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RESEARCH ARTICLE

LAPINDO MUD BEHAVIOR STABILIZATION USING SAND MIXTURE.

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Abstract

Landfill work is now increasingly needed in the project implementation to improve the carrying capacity and to increase the original soil elevation. Good subgrade stability is able to support the above structural loads and is low in plasticity. The soil that is usually used for landfill is hard soil, red soil, or semi-hard soil. The increasing need of landfill soil, hard or semi-hard soil as materials will eventually decrease in its availability. This research tried to use Lapindo mud as landfill soil so as to reduce the volume of mudflow as well as to be a consideration in carrying out the future infrastructure development. To improve the characteristic quality, stabilization using additional sand mixture was carried out. By adding sand to Lapindo mud, the gradation is tighter so that its density level will be increased. This research used experimental method with Soil Mechanics laboratory test. The laboratory test includes Grain Gradation Analysis, Atterberg Limit, Compaction, CBR Laboratory, Direct Shear, Unconfined, and Free Swelling. The specimens include Lapindo mud from Sidoarjo and sand for building materials. The sand concentration used was 10%, 20%, 30%, 40% and 50% of the mud weight.

Conclusion: Due to the addition of 40% sand, the liquid limit value of Lapindo mud decreased from 57.33% to 33.33% and the plasticity index decreased from 24.67% to 13.33%. The compaction test results of γ_{dmax} increased from 1,317 gr/cm³ to 1,624gr/cm³ on the addition of 50% sand. The results of CBR test also increased from 3.65% to 7.59% on the addition of 40% sand. Direct shear test resulted in the increase of inner shear angle from 13.22 degree to 27.92 degree on the addition of 50% sand. Unconfined compression test showed the increase from 0.86 kg/cm² to 1.02 kg/cm² on the addition of 20% sand. While the free swelling test showed a decrease from 2.28% to 1.29% on the addition of 50% sand.

Based on the liquid limit value, plasticity index, and swelling result, Lapindo mud in Sidoarjo is classified as high-plasticity soil. Based on the value of γ_{dmax} , q_u , inner shear angle and C.B.R, Lapindo mud is categorized as soil with low carrying capacity. After being mixed with 40% sand, Lapindo mud is classified as medium-plasticity soil with good carrying capacity.

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Introduction:-

Soil stabilization is one of the methods used to change or improve the subgrade characteristics so that it is expected to have better quality and can improve the subgrade carrying capacity for constructions built on it [1]. More than 640 hectares of productive land in Sidoarjo have been submerged by the mudflow. The original form of mud is semi-crystalline and is rich in silica and aluminum oxide with more than 85% total amount of SiO_2 , Al_2O_3 and Fe_2O_3 . That composition is almost similar to that in cement in which silica is possible to be used as a substitute for cement with a certain degree of tolerance [2].

The levels of Lapindo mud are more than 50% effective in stabilizing the clay soil in Sumenep area to be potential for development, while increasing Lapindo mud carrying capacity to a maximum of 40% [3]. According to the results of attenberg limits and swelling test, the addition of 25% Lapindo mud as the stabilizing agent was the effective amount to change clay physical properties. As for the mechanical properties of clay soil, 20% addition of Lapindo mud was in accordance with the results of standard proctor test, Direct Shear, C.B.R , and Unconfined Compression.[4]

Sand has been known as one of excellent stabilizing agents, especially for clay soil which has greater shrinkage properties that can be reduced or even removed by adding sand mixture to the clay soil. The presence of soil makes the gradation tighter, increases the density, as well as resisting soil expanding property [5]. The greater the combination of the lime and sand, the denser subgrade stabilization will be. It was shown by the CBR rate of 26.78% using the combination of 15% lime and 30% sand. The 96.12% increase of CBR rate for the natural soil indicates that the soil is well-graded. In addition, at each 5% lime increase and 10% sand increase, the CBR average increased between 12.96% - 34.40% [6].

The maximum addition of mud 15% and the minimum of 30% steel slag is effectively used as additional material of clay stabilization because it can decrease plasticity and increase soil carrying capacity [7]. San grains are generally between 0.0625 to 2 millimeters. The addition of sand to Lapindo mud is expected to improve soil stability and to improve the gradation of Lapindo mud so that the mud gradation is not dominant in fine gradation only. In addition, it can function as a filler material in mud so that it may inhibit the soil expansion due to changes in water content. The addition of sand to clay soil in Kebraon is good enough to improve soil physical and mechanical properties [8]. The use of 40% sea sand is good enough to reduce the plasticity and increase soil carrying capacity based on CBR value [9].

Landfill work is now increasingly needed in the project implementation to improve the carrying capacity and to increase the original soil elevation. Good subgrade stability is able to support the above structural loads and is low in plasticity. The soil that is usually used for landfill is hard soil, red soil, or semi-hard soil. The increasing need of landfill soil, hard or semi-hard soil as materials will eventually decrease in its availability [10].

This research tried to use Lapindo mud as landfill soil so as to reduce the volume of mudflow as well as to be a consideration in carrying out the future infrastructure development. To improve the characteristic quality, stabilization using additional sand mixture was carried out. By adding sand to Lapindo mud, the gradation is tighter so that its density level will be increased.

Methods:-

Stages in this research are as follows:

Preparatory Work

The procurement of mud and sand used for this research that was Lapindo mud from Sidoarjo, Indonesia and sand for building materials.

Test specimen making included Lapindo mud and sand mixture (10%, 20%, 30%, 40% and 50%)

Data Collection

1. The data needed were the results of testing at the Soil Mechanics Laboratory including:
2. Preliminary testing

3. Atterberg Limit to determine soil shrinkage properties based on the Liquid Limit (LL) value and Plasticity Index (PI)
4. Density (Standard Proctor) to determine soil density level based on dry volume weight (γ_d) and optimum water content ($\omega_{optimum}$)
5. Further testing with the sample of Standard Proctor density level, including:
6. CBR laboratory to determine soil carrying capacity as the pavement subgrade based on CBR value.
7. Direct Shear to determine the strength of ground shear based on shear stress value (τ), cohesion (C) and inner shear angle (ϕ)
8. Unconfined Compression to determine soil carrying capacity in withstanding direct vertical forces based on the value of limit carrying capacity (q_u)
9. Free swelling to determine soil properties if the water content increases based on the swelling value.

Result And Discussion:-

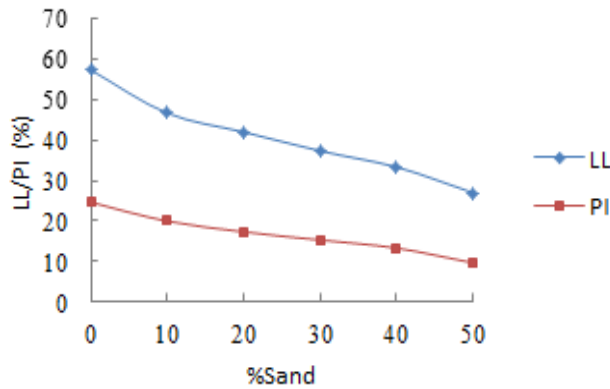


Figure 1:-The Relation of Sand Percentage and Liquid Limit or Plasticity Index

Figure 1, result of atterberg limit test, LL and PI value decreased along with the increase of soil addition percentage to Lapindo mud. Lapindo mud obtained liquid limit value of 57.33%, plastic limit value of 32.67%, and plasticity index of 24.67% that has a high potential for development. After adding sand mixture concentration of 40%, Lapindo mud obtained decrease in liquid limit value to 33.33%, plastic limit value to 20%, and plasticity index to 13.33% showing medium potential for development [11,12]

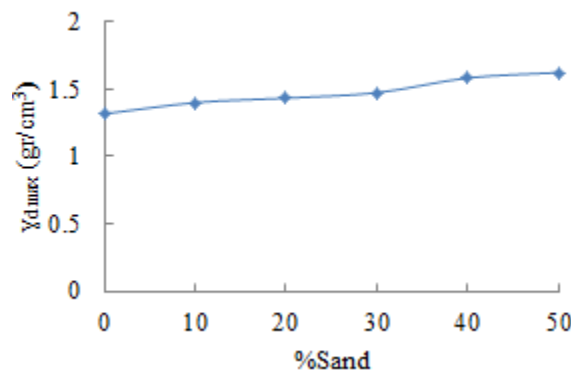


Figure 2:-The Relation of Sand Percentage and Dry Volume Weight ($\gamma_{d\ max}$ (gr/cm³))

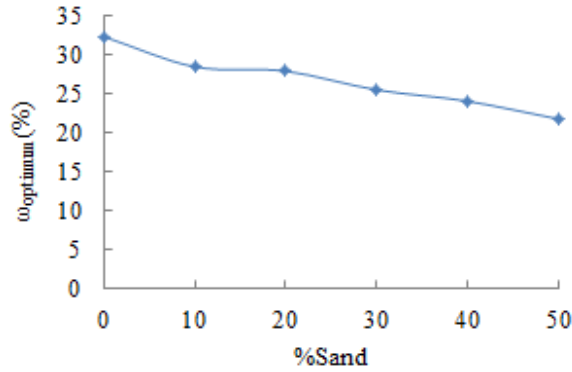


Figure 3:-The Relation of Sand Percentage and Optimum Water Content ($\omega_{optimum}$ (%))

Figure 2. shows that the dry volume weight has an increase after stabilization process of Lapindo mud using sand mixture of 10%, 20%, 30%, 40%, 50%. The addition of sand made the mud gradation more heterogeneous and denser when compacted so that the particles can fill each other.

Figure 3. shows the optimum water content needed to maximize the density of Lapindo mud is decreasing as the more sand added.

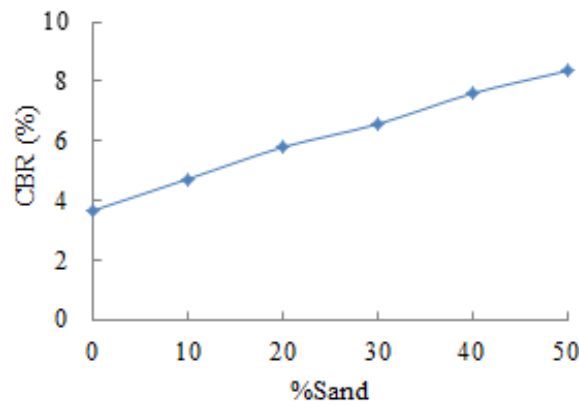


Figure 4:-The Relation of Sand Percentage and CBR Laboratory

Figure 4. shows that CBR value increases as sand concentration for stabilizing agent of Lapindo mud increases. Initially, CBR value of Lapindo mud was 3.65% and fell into poor category, on the sand addition of 50%, CBR value reached 8.35% which was in fair category with CBR range value of 7-20% [12]

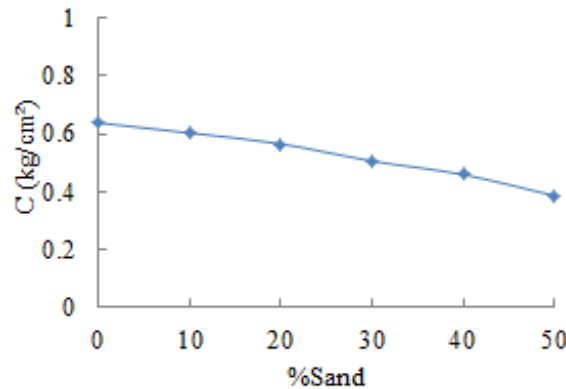


Figure 5:-The Relation of Sand Percentage and Cohesion Value (C (kg/cm²))

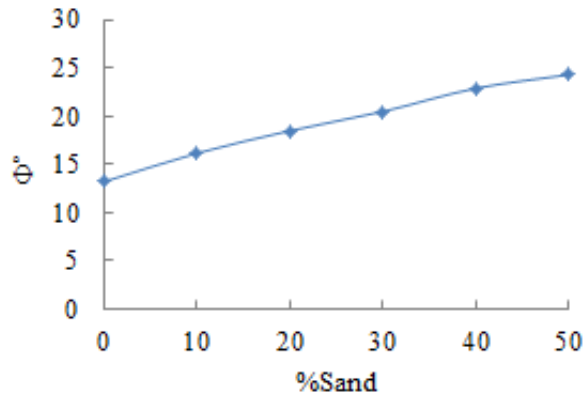


Figure 6:-The Relation of Sand Percentage and Inner Shear Angle (Φ)

Figure 5. shows that the addition of sand as Lapindo mud stabilizing agent decreased the cohesion value from 0.638 kg/cm² to 0.386 kg/cm² on 50% sand.

Figure 6. shows that the addition of sand as Lapindo mud stabilizing agent increased the inner shear angle from 13.217° to 24.297° on 50% sand.

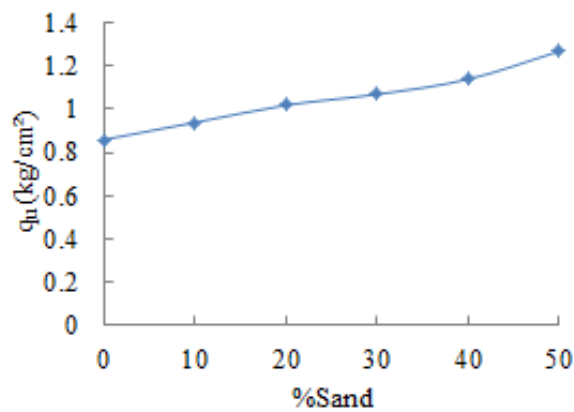


Figure 7:-The Relation of Sand Percentage and Unconfined Compression (q_u (kg/cm²))

Figure 7. shows that there was an increase in the unconfined compression as the sand mixture concentration increased, after being stabilized using sand mixture, the carrying capacity to withstand vertical forces was getting better. Initially, Lapindo mud had $q_u = 0.86$ kg/cm² with medium category after the addition of 50% sand, the value of $q_u = 1.27$ kg/cm² with hard category

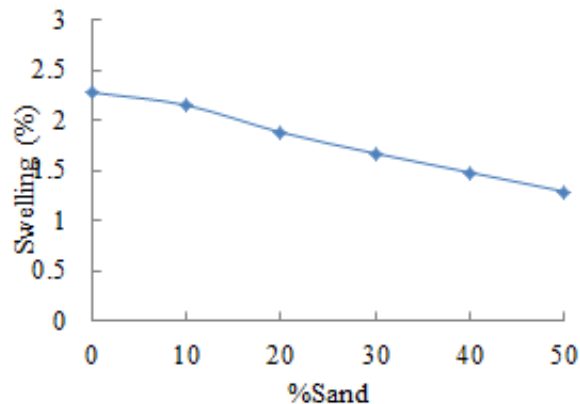


Figure 8:-The Relation of Sand Percentage and Swelling Value (%)

Figure 8. shows that the swelling value is decreasing with sand addition. Lapindo mud has easy-to-swell property which was getting better after sand addition and is suitable for subgrade to support the structure above it. Initially, the swelling value of Lapindo mud was 2.28% with medium swelling rate between 1.5-5%. On the 50% sand addition, the swelling value decreased to 1.29% with swelling rate of 0 – 1.5% which is low [11,12].

Conclusion:-

After the tests at the laboratory, calculation and test result analysis, it can be concluded as follows:

1. Lapindo mud has liquid limit value of 57.33%, plastic limit value of 32.67%, and plasticity index of 24.67%. After 40% sand addition, liquid limit value decreased to 33.33%, plastic limit value to 20%, and plasticity index to 13.33%.
2. Dry Volume Weight value of Lapindo mud was 1.32 gr/cm³ and Optimum Water Content value was 32.35%. After the addition of 40% sand, γ_{dmax} . value increased to 1.58 gr/cm³ and Wopt. value decreased to 24.09%.
3. C.B.R value of Lapindo mud was 3.65% and on the 40% sand addition, it increased to 7.59%.
4. Based on direct shear test, the cohesion (c) value of Lapindo mud was 0.638 kg/cm² and the inner shear angle (Φ) was 13.217°. After 40% sand addition, the cohesion value decreased to 0.459 kg/cm² and the inner shear angle increased to 22.897°.
5. Unconfined compression test on Lapindo mud resulted in unconfined compression value (qu) of 0.86 kg/cm², after 20% sand addition, it increased to 1.02 kg/cm².
6. Swelling test on Lapindo mud resulted in swelling rate of 2.28% and after 50% sand addition, it increased to 1.29%
7. The best and most effective amount of sand mixture used as stabilizing agent of Lapindo mud was $\geq 40\%$ sand concentration. Based on the value of liquid limit, plasticity index, and swelling rate, Lapindo mud was categorized as soil with high plasticity. From the result of dry volume weight, unconfined compression, inner shear angle, and C.B.R, Lapindo mud was categorized as soil with low carrying capacity. After being mixed with $\geq 40\%$ sand, Lapindo mud was categorized as soil with medium plasticity and good carrying capacity.

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