Iranian Journal of Engineering Geology
Winter 2023, Vol.15, No.4

Effects of saw dust ash on geotechnical properties of clayey soil

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Abstract

Clay is a type of problematic soil that causees swelling, settlement, and significant deformation due to the absorption of water and moisture. To prevent environmental pollution and stabilize the problematic soils, the use of waste materials as additives is recently under consideration, and sawdust ash is one of them. In the present study, the possibility of improving the properties of clay soil using sawdust ash has been investigated. For this purpose, portions of sawdust ash including 3, 6, and 9 percentages were mixed with clay soil and then cured for 1, 7, and 14 days. To evaluate the geotechnical behavior of stabilized soil, Atterberg limits, standard compaction test, uniaxial compressive strength, direct shear, California bearing ratio (CBR) and consolidation tests have been performed. The results of the present study show that the optimum amount of sawdust ash is equal to 3% during the curing time of 14 days. The geotecnical properties of selected clay soil was improved by increasing plasticity index up to 49%, reducing the compression index by 40% and increasing the maximum dry density up to 14%, increasing the uniaxial compressive strength up to 65% and the shear strength at the moment failure is on average 53.6% compared to untreated soil samples.

Keywords: *Clay, Saw dust ash, Shear strength, Swelling, Consolidation.*

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Extended Abstract:

1. Introduction

The application and mixing of waste materials from factories and different industries in soil for improving geotechnical properties is one of the new interesting methods in civil engineering. Types of ashes are available. Fly ash is one of them, which is an important by-product of coal-fired power plants or from heating the wastes of some factories which has good pozzolanic properties and can be used in concrete and in geotechnical projects for soil stabilization. As, Bayat and Bahreynian (2020) studied the simultaneous effect of fly ash and lime on the geotechnical characteristics of sandy soil. Results showed that the mixing of fly ash up to 20% in sandy soil without lime causes a greater increase in the maximum dry unit weight and this value is reduced to 10% with the presence of 10% lime. Sawdust ash is another pozzolanic material, which is mostly used in improvement of fine-grained soil. In this regard more studies have been performed. As, Kale et al. (2019) studied effects of sawdust ash and lime mixtures on problematic soils. The outcomes showed that 1 to 5 % of ash and lime compound can cause an increasing in maximum dry unit weight and reducing in optimum water content. Quadri et al. (2020), observed Calcium carbide waste with calcined clay can be effective in improvement bearing capacity materials of pavement layers. By reviewing the conducted researches, it can be seen that type of saw dust ash that is prepared from Populus Nigra (Tabrizi) tree with different percentages is mixed with clay and the effect of curing time on its geotechnical properties is less considered. Also, the method of sawdust ash producing from the oven at a temperature of 700 degrees Celsius is one of the innovations of the present study.

2. Materials and Methods

In present study, problematic soil was prepared from Marzdaran area in Tabriz city. According to unified method type of soil was clay (CL) determined. Plasticity index (PI=16%) based on ASTM D4318-95a and specific gravity (Gs=2.62) with using ASTM D854 evaluated. In continue to provide saw dust ash in first Tabrizi sawdust was obtained from sawmill. Then, sawdust is dried at 100 degrees Centigrade. In second step, the sawdust prepared in the oven burned under vacuum conditions at a temperature of 700 degrees Centigrade and sawdust ash was produced. Then, saw dust ash was passed through sieve No. 200 and mixed with the clay at the rate of 3, 6 and 9 percent by weight. In order to sampling, the clay and sawdust ash in optimum water content were mixed and were maintained in closed plastic containers at an ambient temperature of 21 degrees Centigrade. Specimens curing was performed 1, 7 and 14 days. For evaluating saw dust ash effects of geotechnical properties of mixed soil a number of tests such as compaction based on ASTM D698, Uniaxial compressive strength according to ASTM D2166, direct shear with using ASTM D3080-11 under the vertical stresses of 100, 200 and 300 kPa. The speed loading equal to 1.25 mm/min was considered. In continue consolidation and California bearing ratio (CBR) test were performed based on ASTM D2435 and ASTM-D1883 respectively.

3. Results

The obtained results show that the optimum value of sawdust ash to improve the geotechnical properties of the studied clay is equal to 3% in the curing time of 14 days. Its reasons can be mentioned as follows:

1- The same amount of sawdust ash increased γ_{dmax} by 14% and the optimum water content decreased by 46%.

2- 3% of sawdust ash mixed in clay increases the uniaxial compressive strength by 64% compared to the improved condition after 14 days of processing.

3- The internal friction angle (φ^{o}) in improved soil samples with 3% of saw dust increased by 32% and in the same condition, the amount of cohesion in stabilized clay by 2.25 times.

4- According to the results obtained from the CBR test in the dry state, when 3% of sawdust ash is added to the clayery soil, in all the curing times, based on Code No.234, all of the improved specimens are suitable for making subgrade layer in pavement design.

4. Conclusion

It can be expalined that behavior of improved clayey soil is affected by the saw dust ash particles size distribution, minimum void ratio (e_{min}) and the chemical reaction between clay and saw dust ash particles during the curing time. Although, it should be mentioned that sawdust ash particles passed through the 200 sieve can have more contact with clay particles. Also, due to the presence of high calcium oxide in sawdust ash, when combined with air carbon dioxide, it produces calcium carbonate, which gives pozzolanic properties to sawdust ash particles, which can create a suitable chemical reaction. After mixing 3% of sawdust ash and curing for 14 days, it shows the conditions mentioned above. So that this value of saw dust ash in clayey soil reduced the minimum void ratio by 26% and this state indicates that the chemical reaction happened, causing the creation of a new skeleton structure with less minimum void ratio which is a combination of larger dimensions graines, cement materials. The result of which is the reduction of the Plasticity index (PI), increase of the modulus of elasticity, high axial strain in the failure stage, reduction of the consolidation settlement and increase bearing capacity. Therefore, in general, sawdust ash can be used as an alternative material that is compatible with the environment instead of lime and cement.

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