Sigma J Eng & Nat Sci 34 (1), 2016, 31-41

Sigma Journal Engineering and Natural Sciences
Sigma Mühendislik ve Fen Bilimleri Dergisi

Research Article / Araştırma Makalesi

EFFECT OF SAWDUST USAGE ON THE SHEAR STRENGTH BEHAVIOR OF CLAYEY SILT SOIL

Omar Hamdi JASIM, Doğan ÇETİN*

Yıldız Technical University, Department of civil Engineering, Esenler-ISTANBUL

Received/Geliş: 15.12.2015 Accepted/Kabul: 19.02.2016

ABSTRACT

The aim of this paper is to study the effect of sawdust content on the engineering properties of clayey-silt soil. Soil from the district of Büyükçekmece in Istanbul city have been used. Its engineering properties were indicated. The dry soil passing sieves No.40 were mixed with the sawdust, with the amount 1, 2, 3 and 5 % from dry weight of soil, then, samples engineering properties were indicated. The study concluded that the addition of sawdust up to 5% decreased the liquid limits and the plasticity index by 14.9% and 17.6% respectively, and also decreased the plastic limits by 13.15%. Effect of sawdust usage on undrained shear strength of the soil were investigated by unconfined compression test and UU triaxial test. The undrained strength were increased by 41.437% with increasing 3 % but, the undrained strength decreased with 5% of sawdust. Also the results obtained from unconfined compression test and UU triaxial test were compared and looked at compatibility of the results.
Keywords: Undrained Shear Strength, sawdust, triaxial test, unconfined compression test.

TALAŞ KULLANIMININ KİLLİ SİLT ZEMİNİN KAYMA MUKAVEMETİ DAVRANIŞI ÜZERİNE ETKİSİ

ÖZ

Bu çalışma ile killi bir silt zeminin mühendislik özelliklerinin iyileştirilmesi amaçlanmıştır. Büyükçekmece İlçesinden elde edilen Zemin çalışmada kullanılmıştır. Zeminin ilk durumdaki mühendislik özellikleri laboratuar deneyleri ile belirlenmiştir. 40 nolu elekten elenmiş kuru zemin %1, 2, 3 ve 5 oranlarında talaş ile karıştırılarak kompaksiyon deneyi yapılmış ve talaş katkısının zeminin mühendislik özelliklerine olan etkileri deneysel olarak araştırılmıştır. Bu çalışma sonucunda % 5 talaş katkısı ile likit limit, plastic limit ve plastisite indisinde sırasıyla %14.9, % 13.15 ve % 17.6 oranlarında düşüşler görülmüştür. Ancak bu düşüşlerin zeminin sınıfına bir etkisinin olmadığı belirlenmiştir. % 1 ile % 5 arasında değişen oranlarda talaş katkısnın zeminin drenajsız kayma dayanımı üzerine etkileri Serbest basınç deneyi ve üç eskenli basınç deneyi ile araştırılmıştır. Deneyler sonucunda %3 oranında karıştırılan talaş katkısının zeminin drenajsız kayma dayanımını %41.4 oranında arttırdığı ancak % 5 oranında ise drenajsız kayma dayanımı değerinin artış trendinin sona erdiği belirlenmiştir. Ayrıca serbest basınç deneyi ile elde edilen sonuçlar ile UU üç eksenli basınç deneyi ile elde edilen karşılaştırılmış ve sonuçlar arasındaki uyum incelenmiştir.
Anahtar Sözcükler: Drenajsız kayma dayanımı, talaş, üç eksenli basınç deneyi, serbest basınç deneyi.

* Corresponding Author/Sorumlu Yazar: e-mail/e-ileti: dogancetin56@hotmail.com, tel: (212) 383 52 33

1. INTRODUCTION

One of the most common problems in civil engineering projects is the weakness of soils, usually soil improvement can be done by remove the weak soil and replace with a stronger material. The high replacement cost spurred researchers to find alternative ways and solutions of soil improvement. Soil stabilization is a technique introduced many years ago with the main purpose to provide soils capable of meeting the requirements of the engineering projects Kolias et al. [1] .The geotechnical engineering field is witnessing an increasing interest in exploring soil improvement that are based on the addition of stabilizing agents such as synthetic or natural fibers and/or cementing agents for various applications Sadek et al. [2]. The experimental data that is available in the literature for sawdust reinforced for the fine soils is relatively limited, Sawdust by itself has a little cementitious value but, in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils Koteswara Rao.D et al. [3], they also found out the liquid limit of the marine clay decreased by 15.43% on addition of 15% Sawdust , the plastic limit increased by 11.50, the OMC of the marine clay has been decreased by 15.37% on addition of 15% Sawdust. Abdel-Nafii [4] claims that the crushed dry leaves of trees and passed on sieves No.40 were mixed with the soil, with the amount (5, 10, and 15) % from dry weight of soil, its decrease the plasticity (more than 35%). He also observed that high organic matters cause decrease in shear strength (more than 50% decreasing in cohesion at 15% organic content) and considerably increase in the optimum moisture content 25% with decrease of the dry unit weight. There is also a chance to study the behavior for sawdust after burning it and use it as ash, Khan and Khan [5], studied sawdust ash and they found the dry density of the soil was increased by 7.8%, further, there was 22.14% increase of friction angle with addition of 12% sawdust ash and shear strength parameters were improved significantly. Also a study to stabilize the soil which has a high organic materials with lime were done by Thomas et al. [6] .They found that it is possible to improve the bearing properties of the soil and they also reduced the swelling which might happen due to the high moisture content of the organic materials. Geotechnical properties of South-western Nigerian Soil was again tested by Ogunribido [7] who has proved that sawdust ash is an effective soil stabilizer for lateritic soil and road quality can be enhanced by its addition into soils. He further showed that shear strength could be increased from 50.92 to 71.07 kN/m^2 and unconfined compressive strength from 101.4 to 142.14KN/m2 hence overcoming the problem of road failure in Nigeria.

Duraisamy et al. [8, 9] studied the ability of constructing a residential houses above soils has high percent of peat in Malaysia, and he found it is possible with two methods: the first method is the pre-loading and it takes a lot of time. The second method is the vertical sand drains with an applied load on the soil. In the sixth conference of Soil Mechanics held in Singapore. Shih et al. [10] has reviewed the problems of the engineering projects on the organic soils. In the same conference Aziz et al. [11] also suggested the process of application of heavy tamping process to treat the soils which has peat by mechanical compaction which could be done by dropping a very heavy mass from a high height.

2. MATERIALS AND METHODS

2.1. Soil

The clayey silt soil used in this research has been brought from Büyükçekmece in Istanbul city within the coordinates 41.069987N, 28.604636E as shown in Fig.1.

Figure 1. The location of the soil

Normal consolidate, and stiff soil at a depth of 8 m below the existing ground level which consider foundation's level of the project conducted in the area. To determine the basic soil properties, Atterberg limit tests, sieve analysis, hydrometer analysis, pycnometer test were conducted on soil sample. Based on the result obtained the basic soil tests, soil was classified according to the Unified Soil Classification System as high plasticity silt (MH). Soil properties were given in Table 1. The grain size distribution curve of the soil can be seen in Fig. 2.

Table 1. Soil properties

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Specific Gravity, GS	Sand Content (%)	Silt Content (%)	Clay Content (%)	Classification According to Unified Soil Classification System
73	43	30	2.65	0	75	25	MH

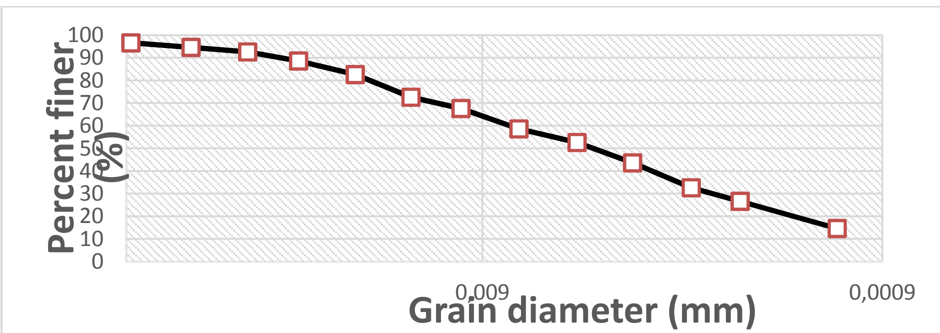

Figure 2. Grain size distribution of the clayey silt soil

2.2. Sawdust

Used sawdust in this study was obtained from carpenter's facility of Yildiz Technical University in Esenler District of Istanbul. According to the Pycnometer test conducted on the sawdust, the specific gravity of sawdust was found as 1.31. It also has 11.22% water content at the mixing time. The grain size distribution of the sawdust was given in Fig.3 and Fig. 4 shows a picture of the used sawdust.

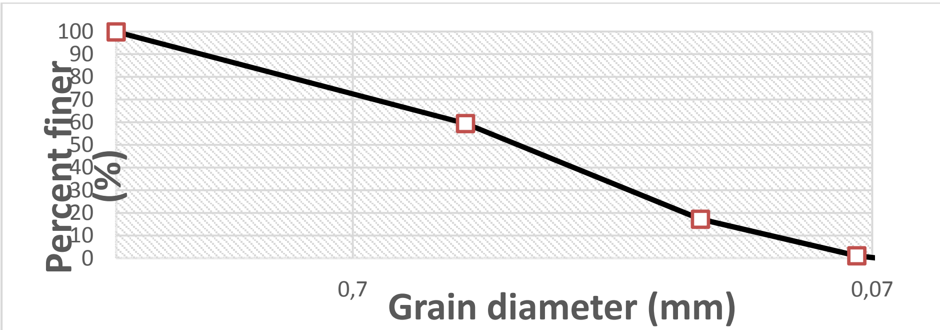

Figure 3. The grain size distribution of the sawdust

Figure 4. A photo of used sawdust.

2.3. Compaction Tests

The method given in the BS 1377: Part 4:1990: 3.3 using the standard compaction test was applied to determine the maximum dry density and the optimum moisture content of the soil. The soil mixtures, with and without additives, were thoroughly mixed. The first series of compaction tests were aimed to determine the compaction properties of the untreated soils. Secondly, tests were carried out to determine the proctor compaction properties of the treated soils with varying amounts of sawdust. It is worth to mention that in our research we have used the soil which passes on sieve No. 40 for all of the tests.

2.4. Soil–Sawdust Mixture Preparation

The soil passing through sieve No.40 was kept for oven drying at 105°C then it was mixed with the sawdust with different percentages (1, 2, 3 and 5) % respectively from the dry weight of the soil. The sawdust was mixed with the soil according to optimum water content for each single mentioned percent. All mixing were done manually, and proper care was taken to prepare homogeneous mixtures at each stage of mixing.

2.5. Preparation of Test Samples

In order to find the effect of sawdust on a clayey silt soil, it is necessary to fix some of the variables of the row soil to use it as a controlling data, four percentages of sawdust were used, the soil and sawdust were compacted according to the corresponding optimum moisture content. Each prepared soil sample is mixed thoroughly with the required amount of water, and then compacted. Samples extruded by a hydraulic jack from mold compacted using standard proctor compaction test. Specimens are obtained by exerting a Shelby tube (40mm) in diameter, of cleaned and oiled walls to the samples, the samples length is (100mm).the UCS and UU triaxial tests were done on the specimens under load with a constant rate of strain, the test stopped when strain is continuing to increase while no further stress increase occurred, or when the strain reached 20%.

2.6. Atterberg Limits Tests

Liquid Limit tests were conducted according to BS 1377: part 2:1990:4.5 and ASTM D 4318 11, 12 using Casagrande device and tools Head, 1994 [12]. Plastic Limit tests were conducted according to the BS 1377: part2:1990:5.3 and ASTM D 4318, 15.

2.7. Specific Gravity Tests

The specific gravity of soils was determined in accordance to the BS 1377: part2: 1990: 8.3 using the density bottle of 50 ml capacity.

2.8. Shear Tests

2.8.1. Unconfined Compressive Strength Tests

Unconfined Compressive strength tests on compacted specimens were conducted according to the ASTM D2166.

2.8.2. Unconsolidated Undrained Triaxial Tests

Triaxial compression tests according to ASTM D2850 were conducted on treated and untreated samples. The Unconsolidated Undrained (UU) tests performed in the triaxial compression apparatus were conducted with confining pressures of 160 and 320 kPa.

3. RESULTS AND DISCUSSION

3.1. Atterberg Limits Tests

The liquid and plastic limits tests mixtures were carried out with different percentages of soil–sawdust. The effects of sawdust content on liquid limit, plastic limit and plasticity index for the sawdust- soil samples are plotted in Fig. 5, and Table 2 respectively.

Table 2. The variation of consistency limits with the sawdust content.

Soil type	Row soil	1% sawdust	2% sawdust	3% sawdust	5% sawdust
L.L	73	71.5	70	66	63.5
P.L	43	42	40.7	39	38
P.I	30	29.5	29.3	27	25.5

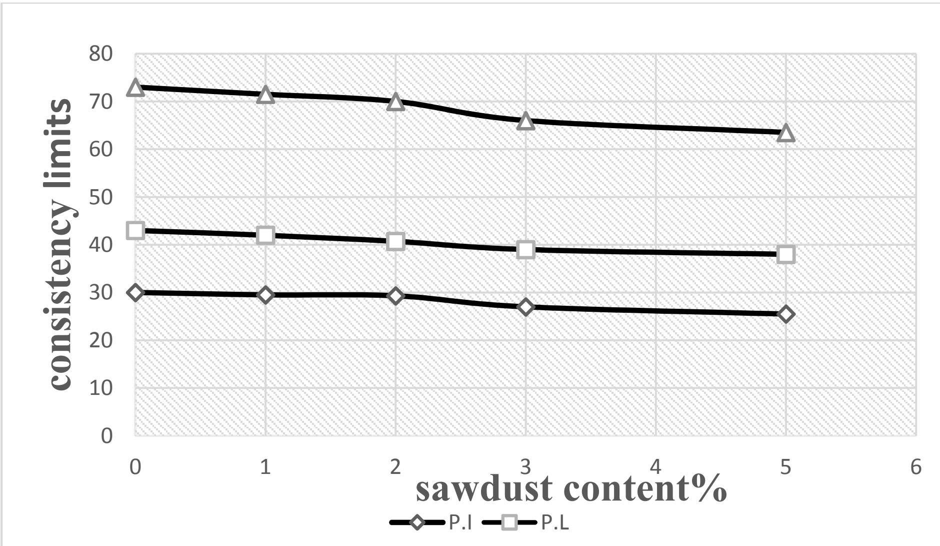

Figure 5. Effect of sawdust content on consistency limits.

The liquid limit and plasticity index values decreased with increasing sawdust content up to 5%. These results are reasonable because of the gradual decrease of the fine materials in the soil. Because the sawdust as a substitute for fine materials in the soil. However, the plastic limit decreased with increasing sawdust content up to 5% for the same mentioned reason.

3.2. Compaction Parameters

The compaction curves were plotted in Fig.6 and the values of optimum water content and maximum dry unit weights were given in Table 3 were determined.

Table 3. The compaction parameters

Soil type	Row soil	1% sawdust	2% sawdust	3% sawdust	5% sawdust
Optimum Moisture content %	40	37.905	37.848	37.375	36.12
Maximum Dry Unit Weight kN/m^3	12.350	12.184	12.047	11.772	11.412

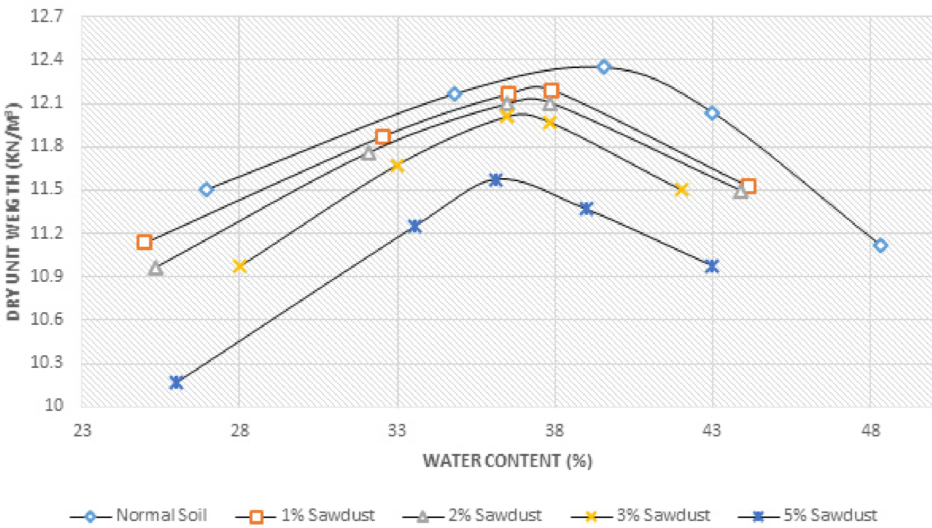

Figure 6. Effect of sawdust content on compaction parameters.

The addition of sawdust affected the compaction parameters of soil-sawdust mixtures. It was observed that the maximum dry unit weight and optimum water content decreased with the addition of sawdust and the reason of that can be understood by knowing the principles of the compaction test, the addition of water to the mixture, sawdust works as a filler for gaps and voids between soil particles. Thus, the soil added sawdust can reach to the maximum unit weight with less amount of water and on the other hand the added sawdust has less moisture content than the natural soil, so it absorbs water from the soil and reduces the optimum moisture content.

3.3. Shear Strength

Two series of shear strength tests were carried out using different percentage of sawdust to determine the shear strength parameters.

3.3.1. Unconfined Compressive Strength

The effects of sawdust on the unconfined compressive strength for stabilized soil samples was shown in Fig. 7.

The cohesion strength due to unconfined compressive test of stabilized samples was increased by 41.437% with increasing sawdust content from 0% to 3%. However, then the strength was decreased by adding 5% of the sawdust. The maximum unconfined compressive strength of clayey soil samples was occurred at 3% sawdust content. This is attributed to soil sawdust reaction, which results in the formation of interaction, the sawdust works as filler and it fill the voids between soil particles.

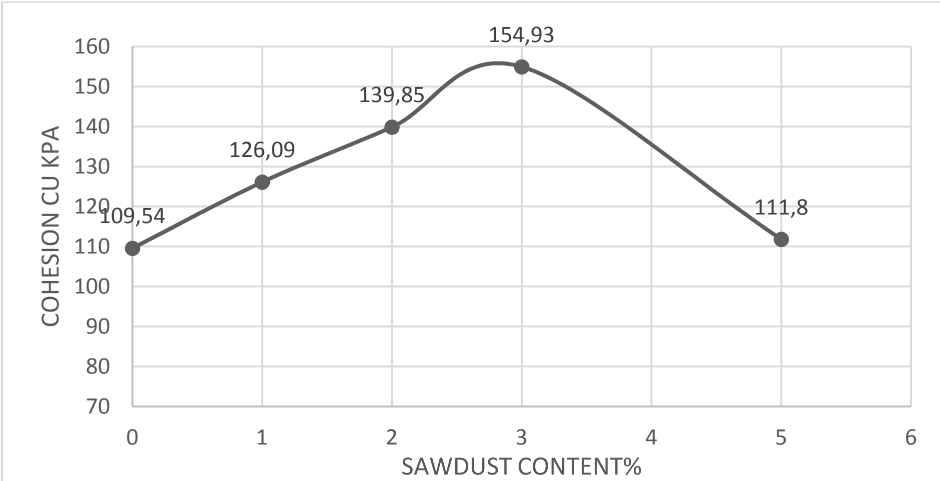

Figure 7. Effect of Sawdust Content on the Cohesion of the soil in the Unconfined Compression test

3.3.2. Unconsolidated Undrained Triaxial Tests

The effects of sawdust on the stress–strain relationships of the soils at the confining pressures of 160 and 320 kPa are studied. Fig. 8 shows relationship between the cohesion of the soil (c_u) with different percentage of sawdust.

Figure 8. Effect of Sawdust on the Cohesion of the soil in the Unconsolidated Undrained Triaxial Test.

Brittle failure was observed in the shear failure mode for specimens stabilized with sawdust. Moreover, for the confining pressure 160 kPa, the addition of a 1% has a marginal increasing effect on shear strength, 2% sawdust content showed an increase in the strength, while increasing the sawdust content up to 5% caused decrease in the strength. A similar behavior was observed for confining pressures of 320 kPa. Clearly, sawdust works as bonding materials tries to bond between soil particles. 3% is the optimum value for an increase of 39.535% in the cohesion of the soil. The total relationship between C_u obtained from unconsolidated undrained triaxial test and C_u obtained from unconfined compression test is available in Fig.9.

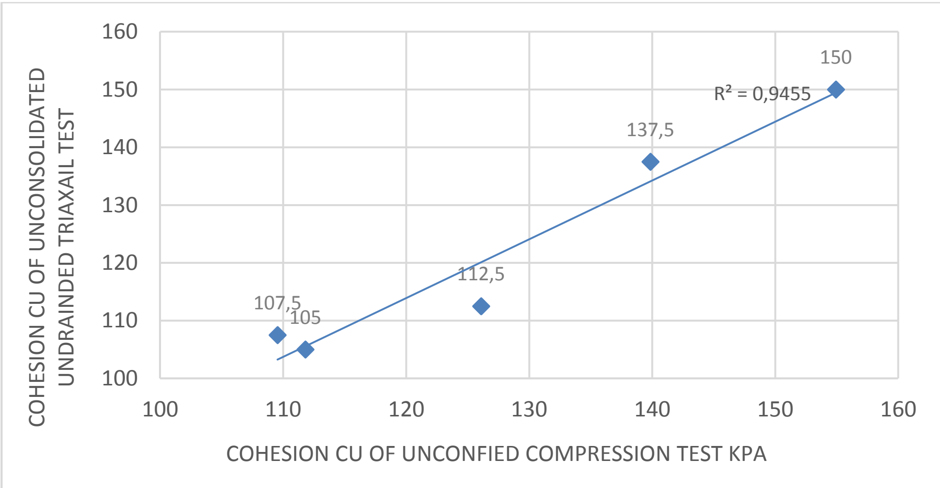

Figure 9. The relationship between c_u from UU-triaxial test and c_u from unconfined compression test.

As can be seen in Fig.9, there is strong relationship between the Cu obtained from UU-Triaxial test and Cu obtained from unconfined compression test, which means that there is no big difference in the Cu values obtained from the unconsolidated undrained triaxial and unconfined compression tests.

5. CONCLUSIONS

Triaxial and unconfined compressions are very important devices used to determine the shear strength properties of soils, shear strength is an important aspect, It uses to design foundations, retaining walls and other geotechnical substructures. The main aim of this paper is to study the effect of sawdust on the shear strength, consistency limits and compaction parameters of a clayey silt soil mixed with sawdust and also the outcome of this paper should allow the researchers to understand the behavior between the unconfined compression test and the unconsolidated undrained triaxial test for the mentioned soil. The following can be concluded from this research,

- Added sawdust up to 5% decreased the liquid limits and the plasticity index by 14.96%, and 17.65% respectively, and also decreased the plastic limits by 13.16%. But it did not have any effect on the classification of the soil.
- Added sawdust up to 5% decreased the maximum unit weight of the soil by 8.22% and also it decreased the optimum water content by 10.74%

- Added sawdust to the soil increased the unconfined compressive strength by 41.436% with increasing sawdust content from 0% to 3%, and then the unconfined compressive strength decreased with 5% of sawdust.
- Added sawdust increased the unconsolidated undrained shear strength by 39.535% with increasing sawdust content from 0% to 3%, and then the unconsolidated undrained shear strength decreased with 5% of sawdust.
- 3% sawdust was the optimum value to increase the shear strength of a clayey silt soil with high liquid limit and plastic limit.
- As clearly can be seen in Fig.9, there is a linear relationship between unconsolidated undrained shear strength and the unconfined compressive strength. The reason behind the little difference between the values of unconsolidated undrained shear strength and the unconfined compressive strength is that the confining pressure.
- Sawdust works as a very good filler material to fill the voids between particles of a clayey silt soil passes on sieve No. 40.

Acknowledgments / Teşekkür

I would like to thank H. Berrak TASLAK, lab technician of Geotechnical Subdivision Department of Yildiz Technical University, for her valuable help during the period of tests.

REFERENCES / KAYNAKLAR

[1] Kolias S., Kasselouri-Rigopoulou V., and Karahalios A., “Stabilization of Clayey Soils with High Calcium Fly Ash and Cement”, Cement and Concrete Composites, 27: 301–313, 2005.

[2] Sadek S., Najjar S., Abboud A., “Compressive Strength of Fiber-Reinforced Lightly-Cement Stabilized Sand”, Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering, Paris, 2013.

[3] Koteswara R. D, Anusha M., Pranav P.R.T., Venkatesh G, “A Laboratory Study on the Stabilization of Marine Clay using Sawdust and Lime”, International Journal of Engineering Science and Advanced, 2(4): 851 – 862, 2012.

[4] Abdel-Nafii, “The Effect of Organic Matter’s Content on the Engineering Properties of Expansive Soils, Engineering and Technology Journal”, 28(8), 2010.

[5] Khan S., Khan H., “Improvement of Mechanical Properties by Waste Sawdust Ash Addition into Soil”, Electronic Journal of Geotechnical Engineering, 20(7): 1901-1914, 2015.

[6] Thomas M., Petry P.E., and Eric J. G., “A study to determine the Effect of Organic on the Results of Quicklime Slurries Treatment of Clay Soil”, University Transportation Center Program at the University of Missouri-Rolla, UTC R76, 2003.

[7] Ogunribido T., “Geotechnical Properties of Saw Dust Ash Stabilized Southwestern Nigeria Lateritic Soils, Environmental Research Engineering and Management”, 2(60): 29-33, 2012.

[8] Duraisamy Y., Huat B. B.K and Aziz A.A, “Compressibility Behavior of tropical Peat Reinforced with Cement Columns”, American Journal of Applied Sciences, 4(10): 786-791, 2007.

[9] Duraisamy Y., Huat B. B. K and Aziz A.A., “Methods of Utilized Tropical Peat Land for Housing Scheme, American Journal of Environmental Sciences”, 3(4): 259-264, 2007.

[10] Shih S. F., “Some Physical Characteristics of Organic Soil Related to Engineering Design”, The Sixth Southeast Asian Conference on Soil Engineering, pp. 01-112, 19-23 May 1980.

[11] Aziz M.A., Daulah I., and Lee S.L., "Treatment of Peaty Soil", The Sixth South east Asian Conference on Soil Engineering, pp. 431-446, 19-23 May 1980.
[12] Head, K.H., "Manual of Soil Laboratory Testing", Pentech Press, London, Vol. 1, 2 and 3., 1994.