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Evaluation Of Cbr Improvement For Cohesive Soil Used As A Subgrade Using A Mix Of Fill Sand And Lime

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ABSTRACT

The results indicated that both lime and cement stabilization significantly improved the CBR value compared to the untreated soil, which did not satisfy the Bina Marga minimum requirement for subgrade material (CBR < 6%). The addition of 4% lime and 4% loose sand increased the CBR value to 6.40%, meeting the minimum specification. Meanwhile, the combination of 4% cement and 4% loose sand resulted in a substantially higher CBR value of 15.50%, demonstrating superior technical performance. Although cement provided greater strength improvement, lime remained a cost-effective alternative capable of enhancing soil stability. Furthermore, a comparison between laboratory and field CBR values showed that laboratory results tended to be higher due to more controlled testing conditions. These findings demonstrate the potential of soil stabilization using lime or cement combined with loose sand to improve the engineering properties of saturated cohesive soils for road subgrade applications.

Keywords : subgrade, California Bearing Ratio (CBR), lime

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi peningkatan nilai CBR (California Bearing Ratio) pada tanah kohesif jenuh sebagai lapisan subgrade melalui stabilisasi menggunakan pasir urug yang dikombinasikan dengan kapur dan semen, serta membandingkan efektivitas kedua bahan stabilisasi tersebut dalam meningkatkan daya dukung tanah. Metode penelitian meliputi pengujian sifat fisis dan mekanis tanah di laboratorium, serta pengujian nilai CBR pada variasi campuran kapur atau semen dengan pasir urug masing-masing sebesar 2% dan 4%. Hasil pengujian menunjukkan bahwa tanah asli memiliki nilai CBR di bawah 6%, sehingga belum memenuhi persyaratan minimum subgrade menurut spesifikasi Bina Marga. Penambahan kapur dan pasir urug mampu meningkatkan nilai CBR secara bertahap, dengan nilai tertinggi sebesar 6,40% pada campuran kapur 4% dan pasir urug 4%, Sementara itu, penggunaan semen yang dikombinasikan dengan pasir urug menunjukkan peningkatan yang lebih signifikan. Campuran semen 4% dan pasir urug 4% menghasilkan nilai CBR sebesar 15,50%, yang merupakan nilai tertinggi dari seluruh variasi campuran yang diuji. Hal ini menunjukkan bahwa semen memiliki kemampuan yang lebih efektif dalam meningkatkan kekuatan dan daya dukung tanah dibandingkan kapur, terutama melalui proses hidrasi yang membentuk ikatan antarpartikel tanah sehingga menghasilkan struktur yang lebih stabil dan padat. Perbandingan hasil pengujian CBR laboratorium dan lapangan juga menunjukkan bahwa nilai CBR laboratorium cenderung lebih tinggi karena kondisi pengujian yang lebih terkontrol. Hasil penelitian ini menunjukkan bahwa stabilisasi menggunakan kombinasi semen dan pasir urug merupakan metode yang paling efektif untuk meningkatkan kualitas tanah dasar jalan pada lokasi penelitian.

Kata kunci: tanah kohesif jenuh, CBR, stabilisasi tanah, semen, kapur, pasir urug, subgrade

INTRODUCTION

Soil plays a crucial role as the foundation supporting road pavement construction. A well-conditioned subgrade is essential to ensure that the structure built upon it has adequate bearing capacity. However, road damage frequently occurs due to excessive loads, high moisture content, and low bearing capacity. To address these damage issues, efforts must be made to improve the soil with the aim of increasing its bearing capacity a process commonly referred to as soil improvement. Chemical stabilization involves adding a special chemical additive that helps create a more stable soil mass. One alternative method involves using lime as a stabilizer and fill sand as a reinforcing material in the subgrade.

To determine the extent of the success of the remediation process, laboratory California Bearing Ratio (CBR) tests were conducted. CBR testing is used to determine the soil's bearing capacity, both before and after remediation. A high CBR value indicates that the soil has a better load-bearing capacity. Therefore, the CBR test serves as a key parameter in evaluating the quality of the improvement results, as well as a reference for planning the thickness of the road pavement layer.

This study focuses on the improvement of saturated cohesive soil on Pasir Jati Road, Sumedang Regency, using fill sand and lime. The objective is to evaluate soil classification testing procedures and identify changes in mechanical properties before and after improvement. The methods used include laboratory CBR (soaked) testing and field CBR testing using a Dynamic Cone Penetrometer (DCP). This study is expected to provide technical solutions to improve subgrade quality in accordance with applicable technical specifications. The scope of the study includes the research location, soil parameters, and the additives used—namely lime, fill sand, and cement. The equipment used in this study was calibrated in 2017. The report is structured into five chapters to facilitate understanding.

METHODOLOGY

Data Collection Methods

1) Primary Data
   Primary data is data obtained directly from the original source through on-site surveys. Data collection was conducted directly at the field site located on Jalan Pasir Jati, Buahdua Subdistrict, Sumedang Regency.
2) Secondary Data
   Secondary data is data obtained from pre-existing sources such as technical guidelines, technical specifications, references to previous studies, websites or the internet, books, journals, and so on. The technical guidelines and specifications used include:
   a. SNI 1965:2008 on the determination of moisture content in soil and rock,
   b. SNI 03-4142-1996 on the method for determining the amount of material in aggregate passing through a No. 200 sieve (0.075 mm),
   c. SNI 1964:2008 on the test for soil specific gravity,
   d. SNI 3424:2008 on the test for soil particle size analysis,
   e. SNI 1967:2008 on the test method for determining the liquid limit of soil,
   f. SNI 1966:2008 on test methods for determining the plastic limit and plasticity index of soil,
   g. SNI 3422:2008 Test for Determining the Shrinkage Limit of Soil,
   h. SNI 1742:2008 Light Compaction Test for Soil,
   i. SNI 1744:2012 Laboratory CBR Test,
   j. Law of the Republic of Indonesia No. 38 of 2004 on roads,
   k. Journals related to soil testing.
   l. Previous references.

Research Methodology

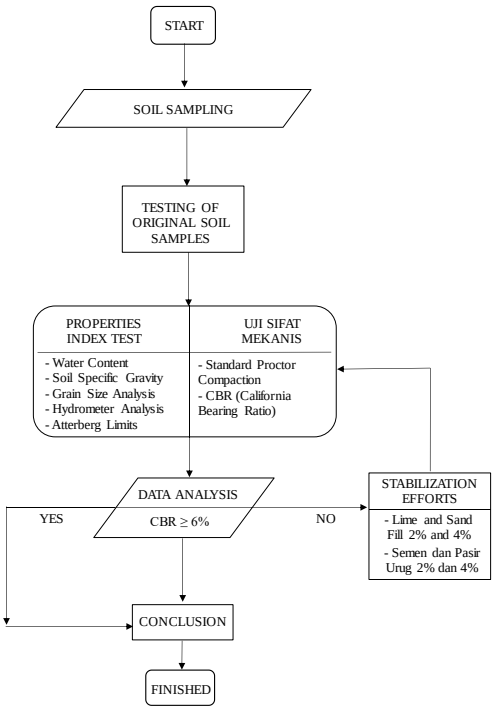

Figure 1. Research Methodology
Source: Analysis Results

Research Location

Field testing and sampling were conducted on Jalan Pasir Jati, Buahdua Subdistrict, Sumedang Regency. The field testing utilized the Dynamic Cone Penetrometer (DCP) test. This testing also included the collection of soil samples for analysis.

Figure 2. Soil Sampling Locations
Source: Google Earth

Research Stages

1) Preparation Stage
2) Testing of Soil Sample Properties
   a. Moisture Content Test
   b. Specific Gravity Test (Specific Gravity)
   c. Sieve Analysis Test
   d. Hydrometer Analysis Test
   e. Atterberg Limit Test
3) Test Specimen Preparation Stage
   a. Natural Soil (Without Additives)
   b. Natural Soil + 2% Lime + 2% Fill Sand
   c. Natural Soil + 4% Lime + 4% Fill Sand
   d. Natural Soil + 2% Cement + 2% Fill Sand
   e. Natural Soil + 4% Cement + 4% Fill Sand
4) Stages of Testing the Mechanical Properties of Soil Samples
   a. Standard Proctor Soil Compaction Test
   b. California Bearing Ratio (CBR) Test
5) Stages of Collecting Test Results Data
6) Stages of Data Analysis
7) Stages of Finalization

ANALYSIS AND DISCUSSION

Initial Characteristics of the Native Soil

Tests were conducted to determine the physical properties of the native soil from Jalan Pasir Jati. The following is a summary of the test results for the physical properties of the native soil samples tested:

Table 1. Summary of Test Results for the Physical Properties of the Original Soil Sample

Testing	Unit	Sample		
		I	II	III
Moisture Content	%	57,12	55,23	53,93
Specific Gravity (Gs)	gr/cm^3	2,53	2,59	2,63
Percentage of Particle Size				
Passing Sieve No. 200	%	73,98	64,72	50,05
1. Gravel	%	0	0	0
2. Sand	%	18,21	26,17	34,63
3. Silt	%	47,45	43,23	26,54
4. Clay	%	26,53	21,49	23,50
Atterberg Limits				
1. Liquid Limit (LL)	%	52,50	54,50	54,80
2. Plastic Limit (PL)	%	29,63	30,34	31,15
3. Shrinkage Limit (SL)	%	24,61	24,44	18,44
4. Plasticity Index (PI)	%	22,87	24,35	25,35

Source: Analysis Results

Based on the summary of the test results above, it can be concluded that the soil sample from Jalan Pasir Jati, Buahdua Subdistrict, Sumedang Regency, falls into Group A-7-6 under the AASHTO classification system because the percentage of fine particles

passing through a No. 200 sieve exceeds 35%, as evidenced by the liquid limit (LL) and plasticity index (PI) meet the criteria for that group. This group consists of clay soils with soil conditions ranging from moderate to poor. The USCS classification system indicates that the soil contains more than 50% fine particles and has LL and PI values consistent with the OH zone, which corresponds to organic clay with moderate to high plasticity.

CBR Test Results for Natural Soil

The CBR test was conducted using the soaked CBR method. The summary of the CBR test results for the native soil is as follows:

Table 2. Summary of California Bearing Ratio (CBR) Test Results for Natural Soil

Sample	CBR Value (%)
Sample I Native Soil	1.55
Sample II Native Soil	1.30
Sample III Native Soil	1.43

Source: Analysis Results

Based on the results of laboratory CBR testing on Sample I, Sample II, and Sample III, it was found that the CBR values obtained from each sample did not meet the minimum CBR value criteria required for the subgrade in accordance with applicable standards. The CBR test results for all three samples showed that the CBR value was < 5%. The CBR value criteria for road subgrade soil indicate that a CBR value < 5% means the soil falls under the clay soil category and is unsuitable for use as a subgrade. This indicates that the clay soil does not meet the minimum subgrade criterion of 6% as specified in the 2018 General Specifications for Road Construction. Clay soil still has low bearing capacity, which is also associated with its high plasticity and volume changes when wet. Therefore, it requires improvement or treatment before being used as a road subgrade to increase its bearing capacity.

Test Results After Remediation

The tests conducted previously were intended to determine the physical properties of the original soil sample after remediation using a mixture of lime and cement from Jalan Pasir Jati, Buahdua Subdistrict, Sumedang Regency. The soil parameters can be determined based on the test results above. The combined or summarized results of the physical property tests of the original soil sample with a mixture of lime and fill sand, as well as cement and fill sand, are as follows:

Table 3. Summary of Test Results for the Physical Properties of Sample I: Native Soil + Lime + Fill Sand

Testing	Unit	Sample
		I Native Soil + 2% Lime + 2% Fill Sand	I Native Soil + 4% Lime+ 4% Fill Sand
Moisture Content	%	6.23	6.23
Berat Jenis (Gs)	gr/cm^3	2.54	2.57
Persentase Ukuran Butiran			
Passing Sieve No. 200	%	11.74	8.49
1. Gravel	%	0	0.69
2. Sand	%	88.26	90.83
3. Silt and Clay	%	11.74	8.49
Atterberg Limits			
1. Liquid Limit (LL)	%	47.60	36.00
2. Plastic Limit (PL)	%	35.76	32.54
3. Shrinkage Limit (SL)	%	13.52	15.54
4. Plasticity Index (PI)	%	11.84	3.46

Source: Analysis Results

Table 4.4. Summary of Test Results for the Physical Properties of Sample I: Native Soil + Cement + Fill Sand

Testing	Unit	Sample
		I Native Soil + 2% Cement + 2% Fill Sand	I Native Soil + 4% Cement + 4% Fill Sand
Moisture Content	%	6.23	6.23
Berat Jenis (Gs)	gr/cm^3	2.55	2.58
Persentase Ukuran Butiran			
Passing Sieve No. 200	%	6.78	5.54
1. Gravel	%	0	0
2. Sand	%	93.22	94.46
3. Silt and Clay	%	6.78	5.54
Atterberg Limits			
1. Liquid Limit (LL)	%	47.20	42.50
2. Plastic Limit (PL)	%	34.44	32.29
3. Shrinkage Limit (SL)	%	21.30	14.52
4. Plasticity Index (PI)	%	12.79	10.21

Source: Analysis Results

Soil classification tests, conducted using both lime and cement mixtures, showed that the soil samples from Jalan Pasir Jati, Buahdua Subdistrict, Sumedang Regency, after being treated with lime or cement mixtures, fall into Group A-2-7 under the AASHTO classification system because the percentage of fine particles passing through a No. 200 sieve is less than 35%, and the liquid limit (LL)

and plasticity index (PI) values also meet the criteria for that group. The soil type is gravelly silt or clayey silt and sand in very good to good condition. Under the USCS classification system, it falls into the SC category, which is sandy loam or a mixture of sand and loam, because the percentage of coarse particles is dominated by the sand fraction, which is more than 50%.

After conducting CBR tests on the loam soil with various improvement mixture variations, the results show an increase in the CBR value for each mixture variation compared to the original soil. The analysis of these post-improvement CBR results aims to determine the effectiveness of each improvement material in enhancing the soil's bearing capacity.

1) Lime and Fill Sand Mixture

The summary of CBR test results for clay soil samples with the addition of lime and fill sand, using several mixture variations, is as follows:

Table 5. Summary of California Bearing Ratio (CBR) Test Results Addition of Lime and Fill Sand

Sample	CBR Value (%)
Sample I Native Soil + 2% Lime + 2% Fill Sand	4.40
Sample I Native Soil + 4% Lime + 4% Fill Sand	6.40

Source: Analysis Results

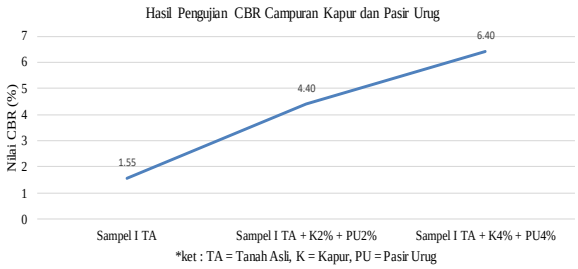

Figure 3. Graph of CBR Test Results for Sample I: Native Soil + Lime + Fill Sand

Source: Analysis Results

Based on the results of laboratory CBR testing of clay soil after improvement through the addition of lime and fill sand at mixture ratios of 2% and 4%, the CBR values indicate that adding lime and fill sand to clay soil increases the CBR value compared to the original soil as the percentage of the improvement mixture used increases. The CBR value for the 2% lime and 2% fill sand mixture was 4.40%. The CBR value for the 4% lime and 4% fill sand mixture was 6.40%. The CBR value of the original soil, which was 1.55%, increased by 183.87% after improvement with the addition of 2% lime and 2% fill sand, and increased by 312.90% with a mixture of 4% lime and 4% fill sand. This increase demonstrates that as the mixture percentage increases, the soil improvement method is highly effective in enhancing soil properties.

According to Bina Marga specifications (2018), the minimum criterion for the subgrade is 6%. With the 4% lime and 4% fill sand mixture yielding a value of 6.40%, the minimum criterion for the subgrade has been met. This indicates that a 4% mixture percentage is effective in increasing the soil's bearing capacity to meet the required criteria for the subgrade. Therefore, this mixture percentage is suitable for use as a subgrade on Pasir Jati Road, Buahdua Subdistrict, Sumedang Regency.Variasi Campuran Semen dan Pasir Urug

2) The results of the CBR test on clay soil samples with added cement and fill sand, using several different mix ratios, are as follows:

Table 6. Summary of California Bearing Ratio (CBR) Test Results Addition of Cement and Fill Sand

No.	Variations in the Mix	CBR Value (%)	Increase in the CBR (%)
1	Sample I: Native Soil	1.55	-
2	Sample I: Native Soil + 2% Cement + 2% Fill Sand	7.00	351.61
3	Sample I: Native Soil + 4% Cement + 4% Fill Sand	15.00	867.74

Source: Analysis Results

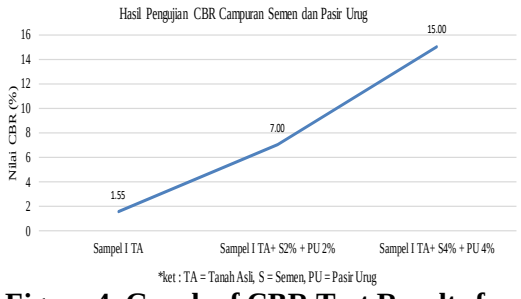

Figure 4. Graph of CBR Test Results for Sample I: Native Soil + Cement + Fill Sand

Source: Analysis Results

In this study, cement was used as a reference material for soil improvement compared to lime to assess the effectiveness of each in improving the CBR. Based on the results of CBR testing after soil improvement using

cement and fill sand at mixture ratios of 2% and 4%, there was a significant increase in the CBR value compared to the original soil. The CBR value for the 2% cement and 2% fill sand mixture was 7%. The CBR value for the 4% cement and 4% fill sand mixture was 15.50%. In the 2% cement and 2% fill sand mixture variation, the CBR value increased by 351.61% from the initial value of the original soil. In the 4% cement and 4% fill sand mixture variation, the CBR value increased by 867.74%.

According to the Bina Marga specifications (2018), the minimum criterion for the subgrade is 6%. Both the 2% cement and 2% fill sand mixture and the 4% cement and 4% fill sand mixture meet the minimum criteria for the subgrade. Test results show that cement mixtures yield a more significant increase in CBR values compared to lime mixtures at the same percentage. Therefore, cement and fill sand mixtures at 2% and 4% on Pasir Jati Road, Buahdua Subdistrict, Sumedang Regency, are effective for use in subgrades and can serve as an alternative soil improvement method. Cement serves as a control material that demonstrates greater improvement effectiveness..

Comparison of Field CBR and Laboratory CBR

To gain an understanding of the soil bearing capacity at the study site, a comparison was conducted between the CBR values obtained from laboratory tests and those obtained in the field using a Dynamic Cone Penetrometer (DCP). The purpose of this comparison was to determine the consistency between the field CBR values and the laboratory CBR values. The results of the comparison of CBR values from the two testing methods are presented in tables and graphs.

Table 7. Comparison of Field CBR Test Results and Laboratory CBR Test Results

No	Sample	Field CBR Value (%)	Laboratory CBR Value (%)	Difference (%)
1	I	1.20	1.55	0.35
2	II	1.00	1.30	0.30
3	III	1.15	1.43	0.28

Source:Analysis Result

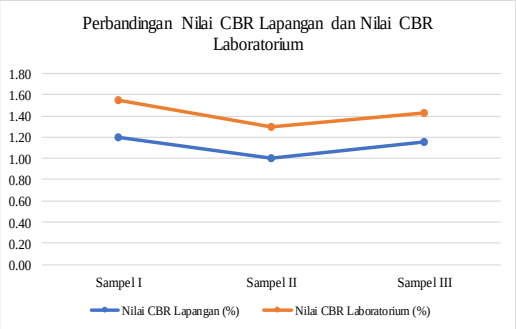

Figure 5. Graph Comparing Field CBR and Laboratory CBR Values

Source: Analysis Results

Based on a comparison of field CBR values and laboratory CBR values, it was found that laboratory CBR values tend to be higher than field CBR values. The laboratory CBR value for Sample I was 1.55%, while the field CBR value was 1.20%. The difference was 0.35%. The laboratory CBR value for Sample II is 1.30%, while the field CBR value is 1.00%. The difference is 0.30%. The laboratory CBR value for Sample III is 1.43%, while the field CBR value is 1.15%. The difference is 0.28%. This difference is still within acceptable limits due to the nature of the clay soil, which has a high moisture content and is very soft.

Comparison of the Results of Lime and Cement Repairs

Test results show that the CBR value of the cement-and-fill-sand mixture increased more significantly than that of the lime-and-fill-sand mixture. The 2% cement and 2% fill sand mixture met the minimum criteria for subgrade, while the 4% lime and 4% fill sand mixture barely met the minimum criteria for subgrade. Although the cement and fill sand mixture is more effective, the lime and fill sand mixture still provides a significant increase in CBR value and can serve as an economical stability alternative.

Conclusion of the Research Findings

Based on the test results and analysis conducted on clay soil with varying mixtures of lime, cement, and fill sand, the following conclusions were drawn:

1) Based on the results of soil physical property testing, it was found that the soil at the Pasir Jati Road site, Buahdua Subdistrict, Sumedang Regency, falls under Group A-7-6 in the AASHTO classification system, with a clay soil type

and soil conditions ranging from moderate to poor. In the USCS classification system, it falls under OH, which is organic clay with moderate to high plasticity.

2) Based on the results of the soaked CBR test on the original soil samples, it was shown that the clay soil does not meet the minimum subgrade criteria of 6% as specified in the General Specifications of the Ministry of Public Works (2018). The clay soil still has low bearing capacity, which is also attributed to its high plasticity. Therefore, improvement or treatment is required before it can be used as a road subgrade to increase its bearing capacity.
4) Soil improvement was carried out by adding several mixing materials, namely lime, cement, and fill sand, in the following mixture variations:
    a. Native Soil + 2% Lime + 2% Fill Sand
    b. Native Soil + 4% Lime + 4% Fill Sand
    c. Original Soil + 2% Cement + 2% Fill Sand
    d. Original Soil + 4% Cement + 4% Fill Sand
5) The test results for the original soil after treatment with lime or cement mixtures, according to the AASHTO classification system, fall into Group A-2-7 because the percentage of fine particles passing through a No. 200 sieve is less than 35%, and the liquid limit (LL) and plasticity index (PI) values also meet the criteria for that group. The soil type is gravelly silt or clayey silt and sand in very good to good condition. Under the USCS classification system, it falls into the SC category, which is clayey sand, a mixture of sand and silt, because the percentage of coarse particles is dominated by the sand fraction, which is more than 50%.
6) The results of the soil particle size distribution analysis for soil mixed with 4% lime and 4% fill sand, and soil mixed with 4% cement and 4% fill sand, indicate that these soils fall into the "well-graded" category, meaning that the particles within the soil effectively fill the voids between them. This condition is highly advantageous in construction work, as soil with a diverse particle size distribution tends to have good bearing capacity and controlled permeability. Soil with these characteristics can be recommended for use as fill material, foundation layers, or road pavement material, provided that other technical parameters also meet the required standards.
7) The results of the CBR test following improvement with the addition of 4% lime and 4% fill sand indicate that a 4% mixture with a CBR value of 6.40% meets the minimum criteria for subgrade as specified by Bina Marga (2018). This mixture is effective in improving the soil's bearing capacity to meet the required criteria for subgrade. Therefore, this mixture ratio is suitable for use as a subgrade on Pasir Jati Road, Buahdua Subdistrict, Sumedang Regency.
8) In this study, cement was used as a comparative repair material against lime to assess the effectiveness of each in improving the CBR. The CBR value for the mixture containing 2% cement and 2% fill sand was 7%. The CBR value for the mixture containing 4% cement and 4% fill sand was 15%. According to the Bina Marga specifications (2018), the minimum criterion for the subgrade is 6%. Both the 2% cement and 2% fill sand mixture and the 4% cement and 4% fill sand mixture met the minimum criteria for the subgrade. This indicates that cement and fill sand mixture percentages of 2% and 4% are highly effective in improving soil bearing capacity to meet the required criteria for the subgrade. Therefore, the 2% and 4% cement and fill sand mixture percentages on Pasir Jati Road, Buahdua Subdistrict, Sumedang Regency, are effective for use as a subgrade and can serve as an alternative soil improvement method. Cement serves as a reference material that demonstrates superior improvement effectiveness.
9) A comparison of field CBR values and laboratory CBR values shows that laboratory CBR values tend to be higher than field CBR values. The difference in CBR values is due to differences in testing conditions: laboratory tests are conducted under controlled conditions with adjustable moisture content and density, while field CBR tests are performed directly in the field under water-saturated and non-homogeneous conditions.

10) A comparison of lime and cement stabilization based on CBR values indicates that the cement–fill sand mixture provides a significantly higher increase in bearing capacity than the lime–fill sand mixture. The mixture containing 2% cement and 2% fill sand already satisfies the minimum subgrade requirement, whereas the lime–fill sand mixture requires a higher dosage of 4% lime and 4% fill sand to achieve the same criterion. This difference is primarily attributed to the hydration process of cement, which produces cementitious compounds such as calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H). These compounds bind soil particles together, reduce voids, increase soil density, and form a stronger and more rigid soil structure, resulting in a substantial increase in CBR values. In contrast, lime stabilization improves soil performance through cation exchange, flocculation, and pozzolanic reactions. These processes reduce soil plasticity, improve workability, and gradually enhance the bonding between soil particles. Although the resulting CBR values are lower than those obtained with cement stabilization, lime remains effective for improving clayey soils because it decreases shrink–swell potential and enhances long-term subgrade stability. Furthermore, lime is generally more economical and can provide a cost-effective alternative for projects where moderate strength improvement is sufficient. Therefore, while cement–fill sand stabilization demonstrates superior performance in increasing bearing capacity, lime–fill sand stabilization offers advantages in terms of economic efficiency and long-term soil conditioning.

CONCLUSION

Based on the results of laboratory testing and data analysis, the following conclusions can be drawn:

1) The soil type at the Pasir Jati Road site, Buahdua Subdistrict, Sumedang Regency, is classified as clay soil with moderate to high plasticity. The testing procedures for soil classification or property indices to be performed on the clay soil samples are as follows:
   a. Water Content Test
   b. Specific Gravity Test (Specific Gravity)
   c. Sieve Analysis Test
   d. Hydrometer Analysis Test
   e. Atterberg Limit Test
2) Based on laboratory test results, the mechanical properties of clay soils under initial conditions showed low CBR values and high plasticity; therefore, these initial soil conditions did not meet the minimum criteria for a subgrade. After improvement through the addition of a mixture of lime and fill sand, the soil characteristics changed, as indicated by an increase in the CBR value and a decrease in the plasticity value.
3) Amendment with lime and fill sand can increase the CBR value of clay soil in mixtures containing 4% lime and 4% fill sand. Although the CBR test results for the cement and fill sand mixture were higher than those for the lime and fill sand mixture. However, lime remains effective for improving clay soil because it reduces plasticity, improves the soil's physical properties, and gradually increases the CBR value. Additionally, lime is more economical and helps maintain the stability of the subgrade.
4) Based on the laboratory CBR test results, it was found that the CBR value of the native soil for Sample I was 1.55%, for Sample II was 1.30%, and for Sample III was 1.43%. These CBR values of the native soil do not yet meet the minimum criteria for subgrade, which is 6% according to the Bina Marga technical specifications (2018). After improvement using various mixtures of lime, cement, and fill sand, there was an increase in the CBR value, with several mixture variations meeting the required specifications.

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