Soil Improvement Using Alkali Activated Flyash And Soil Bond

Maldev Rabari[1],Srinath Karli[2], Vrundani Vaidya[3], Deep Patel[4]
[1]Dept of Transportation Engineering
[2, 3]Assistant Professor, Dept of Civil Engineering
[4]Consulting Chartered Engineer
[1, 2, 3, 4] HGCE, Vahelal, Gujarat

Abstract- *Soil improvement is the alteration of one or more properties of soil by mechanical or chemical means, to create an improved soil material possessing the desired engineering properties. Soils may be improved to increase strength and durability or to prevent erosion and dust generation.The present study mainly focusing on improvement and stabilization of expansive soil for which samples had been collected from proposed road construction site of Chital – Bhildi section in Monpar, Saurashtra.India is currently confronted with the tremendous test of safeguarding and upgrading the transportation framework, these require the interest of new material to enhance the properties of soils.Two materials, Acrylic Polymers & Alkali Activated Fly Ash, would be used for stabilization of expansive soil.*

Keywords- Soil Stabilization, Soil Strength, Pavement Design

I. INTRODUCTION

The construction industry's technological advancements, the globalization of the economy, and greater foreign direct investments have all aided the country's infrastructure growth. Specifically, the rapid growth of urbanization necessitates a variety of civil engineering structures and facility services in readily available places. Because of the shortage of suitable land with sound soil, construction activities on problematic soils are now unavoidable all over the world. As a result of the undesired soil qualities, the number of construction sites has expanded dramatically, and these regions have been mostly extended with clays and organic soils. The requirements for designing and constructing structures in natural soft ground have risen dramatically, necessitating special attention. As a result, in the vast majority of civil engineering projects, selecting a suitable region that meets the design requirements is impossible.

When it comes to natural soils, which are often characterized by low strength and excessive compressibility, extreme caution is required. As a result, construction on such soils creates serious geo risks, including excessive structure settlement. Traditionally, the process of replacing low-strength soil deposits with engineered fill was used to solve soil concerns. Later, it was established that different procedures are appropriate for different soil types, and the concept was grouped as ground improvement approaches.

Construction over problematic or weak soils has been a significant challenge for geotechnical engineers in implementing projects among various types of soils. Sites with poor clay soils absorb and hold water, causing the soil to show higher volume variations as the moisture level varies. The kind and amount of clay minerals in the soil, as well as the soil conditions, are the primary sources of soil problems. As a result of the change in soil behaviour, building foundations and other lightly loaded structures are damaged, necessitating repeated repairs.

Aim of the study:

The main aim of this study is to check the feasibility of usage of Alkali activated fly ash and Soil Bond chemical for improvement of soil properties.

Objective of the study:

The objectives of the study are as below:-

1. To study the addition effects of Acrylic polymers and Alkali activated fly ash on CBR & UCS properties of soil
2. To design flexible pavement based on optimum concentration and to perform cost estimation for it

Scope of the study:

Present study having scope for utilization of Acrylic polymers and Alkali activated fly ash addition for soil properties improvement for highway flexible pavement. Soil having problematic nature with volumetric changes is high is selected for present work. Design of experiments would be conducted and experiments would be performed on different dosages. Optimum dosage would be determined based on analysis of test results.

II. LITERATURE REVIEW

N Sohaib (et. al.) conducted study for improvement of soil properties using Acrylic polymer. Because of their poor engineering properties, soft soils, also known as clayey soils, are always troublesome and rarely ideal for construction. The Chinese, Romans, and Incas used a variety of strategies to improve the strength of clayey soils in prehistoric times. Because soil must offer a foundation for structures, engineering works are based on cost, strength, and durability. As a result, it must provide a cost-effective soil-strengthening substance. The purpose of this research is to investigate the usage of waste acrylic polymer in geotechnical applications and the impact of waste acrylic on the engineering features of clayey soil. Six distinct formulas were tested, each with a different amount of acrylic polymer ranging from 0% to 10%. After three, seven, and fourteen days of curing, the samples were examined for unconfined compressive strength. The addition of acrylic polymers to clayey soil improved engineering properties such as optimum moisture levels, maximum dry density, unconfined compressive strength, and California bearing ratio of clayey soil, according to the findings.

Pratha Parhi (et. al.) conducted study for expansive soil stabilization by using Alkali activated fly ash based geo polymer. Expansive soil is one of the most destructive types of soil, causing millions of dollars in damage to roads, buildings, and pipelines each year. Efforts are being made to stabilise the soil and reduce the harm it has caused. One of the sustainable methods for industrial expansion is to use industrial waste as a low-CO2 cement. Alkali activated fly ash was used as an alternate cementitious material in this work to stabilise an Indian expansive soil. In terms of the Na2/SiO2 ratio, many combinations of sodium hydroxide and sodium silicate were employed. With different percentages of class F fly ash, the activators to ash ratios (liquid to solid mass ratio) were also altered. The fly ash is activated with sodium hydroxide concentrations of 10, 12.5 and 15 molar, as well as a 1 molar sodium silicate solution. The percentages of fly ash (20, 30, and 40%) applied in relation to the total solids of the expanding soil are different. The activator-to-ash (liquid-to-solid mass-ratio) ratios were kept between 1 and 2.5.

Darshan M R (et. al.) carried out study using Cement and Acrylic and Vinyl Acetate Polymer Emulsion for soil stabilization. Soil stabilisation is frequently required to provide a proper foundation for roadways, defend against erosion and slope failure, and even minimize natural disasters like landslides. Vegetation and goofier are two extensively used soil stabilizing technologies that have been seen in practice. Aside from these two approaches, there is a third one called Soil Cement. The goal of this research is to characterize the soil stabilisation benefits of various soil samples with various soil cement mix designs. A polymer emulsion is used to achieve excellent performance. Acrylic and Vinyl Acetate polymer are the chemicals used. To create the needed cement ratio of soil cement mixers, varied cement contents of 2 percent, 4 percent, 6 percent, 8 percent, and 10 percent by weight were used. For soil samples, the outcome may differ. When these materials were manipulated with varied cement contents, standard Proctor tests were done to determine the maximum dry density and optimum moisture level. The soil cement mix design, laboratory experiments, and test results are all presented in this publication.

Sanjay Kumar Shukla (et. al.) used alkali activated waste binder for soil stabilization. Alkali-activated binders have gotten a lot of press in recent years because of their energy efficiency, ecologically friendly manufacturing process, and superior technical features. In light of this, the purpose of this research is to look into the effects of alkaline activation reactions on residual soil using various percentages of fly ash as a precursor. Fly ash was mixed with potassium hydroxide (10M) to stabilize the soil and make it more suitable for a variety of construction projects. This investigation focused on determining the mechanical performance of stabilized soil in particular. The results clearly revealed that the varying percentages of fly ash employed to stabilize the residual soil (40 percent, 50 percent, 60 percent, and 70 percent by weight) had an effect on the unconfined compressive strength of the soil matrix. In addition, with the addition of fly ash, the compressive strength of the soil increased gradually. However, the higher the unconfined compressive strength of the stabilized soil, the longer the cure duration. In fact, scanning electron microscopy (SEM) micro structural examination revealed material alterations that can be linked to the strength behaviour.

III. STAGES OF STUDY

Stage 1:- Problem Identification

In study area soil is having problematic nature with greater volumetric changes and having low strength.

Stage 2:- Review of literatures

Extensive study material is available for soil improvement using lime and cement as they are conventional material. Very less material is available for use of non conventional material. Various materials would be referred and critical review would be carried out to define research gap. Based on that objectives for the study would be defined.

Stage 3:- Design of proportion mix & experiment

Polymers and Fly Ash proportion would be fixed after number of trials.

Tests required for study are:-

1) Sieve analysis
2) Swell Index Test
3) Specific Gravity Test
4) Consistency Limit Test
5) California Bearing Ratio Test
6) Unconfined Compressive Strength Test

Stage 4:- Analysis of results

Test results obtained would be analyzed and possible causes for alteration in test results with addition of fiber and fly ash would also be discussed.

Stage 5:- Design & Cost Estimation

Based on test result analysis optimum dosage would be determined and for that result value pavement design & cost estimation would be carried out.

IV. MATERIAL

Soil:-

Soil samples had been collected from proposed road construction site of Chital – Bhildi section in Monpar, Saurashtra.

Figure 1:- Soil Sample

Alkali Activator:-

The alkaline activator solution used would be of a combination of Sodium silicate (Na_2SiO_3) and Sodium hydroxide (NaOH). The sodium silicate originally would be in powder form and having molecular weight of 284.20 gm/mole and specific gravity of 1.5. While the sodium hydroxide originally would be in flake form with a molecular weight of 40 gm/mole, and specific gravity of 2.13 at 20º C and 95–99% purity.

V. EXPERIMENTS & RESULTS

Experiments to be performed

- Sieve Analysis
- Liquid limit test
- Plastic limit test
- Specific Gravity test
- Proctor compaction test
- Swelling test
- California Bearing ratio test
- Unconfined Compressive Strength test

Sieve Analysis

1000 gram soil sample had been taken for sieve analysis purpose.

Sieve size	Retained material (g)	Retained material (%)	Cumulative Retained (%)	Cumulative finer (%)
4.75	79	7.9	7.9	92.10
2	49	4.9	12.8	87.20
1	78	7.8	20.6	79.40
600 µ	89	8.9	29.50	70.50
300 µ	76	7.6	37.10	62.90
150 µ	88	8.8	45.90	54.10
75 µ	69	6.9	52.80	47.20
Pan	472	47.2	100	0

Atterberg's limit

Mix	LL (%)	PL (%)	PI (%)
Soil	50.35	32.18	18.17
Soil + 10% AAFA + 2% SB	48.20	31.90	16.3
Soil + 15% AAFA + 3% SB	46.08	30.93	15.15
Soil + 20% AAFA + 4% SB	43.5	28.80	14.7
Soil + 25% AAFA + 5% SB	41.44	27.12	14.32
Soil + 30% AAFA + 6% SB	39.08	25.77	13.31

CBR Test

Type of mixture	CBR (%)
Soil	3.57
Soil + 10% AAFA + 2% SB	4.90
Soil + 15% AAFA + 3% SB	5.80
Soil + 20% AAFA + 4% SB	7.60
Soil + 25% AAFA + 5% SB	8.89
Soil + 30% AAFA + 6% SB	10.24

UCS Test

Type of mixture	UCS (kN/m^2)
Soil	56.7
Soil + 10% AAFA + 2% SB	65.55
Soil + 15% AAFA + 3% SB	75.72
Soil + 20% AAFA + 4% SB	83.23
Soil + 25% AAFA + 5% SB	78.69
Soil + 30% AAFA + 6% SB	76.21

VI. CONCLUSION

For soil sample Uniformity co – efficient obtained as 12 and Co – efficient of curvature obtained as 0.75 from interpretation of test results obtained from sieve analysis test. Soil is poorly graded gravel.

From the test results of soil liquid limit, plastic limit and plasticity index obtained as 50.35%, 32.18% and 18.17% respectively. According to USCS classification soil is CL, say clayey soil.

Liquid and plastic limit as well as plasticity index of soil is decreasing with addition of alkali activated fly ash and Soil Bond chemical. As the fly ash is non plastic material hence due to its addition plastic behaviour of soil is fluctuating.

With increasing in replacement by alkali activated fly ash content and addition of polymer chemical CBR is increasing gradually. Maximum dry density and specific gravity is increasing and granular formation occurs due to replacement with Alkali activated fly ash. Due to this CBR is increasing when we replace soil with more fly ash content.

REFERENCES

[1] N Sohaib, "Use of Acrylic polymer for stabilization of clayey Soil", International Journal of Scientific & Engineering Research Volume 9, Issue 11, November-2018

[2] Pratha Parhi, "Stabilization of an Expansive Soil Using Alkali Activated Fly Ash Based Geo polymer", Advances in Characterization and Analysis of Expansive Soils and Rocks, Sustainable Civil Infrastructures, 2018

[3] Parikshith M V, "Feasibility of Flyash based Geopolymer for Soil Stabilization", International Journal of Innovative Technology and Exploring Engineering, November 2019

[4] Darshan M R, "Stabilization of Soil Using Cement and Acrylic and Vinyl Acetate Polymer Emulsion", International Journal of Trend in Research and Development, 2017

[5] Soil Mechanics & Foundation Engineering, B.C. Punamia, Laxmi Pub. Pvt. Ltd., New Delhi

[6] IS 2720, Methods of tests for soil