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# Stabilization of Soil Using Geoploymer and Biopolymer

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**ABSTRACT-** As stabilization of soil improves its engineering properties, chemical and mechanical stabilization processes are in use. In the present study two difficult soils; expansive soil and dispersive soil are stabilized with geopolymer and biopolymer. Sodium based alkaline activators and fly ash as an additive are used as geopolymers and Xanthan gum and Guar gum are used as biopolymers. The effectiveness of geopolymer is studied in terms of unconfined compressive strength (UCS), differential free swelling (DFS), swelling pressure (SP), durability and dispersion tests. The swelling pressure got reduced by 97.14% finally with addition of 40% fly ash and 15% bentonite. The dispersion test showed bentonite to be an extremely dispersive soil, whose dispersiveness is controlled by addition of alkali activated fly ash. From UCS and durability test it is observed that bentonite added with 40% fly ash and 10% solution gave better results. The effectiveness of biopolymer is studied based on UCS tests on dispersive soil and pond ash at their moisture content. For dispersive soil, durability, dispersion and DFS tests are also done. It is observed that dispersive soil and pond ash mixed with various percentages of Xanthan gum and Guar gum are not dispersive and are more durable than ordinary bottom ash and dispersive soil samples.

**KEYWORDS-** soil improvement, Compaction, Stabilization, Geopolymers, Biopolymers, Xanthan gum.

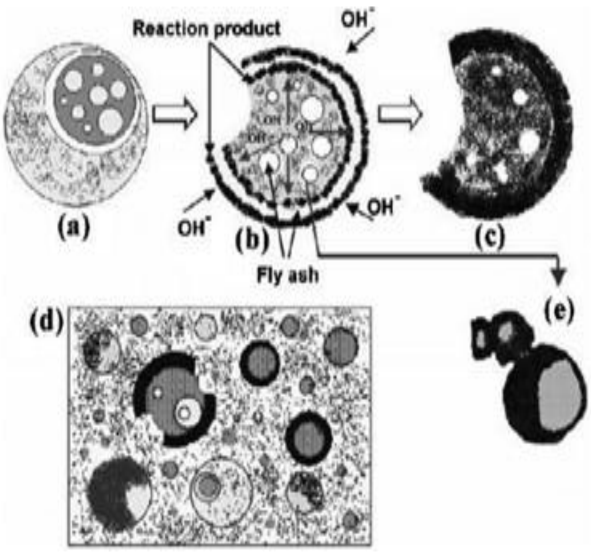


Figure 1: Descriptive model of the alkaline activation processes of fly ash (Palomo and Jimenez 2005)

## I. INTRODUCTION

In the present study two difficult soils are considered amely expansive and dispersive soil. Both have been stabilized using geopolymers (alkali activators, sodium silicate: sodium 1 hydroxide in 2:1 ratio) [1]and biopolymers (commercially available Xanthan gum and Guar gum). The alkali solution sodium silicate: sodium hydroxide in 2:1 ratio was used in different concentrations.[2]

## II. OBJECTIVES

The objective of the current research work is to determine the suitability of geopolymer (alkali-activated fly ash) and biopolymer as soil stabilizing agent for expansive soil and dispersive soil.Scope. Secondary resources supported by a series of laboratory experiments have supported this investigation[8]. However, the investigation results are restricted to a sub grade soil sample which is considered in the research. The results are also specific to the type of chemical additives used in the experiments, as well as the test methodologies used[9]. As a result, findings for field applications should be regarded as indicative rather than decisive[10].

## III. SCOPE

- Laboratory investigation for characterization of expansive soil (bentonite) with alkali activated fly ash (geopolymer) as binding material.
- It includes laboratory investigation for characterization of dispersive soil with two commercially available biopolymers i.e., Xanthan gum and Guar gum.

## IV. MATERIALS USEDREACTION MECHANISM

A highly simplified diagram of the reaction mechanism in the alkaline activation process is shown in Fig.1 which outlines the key processes occurring in the transformation of a solid alumina silicate source into a synthetic alkali alumina silicate (N-A-S-H) gel. When the fly ashes are submitted to the alkaline solution, a dissolution process of the Al and Si occurs. Then the higher molecules condense in a gel (polymerization and nucleation) and the alkali attack opens the spheres exposing small spheres on the inside which will be also dissolved until the spheres, became almost dissolved with the formation of reaction products inside and outside the sphere (Fig. 1). and Fig. 2

shows the Conceptual model for alkaline activation processes (Palomo and Jimenez 2011)

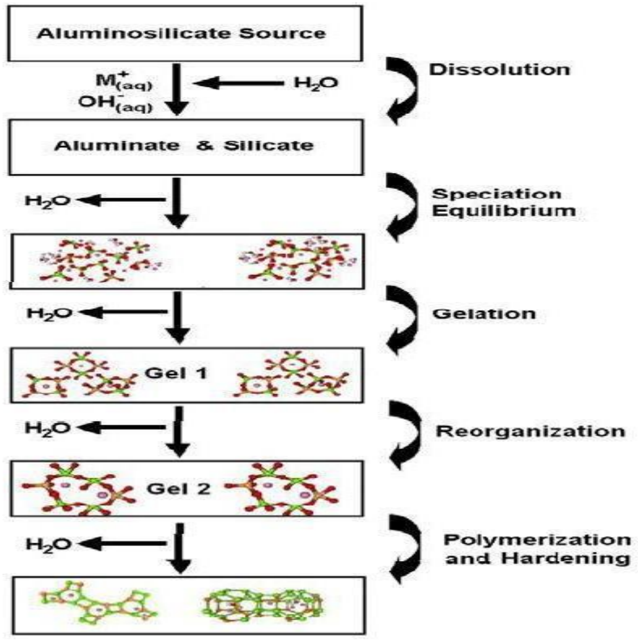


Figure 2: Conceptual model for alkaline activation processes (Palomo and Jimenez 2011)

### *A. Stabilization Using Geopolymer*

In the present study, the alkali was prepared by taking sodium silicate and sodium hydroxide keeping in view, the ratio of sodium silicate to sodium hydroxide in their dry mass as 2. The prepared alkali (S) was added in varying percentages (5%, 10%and 15%) with fly ash (FA) in different percentages (20%, 30% and 40%) by dry weight of total solids to bentonite. The alkali, taken in 10% with fly ash 40% by dry weight of total solids was also added with dispersive soil. Then, optimum moisture content (OMC), maximum dry density (MDD), unconfined compressive strength (UCS), and durability of different.

### *B. Stabilization Using Biopolymer*

The experimental investigations were made on soil and stabilized soil using biopolymer as per Indian standards. It was observed that Guar gum (GG) is more viscous compared to Xanthan gum (XG)[4]. Hence, Xanthan gum solutions with percentages of 1, 2 and 3% and Guar gum solutions with percentages of 0.5, 1 and 2% were added with dispersive soil (WS) and pond ash (PA)to investigate the effect of biopolymers on compaction characteristics unconfined compressive strength[5]. Durability and dispersion tests were also done for biopolymer modified dispersive soil and compared to only dispersive soil samples[6]. Table1 and Table 2 shows the details of the biopolymer modified dispersive soil and pond ash samples, respectively. Evaluation of UCS of biopolymer modified dispersive soil samples were done on an interval of 0, 3 and 7days and also done for sample kept for sundried (1 day) and compared with only dispersive soil samples. [7] The samples which were tested after 3 and 7 days were wrapped in cling film and left at ambient temperature of 32-35ºC and humidity conditions (50–60 % RH). Table 3.9 and Table 3.10 show details of the dispersive soil specimens and pond ash specimens mixed in different percentages with Xanthan gum (XG) and Guar gum (GG), respectively.Table 1 shows Details of the alkaline activator mixed soil specimens

Table 1: Details of the alkaline activator mixed soil specimens

| S. N O. | Name of the mix | Particulars of the mix |
|---|---|---|
| 1 | Bentonite + FA (20%) + S (5%) | il+20%fly ash by weight of total solids+5% alkali by weight of total solids |
| 2 | Bentonite + FA (30%) + S (5%) | Soil+30%fly ash by weight of total solids+5% alkali by weight of total solids |
| 3 | Bentonite + FA (40%) + S (5%) | Soil+40%fly ash by weight of total solids+5% alkali by weight of total solids |
| 4 | Bentonite + FA (20%) + S (10%) | Soil+20%fly ash by weight of total solids+10% alkali by weight of total solids |
| 5 | Bentonite + FA (30%) + S (10%) | Soil+30%fly ash by weight of total solids+10%alkali by weight of total solids |
| 6 | Bentonite + FA (40%) + S (10%) | Soil+40%fly ash by weight of total solids+10%alkali by weight of total solids |
| 7 | Bentonite + FA (20%) + S (15%) | Soil+20%fly ash by weight of total solids+15%alkali by weight of total solids |
| 8 | Bentonite + FA (30%) + S (15%) | Soil+30%fly ash by weight of total solids+15%alkali by weight of total solids |

Figure 2.0 (g)

Figure 2.1 (h)

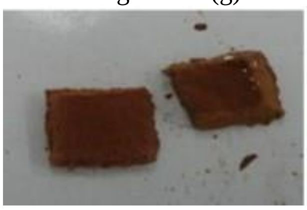

Figure 2.2 (i)

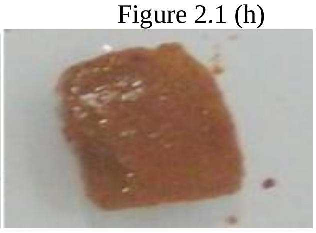

Figure 2.3 (j)

Figure 2: Cubes of bentonite in water after five to seven minutes, Figure 4.1(b), (c), (d), (e), (f), (g), (h), (i) and (j) Cubes of Bentonite added with fly ash (20%, 30% and 40%) and alkali activator (5%, 10% and 15%), respectively in water after five to seven minutes

## V. METHODOLOGY

In the present study, methodology of stabilizing soil using geopolymer and biopolymer is explained as follows. Fig.3 shows FE-SEM of dispersive soil with Guar gum at (a) 5000X (b) 7000X magnification

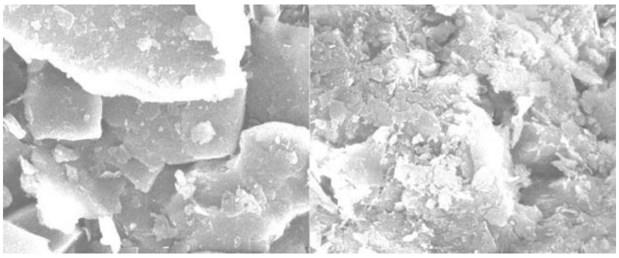

Figure 3 (a) Figure 3 (b)

Figure 3: FE-SEM of dispersive soil with Guar gum at (a) 5000X (b) 7000X magnification

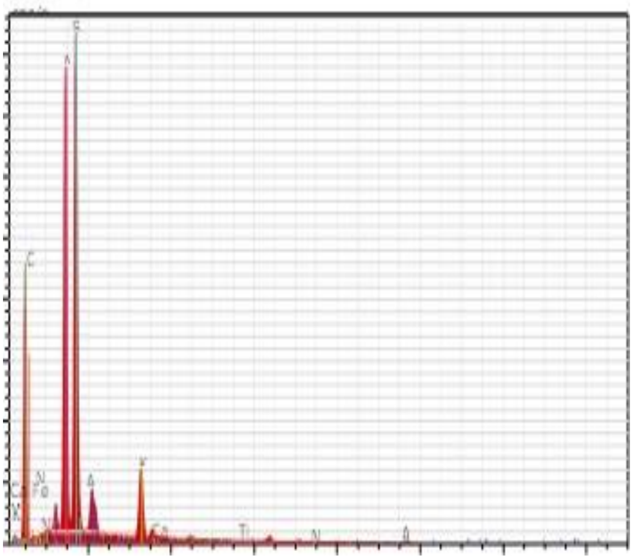

Figure 4: EDX of dispersive soil added with Guar gum

Table 2: OMC and MDD of dispersive soil and dispersive soil with fly ash (40%) and alkali solution (10%)

| Sample Name | OMC (%) | MDD (kN/m$^3$) |
|---|---|---|
| W.S | 15.19 | 17.18 |
| W.S + FA (40%) + S (10%) | 18.03 | 15.25 |

## VI. RESULT WITH RESPECT TO WHITE SOIL (DISPERSIVE SOIL)

In the present section experimental studies of white soil are presented as follows.

### *A. Compaction Characteristics*

The following graphs show the compaction characteristics of dispersive soil and alkali activated fly ash added with dispersive soil, showing optimum moisture content (OMC) and maximum dry density (MDD) of the compacted samples. Fig. 4.26 shows the comparison of OMC and MDD of dispersive soil and dispersive soil with fly ash (40%) and alkali solution (10%).

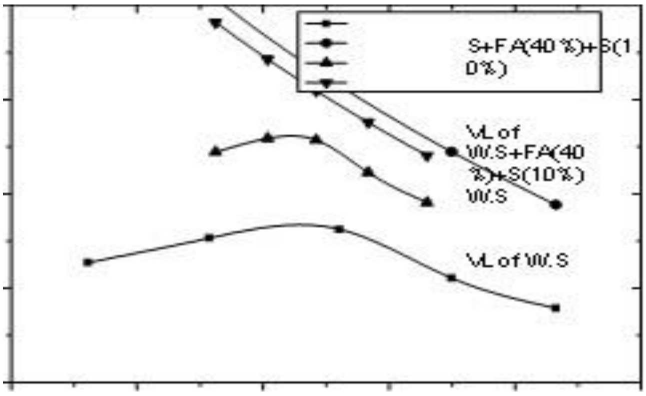

Figure 5: shows EDX of dispersive soil added with Guar gum

Table 4 shows OMC and MDD of dispersive soil and dispersive soil with fly ash (40%) and alkali solution (10%)
From above table, it is observed that OMC of dispersive soil added with fly ash (40%) and alkali solution (10%) is more compared to only dispersive soil and MDD of only dispersive soil is more compared to W.S + FA (40%) + S (10%) sample. As disclosed earlier, the UCS obtained for bentonite stabilized with geopolymer, i.e., with fly ash 40% and alkali solution 10%wasmaximum

## VII. CONCLUSIONS AND FUTURE SCOPE

The stabilization of expansive soil and dispersive soil has been done to avoid its disastrous effect on infrastructural components like road, building, dams, embankments etc. In this work a new idea of stabilizing the expansive soil (bentonite) and dispersive soil (white soil) with geopolymer and biopolymer was discussed.

## VIII. CONCLUSION

Based on the obtained results and discussion there of following conclusions can be drawn.

- The maximum optimum moisture content was for bentonite added with geopolymer with fly ash (20%) and alkali solution (10%) and MDD was maximum for bentonite added with fly ash (40%) and alkali solution (15%).
- The UCS value of the geopolymer stabilized bentonite found to vary with percentage of fly ash and alkali solution, and maximum UCS value was obtained with 40% fly ash and 10% alkali solution.
- Based on durability test, the resistance to loss in strength (RLS) was maximum for bentonite with 40% fly ash and 10% alkali solution and it got reduced with addition of 15% solution.
- Based on differential free swell test, it was observed that with increased percentage of alkali activated fly ash, the swelling percentage decreased considerably. After 3 days of curing for bentonite + FA (20%) + S (10%), and bentonite + fly ash (20%, 30% and 40%)
- + S (15%), the swelling percentage became negligible and the treated soil became non- swelling. Similar

observations were made for bentonite+fly ash (20%, 30% and 40%) + S (5%, 10% and 15%) after 7 days and bentonite + fly ash (20%, 30% and 40%) +

- S (5%,10% and 15%) after 14 days of curing.
- Based on crumb test and double hydrometer test it was observed that bentonite was extremely dispersive (84.87%). However, it became non-dispersive with addition of more than 5 % of geopolymer.
- It was observed that with addition of biopolymer, OMC increased and MDD decreased for dispersive soil. However, The UCS value increased with addition of biopolymer.
- With same percentage of gum, it was observed that dispersive soil stabilized with guar gum has better strength compared to that of Xanthan gum.
- Based on durability test the RLS was maximum for Xanthan gum (1%) and guar gum (1%). The RLS decreased with increased percentage of Xanthan gum but, for guar gum RLS obtained was optimum at 1%.
- Based on crumb test and double hydrometer test it was seen that white soil was extremely dispersive (89.57%) and became non-dispersive with addition of biopolymer.
- It was observed that with addition of biopolymer, OMC increased and MDD decreased for pond ash. However, The UCS value increased with addition of biopolymer.
- With same percentage of gum, it was observed that pond ash stabilized with Guar gum had better strength compared to that of Xanthan gum.
- It was observed that sundried sample has better UCS value than sample stored inside coated with film/wax.
- The present study showed that biopolymer and geopolymer can be effectively used as stabilizing agents for expansive and dispersive soil. IT was also observed that geopolymer is more effective than biopolymer in terms of stabilization.

## CONFLICTS OF INTEREST

The author declare that they have no conflicts of interest.

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