# THE EFFECT OF SAWDUST ON SHEAR STRENGTH PROPERTIES OF PEAT SOIL

NUR SYAZANA BINTI NORRUDDIN

A Final Year Project report submitted in partial fulfillments of the requirements
for the award of the Degree of
Bachelor of Civil Engineering

Faculty of Civil Engineering & Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

## ABSTRACT

Peat soil is an extremely formed of soft soil that always considered problematic by the numerous engineers. In the construction field, peat soil is not being the engineer's choice due to its properties that is low in shear strength and high compressibility. This weakness gives difficulties to engineer to develop infrastructures and facilities due to the limited lands in Malaysia. An appropriate soil improvement is needed. Stabilizing the peat soil is the most effective way to overcome the drawback of this issue. This paper presents a study on the effect of sawdust on shear strength properties of peat soil that has been conducted for sampling area at Kampung Tanah Puteh in area of Pekan, Pahang. A total of 15 samples of peat soil with various mixes proportion of sawdust varies from 0%, 1.0%, 1.5%, 2.0% and 2.5% were analyzed by laboratory testing that subjected to normal stress of 136.2kPa, 272.5kPa and 408.8kPa at each of the proportion. The direct shear test was performed to determine the parameters of shear strength which are cohesion and angle of shear resistance and determination of the optimum mix of sawdust with peat soil which gives the maximum shear strength. The study revealed that by adding sawdust at exact value can give the maximum value of shear strength. The shear strength parameter which is cohesion is inversely proportional to the angle of shear resistance. The optimum mix for peat soil was at 1.0% of sawdust.

# ABSTRAK

Tanah gambut sangat membentuk tanah lembut yang sentiasa dianggap bermasalah oleh banyak jurutera. Dalam bidang pembinaan, tanah gambut tidak menjadi pilihan jurutera kerana sifatnya yang rendah kekuatan ricih dan kebolehmampatan yang tinggi. Kelemahan ini memberikan kesukaran untuk jurutera untuk membangunkan infrastruktur dan kemudahan tersebut disebabkan tanah yang terhad di Malaysia. Pembaikan tanah yang bersesuaian kini diperlukan. Menstabilkan tanah gambut adalah cara yang paling berkesan untuk mengatasi kelemahan isu ini. Laporan ini membentangkan kajian mengenai kesan habuk pada sifat-sifat kekuatan ricih tanah gambut yang telah dijalankan bagi kawasan persampelan di Kampung Tanah Puteh di kawasan Pekan, Pahang. Sebanyak 15 sampel tanah gambut dengan pelbagai campuran nisbah habuk kayu berbeza dari 0%, 1.0%, 1.5%, 2.0% dan 2.5% dianalisis dengan ujian makmal yang tertakluk kepada tekanan biasa 136.2kPa, 272.5kPa dan 408.8kPa di setiap campuran bahagian reka bentuk. Ujian ricih terus telah dijalankan untuk menentukan parameter kekuatan ricih iaitu kejelekitan dan sudut rintangan ricih dan penentuan campuran optimum habuk papan dengan gambut tanah yang memberi kekuatan ricih maksimum. Kajian menunjukkan bahawa dengan menambah habuk papan pada nilai yang tepat boleh memberikan nilai maksimum kekuatan ricih. Kekuatan parameter ricih yang merupakan perpaduan adalah berkadar songsang dengan sudut rintangan ricih. Campuran optimum bagi tanah gambut adalah pada 1.0% daripada habuk papan.

# TABLE OF CONTENT

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF GRAPHS

# LIST OF SYMBOL

| | |
|---|---|
| $W_w$ | Mass of Wet Soil |
| $W_d$ | Mass Of Dry Soil |
| $\omega$ | Moisture Content |
| $\rho_w$ | Dry Density Of Water |
| $\rho_d$ | Dry Density |
| $\gamma_d$ | Dry Unit Weight |
| $v_a$ | Air Voids |
| Gs | Specific Gravity |
| ¢ | Cohesion |
| Ø | Angle of Shear Resistance |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| AAC | Autoclaved Aerated Concrete |
| ASTM | American Society for Testing and Materials |
| BS | British Standard |
| LL | Liquid Limit |
| LPW | Limestone Powder Wastes |
| LW | Limestone Wastes |
| MDD | Maximum Dry Density |
| OMC | Optimum Moisture Content |
| PI | Plasticity Index |
| PL | Plastic Limit |
| STP | Standard Proctor Test |
| WSW | Wood Sawdust Wastes |
| ZAV | Zero-Air Voids |

# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND OF STUDY

Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. A major use of sawdust is for particleboard and coarse sawdust may be used for wood pulp. Sawdust has a variety of other practical uses, including serving as mulch, as an alternative to clay cat litter, or as a fuel. Besides, sawdust also is used for agricultural especially for wood mushroom farmers.

In some country, raw (untreated) sawdust has to be used as roof insulation. Sawdust was deemed the best insulation in icehouses. It also keeps ice cream cool during transportation and storage. In other case, sawdust can present a hazard in manufacturing industries, especially in terms of its flammability. Sawdust is an essential ingredient in the making of fire starters because the sawdust is a combustible material and combined with oxygen would help fuel a fire.

Marshal (1995) states that, waste materials that are organic in nature, such as plant material, food scraps, and paper products, are increasingly being recycled. These materials are put through compost and/or a digestion system to control the biological process to decompose the organic matter and kill pathogens. The resulting stabilized organic material is then recycled as mulch or compost for agricultural or landscaping purposes.

The waste material has caused some problems that disturb people by their smell. Usually waste material was thrown in the residential area, which bring people uncomfortable with this situation. This problem is never stopped even though it always has been exposed to media so that this disturbance can be solved. This was because there was no proper solution for management of waste (Renzoni, 1994). According to Medina (2002), the major models of disposal of solid waste in the United States are land filling or dumping and incineration. People want their refuse taken away and do not want it disposed of near their habitat, or at least they do not can see or smell it.

Therefore, due to this problem an alternative way should be put forward so that it can gives at least a new dimension to this issues. Actually, the waste material also can bring some benefits if it be conducted in proper ways.

In civil engineering field, a stabilization of soil is important to be applied in the construction. The main purposes of soil stabilization are to modify the soil, expedite construction and improve the strength and durability of the soil. To stabilize the peat soil, a natural waste of sawdust is be used in order to enhance the engineering performance of the soil. A modification of the characteristics of peat soil by mixing the soil with additives to change the chemical and physical properties such as stiffness, compressibility, permeability, workability, lower the ground water level and eliminate weak soil.

## 1.2 PROBLEM STATEMENT

The waste material has caused some problems that disturb people by their smell. Usually waste material was thrown in the residential area, which bring people uncomfortable with this situation. This problem is never stopped even though it always has been exposed to media so that this disturbance can be solved. This was because there was no proper solution for management of waste (Renzoni, 1994). According to Medina (2002), the major models of disposal of solid waste in the United States are land filling or dumping and incineration. People want their refuse taken away and do not want it disposed of near their habitat, or at least they do not can see or smell it.

Marshal (1995) states that, waste materials that are organic in nature, such as plant material, food scraps, and paper products, are increasingly being recycled. These materials are put through compost and/or a digestion system to control the biological process to decompose the organic matter and kill pathogens. The resulting stabilized organic material is then recycled as mulch or compost for agricultural or landscaping purposes.

## 1.3 RESEARCH OBJECTIVES

The research objectives are as below:

1. To determine the angle of shearing resistance of the peat soil and sawdust for various mixes.
2. To determine the cohesion of the peat soil and sawdust for various mixes.
3. To determine the optimum mix for the peat soil and sawdust, which gives the optimum shear strength.

## 1.4 SCOPE OF STUDY

In approaching the study, some experiments should be run to achieve the objectives of this research. Then, a technique that be used for soil stabilization was by using an additive natural material to be applied on peat soil. The additive natural material that has been used was sawdust, which was taken from Kilang Papan Mohd Yusuf & Anak2 at Bukit Kubang Jambu in Kuala Terengganu. The sample of peat soil was taken and been considered as a disturb soil because it is very hard to get the undisturbed sample. The peat soil sample was taken from Kampung Tanah Puteh in an area of Pekan, Pahang. The sawdust was measured by ratio to four different amounts separately and the amounts of sawdust be used to mix with peat soil is varies from 0%, 1.0%, 1.5%, 2.0%, and 2.5% respectively to get a comparative value of peat properties. The results were showed the effectiveness or the performance of the sawdust on the shear strength properties of peat soil.

The experiments that has been run for this study is Specific Gravity (BS1377: Part 2:1990:8.3) - Standard test of Specific Gravity for fine grained soil using density bottle). Then, Atterberg Limits (BS1377: Part 2:1990:43 – Standard Test Method for Liquid Limit) and (ASTM D 4318 - Plastic Limit, and Plasticity Index of Soils) test also should be run. The compaction also has been done which accordance to (ASTM 698) – Standard Test Method for Standard Proctor Test. The main experiment for this study is Direct Shear Strength (ASTM D 3080 – Standard Test Method for Direct Shear Test of Soils under Consolidated Drained Conditions).

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 PEAT SOIL

There are about 2.7 million ha of peat and organic soils in Malaysia accounting for about 8% of the total land area of the country. In Sarawak, peat lands are in abundance and Sarawak has the largest area of peat in the country, covering about 1.66 million ha and constituting 13% of the state (Said, J.M. et al, 2009).

### 2.1.1 Physical Characteristic

As referred in Huat, (2004), the physical characterictics such as colour, degree of humification, water content and organic contents should be included in a full description of peat. The physical properties of peat are influenced by main component of its formation such as mineral content, organic content, moisture and air. When one of these components changes, it will result in the changes of the whole physical properties of the peat soil. These are some of the important physical properties of peat:

a. Colour. The colour of peat range of light-yellow to yellowish, reddish and dark brown to dense black. The colour of peat indicates the degree of decomposition it has experienced.
b. Degree of humification. Represents the degree to which the organic content has decayed.

c. Moisture content. The moisture content of peat ranges from 100 to 1300 percent on a dry basis. The moisture content value of peat depends on the origin, degree of decomposition and chemical component of peat. Hanzawa et al (1994), states that the natural water content of some peat could exceed 1000%.

Peat has certain characteristic that sets it apart from mineral soils and it also requires special consideration. These special characteristics include (Deboucha eta al):

- High natural moisture content (up to 800%).
- High compréssibility including significant secondary and tertiary compression.
- Low shear strength (typically 5-20 kPa).
- High degree spatial variability.
- Potential for further decomposition as a result of changing environment conditions

Peat soil usually contains organic material with normal depth of 0.5metre. Peat is known for its high organic content which could exceed 75 percent. The organic contents classified as peat are basically of plant whose rate of accumulation is faster than the rate of decay. The content of peat soil differs in terms of locations due to factors such as temperature and degree of humification. Decomposition or humification involves the loss of organic matter either in gas or in solution, the disappearance of physical structure and change in chemical state (Huat, 2004). Table 2.1 presents the properties of peat soils (A. Alwi, 2008).

**Table 2.1:** Properties of In-situ peat soil (A. Alwi, 2008)

| **Properties** | **Value** |
|---|---|
| Bulk density (γb) | 1.059 Mg/ m 3 |
| Dry density (γd) | 0.112 Mg/ m 3 |
| Moisture content (*w*) | 700-850% |
| Void ratio (*e*) | 10.99 |
| Fiber content | 84.99% |
| Degree of saturation (*S*) | 100 |
| Specific gravity (*Gs*) | 1.343 |
| Classification /Von Post | H4 |
| Linear Shrinkage | 5.58% |
| Liquid limit | 173.75% |
| Plastic limit | 115.8% |
| Plasticity Index | 57.95% |
| pH | 4.6 |
| **Scanning Electron Microscopy** | |
| Loss on Ignition | 98.46 % |

Basically, peat is predominantly made up entirely of plant remains such as leaves and stem. It is produced by the partial decomposition and disintegration of mosses, sedges, trees, and other plants that grow in marshes and other wet place in the condition of lack of oxygen. Therefore, the color of peat usually is dark brown or black and with a distinctive odor (Craig, 1992). This characteristic also made the peat pose its own distinctive geotechnical properties compared with other inorganic soils like the clay and sandy soils which are made up by the soil particle only (Deboucha et al., 2008).

### 2.1.2 Problems with Peat from Geotechnical Engineering View Point

Peat soil is an extremely soft soil and often referred to problematic soil by engineers. Peat soil is not only soft, it is compressible too where this characteristic will lead to excessive settlement which is a very serious problem (Said,J.M. et al, 2009). Peat is considered as problematic soils in the view of design parameter by the geotechnical engineers because its engineering characteristic are inferior to those of the other soft soils which make it unsuitable for construction in its natural stage. Peats are found to contain high organic matter and are generally associated with poor strength characteristics, large deformation, high compressibility, and high magnitude and rates of creep (Haan and Kruse, 2006).

Peat is subjected to problems of instability such as local sinking and development of slip failure. It is also subjected to very large primary and long term settlement under an even moderate increase in load. There is also some difficulty in accessing the sites, a large variation in material properties coupled with difficulty in sampling. There is also some possibility of chemical and biological changes in these materials with time. As an example, the organic constituents upon further humification may change the mechanical properties of peat such as shear strength, compressibility, and hydraulic conductivity (Huat, 2004).

### 2.1.3 Shear Strength of Peat

Shear strength is considered as one of the most important parameters in engineering design and decision when dealing with soil especially during pre and post-construction since it is used to evaluate the foundation and slope stability of soil. When the ultimate shear strength is exceeded, the soil will fail or deform. The failure criteria is developed using the stress-strain relationship and the concept of elasticity theory is applied too. The magnitude of the strain in soil depends on the parameters such as the magnitude of applied load, the composition of the soil, past stress history, void ratio, and also on the manner in which the stress is applied (Anggraini, 2006).

Peat usually has very low shear strength and the determination of shear strength is somehow a difficult job in geotechnical engineering because the difficulties will depend on factors such as the origin of the soil, its water content, organic matters and also on the degree of humification. During the sampling stage, the sample disturbance will also affect the evaluation of shear strength of peat (Kazemian, Huat, Prasad, & Barghchi, 2011).

Peat is a type of soil that has very low shear strength but the increase in strength upon consolidation could be significant. The shear strength of peat is dependent on some factors such as moisture content, degree of decomposition and mineral content. According to Munro (2005), higher the moisture content and decomposition, the lower is the shear strength; in addition, the higher mineral content causes higher shear strength. In general, shallow peat, due to its more fibrous nature, is likely to have greater strength than more humified peat at depth (Culloch, 2006).

Mostly, peat is considered a frictional or non-cohesive material due to the fiber content and the spatial orientation of the fibers. The high friction angle of peat will not actually reflect high shear strength due to the fact that the fibers are not always solid and may be filled with water and gas. The presence of fibers will modify the strength behavior of peat since the fibers can be considered as reinforcement and the fibers can provide effective stress where there is none and it induces an isotropy (Kazemian, Huat, Prasad, & Barghchi, 2011).

The shear strength of peat generally can be found out in many ways. In-situ methods such as field vane shear test and cone penetration test are very useful and these tests can be used to avoid many of the problems Kazemian et al. 1977 associated with the soil sampling. However, these methods have some inherent limitation since the shear strength can only be determined indirectly through correlations with laboratory results and also from the back calculation from the results of actual failures. Further, the variable nature of peat and the difficulties in obtaining good representative samples from the field, laboratory testing can only give indicative results (Culloch, 2006).

The most common laboratory test is direct shear test in determining the drained shear strength of fibrous peat, while triaxial test is frequently used for evaluation of shear strength of peat in the laboratory under consolidated-undrained (CU) conditions. This is due to the fact that the results of tri-axial test on fibrous peats are difficult to interpret because fiber often act as horizontal reinforcement, so failure is seldom obtained in a drained test. The reason being the tri-axial test for peat with low permeability, if performed under a drained condition, may take several days to complete (Kazemian, Huat, Prasad, & Barghchi, 2011).

Edil and Dhowian (1981) and Landva and La Rochelle (1983) showed that the effective internal friction, φ of peat is generally higher than inorganic soil (e.g. undrained friction angle of amorphous peat and fibrous peat is in the range of 27 – 32° under a normal pressure of 3–50 kPa; on the other hand, for amorphous granular peat effective internal friction is 50° and for fibrous peat is in the range of 53- 57°). Whereas, the undrained friction angle of peat, in West Malaysia, is in the range of 3- 25° (Huat, 2004).

## 2.2 SAWDUST

Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. It can present a hazard in manufacturing industries, especially in terms of its flammability. The sawdust is practical used in variety ways.

### 2.2.1 Effect of Sawdust on Shear Strength Properties

The shear strength of soils is derived from the frictional and interlocking nature of granular material. The friction and interlocking depend on the interaction of many of the soil parameters of grain size distribution, void ratio, water content and degree of saturation, particles shape, particles roughness and state of effective stress (Fratta, 2007).

Undrained strength of soft soil is important for short and long term condition. The shear strength of soft soil in effective stress can be expressed by Mohr-Coulumb strength criterion as in Eqn 2.1,

$$S = c' + \partial' \tan \theta' \qquad (2.1)$$

With,

S = is the shear strength
c' = is the effective stress cohesion intercept
$\partial'$ = is the effective stress angle in friction
$\theta'$ = is the effective stress

Table 5
Test results

| Mix no | Compressive strength (MPa) | Flexural strength (MPa) | Unit weight (g/cm$^3$) | Absorption (mass) (%) | Absorption (Volume) (%) | UPV (m/sn) |
|---|---|---|---|---|---|---|
| Control mix | 24.9±2.1 | 3.94±0.34 | 1.88±0.01 | 12.4±0.0 | 23.3±1.0 | 2718±31 |
| LW-10 | 16.6±0.9 | 3.65±0.17 | 1.70±0.06 | 13.9±1.2 | 23.5±1.5 | 2627±69 |
| LW-20 | 11.0±0.2 | 3.50±0.54 | 1.66±0.02 | 15.1±0.9 | 25.0±1.2 | 2383±67 |
| LW-30 | 7.2±0.9 | 3.08±0.13 | 1.51±0.02 | 19.2±0.5 | 29.0±0.4 | 2083±90 |

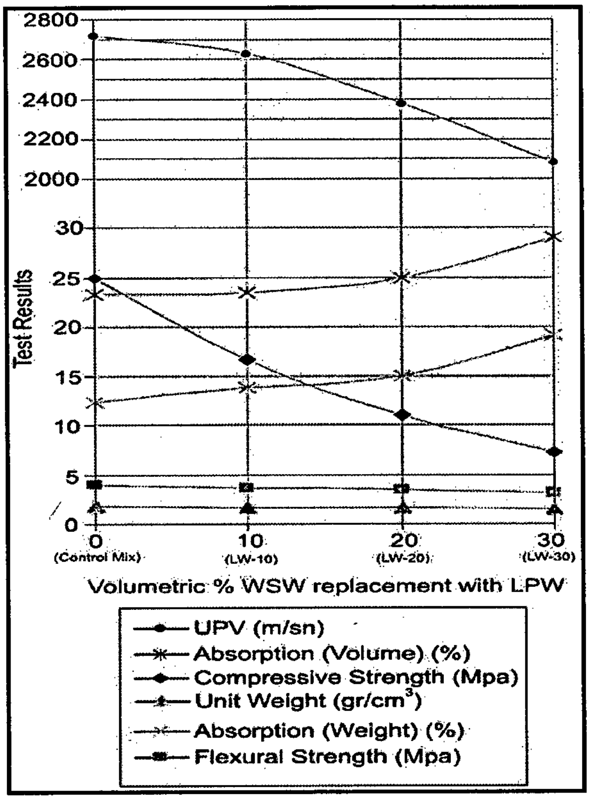


Figure 2.1 Graphical representation of the result in Table 5.

The two water absorption terms corresponding to the volume and the mass of samples are calculated. Fig. 1 shows that the water absorption and the percentage WSW values are proportionate. An improvement of 30% in the WSW content increases the initial water absorption value of about 50%. In this waste WSW content, 29% of water absorption by mass is in relatively acceptable limit compared to the widely used lightweight building materials such as AAC which has an approximate water absorption value of 60% (Ozdemir A., 2002). This is an expected result owing to the water absorption nature of WSW (Paki Turgut, Halil Murat Algin, 2006).

Table 5 shows the results of the compressive strength values obtained from the tests. The average compressive strength values are inversely proportional with the percentage WSW replacement (see Fig. 1). The strength dramatically decreases with an increase in the replacement level of WSW. A 71% reduction in the strength of control mix is obtained from the 30% WSW replacement (LW-30 mix) which attains the average result of 7.270.9MPa complied with BS6073 (British Standards Institution, 1981). It is also observed that the WSW–LPW–cement composite even in this compressive strength value can easily be cut with simple handheld saw (Paki Turgut, Halil Murat Algin, 2006).

Direct shear test, performed according to ASTM D3080, provides shear strength properties of soils under conditions of drained loading, which is required for assessing the stability of earth slopes and bearing capacity of foundations. The shear resistance of soil is changed by reinforcement. Direct shear test is conducted for soil without geonet, for soil with geonet layer placed horizontally and for soil with geonet layer placed inclined at 45 degrees (Bestun J. et al, 2012).

**Table II: Direct shear test results for reinforced and unreinforced soils**

| | | |
|---|---|---|
| Unreinforced Soil | Angle of internal friction, $\phi$ (degrees) | 34 |
| | Cohesion, c (kN/m²) | 38 |
| Soil Reinforced by Geonet (placed horizontally) | Angle of internal friction, $\phi$ (degrees) | 38 |
| | Cohesion, c (kN/m²) | 16 |
| Soil Reinforced by Geonet (placed at 45°) | Angle of internal friction, $\phi$ (degrees) | 44 |
| | Cohesion, c (kN/m²) | 32 |

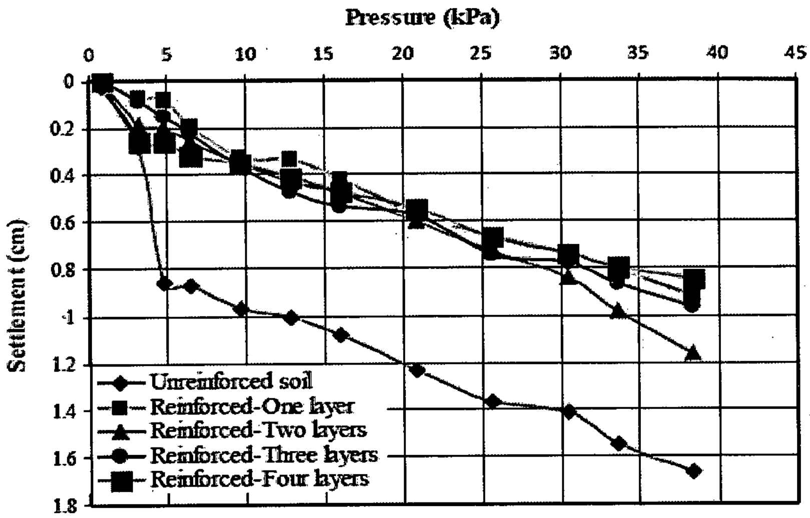


**Fig. 4 Pressure - settlement relationship for reinforced and unreinforced soils.**

It is clear from Table II that the angle of internal friction increased from 34o for unreinforced soil to 38 o for soil reinforced horizontally by a geonet layer and to 44 o for soil reinforced by a geonet layer placed at 45 o inclination. This leads to the fact that geonet increases the friction between the soil and surface of the geonet. Hence, the angle of internal friction increased. On the other hand, cohesion decreased from 38 kPa for unreinforced soil to 16 kPa and 32 kPa, for soil reinforced with a horizontal layer and inclined reinforcement layer, respectively. This might be caused by the two different materials (soil and the polymer). The improvement in the values of the angle of friction is better in case of inclined reinforcement since the geonet intersects the failure surface which is almost horizontal (Bestun J. et al,2012).

Figs. 8 to 10 show direct shear test results for soil reinforced by a geonet layer placed horizontally. By comparing Figs. 4 and 8, it can be easily noted that the shear stress increased for soil reinforced by horizontal geonet layer, while the vertical displacement decreased. This is because the geonet layer works as a reinforcement layer that strengthens the soil and tends to increase shear strength of the soil. It can be seen that both compression and dilation of the soil are decreased by adding reinforcement layers (Bestun J. et al, 2012).