GIJES
Greenation International Journal of Engineering Science
+62 81210467572 https://research.e-greenation.org/GIJES greenation.info@gmail.com
GREENATION RESEARCH

DOI: https://doi.org/10.38035/gijes.v4i1

Cbr Values in the Sub-Grade Layer of Reclamation Fill (Case Study: Patimban Port Project Package 6)

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Abstract: Reclamation work on port projects requires embankment materials with adequate bearing capacity, particularly in soaked areas that are saturated with water and potentially subject to soil strength degradation. In the Patimban Port Development Project (Phase 1–2) Package 6: Container Terminal No. 2 Construction, the use of sand as reclamation embankment requires further assessment using the California Bearing Ratio (CBR) parameter to ensure the soil's suitability as a subgrade layer. Variations in soil characteristics due to the layered embankment process and the potential for liquefaction are important factors influencing soil stability. This study aims to determine the suitability of the subgrade layer's CBR value to existing theory, analyze the effect of the reclaimed material's CBR value on subgrade performance, and assess the suitability of the reclaimed soil as a subgrade layer based on CBR technical parameters. The research method used is quantitative with a descriptive approach. Data were obtained through laboratory testing and field testing using Dynamic Cone Penetration (DCP) at 20 test points. The results of the study indicate that: (1) the CBR value of the subgrade layer is in accordance with existing theory, where all values are above the minimum limit of 6% and follow the theoretical pattern in the form of a decrease in the saturated layer and an increase in depth due to overburden pressure; (2) the CBR value of the reclaimed material has a direct effect on subgrade performance, where a lower CBR value in a particular layer becomes a controlling layer that affects the potential for deformation and overall soil stability; and (3) the reclaimed soil meets the technical requirements as a subgrade layer, with CBR values ranging from 8.98% to 22.64% at various depths, making it suitable for use as a supporting layer for construction.

Keyword: CBR, DCP, Reclamation, Patimban Port, Saturated Soil, Subgrade.

INTRODUCTION

A port is a water area that is protected from waves and used as a berth for ships and other water vehicles that function to raise or lower passengers, goods and animals, repairs, refueling and so on which is equipped with a pier where ships are moored, cranes for

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Note:
However, it needs to be clarified:
What are the main legal issues (e.g., data protection, consumer disputes, or OJK supervision),
What are the shortcomings of previous research,
and why this research is important.

Without a clear research gap, the article seems descriptive.

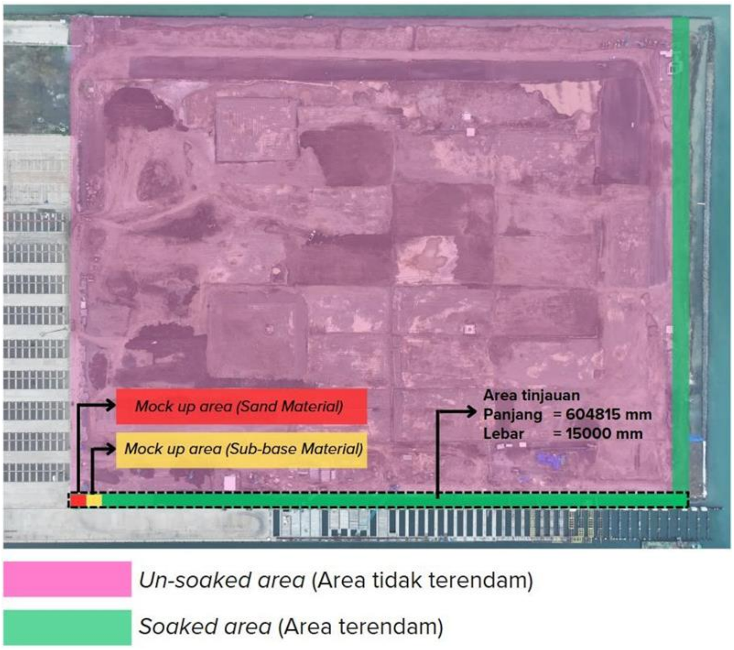
loading and unloading goods, a transit warehouse, and a place to store goods for a longer time (Talizomboi Laia & Lisma Yenni Pandia, 2022). While waiting for distribution to the destination area or the next shipment. Landfill and improvement in the Patimban Port Development Project (Phase 1-2) Package 6: Container Terminal No. 2 Construction is one of the main works with a much wider scope of work zones than other work zones. The hoarding zone is intended as a Container Terminal and a port road (Akbar, 2023). The stockpiling work starts after the CPM (Cement Pipe Mixing) and CDM (Cement Deep Mixing) work is completed (Karso, 2024). Sand reclamation work will be carried out in stages in predetermined areas (Roni Vichaldry et al., 2026).

The Patimban port project is a project that has works that include dredging work, quay wall structure works, land reclamation works, inner port road works, storm water drainage works, pavement works, electrical works, and mechanical works (Sitta Rahmawati & Pramusandi, 2025). Then, the port work requires stockpile materials to accumulate the reclamation area. Reclamation is the process of making new land by accumulating land in the waters as one of the alternatives to the development of coastal areas (Jamika et al., 2023).

In the reclamation area, it is planned to use heap material in the form of sand *filling* to fill the entire planned area (Wahyudi & Lastiasih, 2025). Therefore, the backfill work requires testing materials to meet the required requirements/specifications. The process of determining the material that will be used to hoard the reclamation area includes many stages (Zahrah et al., 2024). The stage starts with finding materials from *the quarry* to be tested in the laboratory to field tests with density control in the field. Testing of materials from *quarries* in the laboratory includes testing *grain* size/PSD (*Particle Size Distribution*), *moisture content natural*, *specific grafity*, *compaction test*, CBR (*California Bearing Ratio*) *soaked* and *unsoaked*. The materials that can be used are materials from *the quarry* that meet the technical requirements, namely *silt and clay* less than 10%, D20 (20% *Passing Grain Size*) more than 0.15 mm, D60 maximum 36 mm, and CBR value > 6% (Lubis, 2024).

In the context of specific conditions in Patimban Port, West Java, sea depth data is an important factor that affects the reclamation process and the stability of the stockpile. Based on the latest hydrographic survey, the sea depth in the Patimban reclamation area reaches 14 meters below the Mean Water Level Spring (MWLS) (Isnaeni & Putri, 2024). The backlog for the reclamation area includes the backlog for *soaked areas* (submerged areas) and *unsoaked* areas (unsoaked areas) (Junaidi, 2022). However, laboratory testing of materials in the form of sand tested from the *quarry* used for soaked heap work showed results that have the *possibility* of liquefaction (Utama, 2023). The liquefaction analysis was carried out by grain size distribution using *the Tsuchida* curve (1970). With the analysis of the liquefaction *of the Tsuchida* curve (Diana et al., 2024), a *mock up was carried out* on the *soaked area* as a *trial* to compare and determine the use of materials in accordance with the technical requirements and design to hoard the planned reclamation area (Suyadi, 2023).

This study aims to determine the suitability of the CBR value of the subgrade layer to the existing theory, analyze the effect of the CBR value of the reclaimed material on the performance of the subgrade, and assess the feasibility of reclaimed land as a subgrade layer based on the technical parameters of CBR.



METHOD

The method used in this study is a quantitative research method. Using a descriptive research type. Descriptive research is a method that functions to describe or give an overview of the object being studied through data or samples that have been collected as they are, without conducting general analysis and conclusions (Sugiyono, 2020).

In this study, the research design began with the collection and review of literature relevant to the topic being studied, especially related to the California Bearing Ratio (CBR) test and soil characteristics as a subgrade layer. This literature study aims to obtain a strong theoretical foundation, understand basic concepts, and identify the right method in the implementation of research.

Furthermore, data is collected which will be used as a basis for research analysis. The data collected includes primary data and secondary data related to the research object. The data is obtained through various relevant sources and has a level of reliability that can be scientifically accounted for. This stage is important because the quality of the data obtained will greatly affect the results of the analysis and the conclusion of the research.

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type of research (normative/socio-legal),
approach (statutory, conceptual, comparative),
sources of legal materials,
analysis techniques.

Without a clear methodology, scientific validity is weakened.

Stages of Fieldwork

The implementation of the field work on the reclamation project is carried out systematically and gradually to ensure that each process meets the technical specifications that have been set. Sand piling work begins after soil improvement works, such as Cement Pipe Mixing (CPM) have been completed. This aims to ensure that the condition of the subsoil has an adequate bearing capacity before receiving the load of the infill material. Furthermore, the reclamation process is carried out in stages in areas that have been planned according to the construction stage.

Material Transportation to Site

The initial stage in the fieldwork is the process of transporting materials. The aggregate material used as a sub-grade layer is obtained from quarries that have met the technical requirements. The material is transported to the project site using a transport vehicle in the form of a truck, then temporarily stored in the laydown area. From this location, the materials are again distributed to the work area according to the needs of the stockpiling. This stage requires good logistical arrangements to ensure the continuous availability of materials during the construction process.

Survey Jobs

Furthermore, survey work was carried out as a first step before the distribution of materials. This activity aims to ensure that the field conditions are in accordance with the design plan, both in terms of elevation and horizontal position. Measurements are carried out using survey equipment such as auto level and total station. In addition, the material to be used must meet the minimum California Bearing Ratio (CBR) value of 6% in accordance with the provisions that have been approved by the supervisor (Engineer). The results of this survey are also used as a reference in determining areas that require cut and fill work as well as a guideline in controlling the thickness of the subgrade layer to be deployed.

Sub Base Material Deployment Work

The next stage is the spreading of the sub-base material, which is carried out in stages with a thickness of about 150 mm for each layer. The distribution of materials in the early stages is carried out using a bulldozer to speed up the process of distributing materials. Meanwhile, in the final layer, a motor grader is used to achieve a higher level of precision in terms of elevation and surface slope according to the pavement design. This process is done in layers to ensure that each layer has uniform and stable conditions.

Compaction Work

After the material dispersion process is completed, the next stage is compaction work which has an important role in improving the technical quality of the backfill layer. Compaction aims to reduce the cavity between soil grains so as to increase the density, strength, and carrying capacity of the material against the load that will work on it. In its implementation, compaction is carried out using heavy equipment in the form of a steel wheel vibratory roller, which can be operated by two methods, namely using vibration (vibratory compaction) and without vibration (static compaction). The selection of this method is adjusted to the characteristics of the material and field conditions, where the use of vibration is generally more effective for coarse-grained materials such as sand, but it must still be controlled so as not to cause degradation or damage to the aggregate grains due to excessive vibrational energy.

During the compaction process, moisture content control is a very crucial factor in determining the success of compaction. The moisture content must be kept close to optimal conditions so that the material can reach maximum density. If the material is too dry, water is watered evenly to increase the humidity until it reaches the desired condition. On the other hand, if the material is too wet, the compaction must be temporarily stopped and the drying process is carried out naturally until the moisture content is back in the appropriate range. This control of moisture content is very important because the condition of water in soil pores has a direct effect on the ability of soil particles to bind to each other and form denser structures.

The compaction process is carried out gradually and repeatedly until it reaches the required density level, which is a minimum of 95% of the Maximum Dry Density (MDD) based on the results of the compaction test in the laboratory. In addition, the soil carrying capacity value must also meet technical requirements, namely the California Bearing Ratio (CBR) value of more than 6% based on the results of the Field Density Test (FDT) or other field test methods. The achievement of this parameter indicates that the material has sufficient strength to be used as a subgrade layer in construction.

After the compaction is completed, an inspection of the work results is carried out to ensure conformity with the design specifications. The surface of the subgrade layer must meet a predetermined elevation tolerance, i.e. no more than ±1.5 cm to the planned elevation. In addition, the thickness of each layer must also be controlled so that it is not thinner than the stipulated provisions. This control of elevation and thickness aims to ensure the uniformity of the layers and ensure that the distribution of the load on the structure above it can take place optimally. Thus, the compaction stage not only serves to increase material density, but is also a key factor in ensuring the stability and overall performance of the construction.

RESULT AND DISCUSSION

This section contains the data (in summarised form), data analysis and interpretation of the results. Results can be presented with tables or graphs to clarify verbal results, because sometimes the display of an illustration is more complete and informative than the display in the form of a narrative.

The discussion section should answer the research problem or hypothesis that has been formulated previously.

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Do OJK regulations sufficiently protect consumers?
What is the mechanism for resolving fintech disputes?
Is personal data protection effective?
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Without critical analysis, the article becomes too normative and general.

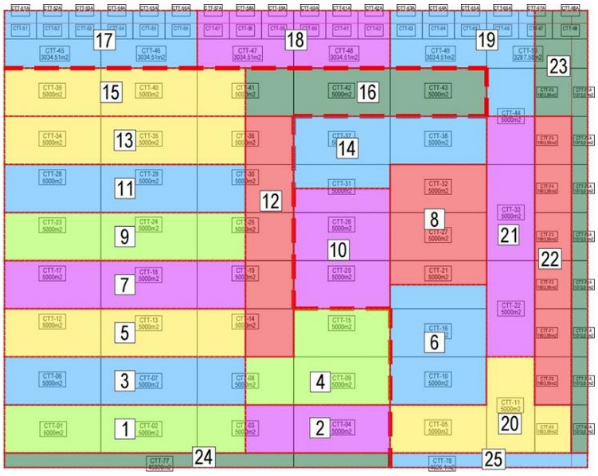
Note:
Use an evaluative approach to regulations.

Overview of The Final Project Location

Reclamation work at the Patimban Port project is generally classified into two areas, namely soaked areas and unsoaked areas. This research was conducted in a soaked area. In this study, a stockpile analysis was carried out in the laboratory and a mock up trial compaction in different material fields.

The implementation of the mock trial compaction aims to obtain results in the form of determining the type of material that is able to meet the requirements of technical specifications and standards that have been set so that it can be used to hoard the area to be planned. The soaked area that is the object of the study is a submerged area located between the dock structures and is on top of the soft soil reinforcement layer using the Cement Deep Mixing (CDM) method, which was part of the construction work at the previous stage of the project.

The mock up trial compaction activity in the reclamation of this soaked area was carried out in Area 24 Container Terminal, as shown in the image referred to in the study.



Stockpile Materials

The selection of materials used in the backfill work includes sampling for testing materials in the laboratory in the form of Particle Size Distribution (PSD), moisture content natural, specific grafity, compaction test, soaked and unsoaked California Bearing Ratio (CBR).

However, laboratory testing of materials in the form of sand tested from the quarry (material source) used for the work of the soaked area pile shows results that have the possibilty (possibilty) of liquefaction, liquefaction is a geotechnical phenomenon in which water-saturated soils, especially loose sand, experiences a decrease in shear strength and rigidity due to increased pore water pressure which are generally triggered by dynamic loads such as earthquakes. Under these conditions, the effective voltage of the soil decreases to close to zero so that the soil grains lose contact with each other and their behavior changes to resemble a fluid. As a result, the soil is unable to support the load on it, which can lead to subsidence, lateral shift, and damage or collapse of the building structure. Therefore, the identification and analysis of liquefaction potential is important in construction planning, especially in earthquake-prone areas, so that a mock up trial compaction is carried out in the soked area or below the water surface.

Method of Execution Of The Stockpile

The implementation of the backfill in the reclamation work includes many stages to replenish the planned area. The work began with the approval of the work method. After the approval of the working method, material sampling will be carried out from the quarry (material source) for laboratory testing. The material testing includes Particle Size Distribution (PSD), moisture content natural, specific grafity, compaction test (modified proctor), soaked and unsoaked California Bearing Ratio (CBR). After the material meets the technical specifications, the material can be done in the field for mock up trial compaction.

After the material meets the criteria, then the material can be sent to the project site to accumulate the reclamation area.

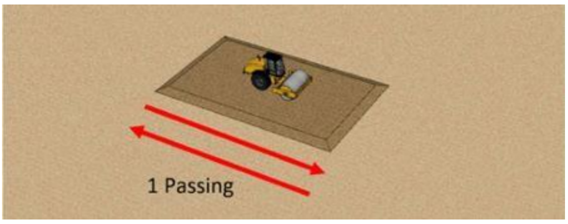
Initial MC Check and Stockpile Compaction

After the process of spreading the material is completed, the next stage is to provide water through watering using a water tank to adjust the condition of the moisture content of the material. This activity aims to achieve a moisture content that is close to the Optimum Moisture Content (OMC) value, which is the optimal moisture content required for the material to reach maximum density during the compaction process. Theoretically, the relationship between moisture content and soil density is explained through the compaction curve (Proctor), where under OMC conditions the soil has the best combination of particle lubrication and air cavity reduction, resulting in a denser and more stable soil structure.

After watering is done, the next step is to check the moisture content of the material to ensure its suitability with the technical specifications that have been set. This test is important because too low a moisture content will inhibit the compaction process due to a lack of lubrication between particles, while too high a moisture content can lead to a decrease in soil strength due to increased pore water pressure. Therefore, water content control is a crucial factor in the construction process, especially in reclamation heap work that demands optimal soil stability and carrying capacity. By ensuring that the moisture content is at conditions close to OMC, it is hoped that the compaction process can take place effectively and produce a soil layer with mechanical characteristics that are in accordance with design requirements..

Stockpile Compaction

The compaction of the stockpile area is carried out using a roller vibrator with a capacity of 12 tons. However, at this stage of compaction, settlement plate monitoring is carried out on each passing (trajectory). One pass is a forward and backward movement of the vibrator roller without the use of vibration. Then, after the mapping work is done, it is followed by the reading of the settlement plate on each layer (layer). Passing illustration can be seen in the picture.



Field Density Test

After the compaction work was carried out, field density testing was carried out by testing the sand cone at three points in the stockpile area. The technical specifications in the field density test are 95% of the Moisture Dry Density (MDD) for the pavement area and 90% for the non-pavement area.

Dynamic Cone Penetration (DCP) Testing

Dynamic Cone Penetration (DCP) testing on the soaked area was carried out to determine the soil carrying capacity of the sand material and subgrade layers directly in the field. This test is a commonly used method in geotechnical investigations because it is able to provide a quick overview of the variation in soil strength to depth. In this study, DCP testing was carried out at 20 points that were evenly distributed with a distance between points of about 10 meters from the east of the pier, so that it could represent the soil conditions in the research area as a whole.

The DCP test is carried out by repeatedly dropping the load on the penetration rod equipped with a cone end with a certain angle. Each blow will cause penetration into the ground, and the magnitude of the penetration is recorded in millimeters per impact (mm/blow). The data is then used to evaluate the density and relative strength of the soil at various depths. The smaller the penetration value produced, it indicates that the soil has a higher resistance to penetration, which means it has a better bearing capacity.

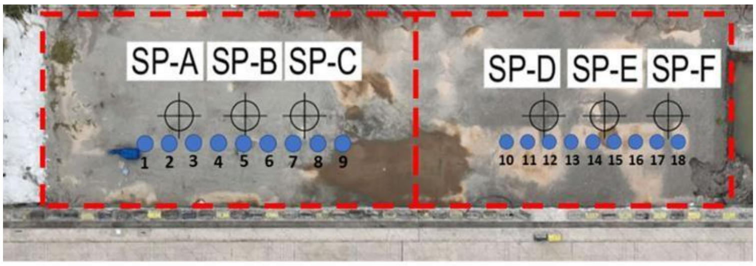
DCP testing in soaked area conditions has special characteristics because the soil is in a water-saturated condition. This condition can affect the test results, where the soil tends to have a greater penetration value than dry conditions due to reduced soil shear strength. Therefore, the results of the DCP test in this study are considered to represent the critical condition of the soil in receiving loads, so it is very relevant to be used as a basis for evaluating the feasibility of soil as a subgrade layer.

In addition, the testing is carried out in stages until it reaches a certain depth that has been determined in the study. At each depth interval, penetration values are recorded for further analysis. Thus, a vertical profile of the soil is obtained that describes the variation in carrying capacity to depth. This profile is very important in understanding the characteristics of reclaimed soils which are generally inhomogeneous and consist of several layers of landfills.

An even distribution of test points also aims to identify possible lateral variations in soil conditions. In reclamation projects, this variation can occur due to differences in landfill methods, types of materials, and the level of compaction in the field. With data from various points, the test results become more representative and can be used to draw more accurate conclusions about the overall soil condition.

The results of the DCP test are then correlated to the California Bearing Ratio (CBR) value using standardized empirical equations. This correlation allows penetration data obtained in the field to be translated into soil carrying capacity parameters that are more commonly used in civil engineering planning. Thus, DCP testing not only provides information regarding the level of soil penetration, but can also be used as a basis in the evaluation of soil strength and construction planning on it.

Overall, the Dynamic Cone Penetration (DCP) test in this study provides comprehensive information about the condition of the reclaimed soil in the soaked area, both in terms of the distribution of strength to depth and variation in soil conditions horizontally. The data obtained is an important basis for further analysis, especially in determining the value of CBR and evaluating the feasibility of land as a subgrade layer in the Patimban Port reclamation project.



California Bearing Ratio (CBR)

CBR testing is carried out by testing a Dynamic Cone Penetrometer (DCP) whose results are converted to CBR values. In the soaked area, the CBR test is represented by the DCP test results converted to CBR with the formula in equation 4.1. based on ASTM D 6951-03.

CBR value = 292/〖DCP〗^1,12 .... (4.1)

Description:
DCP = mm/blow

Then, the calculation of DCP correlated to the CBR value is carried out based on the Circular Letter of the Minister of Public Works No. 04/SE/M/2010 concerning the Implementation of Guidelines for California Bearing Ratio (CBR) Test with Dynamic Cone Penetrometer (DCP) using a 30º cone in equation 4.2.

Log10 (CBR)= 1,352 – 1,125 Log10 (cm/crest)

Theoretical Review of CBR Minimum Values on Reclamation

In reclamation work, soil conditions are generally formed in layers due to the landfill process that is carried out in stages. This layered structure causes the soil characteristics to be heterogeneous, both in terms of density, moisture content, and shear strength. Therefore, the evaluation of the California Bearing Ratio (CBR) value cannot be done in general, but rather must be reviewed based on the depth distribution. Theoretically, the CBR value is used as the main parameter in assessing the bearing capacity of the soil against the penetration load, so it plays a very important role in the planning of the subgrade layer. According to Braja M. Das, the CBR value of 5%-10% is categorized as soil with medium carrying capacity, while a value above 10% indicates good to very good soil conditions. Thus, the minimum value of 6% is generally used as a technical limit so that the soil is still suitable to function as a subgrade layer.

In layered soil systems, the main principle to be observed is that the strength of the soil is determined by the layer with the lowest value. This concept is known as the controlling layer, where the weakest layer will control the deformation behavior and stability of the overall soil system. Therefore, even if there is a layer with a high CBR value, the presence of a single layer with a low value can still be a critical factor in structural failure. This is in line with the concept of soil mechanics put forward by Karl Terzaghi, that the stress distribution and deformation of the soil are greatly influenced by the conditions of the weakest soil layer.

Conceptually, the minimum limit of CBR values for each layer of reclaimed soil can be elaborated based on the characteristics and functions of each layer as follows:

0–1 meter layer (Surface Layer / Working Platform)

This layer is a zone that receives direct loads from construction activities and initial traffic, so it requires higher strength than other layers. The minimum recommended CBR value is in the range of ≥10%, with ideal values ranging from 10% to 20% or more. According to Ralph B. Peck, the surface layer must have sufficient strength to distribute the load evenly to the layer below it to prevent initial deformation.

1-2 meter layer (Critical Layer)

This layer is often in a condition of water saturation and has not been compaction or consolidation optimally. Therefore, the minimum CBR value must still meet the technical limit of ≥6%, with a theoretical range between 8% to 12%. According to Joseph E. Bowles, increased moisture content and low soil density will decrease the shear strength, resulting in a relatively lower CBR value in this layer.

2-3 meter layer (Transition Layer)

This layer serves as a transition zone between the relatively weak upper layer and the more stable lower layer. The minimum CBR value remains ≥6%, with a theoretical range of 8% to 12%. The stability of this layer is essential to maintain an even voltage distribution and avoid voltage concentrations that can lead to local failures.

4-7 meter layer (Bearing Layer)

At this depth, the soil has generally experienced an increase in density due to overburden pressure. The minimum CBR value remains ≥6%, but theoretically it is in the range of ≥10% to more than 20%. According to Karl Terzaghi, increasing pressure effectively will increase the shear strength of the soil, so that the bearing capacity of the soil becomes higher. This layer acts as the main supporting layer that determines the long-term stability of the structure.

Based on this discussion, it can be stated that although the California Bearing Ratio (CBR) minimum value is generally set at 6% as the basic criterion for technical feasibility, the evaluation of the variation in the CBR value based on depth is essential. An approach that focuses only on average values has the potential to result in a less comprehensive interpretation, especially if it does not consider the existence of the layer with the lowest CBR value that acts as a critical layer. The layer with the lowest strength has a significant influence on the deformation response and stability of the soil system as a whole.

Therefore, the vertical distribution of CBR value is a more representative approach in assessing the feasibility of reclaimed land as a subgrade layer. This approach allows for more precise identification of zones that have the potential to be weak points in the soil structure, so that targeted improvement or reinforcement actions can be taken. Thus, in infrastructure construction planning, especially in port reclamation projects, the assessment of the carrying capacity of the soil should not only be based on the fulfillment of the minimum limit, but also consider the uniformity and consistency of the strength of the soil to the depth to ensure the performance of the structure in the long term.

Average Result of CBR values in layer 1 (Depth 0-1 M)

The test results showed that the average CBR value in this layer was 21.21% This value was relatively high and significantly exceeded the minimum required limit, thus indicating that the soil layer has a good bearing capacity and meets the criteria as a subgrade for pavement construction.

CBR=14,85/70 x 100%=21,21%

Thus, this layer has excellent characteristics as a load-supporting layer.

Average Result of CBR values in layer 2 (Depth 1-2 M)

The decrease in the average value of CBR in the second layer to 10.34% indicates a change in soil characteristics compared to the layer above. However, the variation in CBR values between test points was relatively small, indicating that the soil conditions on this layer were quite homogeneous. Geotechnically, the decrease in the value of the CBR can be caused by several factors, including increased moisture content which affects a decrease in soil shear strength, reduced soil density levels, and the possibility of changes in soil type to be smoother. Fine-grained soil materials generally have a lower bearing capacity than coarse-grained soils.

Despite the decrease in CBR value, all test results on this layer are still above the required minimum limit, which is 6%. Therefore, the soil in the second layer can still be categorized as meeting the requirements as subgrade soil that is suitable to support construction.

CBR=10,86/105 x 100%=10,34%

Average Result of CBR values in layer 3 (Depth 2-3 M)

At this layer, the average value of CBR decreased to 8.98%.

CBR=9,43/105 x 100%=8,98%

Average Result of CBR values in layer 4 (Depth 3-4 m)

The average value of CBR in this layer shows a relatively stable tendency, which is 9.47%. When compared to the previous layer, the variation in CBR values between test points tended to be smaller, indicating a better level of soil uniformity at that depth.

This condition shows that the soil layer at that depth has more homogeneous geotechnical characteristics. The stability of the CBR value indicates that the soil structure is in a relatively balanced condition, so that it is able to provide a consistent carrying capacity for the load working on it.

CBR=6,63/70 x 100%=9,47%

Average Result of CBR values at layer 5 (Depth 4-5 m)

The average CBR value in this layer has increased to 14.98%. The increase indicates an improvement in soil conditions in terms of carrying capacity to the load working on it.

Theoretically, the increase in CBR value can be influenced by several geotechnical factors, including an increase in soil density due to overburden pressure from the layer above, a reduction in soil porosity which causes the soil structure to become tighter, and the dominance of granular materials which have higher shear strength characteristics than fine-grained materials.

CBR=10,49/70 x 100%=14,98%

Average Result of CBR values at layer 6 (Depth 5-6 m)

The average value of CBR in this layer has increased significantly, which is 22.14%. The increase in value shows that the soil at this depth has a higher carrying capacity than the previous layer.

Geotechnically, the phenomenon of increasing the CBR value can be explained by several factors, including the natural compaction process due to the overburden pressure, as well as reduced free water content in the soil pores. This condition causes an increase in the density of soil grains so that the shear strength of the soil becomes greater.

Thus, this layer can be classified as a soil layer that has strong characteristics and has good bearing ability against construction loads.

CBR=15,50/70 x 100%=22,14%

Average Result of CBR values at layer 7 (Depth 6-7 m)

In the deepest layer, the average CBR value obtained was 22.64%. This value is one of the highest values in the soil profile analyzed.

These results show that the soil at this depth has a high level of density and a more stable structure than the layer above it. Geotechnically, these conditions are very favorable because they indicate the soil's good ability to withstand loads, thus contributing to the overall increase in the carrying capacity of the soil.

CBR=23,77/105 x 100%=22,64%

CONCLUSION

The CBR value of the reclaimed subgrade layer shows a variation in depth, but in general all layers meet the minimum technical requirements set, which is greater than 6%. The average value of CBR in the surface layer (0–1 m) of 21.21% indicates excellent soil conditions as a working platform, while in the next layer it decreases to the range of 8–10% at a depth of 1–4 meters. Furthermore, at a depth of more than 4 meters, the CBR value increased again to above 20%, which indicates an increase in density due to overburden pressure. The variation in the CBR value that occurred showed that the characteristics of the reclaimed soil were inhomogeneous, which was influenced by the gradual accumulation process, moisture content, and the level of compaction in the field. Layers with lower CBR values have the potential to become a controlling layer that can affect the overall performance of the structure. However, the results of the study show that all layers are still in the category of soil with medium to good carrying capacity, so they are still suitable for use as subgrade

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They should be more specific:
What are the weaknesses of current regulations?
What are the concrete solutions?
What are the policy implications?

Note:
Focus conclusions on:
Main findings,
Research contributions,
Regulatory recommendations.

layers. CBR testing conducted through the Dynamic Cone Penetrometer (DCP) method has proven to be effective in providing a quick and representative picture of soil carrying capacity, especially in reclamation areas that are in soaked areas. The results of this test show that the sand material used as a backfill has met the technical criteria, although it has liquefaction potential that needs to be anticipated through soil improvement methods such as Cement Deep Mixing (CDM) and Cement Pipe Mixing (CPM). Overall, the reclaimed soil in the research area can be categorized as feasible as a subgrade layer because it meets the minimum CBR value requirements and shows an increase in carrying capacity in the deeper layers. This shows that the reclamation methods applied, including the use of hydraulic fill management systems and a combination of soil improvement, are able to significantly improve soil stability and support port construction in the long term

REFERENCES

Commented [RA6]: The lettering format in references is inconsistent. Correct and standardize it. Follow the guidelines in the journal template.

Akbar, R. A. (2023). *ANALISIS KINERJA LAPANGAN PENUMPUKAN PELABUHAN MALUNDUNG TARAKAN KALIMANTAN UTARA = ANALYSIS OF CONTAINER YARD PEFORMANCE OF MALUNDUNG TARAKAN PORT*. Skripsi, Universitas Hasanuddin.

Diana, N. A., Soemitro, R. A. A., Ekaputri, J. J., Satrya, T. R., & Warnana, D. D. (2024). Evaluasi Risiko Likuifaksi Berdasarkan Karakteristik Ukuran Butir Tanah dan Hasil Tahanan Standart Penetration test (N-SPT) Studi kasus Bandara Yogyakarta Internasional Airport. *Publikasi Riset Orientasi Teknik Sipil (PROTEKSI)*, *6*(1), 51–58. https://doi.org/https://doi.org/10.26740/proteksi.v6n1.p51-58

Isnaeni, K. ., & Putri, M. . (2024). Pemodelan Hidrodinamika Perairan Subang: Analisis Awal Sebelum Pembangunan Pelabuhan Patimban. *Journal of Marine*, *1*(1), 48–60.

Jamika, F. I., Monica, F., Razak, A., & Kamal, E. (2023). PENGELOLAAN PESISIR DAN KELAUTAN DALAM STUDI KASUS DAMPAK REKLAMASI PANTAI DAN TAMBANG PASIR TERHADAP EKOSISTEM LAUT DAN MASYARAKAT PESISIR. *JOURNAL OF INDONESIAN TROPICAL FISHERIES*, *6*(1), 99–109. https://doi.org/10.33096/joint-fish.v6i1.162

Junaidi, J. (2022). Perbandingan Daya Dukung (CBR) Kondisi Soaked Dan Unsoaked Agregat Kelas B Berdasarkan Variasi Gradasi Lapangan (Studi Kasus : Material Agregat Kelas B di Quary Pulau Bengkalis). *International Conference on Industrial Technology and Business Proceeding (INTECHBIZ)*, *1*(1), 124–133.

Karso, A. J. (2024). *Menyongsong Kota Metropolitan: Teori dan Praktik Pengembangan Kawasan dan Pertumbuhan Ekonomi*. Samudra Biru.

Lubis, R. R. A. (2024). *PENGUJIAN NILAI CBR LABORATORIUM GRANULAR SELECTED SEBAGAI LAPISAN PENOPANG (CAPPING LAYER) PADA RUAS JALAN TOL INDRAPURA – KUALA TANJUNG (Studi Penelitian)*. Fakultas Teknik, Universitas Islam Sumatera Utara.

Roni Vichaldry, Sinta Aulia, Jamilah, & Osronita. (2026). Transformasi Lahan Bekas Tambang Menjadi Lanskap Wisata Berbasis Masyarakat dan Ketahanan Pangan di Desa Lubuk Alung. *Jurnal Ragam Pengabdian*, *3*(Spesial Issue), 1666–1683. https://doi.org/10.62710/6cx2ra87

Sitta Rahmawati, N., & Pramusandi, S. (2025). PELAKSANAAN PEKERJAAN STEEL PIPE PILE (SPP) PADA PROYEK PELABUHAN PATIMBAN PORT SUBANG JAWA BARAT. *Prosiding Seminar Nasional Teknik Sipil*, *7*(1), 402–416. https://prosiding.pnj.ac.id/index.php/snts/article/view/4861

Sugiyono. (2020). *Metode Penelitian Kuantitatif, Kualitatif dan Kombinasi (Mixed Method (Kedua)*. Alfabeta.

Suyadi, S. (2023). *UJI MODEL PERKUATAN TANAH MENGGUNAKAN CERUCUK*

KAYU PADA DAERAH RAWAN LIKUIFAKSI = Soil Reinforcement Model Test Using Timber Pile at Liquefaction Area. Disertasi thesis, Universitas Hasanuddin.

Talizomboi Laia, & Lisma Yenni Pandia. (2022). IMPLEMENTASI INAPORNET TERHADAP PELAYANAN KAPAL DAN BARANG PADA PT. SAMUDERA ARKAN NUSANTARA. *JITA (Journal of Information Technology and Accounting)*, *5*(1), 36–40. https://jurnal.uimedan.ac.id/index.php/JITA/article/view/768

Utama, K. A. (2023). *Perilaku Timbunan Tanah Kerukan-Karet Serut yang Distabilisasi dengan Mineral Alami sebagai Lapis Fondasi Jalan = The Behavior of Dredged Soil-Shredded Rubber Embankment Stabilized with Natural Minerals as a Road Foundation Layer*. Disertasi, Universitas Hasanuddin.

Wahyudi, H., & Lastiasih, Y. (2025). *Reklamasi Pantai*. Penerbit Andi.

Zahrah, S. O., Franto, F., & Mardiah, M. (2024). Perencanaan Tahapan Persiapan Dan Perhitungan Reklamasi Di Lahan Bekas Tambang Air Rikai PT Timah Tbk Kabupaten Bangka: Planning for Preparatory Stages and Reclamation Calculations on the Former Air Rikai Mine Land of PT Timah Tbk, Bangka Regency. *MINERAL*, *9*(1), 25–32. https://doi.org/10.33019/mineral.v9i1.5140