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UTILISATION OF PLASTIC SACKS FIBRE AND BRAN ASH FOR SOFT CLAY SHEAR STRENGTH

Nyimas Septi Rika Putri*, Ratna Dewi, Muhammad Ilham

Faculty of Civil Engineering, Sriwijaya University, South Sumatera, Indonesia

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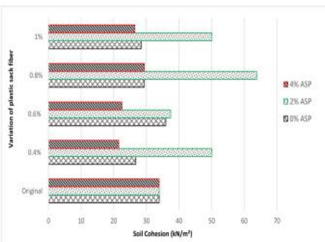
*Corresponding author
nyimasputri118@ft.unsri.ac.id

Graphical abstract



Abstract

Soft soil possess poor mechanical properties, thus produce problems when bearing load. To overcome the problems, soft soil has to be stabilised. To do soil stabilisation, it Is imperative to add some mixture as additional substance in order to improve the characteristic of the soft soil. Plastic sacks fibre is one of the easily obtainable material which consists of high density profile, while bran ash contains good carbon and silica. This research aimed to determine the optimum level of plastic sacks waste fibre and bran ash to obtain the maximum soil shear strength and to compare the original soil shear strength with the modified mixture soil shear strength. The strength tests were conducted on the laboratory scale using the triaxial test device for the Unconsolidated Undrained (UU) test. Soft clay sample was mixed with the chop of plastic sacks fibre with the following level of composition : 0.4 % , 0.6 %, 0.8 %, 1 %, and also the bran ash composition content of 0 %, 2 % and 4 % to the dry weight of soil with the test unit of 36 pieces. Based on laboratory testing, the maximum cohesion value reside on variation of 0.8 % plastic sacks fibre and 2 % bran ash with the value of 0.65 kg/cm^2, and the maximum shear angle lays on variation of 1 % of plastic sacks fibre and 0 % of bran ash with the value of 9.95 degree. For the mixture variation of 0.8 % plastic sacks fibre and 2 % of bran ash, it produced a shear strength of 0.67 kg/cm^2 and abled to increase the soil shear strength by 87.08 %. As a conclusion, the use of plastic sacks fibre and bran ash was found to be able to improve the soft clay shear strength properties.

Keywords: Unconsolidated undrained triaxial test; plastic sack fibre; bran ash, soil shear trength

Abstrak

Tanah lembut memiliki sifat-sifat mekanikal yang lemah yang menyebabkan masalah apabila menggalas beban. Penstabilan tanah adalah perlu untuk mengatasi masalah ini. Beberapa campuran bahan tambah perlu di tambah kepada tanah yang lemah untuk meningkatkan ciri-ciri tanah yang lembut. Karung plastik berserat adalah antara salah satu alternatif bahan yang mudah diperolehi, terdiri daripada profil berkepadatan tinggi, manakala abu bran mengandungi karbon yang baik dan silika. Matlamat kajian adalah untuk menentukan tahap optimum serat karung plastik dan abu bran untuk mendapatkan kekuatan ricih tanah maksimum dan untuk membandingkan kekuatan ricih tanah asal dengan kekuatan ricih tanah campuran yang diubah suai. Ujian kekutan telah dilakukan pada skala makmal mengunakan alat tiga paksi melalui ujian tak terkukuh tak tersalir (UU). Sampel tanah liat lembut dicampur cop serat karung plastik dengan komposisi seperti beriukut: 0.4 %, 0.6 %, 0. 8%, 1 %, dan juga kandungan abu bran dengan komposisi 0 %, 2 % dan 4 % dari berat tanah kering dengan unit ujian sebanyak 36 keping. Berdasarkan ujian makmal, nilai maksimum kejelekitan berlaku pada 0.8% serat karung plastik dan 2 % abu bran dengan nilai 0.65 kg/cm^2, manakala sudut ricih maksimum berlaku pada 1 % serat karung plastik serat dan 0 % abu bran dengan nilai 9.95 darjah. Untuk variasi campuran sebanyak 0.8 % serat karung plastik dan 2 % abu bran, ia menghasilkan kekuatan ricih 0.67 kg/cm^2, dan dapat meningkatkan kekuatan ricih tanah sebanyak 87.08 %. Kesimpulannya penggunaan serat karung plastic bersama abu bran dapat meningkatkan kekuatan ricih tanah liat lembut.

Kata kunci: Ujian tiga paksi tak terkukuh tak tersalir; karung plastik berserat,; abu bran; kekuatan ricih tanah

1.0 INTRODUCTION

In the construction of infrastructure such as bridge, building, road, and many others, soil plays a critical role. Generally, soil has three parts; soil particle; water; and air; that fill up the space between granular or in other word called pore. Soil is having such characteristic as; soil attribute; classification; and strength; which the value is obtain from laboratory test or in-situ field test [1].

Soil will always have a significant role to construction, but there's a condition where it has to be built on a structure that have less favourable by geotechnical perspective, for example the soft clay. Soft clay generally consist of layers with fine granular shaped such as clay and silt. Soft soils possess poor mechanical properties that create problems when faced to bear the load.

The main problem is, soft soil is greatly influenced by the water content, low soil bearing capacity, low permeability, and slow consolidation process. The nature of soft soil that have low shear strength, made the bearing capacity to be very low. To solve this problem, things that can be done are to stabilise the soil. Soil stabilisation is a method used to improve the soil characteristics such as the shear strength, bearing capacity, and also reduce soil compressibility.

The process of soil stabilisation, could be achieved through mixing with compound such as additive to improve the soft clay properties. Plastic is one of the materials that relatively easy to be obtained, and have a high density profile, while bran ash contains carbon and silica. Previous research has also been conducted by Muntohar [2] who mixed the soft clay with lime, bran ash, and plastic sack fibre. The weight ratio of lime to bran ash was 1:1. The length of the plastic fibre was 10 mm, 20 mm and 40 mm with fibre variation content of 0.1%, 0.2%, and 0.8% of soil dry weight. The result of the research is concluded that with the addition of fibre to the soil and stabilised with lime and bran ash, increased the unconfined compression strength up to 1.6 times while it was 5 times for the tensile strength.

Weathering of land due to chemical reactions produced a composition of the group of colloidal-sized particles with a grain diameter smaller than 0.002 mm called clay minerals. Most clay is composed of silica and aluminium tetrahedra octahedra. Silica and aluminium can be partially replaced by other elements in the unity; this state is known as isomorphous substitution. Kaolinite is a mineral of kaolin group, consisting of the arrangement of a single sheet of silica tetrahedra with a sheet of aluminium octahedra with units of the composition. Halloysite is almost the same as kaolinite, but the whole sequence is random bond and can be separated by a single layer of water molecules [3]. The water is usually not much affect the behaviour of non-cohesive soil (granular), for example sand soil shear strength approaching the same on both dry and water-saturated conditions. But, if water is in the sand layer is not solid, dynamic loads like earthquakes and other vibration strong influence of sliding [3]. There are three mechanisms that cause dipolar water molecules can be pulled by the surface of the clay particles electrically [4]:

1) Pull the negatively charged surfaces of clay particles with the positive end of a polar.
2) Pull the cations in a double layer with a negative charge of the polar end. Cations are attracted by the surface of the clay particles are negatively charged.
3) Hydrogen atoms in water molecules, by hydrogen bonds between oxygen in the clay particles and oxygen atoms in water molecules.

Water is interested electrically, which is located around the clay particles, called a double layer of water. The plasticity of clay is due to the extension of the double layer. Water double layer at the innermost part which is very strongly attached to the clay particles, called absorbed water. Soil particles are composed by clay minerals will be greatly influenced by the amount of negative charge on mineral network, the type, concentration, and distribution of cations which serves to balance the load [4].

Volume changes may occur in the test with an open drainage (drained). Volume change can be either an increase or decrease because of easing depends on the relative density or pressure bridle or cell pressure (confining pressure). Similarly, the behaviour that occurs in cohesive soils is saturated with water when experiencing loading. In testing conditions with open drainage, changes in volume in the form of compression or easing not only depend on the density and tension bridle alone, but depend also on the history of the voltage. Similarly, the imposition of conditions not drained (undrained), the value of pore water pressure depends on the type of clay, and the clay type is normally consolidated or over consolidated. Usually the operation load of the building on the ground, faster than the speed of the water to escape from the pores of the clay due to loading. This situation raises the excess pore water (excess pore pressure) in the soil. When the load is such that it does not happened collapse of the land, then what happens then is the pore water burst out and volume changes occur. Speed volume changes that occur in sand and clay soil is different. Because of the speed of change of the volume of soil will depend on the permeability of the soil. Because of very low permeability clay soils, while the high sand soil, pore water pressure reduced speed will be faster occur on sandy soil. So, for sand soil, changes in volume due to dissipation of pore water pressure will be faster than clay soil [4].

In the study Muntohar [2] to study clay mixed with lime, rice husk ash, fibre and plastic sacks, comparison between heavy lime and rice husk ash is 1: 1. Long fibres used 10 mm, 20 mm and 40 mm and the variation of fibre content is 0.1%, 0.2%, and 0.8% of the dry weight of the soil, the results of the study states that the provision of fibre in the soil stabilised with lime and rice husk ash increases free compressive strength of up to 1.6 times and 5 times for tensile strength. Based on the comparative value between tensile strength and compressive strength free, fibre content should be mixed into the soil that ranges from 0.4% - 0.6%. Length of fibre should be used in order to contribute to the resistance tap and drag that is 20 mm to 40 mm or 0.4 to 0.8 times the diameter of the test specimen.

In the study Sazuatmo [4] with the title of a plastic material effect on the shear strength of the clay, the material used is an old plastic bag from waste and will be used as reinforcement material clay. Plastic bags are cut into pieces with a size of 2 x 2 cm², 2 x 1 cm², and 2 x 0.5 cm² and mixed with a percentage of the dry weight of the clay was 0 %, 0.5 %, 1%, 1.5 %, 2 %, and 2.5 %. Each mixture will be made 3 samples. Shear strength testing apparatus used is a direct shear tests and came to the conclusion the addition of a plastic bag with a variety of sizes and fibre content is able to raise the value of the cohesion of the soil, the size of the largest fibre obtained i.e., 2 x 0.5 cm² with a fibre content of 2%. For a fibre content of 1% with a size of 2 x 2 cm² has a value of maximum shear strength of the fibre content and the size of the other.

Endang Setyawati Hisham [5] has also been doing research on the use of plastic bags fibres for reinforcement of clay. Their study used fibre sacks from plastic taken from landfills, and studies were carried out in two stages: the first stage was the stage of preparation of the material in which the plastic sacks were prepared with the basket removed and cut with three variations of sizes of 0.5 cm, 1 cm and 2 cm. Later in the second stage was the stage of start-up design mix variations, variation levels used were 0 %, 0.5 %, 1 %, 1.5 %, 2 %, and 2.5 % and compacted with 3 layers and ground 75 times. Shear strength testing was done by means of direct shear tests. The conclusion was the fibre size of 0.5 cm experienced the highest shear strength for the fibre content of 2 %.

With reference to previous research, further research was conducted on the percentage composition of different ingredients and mix, i.e. plastic sacks fibre and rice husk ash as an ingredient. Plastics include plastic sack with a group PP Woven Bag and rice husk ash contain silica and carbon, a mixture of the two materials is expected to increase the shear strength of soft clay. In this research, comparison of strength was made between the base soil (controlled samples) and the mixture of base soil with plastic sacks fibre and bran ash (improved soil). The use of plastic sacks fibre and bran ash will increase the shear strength of soft clay.

2.0 EXPERIMENTAL

2.1 Sampling Test

The study was divided into several parts:

i. Soft Clay samples were taken in the area of Sriwijaya University campus Indralaya
ii. Collection of plastic sacks fibre originate from the purchase or the used one ex from the rice sacks will be pry for fibre extraction.
iii. Collection of Bran ash purchased from farmers and through stores that sell the remains of burning paddy.

2.2 Work Preparation

Soil samples that have been drawn dried or expose in the sun first to make the soil turn into a dry state. Then the soil was filtered through the sieve number 4 and was mixed with other materials such as bran ash and plastic sacks fibre. Plastic sacks fibre being use comes from waste plastic sacks of rice, then cut and pry the fibre part with a length of 2 cm. As for bran ash processed using the sieve number 40.

2,3 Laboratory Testing

Initial testing is done by testing the soil index properties, and then followed by compaction testing of base soil and also triaxial testing for the base soil. All laboratory tests based on ASTM standards that can be seen in the table 1 below:

Table 1 Testing Standard for Research

No.	Testing	Standard
1	Water Content	ASTM D-2216-90
2	Density	ASTM D-854
3	Atterberg Boundaries	ASTM D 423-66 and ASTM D 424-74
4	Sieve analysis + hydrometer Standards	ASTM D 421and ASTM D 422
5	Compaction Testing	AASHTO T-180
6	Triaxial UU	ASTM D 2850-70

2.4 Testing Programme

The triaxial test specimen that has been mixed with the plastic sacks fibre Bran ash was fed into the mould compaction standards and was cast according to triaxial mould. Number of test objects made is 36 pieces. The following percentage of the mixture was shown in the Table 2.

2.5 Unconsolidated Undrained Triaxial Testing

In the unconsolidated undrained (UU) test each variation of the mixture has a total sample of 3 pieces by giving each cell pressure of 1 kg/cm², 1.5 kg/cm², and 2 kg/cm². Given axial loading speed of 1.25 mm/min. Testing was stopped when the sample reached a failure.

Table 2 Percentage variation and number of objects test

Mix Variation				Sample Code
Soil (%)	**Plastic Sack Fibre (%)**	**Bran Ash (%)**	**Number of Sample**	**Specimen**
99.6	0.4	0	3	0.4SKP0ASP
99.4	0.6	0	3	0.6SKP0ASP
99.2	0.8	0	3	0.8SKP0ASP
99	1	0	3	1SKP0ASP
97.6	0.4	2	3	0.4SKP2ASP
97.4	0.6	2	3	0.6SKP2ASP
97.2	0.8	2	3	0.8SKP2ASP
97	1	2	3	1SKP2ASP
95.6	0.4	4	3	0.4SKP4ASP
95.4	0.6	4	3	0.6SKP4ASP
95.2	0.8	4	3	0.8SKP4ASP
95	1	4	3	1SKP4ASP
Total Sample			36	

Description : SK = Plastic Fibre, ASP = Rice Husk Ash

3.0 RESULTS AND DISCUSSION

3.1 Soil Properties Index Testing Results

The physical properties of the soil samples were shown in Table 3.

Table 3 Soil Properties Index Testing Result

Soil Testing Type	Result
Original Water Content	33.75 %
Density (Gs)	2.53
Soil Sieve Numb.200 Pass	61.02 %
Liquid Level (LL)	48 %
Plastic Level (PL)	21.2 %
Plastic Index (IP)	26.8 %
Soil Classification According to AASHTO	A-7-6
Soil Classification According to USCS	Inorganic Clay (CL)

3.2 Standard Compaction Test Results

From the compaction test, it is obtained that the optimum moisture content is 20.15 % and the maximum dry weight is 1.62 g/cm³. The optimum moisture content of the original land obtained had been used as a benchmark for the provision of water content for soil mix.

3.3 Unconsolidated Undrained (UU) Triaxial Results

The original soil cohesion and friction angle value acquired is 0.35 kg/cm² and 5.25 degree, respectively. The mixed soil test results can be seen in the Table 4. Based on Figure 1, the highest cohesion value is in a mixture of 2 % bran ash and 0.8 % of fibre plastic sacks (0.8SKP2ABS) of 0.65 kg/cm².

For 0 % and 4 % of bran ash composition, soil cohesion tends to be impaired when compared to the original value of soil cohesion, while for each additional 2 % bran ash it increased the value of the soil cohesion with addition of fibre plastic sacks. The smallest value of soil cohesion of 0.22 kg/cm² is obtained on 4 % bran ash and 0.4 % fibre plastic sack (0.4SKP4AB) mixture.

Table 4 Triaxial UU testing results of soil shear strength

No.	Variety Mixed	Cohesion Value (kN/m²)	Friction Angle (degree)	Shear Strength (kN/m²)
1	Original Soil	33.93	5.255	34.81
2	0.4SKP0ASP	26.77	6.851	27.95
3	0.6SKP0ASP	35.99	6.99	37.17
4	0.8SKP0ASP	29.32	7.714	30.6
5	1SKP0ASP	28.44	9.95	30.11
6	0.4SKP2ASP	50.11	7.477	51.39
7	0.6SKP2ASP	37.46	6.881	38.64
8	0.8SKP2ASP	63.84	7.616	65.21
9	1SKP2ASP	50.11	6.809	51.29
10	0.4SKP4ASP	21.57	5.41	22.06
11	0.6SKP4ASP	22.56	6.83	23.83
12	0.8SKP4ASP	29.42	6.68	30.2
13	1SKP4ASP	26.48	5.9	27.07

Description: SKP = Plastic Fibre, ASP = Rice Husk Ash

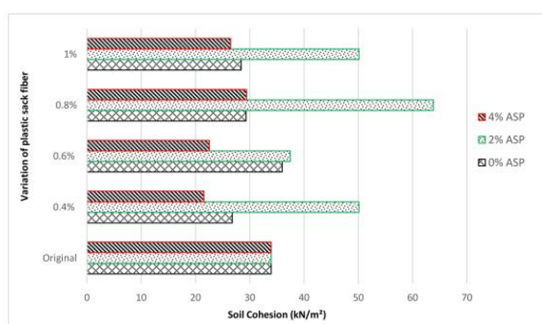


Figure 1 Soil cohesion chart value (ASP = Rice Husk Ash)

Based on Figure 2, for every additional of bran ash there would be an increment of friction angle value when compared to the value of the friction angle of original soil. For the additional of bran ash 0 % and 1 % fibre plastic bag (1SKP0ASP), it produced the largest friction angle value for 9.95 degrees. As for the 2 % bran ash, it produced the greatest value of the friction angle at the time of adding 0.8 % fibre plastic bag (0.8SKP2ASP), with the value of 7.62 degree. With 4 % bran ash addition, maximum friction angle value reached 6.83 degree, also by adding 0.6 % fibre plastic bag (0.6SKP4ABS). The smallest Friction angle value contain of the variation mixture of 4 % bran ash.

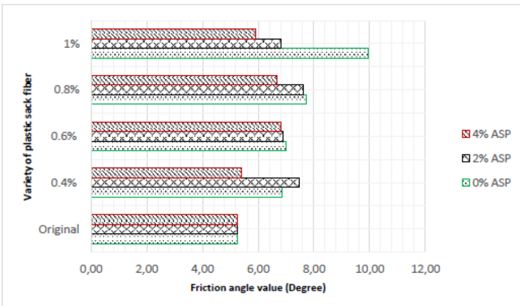


Figure 2 Soil Friction angle value chart (ASP = Rice Husk Ash)

Based on Figure 3, the effect of adding plastic sacks fibre and bran ash tends to be able to increase the value of shear strength when compared to the original value of shear strength. The value of shear strength that contain a mixture of 0.8 % fibre plastic sacks and 2 % bran ash (0.8SKP2ASP) is 0.67 kg/cm^2. At 0 % bran ash the greatest shear strength value of 0.39 kg/cm^2 was reach with 0.6 % addition of fibre plastic sacks. On the content of 2 % and 4 % bran ashes the highest shear strength value at 0.8 % fibre plastic sacks are 0.67 kg/cm^2 and 0.31 kg/cm^2, respectively. The smallest shear strength value appears at 4 % mixture of bran ash and 0.4 % fibre plastic bag (0.4SKP4ASP) which is 0.23 kg/cm^2.

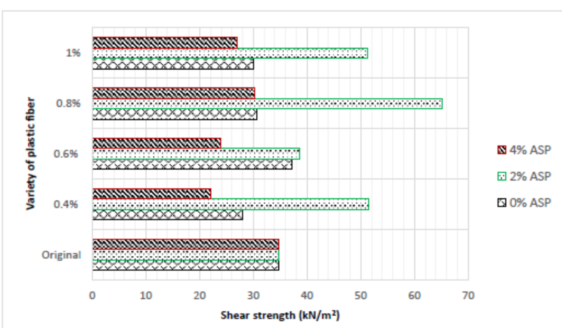


Figure 3 Soil Friction shear strength value chart (ASP = Rice Husk Ash)

Based on changes of value in Figure 4, the shear strength values tend to increase compared to the value of the original soil shear strength. At the sample 0.8SKP2ASP the shear strength value increased up to 87.08 %, this is achieved because the elastic nature of fibre plastic sacks is able to contribute the binding force (adhesive/grip) of each soil particle, while the bran ash with little amount can react with water to close the cavities of soil. However, with 4 % addition of bran ash will decreased the shear strength value cause bran ash that too much will make the soil became friable and the adhesive bonding of soil particle will be weak and damage.

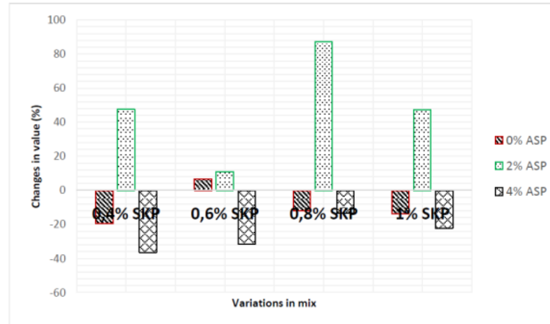


Figure 4 The value changing chart of soil shear strength

In the sample 0.8SKP2ASP, the increased shear strength value of 87.08 % occurred. This was due to the fibre plastic sacks that were able to provide the elastic force between grains of soil put, while the rice husk ash to levels that are not too much can react with water thereby closing the empty cavities in the soil granules. However, when the addition of rice husk ash 4 % was done, the shear strength value decreased; due to rice husk ash that was too much which make the soil to become loose as the bonds between grains of soil were damaged and weakened.

Table 5 Improvement value treated compared to the original soil

No.	Variety Mixed	Changing Result of Original Soil (%)		
		Cohesion	Friction Angle	Shear Strength
1	0.4SKP0ASP	-20.97	30.37	-19.7
2	0.6SKP0ASP	6.03	33.03	6.64
3	0.8SKP0ASP	-13.5	46.8	-12.06
4	1SKP0ASP	-16.08	89.36	-13.69
5	0.4SKP2ASP	47.8	42.29	47.5
6	0.6SKP2ASP	10.5	30.96	10.94
7	0.8SKP2ASP	88.4	44.94	87.08
8	1SKP2ASP	47.71	29.58	47.13
9	0.4SKP4ASP	-37.64	2.98	-36.56
10	0.6SKP4ASP	-33.18	30.02	-31.59
11	0.8SKP4ASP	-14.44	27.09	-13.42
12	1SKP4ASP	-23.27	12.2	-22.35

Description: SKP = Plastic Fibre, ASP = Rice Husk Ash

4.0. CONCLUSION

The analysis and explanation of the results can be concluded as follows:

(a) Based on the test results, the soil samples were used according to the classification system USCS including CL group and according to the classification system AASTHO including group A-7-6.

(b) The maximum cohesion value lies in the variation of 0.8 % fibre plastic sacks and 2 % bran ash which is 0.65 kg/cm^2, and the value of maximum shear angle lies in the variation of 1% fibre plastic sacks and 0 % bran ash which is 9.95 degree.

(c) In a variation of 0.8 % mixture of fibre plastic sacks and 2 % bran ash will increase soil shear strength value of 87.08 %, and for variations in mixture of 0.4 % plastic sacks fibre and 4 % bran ash will degrade shear strength to 36.56 %.

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