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USES OF LIME -RICE HUSK ASH AND PLASTIC FIBERS AS MIXTURES-MATERIAL IN HIGH-PLASTICITY CLAYEY SUBGRADE: A PRELIMINARY STUDY

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ABSTRACT

Silica produced from rice husk ashes have investigated successfully as a pozzolanic material in soil stabilization. However, rice husk ash cannot be used solely since the materials lack in calcium element. As a result, rice husk ash shall be mixed with other cementitious materials such as lime and cement to have a solid chemical reaction in stabilization process. The main objective of this study focused on bearing capacity of the stabilized clayey subgrade with lime-rice husk ash and fibers. The main laboratory test shall be compaction and CBR tests. The investigation results revealed that the inclusion of lime-rice husk ash-fiber into the soil decreased MDD and OMC. On the other hand, stabilization and reinforcement with lime-rice husk ash and fibers waste improved significantly the CBR values.

***Keywords**: soil improvement, clay soil, lime-rice husk ash, plastic-sack fiber, compaction, CBR.*

INTRODUCTION

Soil improvement by using rice husk ash has been investigated in early 1970s. During the 30 years, many laboratory investigations have done to study the effect of rice husk ash on the mechanical properties of the stabilized soils. Rice husk ashes are rich with siliceous materials. A material containing siliceous material is suitable to be used as pozzolana mix and replacement of portland cement. In practice, rice husk ash cannot be used solely since the materials lack in calcium element. As a result, rice husk ash shall be mixed with other cementitious materials such as lime and cement to have a solid chemical reaction in stabilization process. In this paper, utilization of the rice husk, lime, and fiber is presented to illustrate its application for subgrade mixtures.

Review Of The Rice Husk Ash Stabilized Soils

Basha et al (2004) reported that rice husk ash was potentially to stabilize the expansive and non expansive soils solely or by mixing with cement. In general, 6 – 8 % of cement and 10 – 15 % rice husk ash showed optimum amount to improve the properties of soils. Reduction in plasticity index, the increase of strength and resistance to immersion were indicator of soil improvement. Addition of lime and rice husk ash reduced liquid limits while the plastics limits increase. As a result, the plasticity indices reduced. Reducing the plasticity index resulted in increases of the shear strength, cohesion, and internal friction angle of the stabilized soils (Muntohar, 2002).

To improve tensile strength of the stabilized soils, Muntohar (2006) reinforced the stabilized soil by using plastic-sack fibers. The investigation showed that plastic-sack fiber increased the tensile strength of the stabilized soil with lime and rice husk ash. Santoni et al. (2000) observed that inclusion of the fiber in sand soils improved the unconfined compressive strength.

RESEARCH METHOD

Materials used

Soil

The soil used in this study comprises of 14% sands, 67% silts, and 19% clays fraction. The particle size distribution is shown in Figure 1. The soil texture is likely to be categorized as clayey-silt soils. The liquid limit was tested using Casagrande method, and the N-flow curve is shown in Figure 2. Based on the figure, the liquid limit of the soil sample was range from 66% to 90%. The plastic limit of the soil sample is 29%. Hence, the plasticity index of the soil sample is about 37% to 615, and the soil is classified into CH symbol (high-plastic clay) and A-7-6 group according to USCS and AASHTO classification respectively. Table 1 presents the index properties of the soil used in this study.

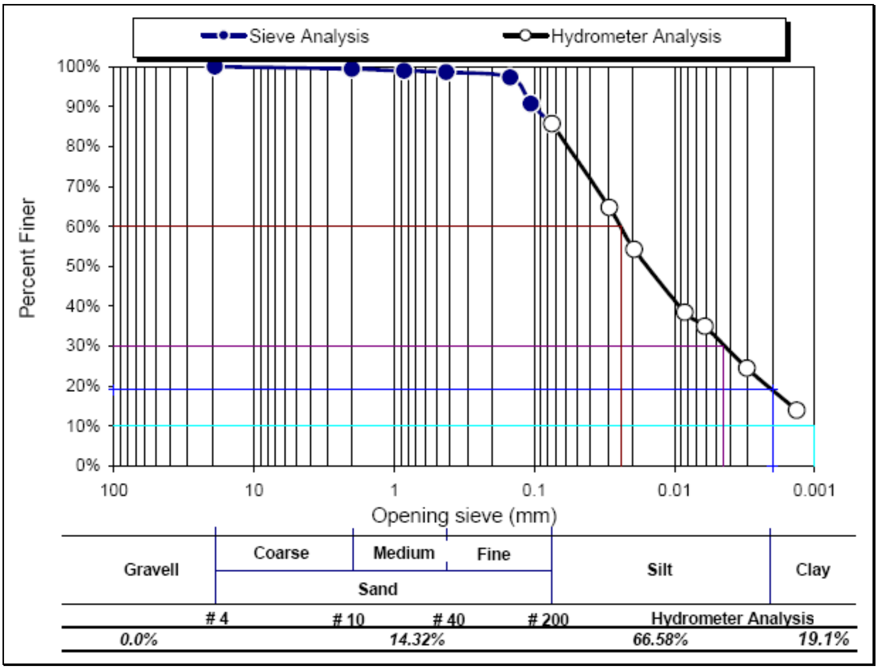

Figure 1 Particle size distribution of the soil used in this study.

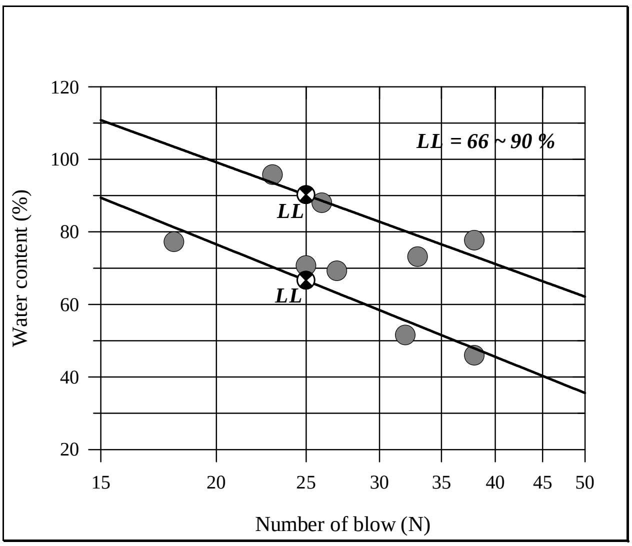

Figure 2 Liquid limit determination of the soil used in this study.

Table 1 Index properties of the soils sample.

Properties	Results
Specific Gravity, G_s	2.35
Liquid limits, LL Plastic limits, PL	60 %-90 % 29
Maximum dry density, MDD Optimum moisture content, OMC	12.7 kN/m^3 20.27 %
Soil fraction: a. Clay b. Silt c. Sand	 19 % 67 % 14 %
Soil classification:	CH (USCS) A-7-6 (AASHTO)

Lime and Rice Husk Ash

The lime used in this study was powder-hydrated lime. For soil stabilization purpose, materials passed ASTM sieve No. 40 (0.43 mm) was used as mixture material. The rice husk ash was produced locally which has obtained from rice husks burnt in a brick industry near Yogyakarta. To produce a fine rice husk ash, the rice husk should pass the ASTM sieve size No. 40. Both of the lime and rice husk ash are stored in air-tight plastic bag to prevent hydration reaction with environment-moist.

Fibers

The fibers used in this research were obtained from plastic-sack waste which is predominantly made from *polypropylene* materials. The fibers was decomposed and seized in 5 mm to 25 mm length. The fibers width was about 1.5 mm.

Laboratory Tests

The main objective of this study focused on bearing capacity of the stabilized clayey subgrade with lime-rice husk ash and fiber. Hence the main laboratory test shall be compaction and CBR tests. The test procedures of compaction and CBR were conducted according to ASTM D 968-70 and ASTM 1883-73 respectively. For the stabilized soils, the admixture materials, i.e. lime, rice husk ash, were mixed in 12 % and 24 % of the dry weight of soil matrix respectively. The fiber content was varied from 0.3 % and 0.6% of the dry weight of soil matrix. The specimens for CBR test were prepared at their optimum moisture content and maximum dry density of proctor-standard compaction. Before the CBR test, the samples were kept cured in air-tight plastic bags to prevent the loss of moisture for 14 days and to allow chemical reaction between the soil and admixtures.

The basic CBR test involves applying load to a small penetration piston at a rate of 1.3 mm (0.05") per minute and recording the total load at penetrations ranging from 0.64 mm (0.025 in.) up to 7.62 mm (0.300 in.). Figure 3 shows the sketch of CBR test. Values obtained are inserted into the following equation to obtain a CBR value:

$$CBR = \frac{P_a}{P_s} \times 100\%$$

where:

P_a = unit load on the piston (pressure) for 2.54 mm (0.1 in.) or 5.08 mm (0.2 in.) of penetration

P_s = standard unit load (pressure) for well graded crushed stone:

P_s = 6.9 MPa (1000 psi) for 2.54 mm (0.1") penetration

P_s = 10.3 MPa (1500 psi) for 5.08 mm (0.2") penetration

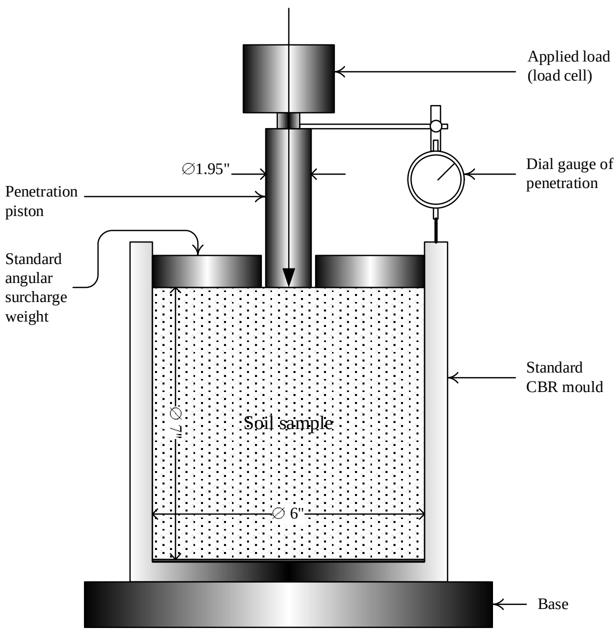

Figure 3 Sketch of CBR test.

ANALYSIS AND DISCUSSION

The tests results of proctor-standard compaction and CBR are presented in the Table 2. The following section will present the discussion of the test results.

Table 2 Geotechnical Properties of Treated Samples.

o.	Soil samples	MDD (kN/m^3)	OMC (%)	CBR (%)
1	Original soil	12.7	20.3	4
2	Soil + L + RHA	10.3	15.6	8
3	Soil + L + RHA +0.3% Fiber	10.54	15.5	27
4	Soil + L + RHA +0.6% Fiber	10.5	15.4	3

Note: L = 12 % lime, RHA = 24 % rice husk ash, MDD = maximum dry density, OMC = optimum moisture content.

Compaction Characteristics

Figure 4 shows the effect of adding plastic-sack fiber on the compaction characteristic of the stabilized soils. In general, the compaction curves of the stabilized soils (S2, S3, S4) are lower than the compaction curve of the unstabilized soils (S1). All the stabilized soils are on the left-side of the optimum moisture content of the unstabilized soil (S1). This characteristic imply that maximum dry density and optimum moisture content of the stabilized soil decreased with addition of fiber amount in stabilized soils. As presented in Table 2, the maximum dry density decreased from 12.7 kN/m^3 (S1) to 10.3 kN/m^3 (S2). The results show that the maximum dry density increased slightly if the stabilized soils are reinforced with 0.3 % (S3) and 0.6 % (S4) fibers. The results also show that the optimum moisture content decreased from 20.3% (S1) to 15.4 % (S4). The characteristics indicated that inclusion of fibers into stabilized soils do not change significantly the maximum dry density and optimum moisture content.

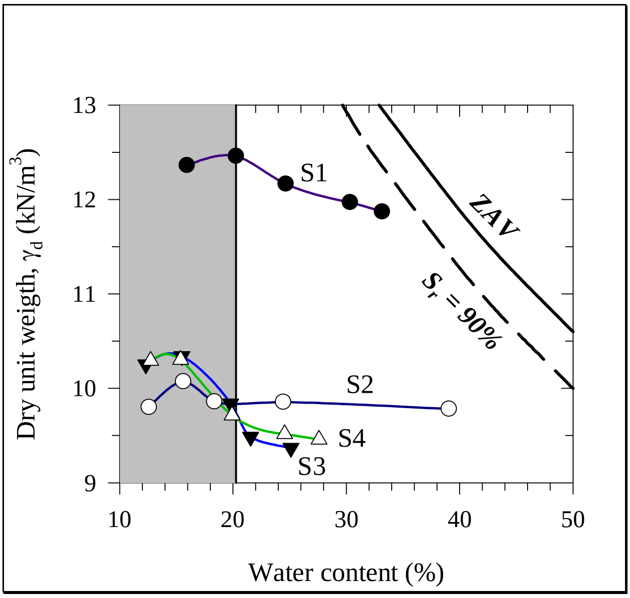

Figure 4 Compaction characteristics of the soil samples (ZAV = zero air void, S_r = degree of saturation).

Theoretically, increasing of maximum dry density value is an indicator of improvement. But, this characteristic is shown in the recent study. The possible reasons causing the behavior is owing to the flocculated soil-grain as a result of the pozzolanic reaction between lime-rice husk ash and soils. Coincidently, a larger void was formed between the soil particles and then, the void was occupied by air. However, since the pozzolanic reaction yield stiffer granulated-soil skeleton, the stabilized soil was not easier to be compacted at the same compactive energy as the unstabilized soil. As shown in Figure 4, the dry density of stabilized soils is located below the zero air void curve. Muntohar (2002) indicated that decreases in maximum dry density of stabilized clay soil with line-rice husk ash were owing to low specific gravity.

California Bearing Ratio (CBR)

California bearing ratio (CBR) value are the commonly method used to evaluate the bearing capacity of a subgrade for roadway. Subgrade strength is expressed in terms of its CBR value in percentage. The CBR value is measured by an empirical test devised by the California State Highway Association and is simply the resistance to a penetration of 2.45 inch of a standard cylindrical plunger to various penetrations in crushed aggregate, notably 13.24 kN (or 6.9 MPa) at 2.54 mm (0.1 in.) penetration and 19.96 kN (or 10.3 MPa) at 5.08 mm (0.2 in.)

penetration. Figure 5 shows the CBR test results of the soil samples which present pressures at various penetrations.

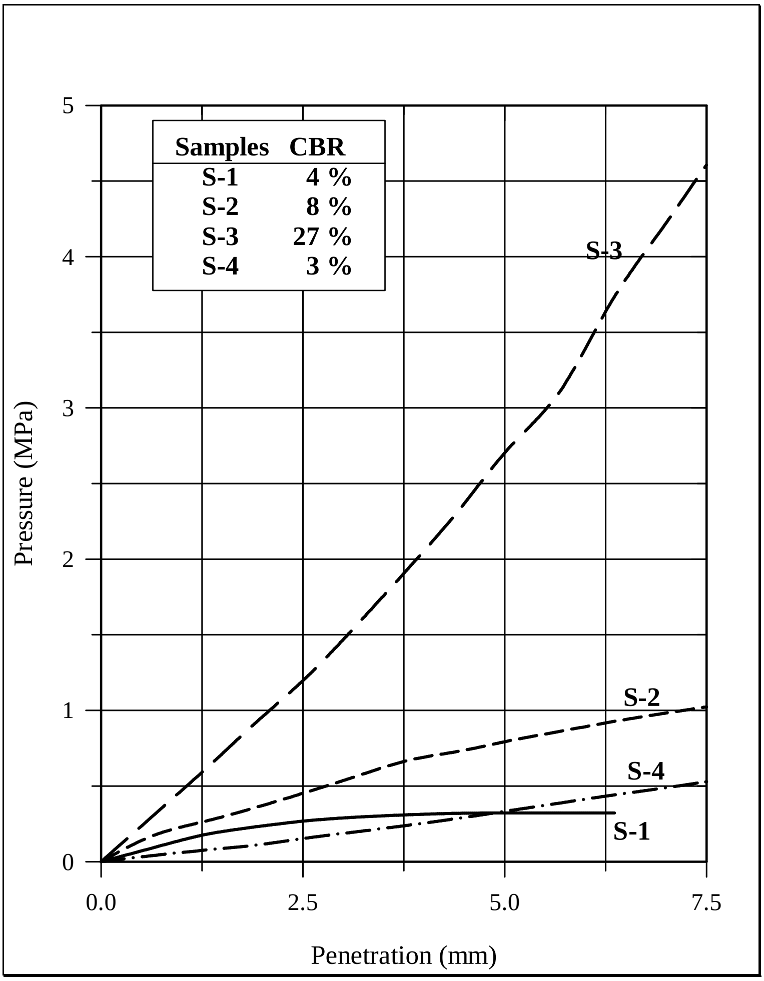

Figure 5 Pressure and penetration relationship of the tested soil samples.

Figure 5 shows that the stabilized soils with lime-rice husk ash (S2) has higher resistivity against the applied load at 2.54 mm and 5.08 mm penetration if comparing with unstabilized soil (S1). By mixing with lime-rice husk ash, the CBR value of clay soils enhances double from 4% to 8%. This behavior indicates that stabilization process has worked as expected of pozzolanic reaction. Inclusion of 0.3% fibers into stabilized soils (S3) increase the CBR value about 7 times from 4% to 27%. This result indicates that inclusion of the fibers contribute to against the applied load. Additional inclusion fibers to 0.6% into stabilized soil cause decreasing of the CBR value to about 3%. However, the penetration curve of the stabilized soils (S4) can be extended up to 7.5 mm.

Table 3 Classification of the CBR values for subgrade or base course layer. (Bowles, 1986)

CBR (%)	General rating	Uses
0 – 3	Very poor	Subgrade
3 – 7	Poor to fair	Subgrade
7 – 20	Fair	Subgrade
20 – 25	Good	Base subgrade
>75	Excellent	Base

Uses the classification given in Table 3, the stabilized soil samples can be used as subgrade and base course respectively for S2 sample and S3 sample. For the given CBR values, the rating of the subgrade range from fair to excellent.

CONCLUSIONS

This study has been successfully investigated the used of lime-rice husk ash and fiber waste as stabilization and reinforcement for clay soils. Based on the investigation results, the following conclusions can be drawn:

1. Addition of the lime and rice husk ash in clay soil decreases significantly the maximum dry density and optimum moisture content. Inclusion of the fibers waste only reduces slightly the maximum dry density and optimum water content of the stabilized soils.
2. The CBR value of the stabilized soil with lime and rice husk ash increases double. Inclusion of the fiber waste in the stabilized soils increases significantly the CBR value.
3. Stabilization and reinforcement of the clay soil with lime-rice husk ash and fibers waste can be applied as subgrade or base course for roadway construction.

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