Stabilization of Clayey Soils by Using the Organic Waste-Material

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Abstract: Soil stabilization known as the process of improving the engineering properties of soils is a method applied when the engineering properties of soil are not suitable for purpose. There are several methods of soil stabilization that could be implemented to improve the physical characteristics of the soil. In this study, the pine tree sawdust as an organic material wase used as additive material for stabilization of clayey soils and the influence of pine tree sawdust on the geotechnical properties of clayey soil was investigated in terms of strength behaviors. The pine tree sawdust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various standard shapes and useable sizes. The strength properties of the clayey soil when blended with pine tree sawdust indicates that the pine tree sawdust is a good stabilization material for this problematic soil. As a result, it is concluded that the pine tree sawdust material as an organic material can be successfully used for the reinforce of clayey soils in the geotechnical applications.

Keywords: Soil; clayey soil; pine tree sawdust; soil stabilization; strength behavior

1. INTRODUCTION

The soil is one of the oldest and perhaps most complex geological materials that humanity has been working on. Various problems have begun to be encountered by using the expansive soil as foundation or material. The expansive soil changes in volume in relation to changes in water content. This occurs as swelling upon wetting, and shrinkage upon drying. These soils have poor volume stability in the presence of water (Jones and Jefferson, 2012; Li et al., 2014). These soils have a problem worldwide undergoing considerable volume changes such as swelling on absorbing water and shrinking on evaporation.

Moreover, moisture fluctuations of them cause distinct changes in soil strength (Fredlund and Rahardjo, 1993; Sheng et al., 2008; Phanikumar, 2009; Lin, and Cerato, 2012; Pooni et al., 2019). Such soils should generally be avoided for the purpose of construction. Because, the structural damages of constructures built on expansive soils is well documented in literature (Petry and Little, 2002; Fall and Sarr, 2007; Kalkan and Bayraktutan, 2008; Ozer et al., 2011; Jones and Jefferson, 2012; Tiwari et al., 2012; Kalkan et al., 2019; James, 2020; Yarbaşı and Kalkan, 2020). Also, the damage to lightly loaded structures founded on expansive soils has been widely reported (Cameron et al., 1987; Walsh and Cameron, 1997; Fityus et al., 2004; Delaney et al., 2005; Miao et al., 2012; Li et al., 2014; Kalkan et al., 2020).

When the mechanical qualities of expansive soils are lower than those required, stabilization can be an option to improve performance, notably in enhancing its strength. Improvement of certain desired properties like bearing capacity, shear strength and permeability characteristics of soil can be undertaken by a variety of ground (Kalkan, 2013). The soil improvement techniques can be divided into four main categories. These categories are soil improvement without admixtures, soil improvement with admixtures or inclusions, soil improvement using stabilization with additives and grouting methods and soil improvement using thermal methods (Chu et al., 2009; Manar et al., 2015).

There are various methods of stabilization including either mechanical stabilization or chemical stabilization. Mechanical techniques densify the soil expelling air from the voids. Chemical techniques incorporate additives that improve the properties of problematic soils and the chemical stabilizers are characterized as traditional and non-traditional additives. Traditional stabilizers include calcium-based stabilizers such as lime and cement (Tingle et al., 2007; Pooni et al., 2019).

Several soil stabilization methods are available for stabilization of expansive clayey soils. These methods include the use of chemical additives, rewetting, soil replacement, compaction control, moisture control, surcharge loading, and thermal methods (Chen, 1988; Nelson and Miller, 1992; Yong and Ouhadi, 2007). Many investigators have studied natural, fabricated, and by-product materials and their use as additives for the stabilization of clayey soils.

All these methods may have the disadvantages of being ineffective and expensive. Therefore, new methods are still being researched to increase the strength properties and to reduce the swell potential of expansive soils (Akbulut et al., 2007; Al-Rawas et al., 2005; Asavasipit et al., 2001; Bell, 1996; Cetin et al., 2006; Guney et al., 2007; Kalkan and Akbulut, 2004; Kolias et al., 2005; Miller and Azad, 2000; Moavenian and Yasrobi, 2008; Prabakar et al., 2003; Puppala and Musenda, 2002; Senol et al., 2006; Sezer et al., 2006; Mohamedgread et al., 2019; Yarbaşı and Kalkan, 2019; Kalkan, 2020).

In this study, the pine tree sawdust as an organic material was used as additive material to stabilize the clayey soils. These soils were evaluated in an attempt to develop alternative stabilization material with high compressive strength for geotechnical applications. Also, obtained engineering properties of stabilized clayey soil samples with pine tree sawdust were presented and discussed.

2. MATERİLA and METHODS

2.1. Clayey Soil Material

The clayey soil material was supplied from the clayey soil deposits of Oltu-Narman sedimentary basin, Erzurum, NE Turkey. The clayey soil samples were taken 0,75 m deep. According to the United Soil Classification System, clayey soil are inorganic clays of high plasticity (CH). These soils have high expansion potential as a result of over consolidation, high-very high plasticity and montmorillonite content (Kalkan, 2003; Kalkan and Bayraktutan, 2008). The grain-size distribution of clayey soil was given in Figure 1.

2.2. Pine Tree Sawdust

Wood cutting factories, generates a by-product known as sawdust. The pine tree sawdust waste material was obtained from the carpenters in the industrial zone of Oltu (Erzurum), NE Turkey. The pine tree sawdust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various standard shapes and useable sizes. Consisting of soil-like particulate materials that are lighter than soil, sawdust inexpensive and environmentally safe (Rao et al., 2012; Oyedepo et al., 2014). The grain-size distribution of the pine tree sawdust waste material was illustrated in the Figure 1.

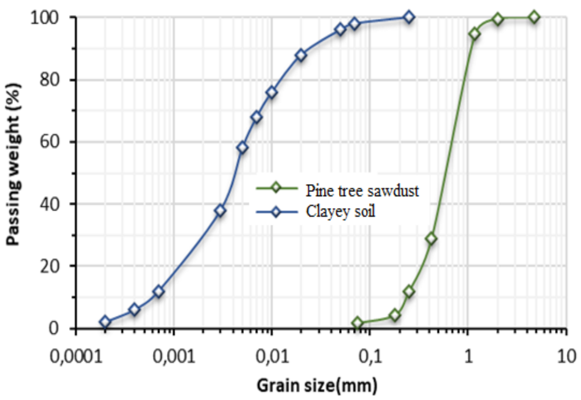

Figure 1. The grain-size distributions of clayey soil and pine tree sawdust

2.3. Preparation of the Samples

The clayey soil and pine tree sawdust were mixed under dry conditions to prepare mixtures of clayey soil-pine tree sawdust. The amounts of pine tree sawdust were selected to be 0,5%, 1% and 1,5 % of the total dry weight of the mixtures (Table 1). The dry mixtures were mixed with the required amount of water recognized to give the optimum water content. All mixing was done manually and proper care was taken to prepare homogeneous mixtures at each stage.

2.4. Unconfined Compression Test

The UCS values of clayey soils and stabilized clayey soil samples with pine tree sawdust were determined from the unconfined compression tests in accordance with ASTM D 2166. The unconfined compression test was carried out on the cylindrical samples compacted at optimum moisture content. The samples of unconfined compression tests had 35 mm in diameter by 70 mm in length. During the tests, at least three samples were tried for each combination of variables. In this study, three cylindrical samples were prepared and tested for each combination of mixtures. The unconfined compression tests were performed at a deformation rate of 0,8 mm/min.

Table 1. Clayey soil and pine tree rates of samples

Samples	Clayey soil	Pine tree sawdust	Total
SMP0	100	-	100
SMP1	99,5	0,5	100
SMP2	99,0	1,0	100
SMP3	98,5	1,5	100

3. Results and Discussion

3.1 Compaction Properties

The maximum dry unit weight in various clayey soil-pine tree sawdust mixture sample decreases with an increase in the percentage of pine tree sawdust contents, while the optimum moisture content increases. On the mixing the clayey soil with 0,5%, 1% and 1,5% pine tree sawdust, the maximum dry unit weight of mixtures decreased and the optimum moisture content increased. Similar results were reported by Okagbue (2007), Rao et al. (2012) and Shawl et al. (2017).

3.2 Effects of Pine Tree Sawdust on the Unconfined Compressive Strength

The effect of pine tree sawdust organic waste material on the unconfined compressive strength values of clayey soil was investigated by carrying out the unconfined compression tests under laboratory conditions. The tests were repeated for different contents of the pine tree sawdust and the changes in strength behaviors of stabilized clayey soil samples were examined. Also, the samples were cured for 1, 7, 28 and 90 days of curing periods. The results obtained from the experimental studies showed that the pine tree sawdust organic waste material improves the strength behavior of clayey soils and their unconfined compressive strength values increased with the addition of the pine tree sawdust organic waste additive (Figure 2).

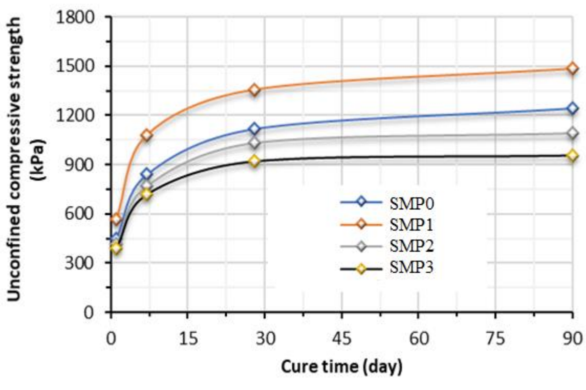

Figure 2. Change in the strength behavior of the samples with pine tree sawdust

At the same time, it was observed that the curing period played an important role on the strength behaviors of stabilized clayey soil samples with pine tree sawdust additive and the unconfined compressive strength values increased with the increasing curing period. Similar results were reported by Udoeyo and Dashibil (2002), Okagbue (2007), Okunade (2008), Mageswari and Vidivelli (2009) and Oyedepo et al. (2014). At the stabilization studies, it was observed that the maximum increase in the unconfined compressive strength was obtained with the 0.5% content of fine tree sawdust. Also, 90 days of curing period was the best time interval for the maximum unconfined compressive strength values of stabilized clayey soils.

4. CONCLUSIONS

In this study, the pine tree sawdust as an organic material was used as additive material to stabilize the clayey soils. The obtained results for different pine tree sawdust contents under different curing period were discussed. In all cases, the addition of pine tree sawdust to the clayey soils the maximum dry unit weight decreased and the optimum moisture content increased in the stabilized clayey soil samples. The unconfined compressive strength values of stabilized clayey soil samples with the pine tree sawdust increased due to the increase of the pine tree sawdust content. This increased strength contributed to the 0,5% the pine tree sawdust rate. As a result, the pine tree sawdust waste material can be used to improve the geotechnical properties of clayey soils in terms of strength behavior. In addition, the pine tree sawdust waste material can potentially reduce stabilization costs by utilizing wastes in a cost-effective manner.

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