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Study on Swelling Properties of Expansive Soil

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Abstract- Industrial alkali residue was utilized as a stabilizing agent in expansive soil with a medium swelling potential in order to recycle waste materials and lessen the geological catastrophes brought on by expansive soil. The quantity of alkali residue clearly influenced the Atterberg limits, according to the findings of a series of studies conducted on the stabilized soil. The plasticity limit, lower liquid limit, and lower plasticity index increase with the amount of alkali residue. As the percentage of alkali residue increases, the free swelling ratio, swelling ratios without pressure, and swelling force under pressure decrease. Additionally, models of negative index functions were consistent with the relationship between the swelling index and the percentage of alkali residue. 20% was proposed as the adaptive ratio of alkali residue in costly soil after taking into account the overall improvement in efficiency. With setting time, swelling ratios without pressure rapidly decreased. The primary idea behind how alkali residue improves expansive soil is that it sets and hardens the expansive soil by replacing a part of it with alkali residue.

Keywords- Expansive Soil, Alkali Residue, Atterberg Limits, Swelling Ratio,Swelling Pressure.

I. INTRODUCTION

The expansive soil, which contains strong hydrophilic minerals such as montmorillonite and illite, is a kind of unique clay generated during the natural geological process. Expansive soil has unique engineering qualities such as fissure, shrinkage, and superconsolidability, which distinguish it from typical cohesive soil. When the water content in expansive soil varies, the volume of expansive soil fluctuates, resulting in expansion pressure or shrinkage fractures, which cause damage to industrial and building construction, railroads, and highways. At the same time, expansive soil dangers are often associated with recurring and long-term latent characteristics, earning expansive soil the nickname "engineering cancer." How to enhance expansive soil has emerged as a key worldwide engineering concern in geology and geotechnical engineering today.

The waste residue that an alkali producing facility releases is known as alkali residue. Up to 100 million tons of alkali residue are produced annually in India produced India by the ammonia-soda process. For the production plant, this becomes a major issue that has to be resolved immediately. Calcium carbonate, calcium sulfate, calcium chloride, and other calcium salts make up alkali residue, which is suitable for use as a soil curative material. Alkali residue was used as a supplement to poor expansive soil Unfortunately, there is currently no study on the improving impact of alkali residues affected by the curing duration. It is common knowledge that medium or strong expansive soils have a significant negative impact on the environment. pay attention to this element.

Aim of the Study

The aim of the study to achieve expansive soil with a reasonable capacity for swelling, the indoor expansibility test is used to examine the impact of varying mixing amounts on the limit moisture content, swelling ratios and swelling force of expansive soil.

II. MATERIALS AND METHODS

Materials Properties

Table 1: The physical properties of alkali residue

Chemical composition	mass fraction %	
	alkali residue	expansive soil
CaO	52.25	5.78
SO_3	16.97	—
Cl^-	18.39	—
SiO_2	4.06	60.45
Na_2O	2.46	2.20
MgO	2.33	1.86
Al_2O_3	1.76	19.34
Fe_2O_3	1.17	3.42
K_2O	0.15	3.13
LOI	0.46	3.82

Figure 1: Alkali residue

Method & Experimental Procedure

When sampling, the tester may readily get standard cutting ring samples by unscrewing the bolts and removing In this research, the mixing rate is defined as the dry mass ratio of alkali residue to expanding soil. To facilitate sample operation, the mixing rate is set to 0%, 10%, 20%, 30%, 40%, and 50%. the sampler was self-made while keeping the mixing ratio consistent and the ease of producing samples in mind]. The sampler uses the half-and-half type. away sample-press piston easily and efficiently, and this method can guarantee the height, flatness, and uniformity of the cutting ring specimen, as well as ensure that the consistency of the same batch of samples meets the test's accuracy requirements.

- After drying, the alkali residue and expanding soil are combined in the specified ratio. And the mixture is added and mixed with water before being put in a sealed bag to simmer for 24 hours.
- After weighing a certain quantity of alkali residue-expansive soil combination into the sampler, the soil sample will be compacted with a tiny press before being removed using a ring knife. Meanwhile, verify the sample surface roughness and height to see whether they meet the requirements.
- The swelling ratio with and without pressure is measured, as well as the swelling force. The swelling ratio without pressure test is performed using a WZ-2 dilatometer equipped with a YWD-50 displacement meter and a DH3816 static strain measuring device to automatically and completely gather the sample's expansion amount. Swelling ratio and swelling force tests with pressure are performed on a single lever consolidation equipment at a constant pressure of 50kPa. The swelling force test employed the load balancing technique, and the operation completely adhered to the "Test Method of Soils for Highway Engineering".
- Expansion tests without pressure are completed by selecting a certain percentage of alkali residue - expansive soil combination and curing for 0, 7, 14, and 28 days, respectively, to investigate the effect of the setting period on expansion and deformation.

III. RESULT & DISCUSSION

The limit moisture content of soil is one of the sensitive indicators that, to a certain degree, indicates the hydrophilic characteristic of soil and the interaction between soil particles and water, according to soil mechanics. The composition of soil particles, mineral components, positive ion exchange performance, soil dispersion, and specific surface area are all closely related to it. Li Shenglin has distinguished expansive soil using the plasticity diagram (combined usage of plastic index, liquid limit). Therefore, as shown in Fig. 2, the changing trend of the percentage of alkali residue is used to examine the liquid limit, plastic limit, and plasticity index of the alkali residue-expansive soil combination. Evidently, the plastic limit rose and the liquid limit gradually reduced as the alkali residue amount grew; nevertheless, the plastic limit only slightly increased when the alkali residue content reached 20%. Its plastic index therefore falls, and at a 20% mixing ratio, the plasticity index is only approximately 18, much lower than its starting value of 31.6. In this instance, it can be said that the 20% slag component of the amended soil significantly lowers its expansibility.

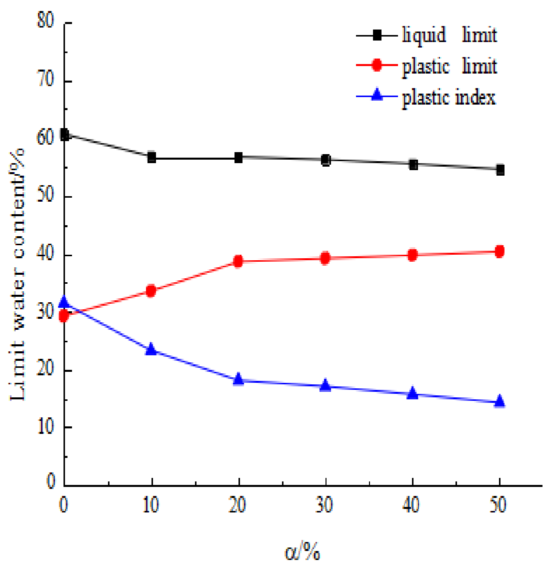

Figure 2: The relation between limit water content and mixing amount of alkali residue

The expansion test of expansive soil with alkali residue is thus conducted in order to examine the variation rules of both pressure-free and pressure-assisted expansion. There are certain outcomes, and Fig. 3 illustrates the shifting pattern.

(1) The free expansion of the modified expansive soil is considerably decreased when the alkali residue ratio rises. The free expansion of the changed soil is 20.4% at a 20% mixing rate, which is less than 40% of the weak expansive soil's minimal limit and much less than the original value of 77.2%.

(2) Likewise, when the alkali residue rate rises, it falls. Without pressure, swelling ratios drop from 15.7% to 3.2% when the mixing rate approaches 20%.

(3) The overall rate of expansion of expansive soils is a reflection of the structural properties and composition of clay minerals in expansive soils. In general, Figure 3 swelling ratio under pressure, or expansion at 50 kPa pressure, may be used to estimate the overall swelling rate. It is evident from Figure 3 that the dilatancy rate significantly decreases as the doping rate rises. Less than 0.7%, or 0.45%, is the swelling ratio under pressure when the mixing ratio is 20%. "Specifications for Design of Highway Subgrades" (JTG D30-2015) states that the following criteria must be met for subgrade filling: "Weak expansive soil used as roadbed packing must be reformed prior to filling." The adjusted overall expansion rate is limited to 0.7%. Naturally, a filler with an alkali residue ratio of 20% and 80% expansive soil will be able to satisfy the regulations.

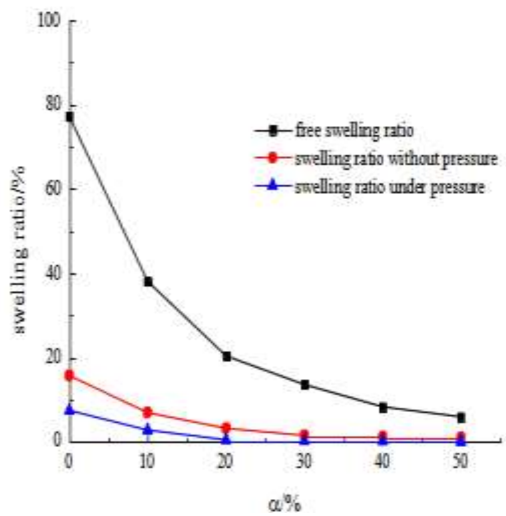

Figure 3: The relation between swelling ratio and mixing amount of alkali residue.

IV. CONCLUSION

- The limit moisture content of expansive soil is somewhat influenced by the quantity of alkali residue. The plasticity index decreases as the dose increases, the liquid limit decreases, and the plastic limit increases.

- As the fraction of alkali residue increased, the free swelling ratio, swelling ratio with or without pressure, and swelling force of the alkali residue-expansive soil combination all dramatically reduced. The alkali residue ratio and the expanding property index have a roughly negative exponential relationship. It is also clear how coagulation affects the mixture's expansibility. The expansion rate decreases with increasing coagulation time.
- The alkali residue significantly improves the expansiveness of expansive soil, as shown by the study of the change law of the limit moisture content, free swelling ratio, swelling ratio with or without pressure, and swelling force. The suggested quantity of alkali residue is 20% owing to its improving advantage.
- The coagulation reaction, ion exchange of caustic soda-expansive soil, and the replacement efficiency of alkali residue are the primary factors that contribute to the expansibility of alkali residue to enhance expansive soil.

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