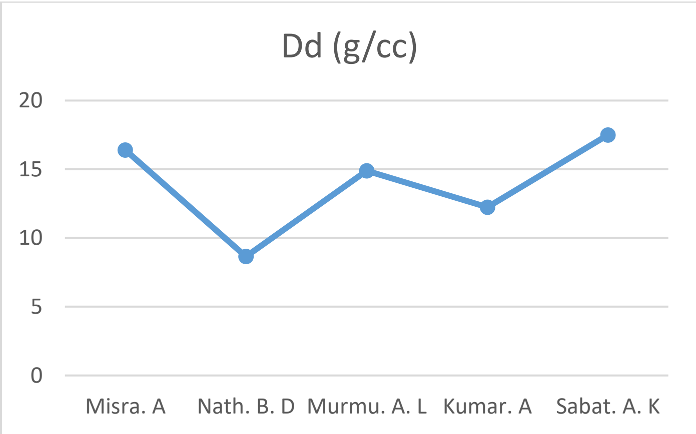


Graph 3

3) For Dry Density:

Based on previous studies, the dry density of soil sample is highest in case of, study conducted by Kumar. A. L with a design mix of Fly Ash 15% along with 2% lime and Sabat. A. K with FA 15%. Both curing the sample for 7, 14, 28 days.

The lowest is in case of, study conducted by Nath. B. D with reason is the curing period. The lesser the duration of curing, the lesser will be the dry density and strength gained.

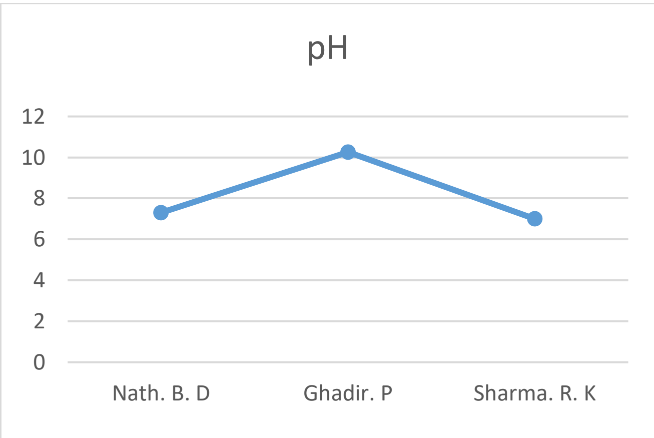


Graph 4

4) For OMC:

Based on previous studies, it is has been observed that the Optimum Moisture Content is attained highest for design mix using FA 15-20 (%) and lime 2-3 (%) along with curing period of 7, 14, 28.

The lowest is observed in case of, study conducted by Mahvash. S using FA 10-15 (%) along with sandy soil.



Graph 5

5) For pH:

Based on previous studies, the value of pH is observed highest if the design mix is of FA 10-20 (%) along with adding cement with a curing period of 1, 7, 28. The lowest is observed when lime is added in case of cement.

5. Conclusion

In this review article, the stabilization of soil is thoroughly discussed with the use of Geopolymers in activating the soil for strength gain. Based on previous papers, varying proportions of fly ash, GGBBS and chemicals have been used in stabilizing the soil. Mostly the curing period for soil samples have been 7, 14, 28 days. Various laboratory tests of samples have been conducted such as CBR, UCS, OMC and the particular proportion of fly ash is indicated where the value obtained is high.

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