USE OF SEWAGE SLUDGE ASH IN SOIL IMPROVEMENT

Süleyman Demir
Kilis 7 Aralık University
suleymandemir@kilis.edu.tr

Ali Fırat Cabalar
Gaziantep University
cabalar@gantep.edu.tr

ABSTRACT: The Sewage sludge ash (SSA) was added to the clay with the mixture ratio of 0% 10%, 20%, 30%. The SSA used in the research is a product generated during the combustion of sewage sludge in Gaziantep municipal wastewater treatment plant. The clay employed in the experimental studies was obtained from the Gaziantep University of Gaziantep campus. An intensive series of fall cone tests (FCT) were performed on the clay-SSA mixtures. The results indicated that the liquid limit estimates and undrained shear strength values of the mixtures were increased by the addition of SSA contents.

Keywords: Sewage sludge ash, fall cone, undrained shear strength.

INTRODUCTION

Sludge waste materials are one of the waste materials which many researches are available (Epstein, 1975; Moo and Zimmie,1996; Al-Sharif et al., 2000; Lo at al., 2002; Ona and Osario, 2006; Deng et al., 2007; Lin et al., 2007; Chen and Lin, 2009). Epstein (1975) mixed SSA with silty soil reviewed effect of SSA on the water retention, hydraulic conductivity, and aggregate stability in periodic time. The results indicated that additional of SSA increased the water retention, the hydraulic conductivity, and the stable aggregates. Some researchers claimed that some specification of sludges such as permeability similar to clays therefore sludges can be used for construction of barrier layers in landfill final covers (Moo and Zimmie, 1996; Lo et al., 2002). Moo and Zimmie (1996) found that Paper mill sludges have a high compressibility, and high Atterberg limits. Lin et al., (2007) use sludge/hydrated lime additive ratio in cohesive soil with 0%, 2%, 4%, 8%, 16%. The researchers rewiewed the pH values, atterberg limits, compaction tests, unconfined compressive strength tests, swelling potential, CBR, and shear values of mixing. The results indicated that sewage sludge/hydrated lime decreased the plasticity index but increased CBR values, triaxial shear strength, unconfined compression strength, and shear strength. Lin et al. (2005) mixed clay and sludge ash indicated that the SSA increased unconfined compressive strength, CBR value, shear strength cohesion and the sludge ash additive reduce swelling and internal friction of the soil. Chen and Lin (2009) carried out a similar research but mixed clay with sludge/cement ratio.

The result showed that CBR, unconfined compressive strength, triaxial compression and swelling properties of soil improved with the sludge/cement additions. Deng et al., 2007 found that dry unit weight, unconfined compressive strength, CBR values, cohesive parameter and shear strength increase with sludge ash added. Al-Sharif et al. (2000) used burned sludge ash as a soil stabilizing agent at 550 °C concluded that sludge could use as a soil stabilizing including dry density, unconfined compression test, swell pressure. In addition sludge could increase the resistance against erosion (Ona and Osorio, 2006).

As a result, SSA which is one of the waste products could improve geotechnical some geotechnical properties. Therefore, in this study, The SSA were added to the clay by dry weigth with the mixture ratio of 0%, 10%, 20%, 30%. Clay used in the study collected from the Gaziantep university campus, SSA collected from Gaziantep municipal wastewater treatment plant. In the study FCT were conducted and how the SSA change of geotechnical properties of clayey soils was investigated.

MATERIALS AND METHOD

The SSA used in the research is a by-product generated during the combustion of sewage sludge in Gaziantep municipal wastewater treatment plant. The scanning elektron microscope (SEM) picture of the SSA is shown in Figure 1.

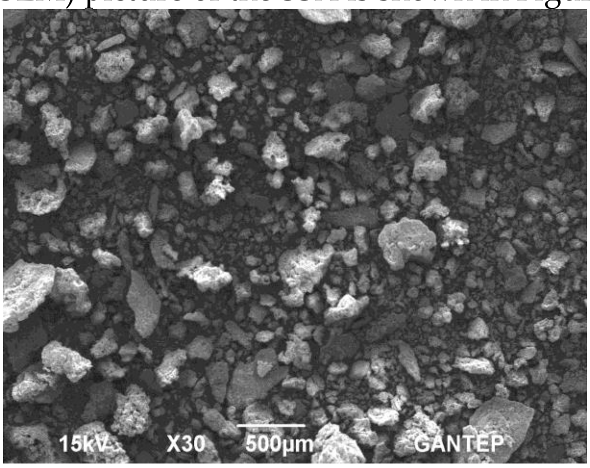

Fig 1. SEM picture for the SSA used the experimental study

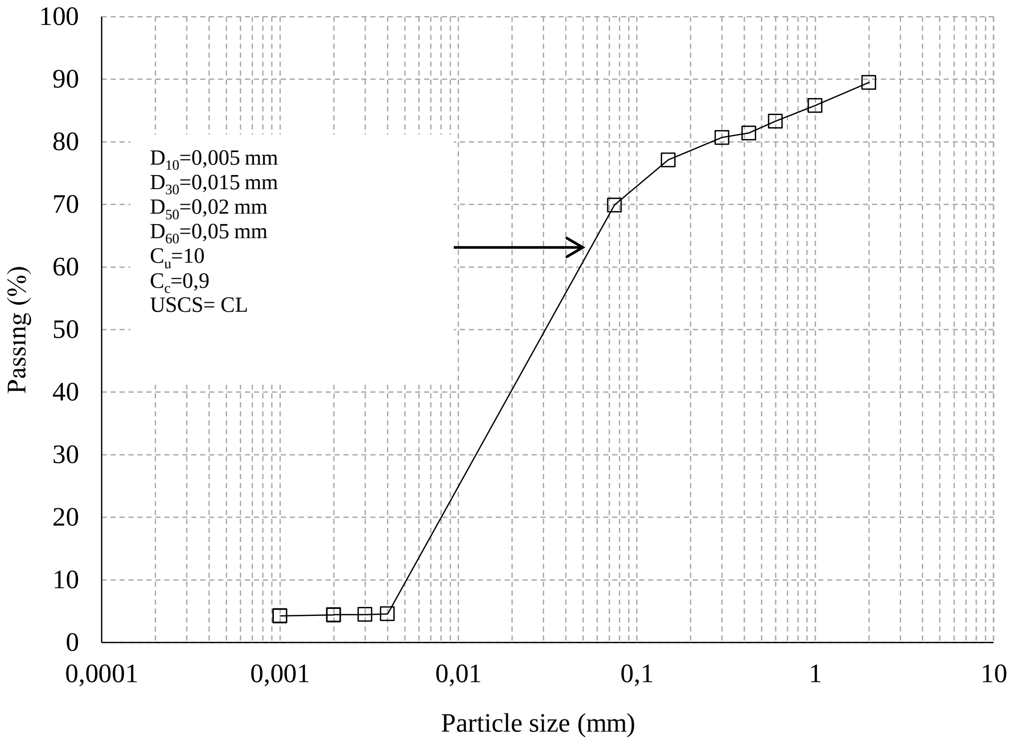

Fig 2. Particle size distributions for the clay used the experimental study

The clay samples used in this study were collected from Gaziantep university campus. The results of sieve analysis of clay are shown in Figure 2. The mixtures were waited in the oven for 24 hours at 105 °C before experimental study. The dry mixtures were prepared by calculated the desired SSA and clay in percent by dry weight and mixed in dry state until a homogeneous distribution was observed. FCT were carried out according to BS 1377 using a British fall cone apparatus having a 30° cone and weighing 0.785 N. It has been indicated that the fall cone testing is a strength measuring device and Hansbo (1957) suggested that undrained shear strength (s_u) can be found by using Equations 1.

$$s_u = k\frac{mg}{d^2} \qquad (1)$$

where, m is the mass of cone, g is the gravitational acceleration, k is a constant, which changes based on the angle of the cone and it is found to be 0.85 for the 30° British cone (Wood, 1985), d is a penetration of cone into soil.

RESULTS AND FINDINGS

Variations of FCT penetration and the water content for each of the mixtures are shown in Fig. 3. As can be seen from Fig. 3, there is an approximately linear relationship between the cone penetration and the water content. As the water content increase the cone penetration values are increase for each mixture. In addition, at a given water content as the SSA content increases, the penetration of mixtures decreased which means SSA increased the resistance of penetration. From

FCT results liquid limit values generally obtained by water content corresponding 20 mm cone penetration (Cabalar and Mustafa, 2015). The liquid limit results are shown in Fig. 4. With the increase of the SSA liquid limit values were increased. While the liquid limit of clay was 30, with the addition of 20% and 30% SSA, the estimated value of liquid limit increased at a rate of 33.33% and 46.66% respectively. s_u values from FCT were found from equation 1 and are showed a relation with water content (Fig.5. As can be seen from Fig.4 as increase water content for each mixing the s_u values are decrease. s_u values increase with the increase of SSA value at same water content. The 10% and 20% SSA content with the following values of 40% water content, s_u values of 10% SSA content was 0.3 kPa while s_u with 20% SSA was 0,8 kPa which mean increased at the rate of 166%. This behaviour could attiributed to increase suction stress with the SSA addition as Veeresh et al., 2003 and Epstein, 1975 concluded. Suction stress could increase penetration resistance and undrained shear strength (Likos and Jaafar, 2014). Similar results were found by Lin et al. (2005) who indicated that SSA increased triaxial shear strength.

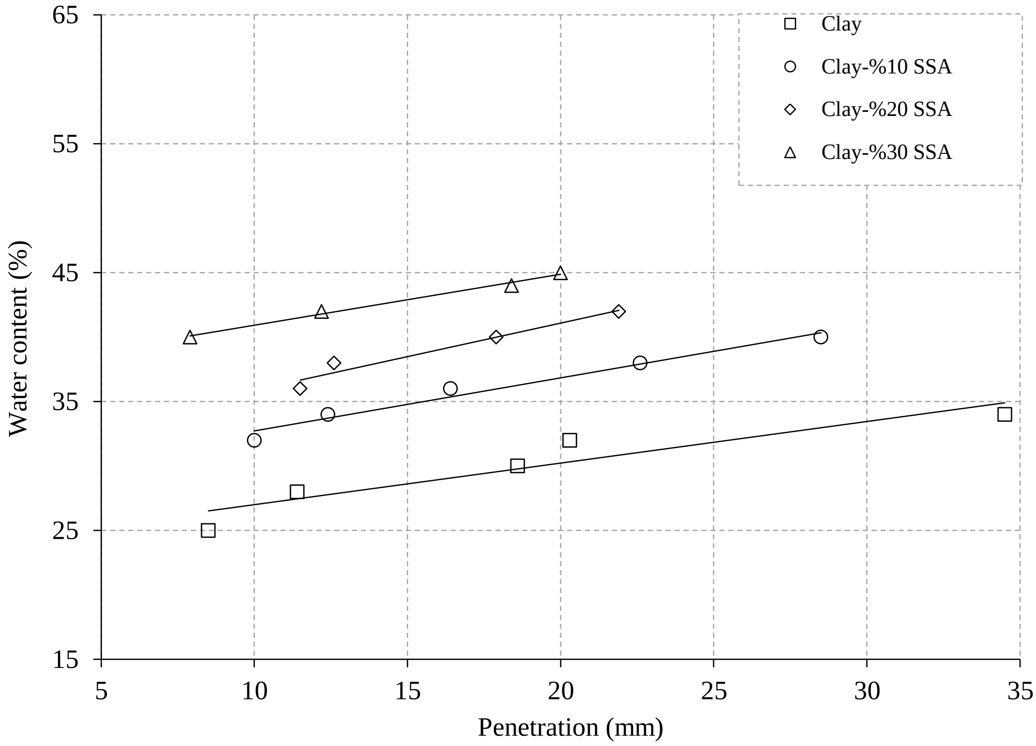

Fig 3. Variation of cone penetration with water content for clay with various SSA content

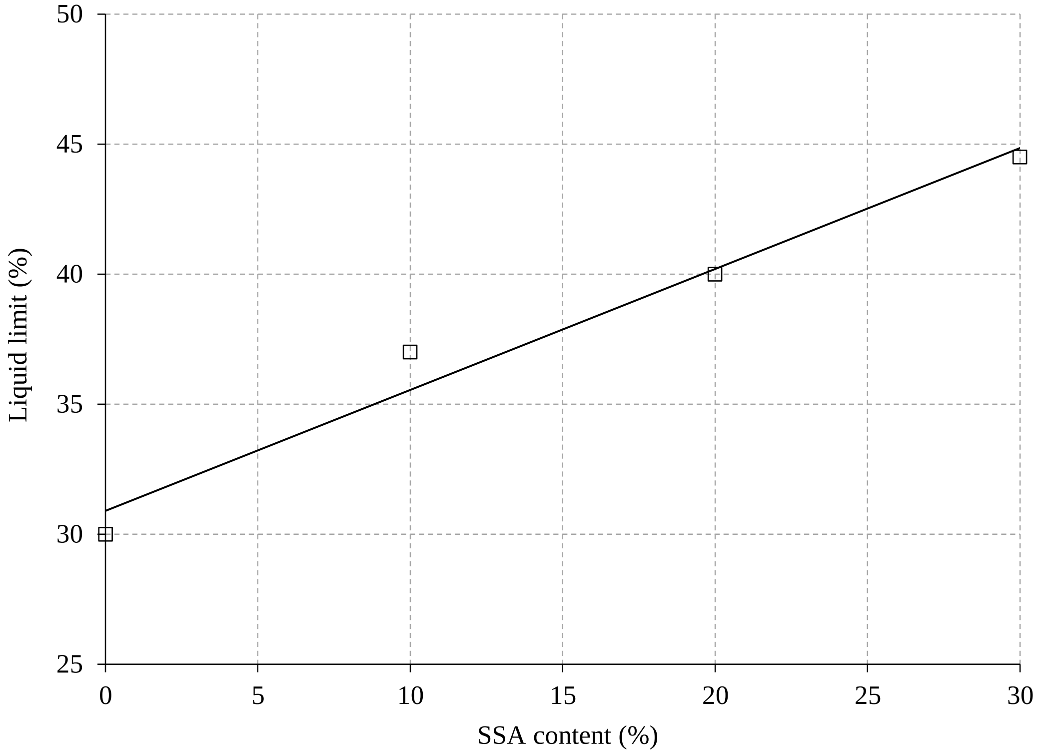

Fig 4. Liquid limit of clay with various SSA content

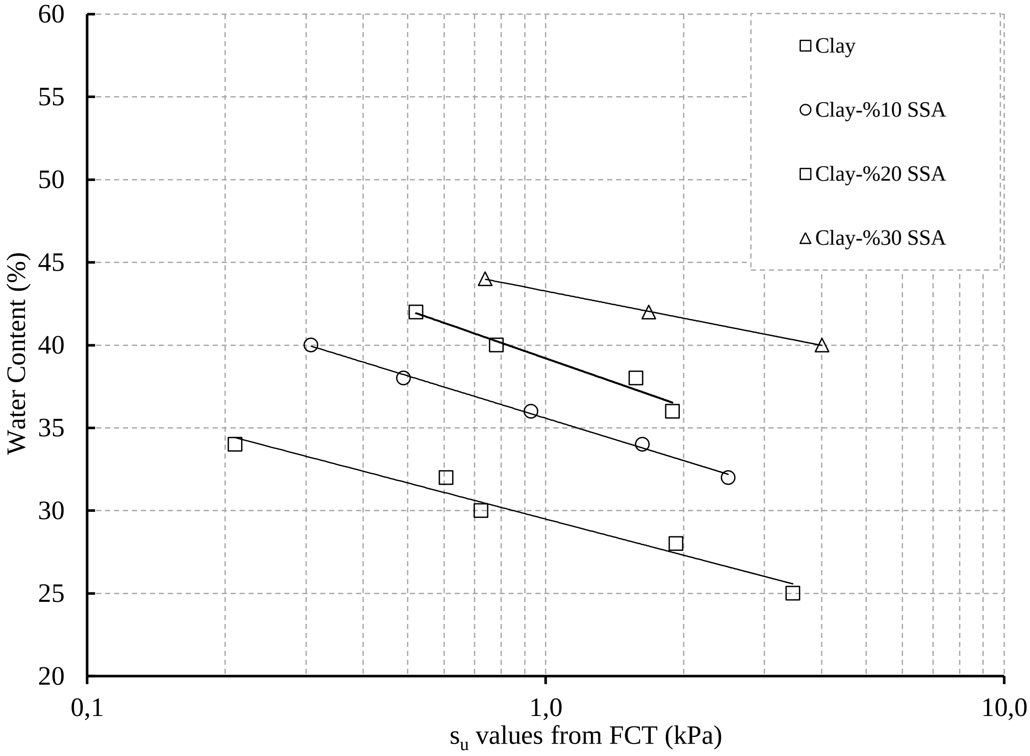

Fig 5. Relationship between undrained shear strength and water content for the clay with various SSA content

CONCLUSIONS

The presence of SSA affected liquid limit and undrained shear strength characteristics of the clayey soil. SSA significantly increased the values of liquid limit of clay soils. Falcone penetration and undrained shear strength values with water content showed a linear behavior in all mixtures. The s_u values were observed an increase with the SSA content.

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