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DECREASING THE PLASTICITY INDEX AND IN DECREASING THE CBR RATE OF THE SUB GRADE USING THE MIXTURE OF LIME AND SAND

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ABSTRACT

Lime and sand are known as the good stabilizing agents, mainly due to the cation (Ca2+) within the lime which provides the bonds between some bigger particles, while the sand becomes denser. Moreover, as it grows denser, it goes against the soil expansion nature and increases its CBR. The soil's CBR remains constant while it is not expanded.
Based on the previous studies:

- Lime can be utilized as the additional material of clay soil's stabilization in order to reduce its plasticity index and enlarge CBR rate by 10%; LL rate by 49.33%; PI by 31.47%; swelling by 27.67%; and CBR by 16.3%. It shows very high plasticity index and fair-graded for sub grade
- Sand can be used as the additional material to stabilize clay soil by 40% minimum in order to reduce its plasticity index and increase CBR rate; with LL rate at 37%; PI at 11.72%; swelling at 1.16%; CBR at 16.48%. It implies medium plasticity index and fair-graded for sub grade

This research continues to find out about the stabilization of the sub grade using the mixture of lime and sand as the additional material in order to reduce the sand's percentage, decrease plasticity index, and increase CBR rate.
Meanwhile, experimental method using laboratory's test result is employed as the research method. The experiments include Atterberg Limit Test, standart proctor test, CBR Laboratory test, and free swelling test.
The findings are then analyzed using quantitative method. This research concludes that sub grade stabilization which is conducted by mixing lime and sand is more effective than using lime-mixed or sand-mixed alone. It is because the same CBR rate and plasticity index can be obtained by reducing the lime percentage and sand percentage. When mixing 15% lime and 30% sand, LL rate is recorded at 35.89%; PI rate is at 3.77%; swelling rate is at 1.33%; and CBR is at 26.78%. It implies low plasticity index and well-graded for sub grade. For the each 5% increase of lime and 10% of sand, there are decreases in LL (7.45% - 14.45%), PI (27.91% - 37.83%), and swelling rates (37.18% - 49.97%); as well as the increase average of CBR rate (12.96% - 34.40%).

Keyword: sand, lime, stabilization, CBR, Swelling.

INTRODUCTION

Background of study

If the sub grade available is too permeable, having low CBR rate, hight plasticity index, or other requirements which do not meet the requirement of standard sub grade, it means that the soil needs to be stabilized. The materials usually utilized are lime, cement, sand, bitumen, and many others (depend on the soil category and its problems) (1), (2), (3).

Andrews, Oflaherty, and Warsity (2009) conducted a study on Enhancing CBR and Decreasing Sub Grade Swelling by Lime Stabilization Method using soil sample from Sendang Mulyo and lime from Purwodadi. The natural soil and lime (with 0%, 5%, 8%, 10%, and 12% percentage). CBR unsoacked: the percentage goes down to 10% from 11.8%, yet increases again to 22.1%; however, at the 12% of lime, the CBR rate decreases to 7.58%. On the other hand, the swelling decreases along with the increase of lime percentage. It implies that the bigger lime percentage are used, the smaller the swelling is. (4)

Gati Sri Utami (2015) stated that lime can be used as the additional material for clay soil stabilization by enhancing the CBR rate and decreasing the swelling at 10% maximum (CBR = 16.3%; LL = 49.33%; PI = 31.47%; swelling = 27.67%). (5)

Gati Sri Utami, Theresian MCA, Lukky A. (20015), sand can also be utilized as the additional material for clay soil stabilization by enhancing CBR and decreasing the swelling at 40% maximum (CBR = 16.48%; LL = 37%; PI = 11.72%; and swelling = 1.16%). (6).

Based on the aforementioned previous studies, this study provides a new insight on the sub grade stabilization using lime and sand as the additional materials. Those aim to reduce the sand percentage, decrease the plasticity index and increase CBR rate as subgrade. By reducing the sand percentage and improving CBR rate, the road stabilization and hardening costs can be lowered. Lower CBR rate implies that the hardening rate is thicker. (3)

Statements of Problems

The statements of problems in this study are as follows:

- How does the addition of lime and sand on the sub grade stabilization impact the plasticity index and swelling rate?

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- How many percentages of lime and sand on the sub grade stabilization needed in order to obtain the maximum CBR rate?

Research objectives

The objectives of this study are as follows:

- To find out the impact of lime and sand addition (in terms of sub grade stabilization) on the plasticity and swelling rate;
- To look into the percentage of lime and sand needed for sub grade stabilization in order to obtain maximum CBR rate.

Research significance of important

This study aims to inform the public, particularly the road construction workers, about one of the alternatives in stabilizing the sub grade to reduce its plasticity and improve its CBR rate.

RESEARCH METHODOLOGY

This study employs experimental method with laboratory's test results by making the samples from the mixture of natural soil, lime (5%; 10%; 15%), and sand (10%; 20%; 30%) with allowed stand of 3 days. It also employs Atterberg Limit test, standard proctor test, CBR laboratory test, and free swelling test. Furthermore, the data analysis is done using quantitative method, raw data is then processed, categorized, and interpreted in tables or graphics. Finally, the data are analyzed descriptively based on the standards of physical characteristics and soil mechanics as the sub grade. (7), (8), (9)

RESULTS AND DISCUSSIONS

Atterberg limit test

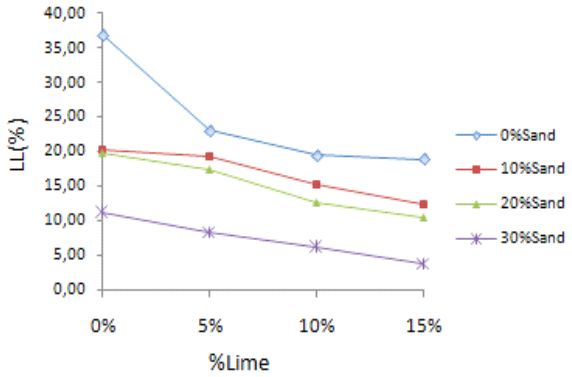

Figure-1. The relationship between the lime percentage and the liquid limit rate (LL) with the sand percentage's variation.

Based on Figure-1, the higher percentage addition from the mixture of sand and lime, the smaller LL value is against the natural soil, additional lime percentage, or additional sand percentage (5) (6).

Table-1. The decreasing of LL rate against the natural soil.

[redacted]

Table-2. The decreasing of LL rate for each additional percentage of lime (by 5%) and sand (by 10%).

[redacted]

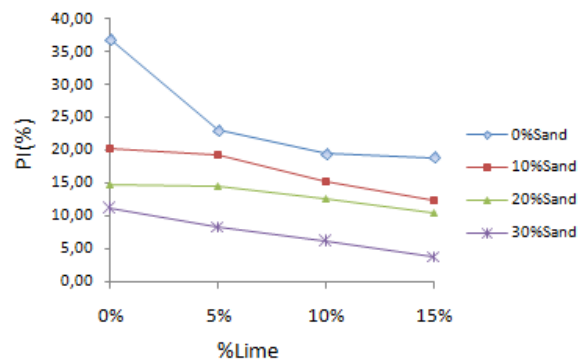

Figure-2. The relationship between lime percentage and the plasticity index with the sand percentage's variation.

Based on Figure-2, the higher percentage addition from the mixture of sand and lime, the smaller the PI is against the natural soil, additional lime percentage, and the additional sand percentage. (5), (6).

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Table-3. The decreasing of PI value against the natural soil.

Lime / Sand (%)	10	20	30
0	45,05	59,84	70,02
5	47,98	61,05	77,41
10	58,74	65,68	83,74
15	66,90	71,71	89,79

Table-4. The decreasing PI value for each additional percentage of lime (by 5%) and sand (by 10%).

[redacted]

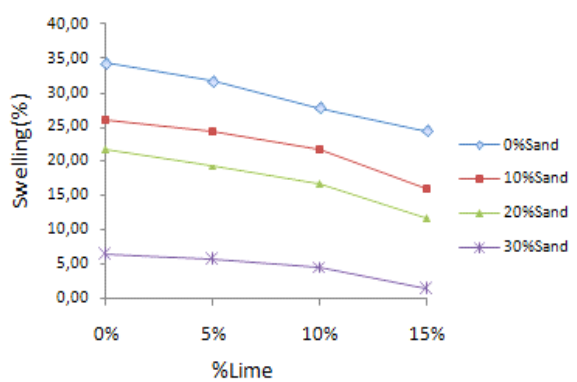

Figure-3. The relationship between lime percentage and swelling rate with the sand percentage's variation.

Based on Figure-3, the bigger the addition of lime and sand percentage, the smaller the swelling rate is (compare to the natural soil, additional lime percentage, or additional sand percentage. (5), (6).

Table-5. The decreasing of swelling rate against the natural soil.

[redacted]

Table-6. The decreasing swelling rate for each additional percentage of lime (by 5%) and sand (by 10%).

[redacted]

The natural soil records LL rate for 67%; PI rate for 36.96%; and swelling rate for 34.33%. It shows very high plasticity index.

The additional lime percentage (optimum 10%) records LL rate for 47.69%; PI rate for 19.42%; and swelling rate for 27.67%. It implies high plasticity index. The additional 30% of sand records LL rate for 41.00%; PI rate for 11.08%; and swelling rate for 27.67%. It implies medium plasticity index.

The additional 15% lime and 30% sand record LL rate for 35.89%; PI for 3.77%; and swelling rate for 1.33%. It is included in low plasticity soil. (7), (8).

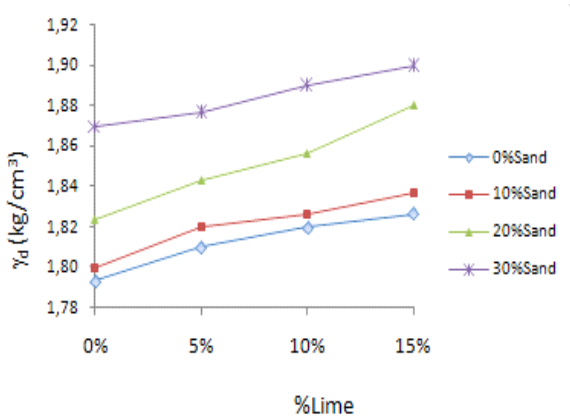

Figure-4. The relationship between lime percentage and γ_d (dry density) with the sand percentage's variation.

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Based on Figure-4, the higher percentage addition from the mixture of lime and sand, the higher γ_d is compare to its natural soil, additional lime percentage, or additional sand percentage. It indicates that the additional percentage from the mixture of lime and sand cause the soil density to solidify. (5), (6).

Table-7. The decreasing of γ_d value against natural soil.

[redacted]

Table-8. The decreasing γ_d rate at each 5% addition to the lime and 10% to the sand.

[redacted]

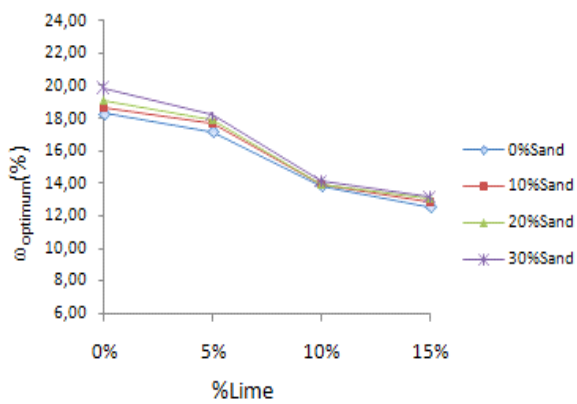

Figure-5. The relationship between the percentage of lime and $\omega_{optimum}$ (optimum moisture content) with the sand percentage's variation.

Based on Figure-5, the higher percentage of lime and sand, the bigger $\omega_{optimum}$ value is. It implies that more water is needed to obtain maximum density.

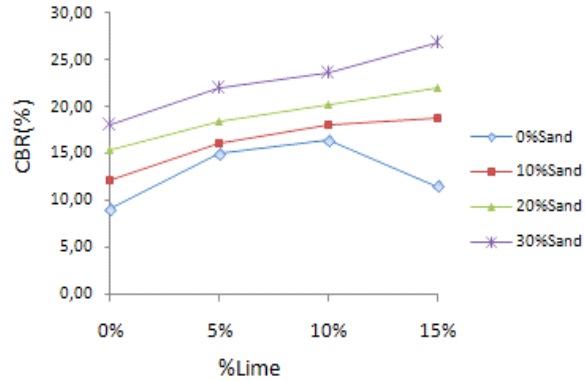

Figure-6. The relationship between lime percentage and CBR rate with sand percentage's variation.

Based on Figure-6, the higher percentage of the mixture of lime and sand, the higher CBR rate is compared to the natural soil, additional percentage of lime, or additional percentage of sand). (5), (6)

Table-9. CBR rate decreases from the natural soil.

[redacted]

Table-10. CBR rate decreases along with the increase of 5% lime and 10% sand.

[redacted]

The natural soil with 9% CBR is considered fair-graded for sub grade.

The additional percentage of 10% for lime with 16.36% CBR rate is considered fair-graded for sub grade.

The additional percentage of 30% for sand with 18.08% CBR rate is considered adequate for sub grade.

The additional 15% for lime and 30% of sand with 26.78% CBR rate is considered well-graded for sub grade.

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CONCLUSIONS

Based on the calculation analyses, the following conclusions are obtained:

- Sub grade stabilization with 15% lime and 30% sand obtain these following results: LL is at 35.89%; PI is at 3.77%; and swelling is at 1.33%. It is included in low plasticity soil, as shown by the LL, PI, and swelling rates (46.43%; 88.78%; and 96.12% respectively). Furthermore, for each 5% lime increase and 10% sand increase, there are average decrease of the LL (7.45% - 14.45%), PI (27.91% - 37.83%), and swelling rates (37.18% - 49.97%);
- The bigger the combination of the lime and sand, the denser sub grade stabilization grow shall be. It is showed 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 increases between 12.96% - 34.40%.

REFERENCES

Ruckman A. 1980. Summary of Open Discussion, session no. 5. Proceeding of the Fourth International Conference on Expansive Soils. 11: 717-720.

Ingles, O.G dan Metcalf J.B. 1972. Soil Stabilization Principles and Practice, Butterworths Pty. Limited, Melbourne.

Hary Christady Hardiyatmo. 2010. Soil Stabilization for Highway Pavement, Yogyakarta: Gadjah Mada University Press.

Warsiti. 2009. Improving CBR and Decreases Swelling Soil Sub Grade With Soil Stability Methods Using Lime. (Online). 14(1): 38-45. (http://puslit2.petra.ac.id/ejournal/index.php/wahana/article/view/17769, access at 11 February 2013, 6:03 AM).

Gati Sri Utami. 2014. Clay Soil Stabilisasi With Lime Effek The Value CBR and Swelling, ARPN vol. 9 no. 10, Pakistan.

Gati Sri Utami, Theresia MCA, Lukky A. 2015. Increased value of CBR and Decreased Swelling of Sub grade With Sand, Proceeding National Seminar of Applied Science and Technology, ITATS Surabaya.

Bowles J.E. 1984. Physical and Geotechmical Properties of Soils, Second Edition, McGraw-Hill, Singapore.

Braja M Das (translate by Mochtar.N.E and Mochtar I.B.), 1995, Soil Mechanics (Principles of Geotechnical Engineering), Erlangga, Jakarta.

Anonim. 2003. Annual Book of ASTM Standards, section 4, Volume 04 08, ASTM International Barr Harbor Drive, West Conshohocken, PA 19428-2959.