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Effect of Fly-Ash and Geo-Polymer in the Stabilization of Pavement Foundation Soil at Nekemte-Gudar Road Ethiopia

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ABSTRACT:

Expansive soils contain minerals such as smectite clays that are capable of absorbing water. When they absorb water, they increase in volume. The more water they absorb, the more their volume increases. Expansions of ten percent or more are not uncommon. This change in volume can exert enough force on a pavement, building or other structure to cause damage.
The road stretch from Nekempte and Gudar road in Ethiopia are having pavement foundation failure, severe rutting and eroded surface and base courses. These kinds of failures are noticed in particular points of road stretch and the causes of failure are examined. Though the soil shows the expansive soil properties and the region shows high rainfall, the foundation of pavement failed to provide good support for the moving vehicles axles.
To increase the strength parameters of soil by stabilizing the soil with fly ash and geo polymers. The results are good to provide the replacement of fly ash and geo polymer in the stabilization of expansive soil.

KEY WORDS: *Expansive soil, Fly ash, Geo polymer, Soil stabilization, Pavement failure*

I INTRODUCTION

Expansive soil is considered as tricky soil because of its inconvenient volume changes with variety in dampness content. When it interacts with water it indicates escalated swelling and therapists with the abatement in water substance and creates splits on drying. This soil gets to be slushy amid storms and hard amid the dry seasons. The mud minerals, for example, illite and montmorillonite are in charge of this sort of soil conduct. Gigantic voluminous variety in the dirt by option shrinkage and swelling harms the structural designing structure developed over it. At the point when the dirt at the site is not perfect for development, the engineers will go for uprooting or supplanting the dirt with the attractive one or by balancing out. In this way, the need of treating soil emerges with a specific end goal to use the provincially accessible soil.
Now-a-days the usage of waste items with soil has picked up consideration because of the deficiency of suitable soil and expanding issues of modern waste administration. Fly ash is a bi-product of coal fired electric power generation facilities. The chemical property of fly ash is similar to that of cement. Its annual production in India is around 10.0 million tonnes. Use of waste materials in the treatment or improvement of the soil properties is one of the small contributions, we are giving to the nature by avoiding hazard causes by dumping these wastes and keep going Eco friendliness with the nature.
Geopolymer which is a type of Cementous material produced by polycondensation effect of geopolymer precursor and alkali polyciliate KNown as geo polymerisation process. Geo polymerisation that can convert some aluminosilicate resources into useful -products called

geopolymers. Geo polymerisation occupy a mixed chemical effect among alkali metal silicate and solid aluminosilicate oxides solutions at highly alkaline circumstances. Geopolymer also utilizes the industrial waste materials such as fly ash, blast furnace slag etc.
Fly ash is collected from thermal power plant. Sodium hydroxide and sodium silicate chemicals store.
Index properties and compaction behaviour of expansive soil treated with fly ash and fly ash based geopolymer is determined. It is well known that the Liquid limit of expansive soil decreases with higher percentage of fly ash. This may be due to the effect of coarser fly ash which reduces the amount of soil to be flocculated. The optimum moisture content of expansive soil decreases and maximum dry density increases with percentage of fly ash. The strength properties of expansive soil treated with fly ash, geopolymer and fly ash based geopolymer are investigated. The strength of expansive soil is increasing up to addition of 30% fly ash then decreases. In the case of fly ash based geopolymer the strength of expansive soil increases, as the geopolymer dosage increases and also gives the higher strength as curing period increases.

The soil near the pavement failure is collected and the experiment is conducted in laboratory.

OBJECTIVE OF THE STUDY

- To study the compressive strength of the expansive soil at different dosage of geo polymer at different curing period.
- To evaluate the optimum dosage of geopolymer required to stabilize the soil.
- To evaluate the optimum dosage of fly ash with the combination of geopolymer required to stabilize the soil.
- To study the effect of curing period on strength property and compressibility property of the soil.
- Comparing the results of combination of expansive soil plus geopolymer with the combination of expansive soil plus fly ash plus geopolymer.

II RESULTS AND DISCUSSIONS

Based on the tests carried out as explained in chapter three the results were presented in this chapter in the form of graphs and tables. Observations and discussions were also made from the graphs and tables.

Compaction Characteristics

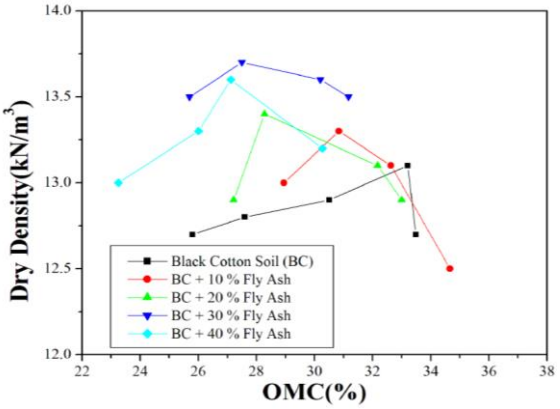
Compaction is a mechanical process in which the densification is achieved through the expulsion of air voids at almost constant water content of the soil mass. While the compaction is relatively an instantaneous process and consolidation is a time dependent process. For the majority of the activities adopted in the field to achieve soil compaction, the major input is the results of laboratory compaction tests (standard or modified proctor or mini compaction tests). The process of compaction, particularly of fine-grained soils seem to be a complex one as the soil may be composed of both active and relatively inactive clay minerals.
Compaction is the process of increasing the density of the soil by packing the particles closer together with reduction in the volume of air. Densification of soil improves their engineering properties. The dry density of a given soil after compaction depends on (i) water content, (ii) compactive effort, (iii) soil type and (iv) admixtures (Bowles, 1984).

Effect of fly ash on compaction characteristics of expansive soil

Compaction tests have been carried out by adding fly ash to expansive soil. Their compaction behaviour has studied and results are presented. The compaction test was conducted on soft soil reacted with a variety of proportion of Fly ash. The percentage fly ash mixed with expansive soil with *OMC* is plotted in fig. The values are exclusively given in figures and it is observed that;

- The maximum dry density of expansive soil mixed with 0%flyash found to be 13.1 KN/m3 and optimum moisture content 33.2%.

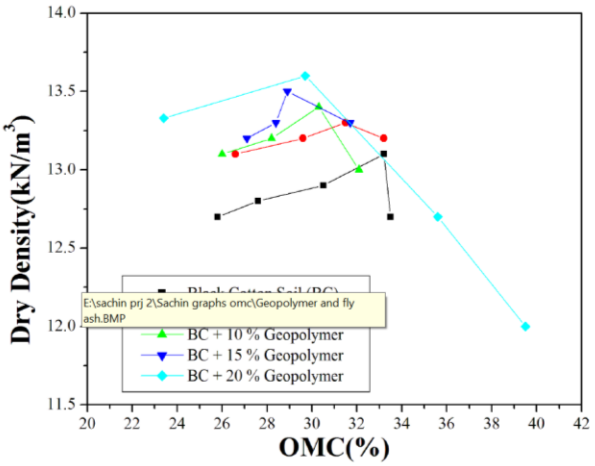
- On adding of fly ash to soft soil, the maximum dry density of the soil increases up to 30% addition of fly ash and decreases further with increase in the addition of fly ash. The MDD at 30% fly-ash is 13.7KN/m3 and OMC is 27.58% as shown in figures.
- The increase in maximum density due to fly ash as higher specific gravity about 2.8, this leads to increase in the density of soil.
- Because the activities of expansive clay is prohibited by soft dual layer. The adding of fly ash in little proportion outcomes in the reduce of repulsive pressure of clay elements. These in turn decreases the opposition to compactive attempt and the mix gets compacted to relatively advanced densities. Though present will be flocculation due to lime in the fly ash, this effect is subjected when the fly ash proportion is small.
- Hence a negligible increase in dry density is identified. More adding of fly ash away from 30-40% results in improved flocculation due to increased accessibility of free lime content of fly ash. Repulsive forces in the soil particle raises rising the resistance to compactive effort and hence the density of mix begins reducing.
- Reduction in the optimum moisture content due to reduction of clay minerals while replacing soil by fly-ash.



Compaction characteristics of various percentages of fly ash treated with expansive soil

Effect of fly ash based geopolymer on compaction characteristics of expansive soil

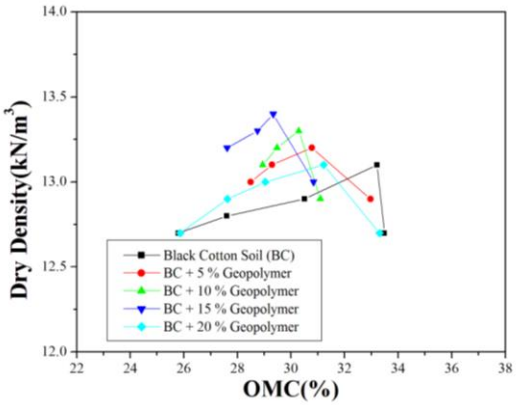
Compaction tests were carried out by adding 30% fly ash based geopolymer to expansive soil. Their compaction behaviour has been studied and results are presented. The compaction test was conducted on expansive soil alone and expansive soil reacted with different proportions of fly ash based geopolymer. The maximum dry density of expansive soil alone found to be 13.2KN/m3 and optimum moisture content 33.2%. On addition of 5% geopolymer with the combination of 30%Flyash and soil shows the increases in the maximum dry density and decreases optimum moisture content of soil as compared to expansive soil +0% fly ash. As the geopolymer dosage increases above this combination, the maximum dry density increases more than the Expansive soil at further geopolymer dosages as shown in figure.



Compaction characteristics of various percentages of fly ash based geopolymer treated with expansive soil

Effect of geopolymer on Compaction Characteristics of expansive soil

Compaction tests have been carried out by adding geopolymer to expansive soil. Their compaction behaviour has been studied and results are presented. The compaction test was conducted on expansive soil+ 0% geopolymer and expansive soil reacted with different proportions of geopolymer. The maximum dry density of expansive soil alone found to be 13.1KN/m3 and optimum moisture content 33.2%. On addition of geopolymer to expansive soil, maximum dry density increases and optimum moisture decreases as shown in table 4.3 and fig

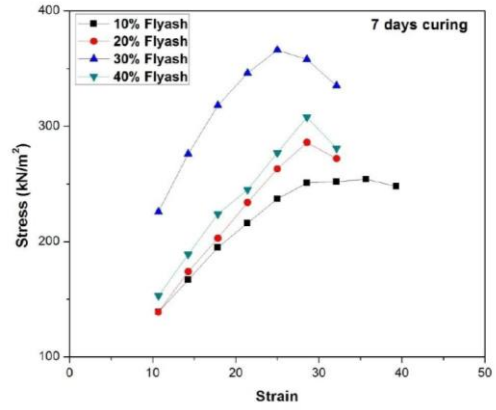


Compaction characteristics of various percentages of geopolymer treated with expansive soil

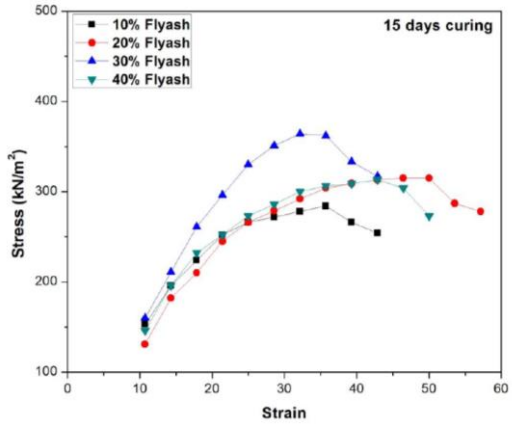
STRENGTH PROPERTIES OF EXPANSIVE SOIL WITH FLY ASH

Effect of fly ash on expansive soil

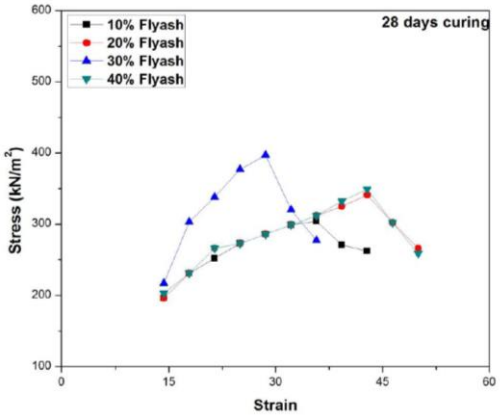
The expansive soil was mixed with various percentage of fly ash and their strength properties have been studied. The strength of expansive soil alone is 213KN/m2. On addition of fly ash to expansive soil the strength increases at lower dosage (<20%), then gets reduces as the fly ash content increases at the immediate testing. With curing, the strength increases up to 30% fly ash to expansive soil and then decreases. It is observed that the strength is maximum at 30% fly ash as shown in table 4.7. Hence 30% fly ash to expansive soil has been chosen as the optimum percentage of fly ash to Expansive soil. The increase in strength is due to pozzolanic reaction between Expansive soil and fly ash. The fly ash containing the high amount of calcium ions and calcium oxide, they interact with the soil elements through a cation replace process resulting in the development of aggregations. When such additives including calcium ions is added to an soft clay, these calcium ion concentration raises in the interlayer of clay, resulting in magnetism between the clay particles and the arrangement of aggregation and flocs. More adding of additives leads to pozzolanic effect that arises among the calcium ions of the fly ash and the silica and alumina of the soil resulting in the development of cementitious products such as calcium silicate hydrates (CSH), calcium aluminium silicate hydrates (CASH) and calcium aluminate hydrates (CAH). These pozzolanic results contribute to the flocculation process by bonding next flocculated clay particles mutually.



Unconfined compressive strength of expansive soil treated with various percentage of fly ash in 7 days curing period



Unconfined compressive strength of expansive soil treated with various percentage of fly ash in 15 days curing

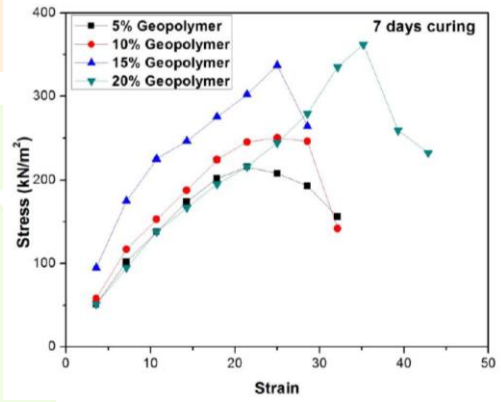


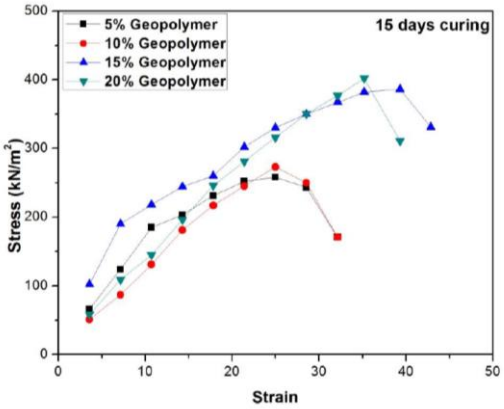
Unconfined compressive strength of expansive soil treated with various percentage of fly ash in 28 days curing period

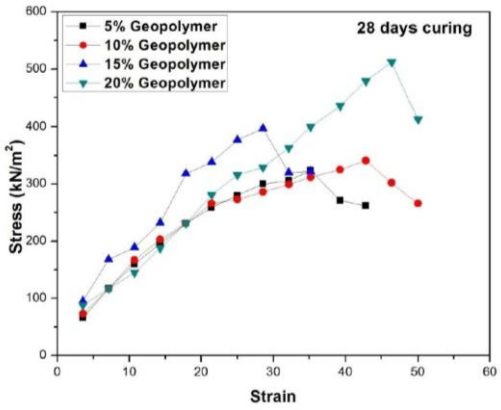
Effect of geopolymer on expansive soil

The Expansive soil was mixed with various percentage of Geopolymer and their strength properties have been studied. From the test results shows that expansive soil alone as compressive strength of 213 KN/m2. when Geopolymer added to the Expansive soil. Hence it needs sufficient time for the polymerisation reaction to gain strength. As the curing period increases compressive strength is also gets increases more than the expansive soil alone. This is because the geopolymer reacts with alumino-silicate sources of Expansive soil. They form a hardened substance has an amorphous, three-dimensional formation. Related to that of an alumino-silicate glass. These materials are created at small temperature and as a result can include an aggregate frame and a reinforcing arrangement, hence as the geopolymer dosage increases the quantity of reaction of alkaline solution with alumino silicates of the Expansive soil increases. So compressive strength is keeps on increasing with increase in geopolymer dosage.

Unconfined compressive strength of expansive soil treated with various percentage of geopolymer

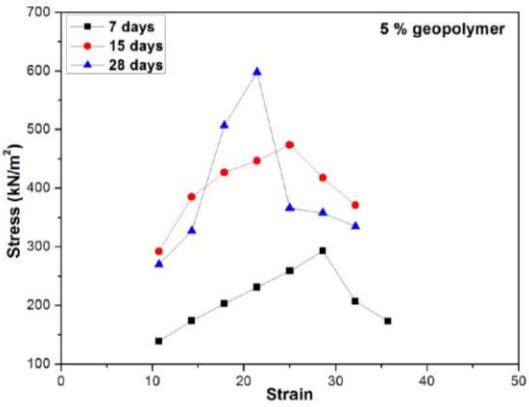






Effect of fly ash based 5% geopolymer on expansive soil

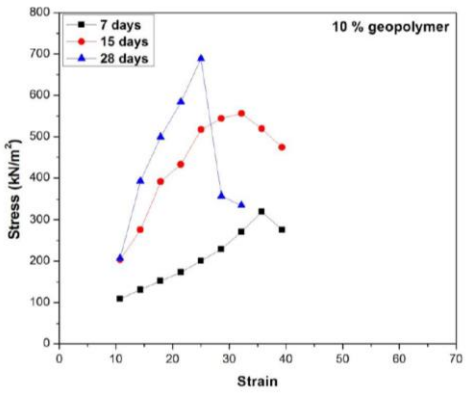
The expansive soil was mixed with various percentage of fly ash based geopolymer and their strength properties have been studied. The strength of expansive soil alone is 213KN/m2. On addition of 5% geopolymer to the soil plus 30%fly ash combination. As the curing period increases the soil strength is keeps on increasing. i.e. from the graph it shows 293KN/m2 strength at 7 days curing for 5%GP & 30% fly ash dosage. Like-wise 474KN/m2 & 598KN/m2 strength at 15days and 28 days curing for 5% GP & 30% fly ash respectively.



Unconfined compressive strength of expansive soil in the curing period of 7,15&28 days treated with fly ash based geopolymer

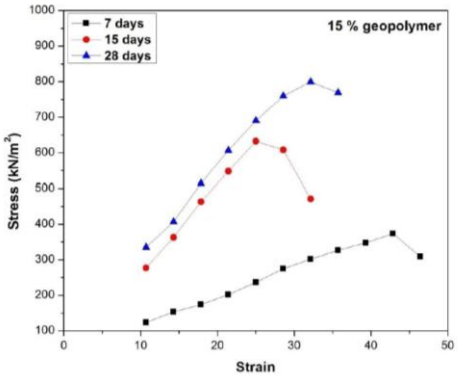
Effect of 10% geopolymer with various combinations of soil and fly ash

The expansive soil was mixed with various percentage of fly ash based geopolymer and their strength properties have been studied. The strength of expansive soil alone is 213KN/m2. On addition of 10% geopolymer to the soil plus 30%fly ash combination. As the curing period increases the soil strength is keeps on increasing. i.e. from the graph it shows 320KN/m2 strength at 7 days curing for 10%GP & 30% fly ash dosage. Like-wise 556KN/m2, & 698KN/m2 strength at 15days and 28 days curing for 10%GP & 30% fly ash respectively.



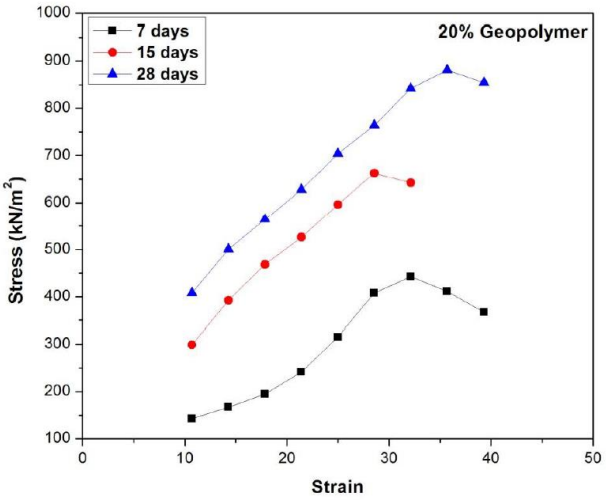
Effect of 15% geopolymer with various combinations of soil and fly ash

The expansive soil was mixed with various percentage of fly ash based geopolymer and their strength properties have been studied. The strength of expansive soil alone is 213KN/m2. On addition of 15% geopolymer to the soil plus 30%fly ash combination. As the curing period increases the soil strength is keeps on increasing. I.e. from the graph it shows 374KN/m2 strength at 7 days curing for 15% GP & 30% fly ash dosage. Like-wise 632KN/m2, & 799KN/m2 strength at 15days and 28 days curing for 15%GP & 30% fly-ash respectively.



Effect of 20% geopolymer with various combinations of soil and fly ash

The expansive soil was mixed with various percentage of fly ash based geopolymer and their strength properties have been studied. The strength of expansive soil alone is 213KN/m2. On addition of 20% geopolymer to the soil plus 30%fly ash combination. As the curing period increases the soil strength is keeps on increasing. I.e. from the graph it shows 442KN/m2 strength at 7 days curing for 20%GP & 30% fly ash dosage. Like-wise 663KN/m2, & 881KN/m2 strength at 15days and 28 days curing for 20%GP & 30% fly ash respectively.



III **CONCLUSION**

The following conclusions are drawn

- The strength of expansive soil is increasing with the increasing in the fly ash ratio. The optimum percentage of fly ash is 30 % and its compressive strength is 398 KN/m2. Increasing in the fly ash in the soil will gets reduces the SiO2/Al2O3 ratio. As the ration gets decreasing the strength of the soil is increasing.
- From previous studies we understand that the strength is increasing due polymerization. Now the ratio of silicon and aluminium also plays as important role in the strength development.
- The compressive strength increases with the increase in geopolymer. This is because the increases quantity of sodium hydroxide in solution leaches more aluminium and silica from the binder material. Hence this process continues to form a longest rigid network of polymers. So, the compressive strength increases with increase in the geopolymer dosage.
- The compressive strength of expansive soil 881KN/m2 for 28days of curing period in 20% geopolymer and optimum percentage of fly ash 30%.
- The compressive strength of Expansive soil is more, when it is treated with fly ash based geopolymer as compared with the soil treated with fly ash.

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