The use of Lapindo mud and emulsion asphalt as mixed materials in clay stabilization to increase compressive strength

H Hendry*, R Imbang, S Syahril, A K Somantri and R M Pramaesti
Department of Civil Engineering Lecturer of Politeknik Negeri Bandung, Bandung, Indonesia

*hendry@polban.ac.id

Abstract. Land is one of the construction materials available in the field that has diverse properties. Clay is a bad type of soil if it has poor soil properties such as high plasticity, low shear strength, high swelling, and large shrinkage potential. Soil stabilization is an effort to improve the quality of the soil by using certain materials to increase soil strength. Soil improvement by using mixture materials are mostly done to stabilize the soil. The mixing material used is Lapindo mud. A number of soil improvement techniques are offered to overcome problems in soft soil. The selection of soil improvement techniques is generally based on the formation of soil geology, soil characteristics, and costs. The stabilization used is emulsion asphalt which is locked of 8% and Lapindo mud variation of 3%, 6%, 9% and 12%. The results of physical and mechanical properties on soil material with stabilization of Lapindo mud and emulsion asphalt were obtained that the specific gravity increased by about 68%, with the density value (\(\omega_{opt}\)) of 16% and the dry weight content (\(\gamma_d\)) of 6%. In the compressive strength testing, the more Lapindo mud mixture, the less compressive strength (\(qu\)) value.

1. Introduction
The development and growth of a city cannot be separated from the increase in population with a variety of diverse activities and a high level of mobility. Various kinds of physical facilities and infrastructure are continuously being built by the government to support the activities of the population, with the aim of increasing the level of welfare and progress of the residents of a city. Increased construction of physical facilities and infrastructure will result in changes in land use, so that less open land.

A number of soil improvement techniques are offered to overcome problems in expansive clay-type soils. The selection of soil improvement techniques is generally based on the geological formation of the soil layer, soil characteristics, cost and availability of materials, ease of implementation/applicability, and experience.

Land is under road construction. Soil conditions in the field greatly affect the type of foundation used by the construction on it. Expansive land is a type of soil that is dangerous if erected building structures on it. Expansive soils have poor soil properties such as high plasticity, low shear strength, high density or volume change, and large potential for shrinkage [1]. This laboratory study investigates whether sands and soil-clay aggregates are amenable to stabilization by asphalt emulsion [2]. Nevertheless, successful use of emulsified asphalt in sand and cohesive graded sands has been reported [3-5]. The vacuum soaking test developed by Dunning and Turner (~ 14) was adopted here for evaluating the moisture sensitivity of the mixtures.
Soil stabilization is an attempt to improve the soil's technical properties by using certain materials to add strength to the soil [6]. Based on the content of the Lapindo mud used as a cement substitute material, in the manufacture of concrete. Lapindo research results mud, can be used as a mixture of materials, manufacturing of solid concrete [7,8]. Soil improvement by using a mixture of materials is mostly done to stabilize the soil. Mixing materials used include Lapindo mud [9], the purpose of this study was to determine and obtain several physical and mechanical parameters in stabilizing soil with Lapindo mud and asphalt emulsion by increasing the value of free compressive strength, as an alternative to soil improvement.

2. Research method

2.1. Research investigation in the laboratory
Laboratory investigations will be carried out to obtain the free compressive strength (\(q_{u}\)) value of the original soil test specimens and the lapindo mud modification. Laboratory investigations carried out must comply with ASTM / SNI standards. Figure 1 is a flowchart of investigation in a laboratory.

![Flowchart](image)

*Figure 1. Research investigation methodology in the laboratory.*

For the above tests with 4 mixed variables, the number of samples that must be prepared can be seen in Table 1 below.
Table 1. Number of test samples.

| Testing Methods               | Sample |
|-------------------------------|--------|
| Specific Gravity              | 15     |
| Atterberg Limit               | 8      |
| Compaction                    | 20     |
| Unconfined Compression (qu)   | 48     |

3. Results and discussion

3.1. Test result of mixed subgrade physical characteristics

In the section explained the results of research conducted, namely the results of testing the characteristic of the subgrade (Grain size, Specific Gravity and atterberg limits) before and after mixing with stabilization materials, Table 2 as follows:

Table 2. Physical properties testing and mix.

| Index Properties | Symbol | Unit | Variable |
|------------------|--------|------|----------|
| 1 Grain Size     |        |      | 0 1 2 3 4 5 |
| 1.1 Gravel       | G      | %    | 0 - - - - |
| 1.2 Sand         | Symbol | %    | 4.62 - - - - |
| 1.3 Silt         | M      | %    | 39.38 - - - - |
| 1.4 Clay         | C      | %    | 56 - - - - |
| 2 Specific Gravity | Gs    | %    | 2.59 1.86 2.05 2.08 2.03 2.46 |
| 3 Atterberg Limit |        | %    | 38 45 20.54 18 18 16 |
| 3.1 Plastic Limit | PL    | %    | 85 48 48.39 43 40 40 |
| 3.2 Liquid Limit  | LL     | %    | 47 3 27.86 25 22 25 |
| 3.3 Plasticity Index | PI   | %    | - 6 3.96 3 11 18 |

Information:
Mixture 0 = Original Soil
Variable 1 = Lapindo Mud
Variable 2 = 89% Soil + 8% Emulsion Asphalt + 3% Lapindo Mud
Variable 3 = 86% Soil + 8% Emulsion Asphalt + 6% Lapindo Mud
Variable 4 = 83% Soil + 8% Emulsion Asphalt + 9% Lapindo Mud
Variable 5 = 80% Soil + 8% Emulsion Asphalt + 12% Lapindo Mud

3.2. Test result of mixed subgrade mechanical characteristics

3.2.1. Compaction. The optimum water content tends to decrease with the increasing percentage of the constant% Emulsified Asphalt mixture and the% Lapindo Mud increase, as shown in Figure 2 below:

The optimum water content tends to decrease with the increasing percentage of the constant% Emulsified Asphalt mixture and the% Lapindo Mud increase, as shown in Figure 2 below:
Figure 2. Curve relationship between addition% Asphalt Emulsion + Variation of % Lapindo mud mix (ωopt).

On the ωopt the picture above shows that at 0 the mixture obtained an optimum water content of 31%, while the optimum water content (ωopt) resulting from a mixture of clay and 8% asphalt emulsion is locked and Lapindo mud mixture varies with a mixture of Lapindo mud 3% the optimum water content (ωopt) was 32.65%, 6% lapindo mud was 26%, 9% lapindo mud was 28.1% and in the mixture of 12% lapindo mud the optimum water level (ωopt) was 28.08%.

Figure 3. Curve Relationship between addition of 8% Asphalt Emulsion + Variation of lapindo Mud % to Dry Weight (γd).

From Figure 3 above it shows the dry weight (γd) of compaction that in 0 the mixture obtained the dry weight (γd) 1.18gr / cm³ while the dry weight content of the mixture results from clay and 8% locked emulsion asphalt and Lapindo mud mixture varied namely with a mixture of Lapindo mud 3% obtained optimum water content of 1.38gr / cm³, 6% Lapindo mud obtained 1,485gr / cm³, 9% Lapindo mud 1,477gr / cm³ and on a mixture of 12% Lapindo mud obtained dry weight of 1,475gr/cm³.
3.2.2. **Unconfined compression (qu)**

**Figure 3. Curve Unconfined Compression (qu).**

Using the compressive strength is considered to be one of the most popular methods for evaluating the performance of soil stabilization, and the compressive strength is one of the main parameters applied in the design of earthwork projects [10]. In addition, it is used to evaluate the durability of stabilized soil subjected to weathering conditions [11,12].

4. **Conclusion**

Based on the results of laboratory tests conducted in this study, there are a number of things that can be concluded, as follows:

- In compaction testing with the addition of Lapindo mud and asphalt emulsions to the soil mixture can significantly reduce the dry weight of the mixture. From compaction that the soil is obtained dry weight content of (\( \gamma_d \)) 1.18gr / cm³, while the dry weight content of the mixture from clay and 8% locked emulsion asphalt and Lapindo mud mixture varies with a mixture of Lapindo mud 3% obtained water content optimum of 1.38gr/cm³, 6% Lapindo mud obtained 1,485gr/cm³, 9% Lapindo mud 1,477gr/cm³ and in the mixture of 12% Lapindo mud obtained dry fill weight of 1,475gr/cm³. The optimum value of dry weight is variable 3 with a mixture of 6% Lapindo mud and 8% asphalt emulsion.

- From the results of testing the value of free compressive strength (qu) of 4 variables during the curing period of 0.3, and 7 days has increased. Whereas during curing 14 days the compressive strength value of 4 variables decreased with value.

**References**

[1] Kurniawan I D 2015 *Pengaruh Variasi Jarak dan Panjang Deep Soil Mixing (DSM) 15% Fly Ash Diameter 3cm Berpola Panels Terhadap Daya Dukung.* 2015.

[2] George K P 1976 Stabilization of sands by asphalt emulsion *Transportation Research Record* **593** 51-56

[3] M D J and K B 1970 Soil-emulsified Asphalt Stabilization *Alberta Departement of High-ways and Transportation*

[4] Fruedenberg G *First Results in Bituminous Stabilization in Agricultural Road Construction* **6**(4)
[5] R L C Use of Emulsified Asphalt in Base Stabilization *Univ. of Corolado.*
[6] Ismail A 2006 *Pengaruh Variasi Jarak dan Panjang Kolom*
[7] Müller H, Michoux N, Bandon D and Geissbuhler A 2004 A review of content-based image retrieval systems in medical applications—clinical benefits and future directions *International journal of medical informatics* **73**(1) 1-23
[8] Aristianto 2006 *Preliminary examination of Sidoarjo Mud for Ceramic Products*
[9] Susilo H and Zaika 2016 Pengaruh Jarak Dan Panjang Kolom Dengan Diameter 4 Cm Pada Stabilisasi Tanah Lempung Ekspansif Menggunakan Metode Dsm Berpola Single Square Terhadap Daya Dukung Tanah *Jurnal Mahasiswa Jurusan Teknik Sipil* **1**(2) pp-1143
[10] Yarbaşı N, Kalkan E and Akbulut S 2007 Modification of the geotechnical properties, as influenced by freeze–thaw, of granular soils with waste additives *Cold regions science and technology*, **48**(1) 44-54
[11] Zhang Z and Tao M 2008 Durability of cement stabilized low plasticity soils *Journal of geotechnical and geoenvironmental engineering* **134**(2) 203-213
[12] Ghazavi M and Roustaie M 2010 The influence of freeze–thaw cycles on the unconfined compressive strength of fiber-reinforced clay *Cold regions science and technology* **61**(2-3) 125-131