INTERNATIONAL JOURNAL OF INTEGRATED ENGINEERING
ISSN: 2229-838X e-ISSN: 2600-7916

IJIE

Vol. 16 No. 4 (2024) 1-7
https://publisher.uthm.edu.my/ojs/index.php/ijie

The Effect of Soaking on CBR Values in Soft Soils Stabilized with Stone Ash and Sand

Nova Juliana[1*], Nor Faizah Bawadi[2], Debby Endriani[3]

[1] *Department of Civil Engineering, Politeknik Negeri Medan, Medan 20155, INDONESIA*

[2] *Faculty of Civil Engineering and Technology, Universiti Malaysia Perlis, 02600 Arau, Perlis, MALAYSIA*

[3] *Department of Civil Engineering, Universitas Amir Hamzah, Medan 20371, INDONESIA*

*Corresponding Author: nova7uliana@gmail.com

DOI: https://doi.org/10.30880/ijie.2024.16.04.001

Article Info

Received: 9 January 2024
Accepted: 12 June 2024
Available online: 12 August 2024

Keywords

Soft soil, stone ash, sand, CBR, stabilization

Abstract

Constructing in the soft soil is necessary to improve. The improvement of soft soil by mixing natural materials, namely stone ash and sand, reduces the impact of environmental damage when using chemical additives. Variations of materials mixture were 0%, 5%, 10%, 15%, and 20%. To determine the strength of the soil that has been mixed with natural materials, a test called the California Bearing Ratio (CBR) is carried out. The CBR laboratory test illustrates the conditions that will occur in the field. This CBR test was carried out using soaked and un-soaked methods. For testing by soaking, mixed variations of 0% and 5% obtained a low CBR value. The highest was 10% mixed variation and decreased to 15% and 20%. The CBR test without soaking had the highest CBR value at 5% mixture variation and the lowest at 0%. Adding a mixture variation above 5% causes the CBR value to decrease slowly. The results of the tests show that soaking the soil makes the soil condition saturated with water so that the resulting CBR value becomes very low.

1. Introduction

Soft soil is very influential on the strength of highway construction, especially on the strength of the subsoil layer [1]–[3]. Soft soil is highly undesirable for construction because it needs better bearing capacity and high swelling and shrinkage properties [4], [5]. In Indonesia, especially areas close to the coast contain soft soil with a relatively large area [6]. This condition, of course, will cause obstacles if road infrastructure development is carried out in the area. Experts have used various methods to solve this soft soil problem [3], [7], [8]. Methods for improving soft soil include replacing soft soil with better materials, stabilizing the soil by mixing the soil with natural materials or artificial additives, and various other methods [9]–[14]. Stone ash is waste generated from stone-crushing plants. If the waste is not reused optimally, it will cause a pile of waste which can be bad for the environment. Certain areas in Indonesia have natural resources such as sand of sufficiently good quality and adequate supply. Therefore, sand is beneficial as a natural soil stabilization mixture, which can reduce the use of chemical additives. With so many environmental issues, the authors carry out soil improvements by mixing soft soil with stone ash and sand, to reduce the impact of environmental damage due to chemical additives that can affect the surrounding environment.

2. Material and Method

Soil sampling origin from Lubuk Bayas Village, North Sumatra Province, Indonesia. Excavation is carried out to take soil samples. Then the soil was put in plastic sacks and taken to the soil testing laboratory at the Jaya Corindo Design Company for testing. The initial tests were Specific Gravity and Standard Compaction tests with AASHTO T-99 and ASTM D-698 Standards. Compaction testing was conducted six times in an experiment that produced a graph showing the optimum moisture content. This process will adjust the moisture content when mixing the soil and its natural stabilizers.

After obtaining the optimum moisture content, the next step is to mix the soft soil with stone ash and sand. Stone ash is a material obtained from a stone crusher factory, with material sizes ranging from 0 mm – 5 mm, where a stone crusher factory can produce around 15% to 20% stone ash. If stone ash cannot be optimal to use, material buildup will occur, which is highly undesirable. The sand used in this study was the one that must be passed through sieve no. 4 (4.75 mm). Mixing natural ingredients is done with a variety of mixing. Variations in the mixing of stabilizers are 0%, 5%, 10%, 15%, and 20%.

After mixing the soil with optimum moisture content conditions, stone ash, and sand, the sample was cured for 24 hours or until the water content was well distributed. After curing, proceed with CBR test. The CBR test uses two methods: CBR soaked and CBR un-soaked. The soaked CBR was soaked for 96 hours while measuring the swelling in the mixed soil before testing. Different from CBR un-soaked, the test is carried out immediately after curing the mixed soil is complete, not through the immersion process. AASHTO shows the relationship between bearing capacity and the CBR value in Table 1 [15] as follows:

Table 1 *Geotechnical characteristics of untreated soil*

CBR	Bearing Capacity
2% – 5%	Poor
6% – 9%	Medium
> 9%	Good

3. Result Analysis and Discussion

3.1 Specific Gravity

The specific gravity values generated from laboratory tests are shown in Table 2.

Table 2 *Specific gravity value (Gs)*

No.	Material	Specific Gravity
1.	Soft Soil	2.60
2.	Stone Ash	2.66
3.	Sand	2.63

3.2 Standard Compaction Test

Fig. 1 shows the results of the Standard Compaction Test. The results are in the optimum water content and the air void ratio. Testing was carried out six times. In the first test, using a water content of 12.91% resulted in a dry unit weight of 1.39 gr/cm^3. The second test, with a water content of 13.99%, produced a dry unit weight of 1.39 gr/cm^3. In the third test, using a water content of 15.78%, the dry unit weight was 1.41 gr/cm^3. In the fourth test, with a water content of 19.53%, the dry unit weight was 1.40 gr/cm^3. In the fifth test, using a water content of 24.51%, the dry unit weight was 1.41 gr/cm^3. Finally, in the last test, namely the sixth test, using a water content of 28.90%, a dry unit weight of 1.37 gr/cm^3 was produced.

From the six tests that have been carried out, a graph is created as in Fig. 1, where the graph will show the Maximum Dry Density value and also the Zero Air Void value. The Maximum Dry Density (MDD) is 1.41 gr/cm^3, and the Optimum Moisture Content (OMC) is 20.30%. After the MDD and OMC values are obtained, they will then be used as a reference for the water content of the material mixture that will be used in the Laboratory CBR experiment.

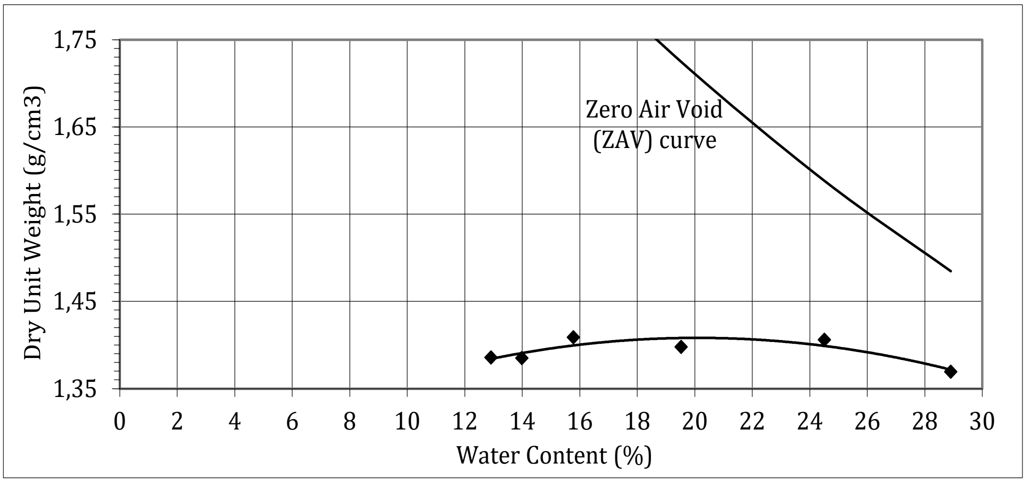

Fig. 1 *Standard compaction test result*

3.3 Laboratory CBR Test

From the results of the Specific Gravity and Standard Compaction that have been carried out, the un-soaked and soaked CBR tests were carried out, as shown below.

3.3.1 Unsoaked CBR Test

CBR testing with the un-soaked method was carried out with various variations of stone ash and sand mixtures with the following results.

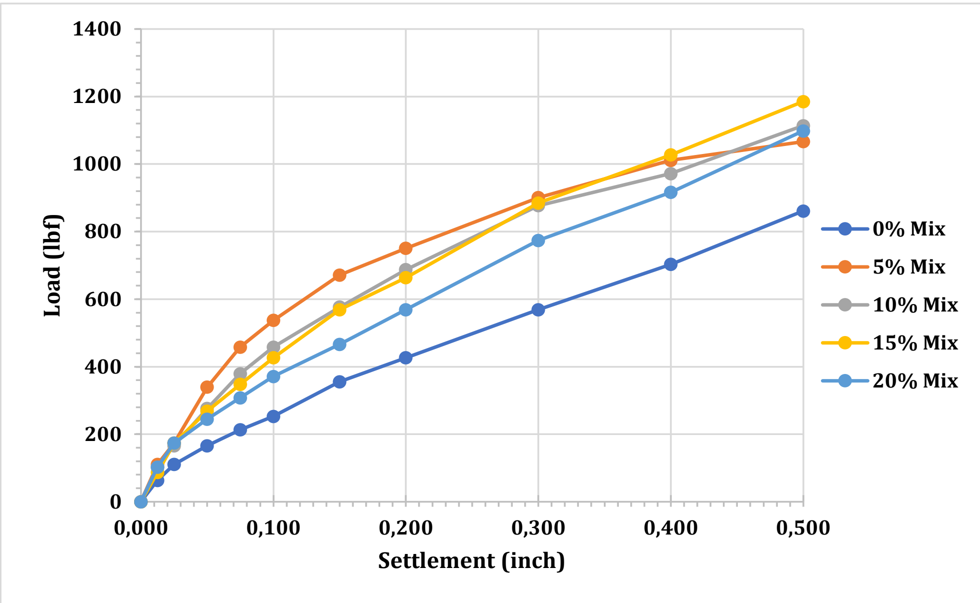

Fig. 2 *Un-soaked CBR test result*

Fig. 2 shows the results of the Un-soaked CBR test with an overview of the settlement that occurs in the load applied to the compacted mixed soil. It can be seen in the settlement of 0.1 and 0.2 inches. For a decrease of 0.1 inches, a 0% material mixture only requires a load of 252.8 lbf. Meanwhile, for soil mixed with stone ash and sand, starting from a 5% material mixture requires a load of 537.2 lbf, a 10% material mixture requires a load of 458.2 lbf, a 15% material mixture requires a load of 426.6 lbf, and finally a 20% material mixture, which requires a load of 371.3 lbf. From the results of this test, we can see that for soil mixed with stone ash and sand, the load required will be lighter or reduced if a more significant percentage of the mixture of stone ash and sand is added. The amount of load and the percentage of material mixture also applies to a decrease of 2 inches.

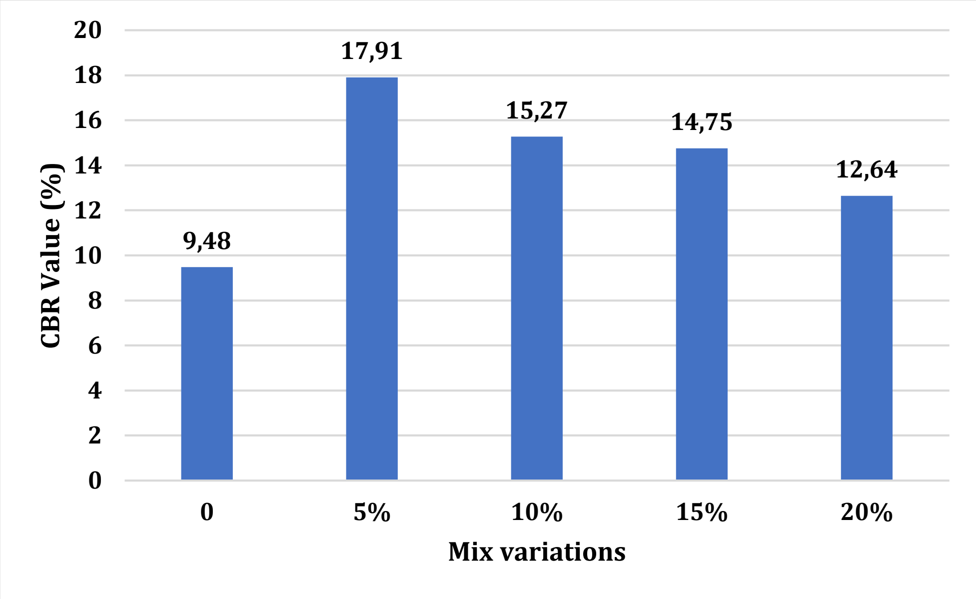

Fig. 3 *The CBR value of various mix variations (un-soaked)*

Fig. 3 shows the percentage of CBR values for mixed variations. From the picture above, it can be seen that the lowest CBR results are at 0% variation with a value of 9.48%. Then the mixed variation of 5%, the highest CBR value, equals 17.91%. It turns out that adding the percentage of stone ash and sand to the soil does not necessarily increase the CBR value; in fact, the CBR value tends to decrease slowly. From the results of this test, it can be seen that the content of the mixture of materials is in excellent condition compared to the others, which is 5%.

3.3.2 Soaked CBR Test

CBR testing was carried out through the soak method with various variations of stone ash and sand mixtures. Soaking is carried out for 96 hours in a soaking tub. During immersion, the swelling of the soil sample is also recorded by reading it via a dial attached to the sample. The dial reading is done every 24 hours. This reading is to find out whether the soil that has been mixed has a high swell and shrinkage value so that better soil conditions can be obtained by stabilizing the soil. The load given to the soil samples that go through the soaking process is much smaller than the load given to the soil samples in the samples that will be tested in the CBR test without soaking. The results of laboratory CBR testing with planning produced results like the following figure.

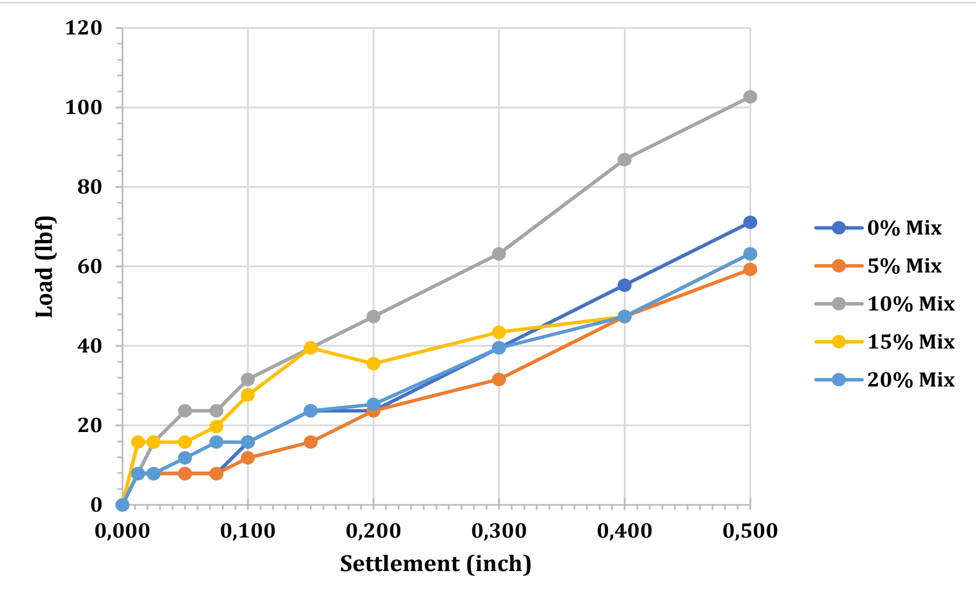

Fig. 4 *Soaked CBR test results*

Fig. 4 is a graph of the CBR test results by soaking. In this figure, it can be seen that the decrease is 0.1 inch and 0.2 inches; the lowest value is in the mixed variation of 0% and 5%. The best results are shown at 10% mixing variation. For a decrease of 0.1 inch, a 5% material mixture requires the most minor load, namely 11.85 lbf. Meanwhile, a mixture of 0% and 20% material requires a load that tends to be the same, namely 15.80 lbf. Furthermore, a material mixture percentage of 10% requires the highest load, namely 31.60 lbf, and a material mixture of 15% requires a load of 27.65 lbf. From the results of this test, we can see that for soil mixed with stone ash and sand, with tests carried out by immersion, the load is very varied, slowly increasing and then decreasing as the percentage of the material mixture increases.

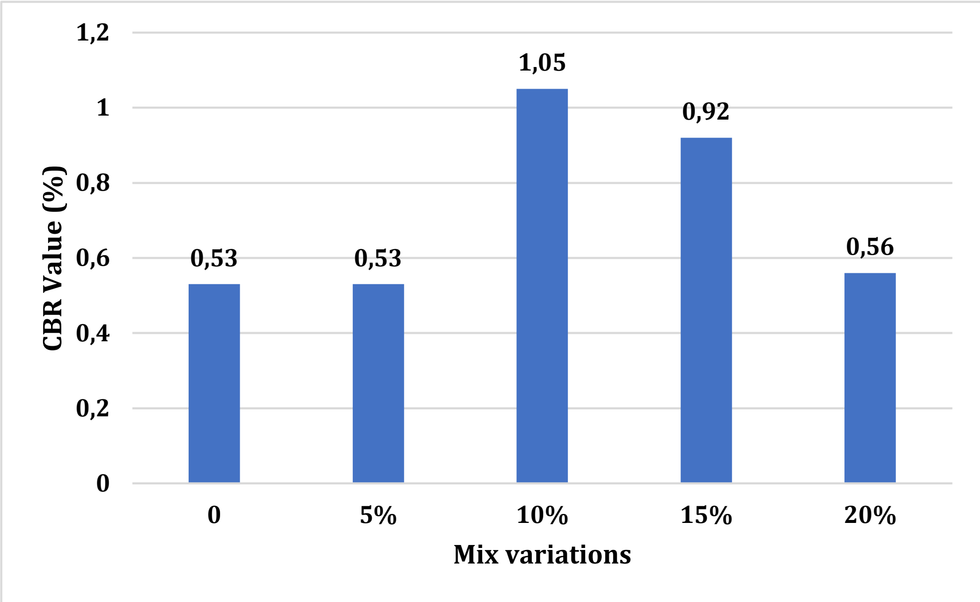

Fig. 5 *The CBR value of various mix variations (soaked)*

Fig. 5 shows a diagram of the percentage of CBR value to the percentage of mixed variations. It can be seen in the figure that the CBR value of 0% and 5% have the same value of 0.53%. The best CBR value is in the 10% mixture variation, which is equal to 1.05%, and then the more the percentage of the mixture is added, the CBR value decreases. In the end, adding the highest percentage of material mixture, namely 20%, made the CBR value even lower, reaching 0.56% (almost similar to the CBR value at mixture percentages of 0% and 5%).

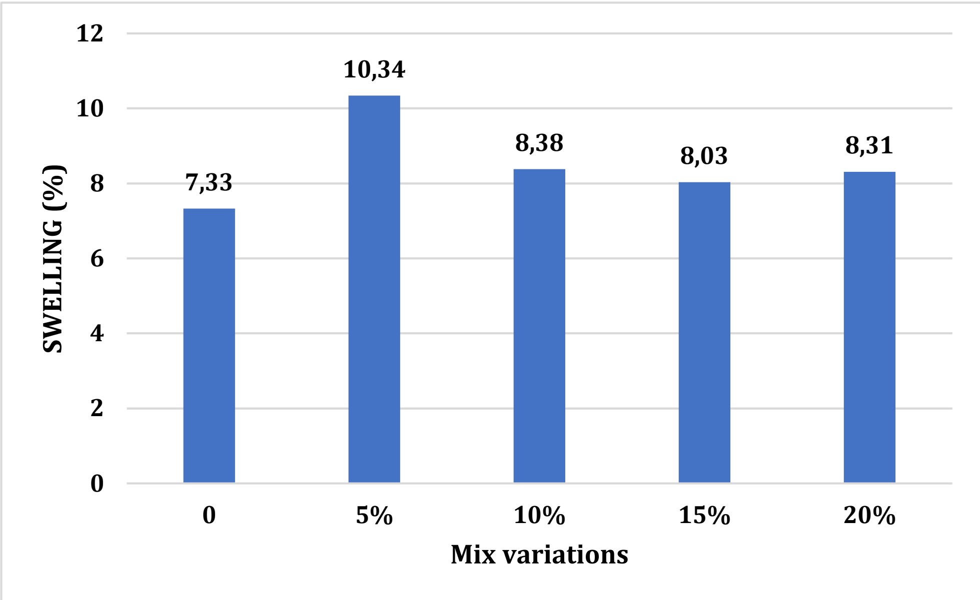

Fig. 6 *The swelling percentage of various mix variations (soaked CBR)*

Fig. 6 shows a diagram of the percentage of swelling values for mixed variations. The figure shows that in the 0% mixture variation, a swelling value of 7.33% was obtained. This condition happened because the soil grains were still original. The potential for swelling was less. When soaked, they were given 10 lbs of ballast. An excellent swelling value was obtained for the next mixing variation, namely at 5%, 10%, 15%, and 20%. At a mixture percentage of 5%, there was a development of 10.34%, where this condition has the highest development value among others. Meanwhile, the percentages of 10%, 15%, and 20% have almost the same development value, namely around 8%. This condition happens because mixing soil with material with a larger grain size can cause air cavities to form so that the opportunity for water absorption is more significant, and the potential for development is also more tremendous.

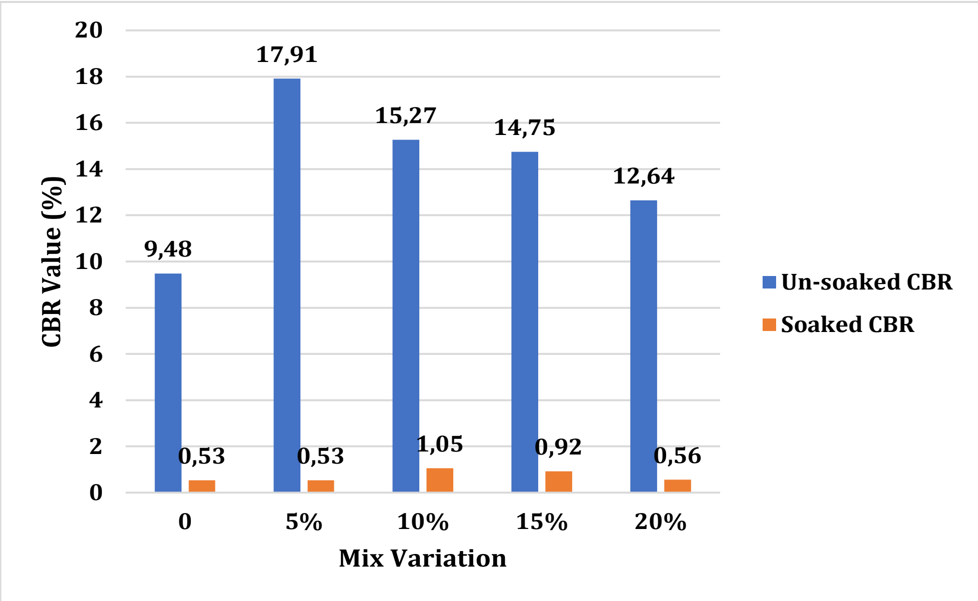

Fig. 7 *The CBR value of various mix variations (soaked and un-soaked)*

Fig. 7 shows a comparison diagram of soaked and unsoaked CBR values. It can be seen in the picture that there is a very significant difference in values between the two. The CBR value is suitable for a variety of soil mixtures with CBR testing without soaking. The percentage difference in CBR values between submerged and non-submerged ranges from 9% to 17%. The increase in CBR values in the un-soaked CBR test is very significant. Starting from a material mixture variation of 0%, which produces a CBR value of 9.48%. The highest value is found in the 5% mixture variation with a CBR value of 17.91%. The more the percentage of material mixture increases, the lower the CBR value will be. This can be seen in the 10% mix variation with a CBR value of 15.27%, the 15% mix variation with a CBR value of 14.75%, and the 20% mix variation with a CBR value of 12.64%. Then, the lowest CBR value was 9.48%, with a mixture variation of 0%. CBR without immersion can describe the original conditions that occur in the field during dry conditions (not the rainy season).

Meanwhile, for the variations in soil mixtures that underwent the immersion CBR test, the CBR values were inferior, all below 2%. The lowest is 0.53%, with mixing variations of 0% and 5%. The 10% mix variation increased slightly by 1.05% but was still in poor condition. Furthermore, the more the mixture percentage of 15% and 20% is added, the more the CBR value decreases. Where a 15% material mixture produces a CBR value of 0.92% and a 20% material mixture produces a CBR value of 0.56%. CBR conditions with immersion can describe the original conditions in the field if the weather is in a state of prolonged rain or flooding, which causes the soil layer to soak in water, which then results in soil swelling (the soil becomes saturated with water) so that the CBR value becomes bad (declines very much).

4. Conclusion and Suggestions

The research results show that the amount of water content greatly affects the performance of soft soil. Even though it has been mixed with natural ingredients such as stone ash and sand, which have larger grains than the grain size of soft soil, it does not have a full effect if the soil is soaked (water saturated). Mixing variations affect the bearing capacity's strength based on the CBR value when the soil is un-soaked (under normal conditions, not saturated with water). In the future, more varied research is needed on other natural mixing materials or changing the amount/amount of variation in the soil mixture and, if necessary, adding drainage in the surrounding area to prevent the soil from being saturated with water.

Acknowledgement

This research was carried out with the direction and Supervisor guidance (Dr. Nor Faizah Bawadi) and also financial assistance from Jaya Corindo Design company through Publication Funds with No. 48/JCD/IV/2023.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nova Juliana, Nor Faizah Bawadi and Debby Endriani;* ***data collection:*** *Nova Juliana, Nor Faizah Bawadi and Debby Endriani;* ***analysis and interpretation of results:*** *Nova Juliana, Nor Faizah Bawadi and Debby Endriani;* ***draft manuscript preparation:*** *Nova Juliana, Nor Faizah Bawadi and Debby Endriani. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Holtz, R. D., & Kovacs, W. D. (1981). An Introduction to Geotechnical Engineering. In Introductory Geotechnical Engineering. Prentice Hall.
[2] Phanikumar, B. R., & Ramanjaneya Raju, E. (2020). Compaction and strength characteristics of an expansive clay stabilised with lime sludge and cement. Soils and Foundations, 60(1), 129–138. https://doi.org/10.1016/j.sandf.2020.01.007
[3] Hardiyatmo, H. C. (2020). Perbaikan Tanah. Gadjah Mada University Press.
[4] Barry, T. (2019). The Soft Soils of Semarang. Seminar of Polder Systems in Waterfront Cities, Jakarta,Indonesia.
[5] Buzatto, L. M., Wilson, W., Moreira, J. R., Gonçalves, R., Batemarco, F., Jesus, M. De, Nóbrega, R., Bentes, F. M., & De, H. R. (2020). Considerations on Characteristics and Improvements of Soft Soils. International Journal of Advanced Engineering Research and Science, 7, 342-352. https://doi.org/10.22161/ijaers.77.38
[6] Departemen Permukiman dan Prasarana Wilayah (2002). Panduan Geoteknik 1. Timbunan Jalan Pada Tanah Lunak. Bandung, pp.1-87.
[7] Putra, C. E., & Makarim, C. A. (2020). Analisis Alternatif Perbaikan Tanah Lunak dan Sangat Lunak pada Jalan Tol. Jurnal Mitra Teknik Sipil, 3(4), 1137–1150.
[8] Muntohar, A. S. (2016). Desain Nilai CBR Tanah Dasar Jalan Dengan Perbaikan Kapur Dan Abu Sekam Padi. Prosiding Seminar Nasional Teknik Sipil 2016, Surakarta, Indonesia.
Karkush, M. O., & Yassin, S. (2019). Improvement of geotechnical properties of cohesive soil using crushed concrete. Civil Engineering Journal, 5(10), 2110–2119. https://doi.org/10.28991/cej-2019-03091397
[9] Abdel-Salam, A. E. (2018). Stabilization of peat soil using locally admixture. HBRC Journal, 14(3), 294–299. https://doi.org/10.1016/j.hbrcj.2016.11.004
[10] Saleh, S. A., & Hussein, S. K. (2021). Effect of soil stabilization on subgrade soil using cement, lime and fly ash. Eurasian Journal of Science and Engineering, 6(2), 39-52. https://doi.org/10.23918/eajse.v6i2p39
[11] Singh, A. P., Saxena, N. K., & Verma, A. (2018). Stabilization of expansive soil by fly ash and stone dust. International Journal of Science and Research, 7(8), 128–130. https://www.ijsr.net/archive/v7i8/ART2019352.pdf
[12] Boobalan, S. C., Dhanabharathi, M., Dineshkumar, S., & Gokuldas, M. (2022). Comprehensive Review on the Influence of Natural Materials in Soil Stabilization. Materials Research Proceedings, 23, 276–283. https://doi.org/10.21741/9781644901953-31
[13] Mishra, S., & Rakesh, S. N. S. (2019). Subgrade soil stabilization using stone dust and coarse aggregate: A cost effective approach. International Journal of Geosynthetics and Ground Engineering, 5(20), 1-11. https://doi.org/10.1007/s40891-019-0171-0
[14] Juliana, N., & Faizah, N. (2023). Effects of physical and mechanical properties of soft soil on subgrades performances in Lubuk Bayas Village, Serdang Bedagai Regency. IOP Conference Series: Earth and Environmental Science, 1216, 1-6. https://doi.org/10.1088/1755-1315/1216/1/012017