International Journal of Civil Engineering
(IJCE)
ISSN (P): 2278–9987; ISSN (E): 2278–9995
Vol. 15, Issue 1, Jan–Jun 2026; 1–10

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

ANALYSIS OF THE EFFECT OF ADDING SEA SAND (EX. SEA SAND FROM LAMBAKO VILLAGE) ON CLAY SOIL STABILIZATION IN ROAD INFRASTRUCTURE WORKS IN BANGGAI LAUT REGENCY

Ratna Sari*, Astri Rahayu & Hendra Setiawan

Tadulako University, Central Sulawesi, Indonesia

ABSTRACT

Road infrastructure development on the Banggai-Lokotoy section in Banggai Laut Regency faces stability challenges due to the subgrade, which is clay soil with high shrinkage and swelling properties and low bearing capacity. This study aims to analyze the effect of adding sea sand from Lambako Village as a stabilizing material on the physical and mechanical characteristics of clay soil. The research method used was a laboratory experiment, testing soil samples mixed with sea sand at proportions of 0%, 15%, and 30%. A series of tests were conducted including physical properties (specific gravity, water content, Atterberg limits) and mechanical tests including modified compaction, California Bearing Ratio (CBR), and Unconfined Compressive Strength (UCT) with varying curing times up to 28 days. The results showed that the characteristics of the original soil at the study site were categorized as clay with high plasticity (CH) according to the USCS classification. The addition of sea sand was proven to be effective in increasing the stability of the subgrade. At the optimal proportion of 30% sea sand, there was an increase in the maximum dry unit weight from 1.623 gr/cm³ to 1.848 gr/cm³, while the optimum water content decreased from 21.15% to 17.35%. Mechanically, the CBR value increased significantly from 11.23% to 24.07%. In addition, the unconfined compressive strength (qu) value of the 30% sea sand mixture also increased with increasing curing time, reaching a maximum value of 6.040 Kg/cm² on the 28th day. The conclusion of this study is that the addition of sea sand effectively improves the consistency and increases the bearing capacity of clay soil in Banggai Laut Regency.

KEYWORDS: *Clay, Sea Sand, Soil Stabilization, CBR, Unconfined Compressive Strength.*

Article History

Received: *13 Dec 2025* | ***Revised:*** *16 Dec 2025* | ***Accepted:*** *20 Dec 2025*

INTRODUCTION

Road construction in the Regency Banggai Laut, especially on the Banggai – Lokotoy section, is facing challenge Serious in the form of damage repetitive structural. As access main towards Maulana Frins Mandafar Airport, road throughout These 150 meters are experiencing condition wavy, cracked wide, up to phenomenon *pumping* (rising) land base to surface). Although has done rehabilitation in 2017, failure infrastructure Keep going occurred which indicates existence fundamental problems with stability land base (*subgrade)* at the location.

Identification field show that land The base in Lelang Village consists of from land clay with characteristic high swelling and shrinkage low support moment submerged in water. For overcome weakness mechanical mentioned, it is necessary method stabilization with utilise source Power local in the form of sand sea from Lambako Village. The addition of granular materials such as sand sea assessed capable repair gradation land, reduce level plasticity, as well as increase strength shift land clay in a way more economical.

This research aims For analyze influence percentage addition sand sea to change characteristics physical and mechanical land clay in the Regency Banggai Sea. Through testing laboratory, it is expected found formulation optimal mix for increase stability road. The results of this study are projected can give contribution technical in election method effective stabilization as well as support sustainability development infrastructure transportation in coastal areas

Characteristics Mineralogy and Behavior of Clay Soils

Clay soil is a material that is composed on particle microscopic sized not enough from 0.002 mm with form slab flattened by force surface [6]. In structural, clay minerals consists of of silica tetrahedra and aluminum units octahedra that form mineral groups such as *kaolinite, illite,* and *montmorillonite* [10]. Characteristics main This land covers permeability low cohesion high, and characteristic large swelling and shrinkage, which causes instability significant on structure land base road [11]

Principle Soil Stabilization and the Role of Sea Sand

R Stabilization land aim For repair characteristic physical and mechanical land to improve Power support as well as strength slide [1]. Use of sand sea as material stabilization utilise mineral content and functional salt ions as catalyst reaction pozzolanic as well as filler pores (*filler*) between grains clay [15]. In addition to improving gradation, the addition of granular material is done in a effective can lower potential growth and development stability source Power natural local in a way sustainable [4].

Evaluation Parameters Soil Physics and Mechanics

Evaluation effectiveness stabilization done through testing characteristic comprehensive physical and mechanical testing. characteristic physique covering heavy type, analysis gradation grains, and Atterberg limits for measure level plasticity soil (11). Strength parameters mechanical determined through compaction test For look for optimum water content, as well as *California Bearing Ratio* (CBR) test and strength press Unconfined Compression *Test* to assess ability land base in withhold burden axial in accordance standard specification technical [15;14].

Methodology Study

This research was conducted on the section road Banggai – Lakotoy 150 meters long in Lelang Village, Regency Banggai Laut, which is vital connecting access inter-district and heading to Maulana Frins Mandafar Airport,

Figure 1: Research Location Map

In a way geographically, this location has rainfall Rain height that impacts conditions land dominated base type clay with characteristics Power high water absorption However stability its structure low. Although has rehabilitated in 2017, found damage significant in the form of holes, cracks, and surfaces uneven along the length section This indicates that that repair previously not optimal in face burden Then cross and influence weather, so that need handling technical more further to improve Power stand road.

Data Collection

In this study, primary data was obtained through field observations and direct interviews with relevant agencies. This included site documentation, field surveys to collect road geometric and damage data, and soil sampling.

Data Analysis

This study uses a systematic approach to synthesize data from field surveys, tests This study uses clay from Tolokibit Village and sea sand as stabilization materials with mixture variations of 0%, 15%, and 30%. The physical properties of the subgrade are tested based on SNI standards including unit weight (SNI 3637:1994), water content (SNI 1965:2008), specific gravity (SNI 1964:2008), sieve analysis and hydrometer (SNI 3423:2008), and Atterberg limits (SNI 1966:2008). The main equipment used includes a *modified compaction test device,* a CBR test device, and an unconfined compression test *device.*

Result data testing laboratory processed in a way quantitative through calculation technical and visualization graph. Analysis focused on relationships between variation mixture sand sea and duration ripening to improvement Power support as well as strength structure land clay.

RESULTS AND DISCUSSION

The results obtained as following:

Condition Existing and Subgrade Characteristics

Research location own rainfall Rain height that reaches peak in 2024 at 112.1 mm/ day. This condition causes damage road in the form of *alligator cracking, rutting,* and *potholes* Because system poor drainage and soil the basis that is not stable. Based on the sounding test and Robertson classification, the soil base dominated by clay soft (Zone 3) to depth of 3.00 meters. Laboratory test results classify land original as CH (*Clay High Plasticity)* according to USCS system, with mark *Liquid Limit* (LL) 60.28% and *Index Plasticity* (PI) 15.03%

Analysis Compaction (*Modified Proctor*) and *California Bearing Ratio* (CBR) of Native Soil

Table 1: Influence Addition Sand Sea to Compaction

Parameter	Mark	Unit	Information
Level Water Optimum	21.15	%	-
Dry Bulk Weight Max	1,623	gr/cm ^{3}	-
CBR Value	11.23	%	Currently

Based on Table 1 from the compaction test, it was obtained that land original own The maximum dry unit weight is 1.623 gr/cm^3 with an optimum water content of 21.15%. Table 4.5 also shows the results of the *California Bearing Ratio* (CBR) test of the original soil obtained at 11.23% which is good enough to be used as a road subgrade layer to support traffic loads, because according to Bina Marga which has been stipulated by SNI 03-1744, a subgrade or base soil layer can be categorized as good if it has a CBR value > 6 (Melina Afrida, 2023). However, although the CBR value of this natural soil is categorized Well, the road conditions at the research point are still mostly bumpy due to unstable ground, cracks, and potholes.

Optimal Proportion of Sea Sand for Clay Soil Stabilization

Knowing the proportions used is crucial to determine the optimal proportion of sea sand for stabilizing clay soil. Sea sand was added at concentrations of 0%, 15%, and 30% of the dry weight of the soil. The results of the test on the effect of sea sand addition on compaction are shown in **Table 2.**

Table 2: Influence Addition Sand Sea to Compaction

Percentage Sand Sea (%)	Heavy Contents Dry Max (gr/cm^3)	Level Water Optimum (%)
0	1.62	22.35
15	1.76	21.15
30	1.80	17.35

In this test, the maximum dry weight was obtained at 1.8 gr/cm 3 with the optimum water content dropping to 17.35%. at a proportion of 30% sea sand. This shows that the higher the percentage of sea sand used, the better the soil quality, the level of compaction becomes denser during mixing. produce the relationship that more congested between land land clay and sea sand, reducing the voids in clay soil. For more details, see Figure 2 and Figure 3

Figure 2: Maximum Dry Density (γ dmax) vs Sea Sand Ratio (%)

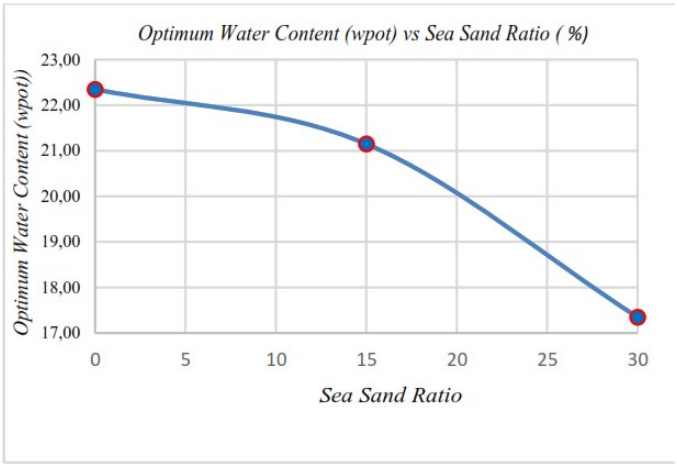

Figure 3. Optimum Water Content (wpot) vs Sea Sand Ratio (%)

Unconfined Compression Test (UCT)

Table 3: Unconfined Compressive Strength Test Results

Variation Clay + Sand (%)	Time Incubation (Day)	Mark qu Average (Kg/Cm 2)
0	1	2,200
	3	2,736
	7	3,289
	14	3,842
	21	4,402
	28	4,966
15	1	2,718
	3	3,245
	7	3,808
	14	4,378
	21	4,966
	28	5,554
30	1	3,207
	3	3,718
	7	4,283
	14	4,860
	21	5,414
	28	6.040

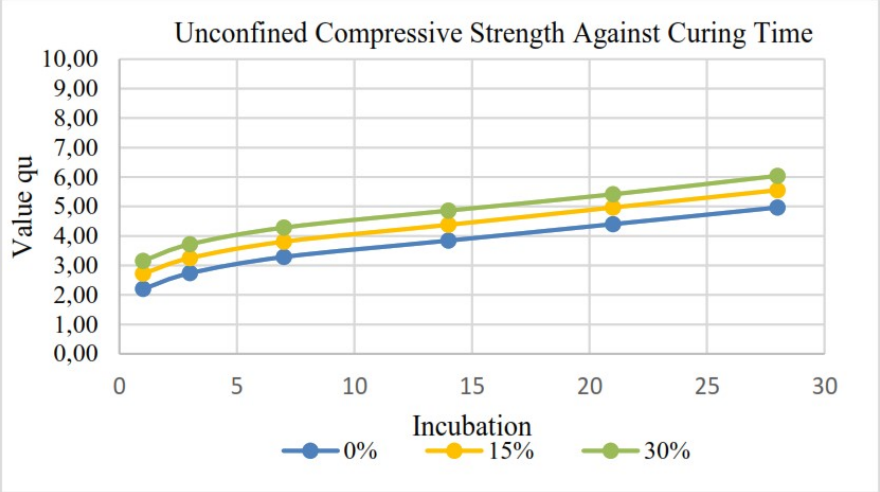

Figure 4: Chart Results Test Strong Pressure Free Sand 0%, 15% and 30% on the Duration of Fermentation.

Based on Figure 4. shows mark qu which is getting bigger increase along with increase proportion sand sea on land clay with a long time ripening. This happens Because existence high amount of calcite mineral in the soil clay react with sand sea and deep time calcite mineral known as material a loudspeaker that can increase strength land. The land that was previously cavity filled with replaced water with sand the sea that forms bond during time ripening. There are salt ions present in sand beach functioning For become pozzolanic process catalyst (Woelandari) Fatonah, 2022), seen increasing mark qu the curing time is 28 days

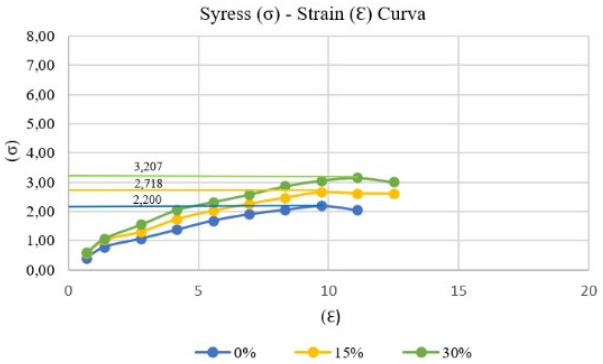

Figure 5: Graph Results Test Strong Pressure Free incubation period of 1 day

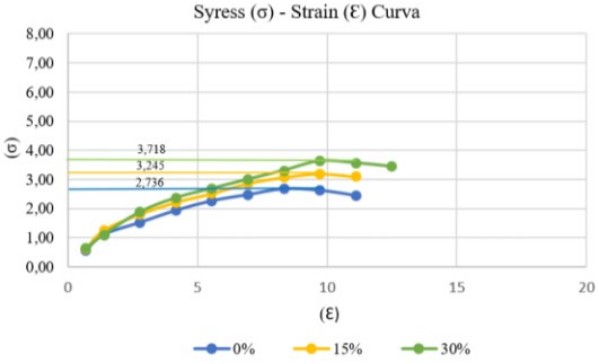

Figure 6: Graph Results Test Strong Pressure Free during 3 days of incubation

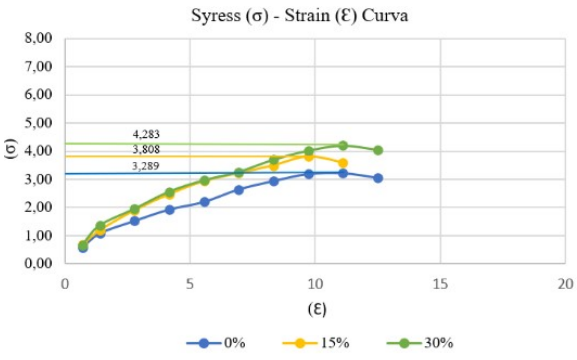

Figure 7: Graph Results Test Strong Pressure Free during the 7-day incubation period

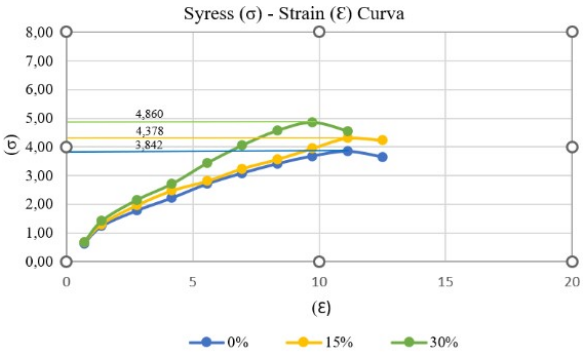

Figure 8: Graph Results Test Strong Pressure Free during the 14-day incubation period

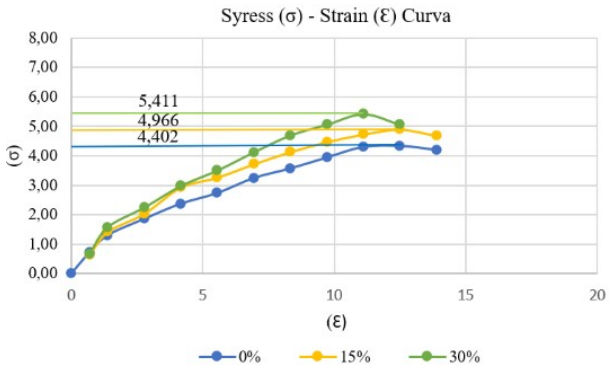

Figure 9: Graph Results Test Strong Pressure Free during the incubation period of 21 days

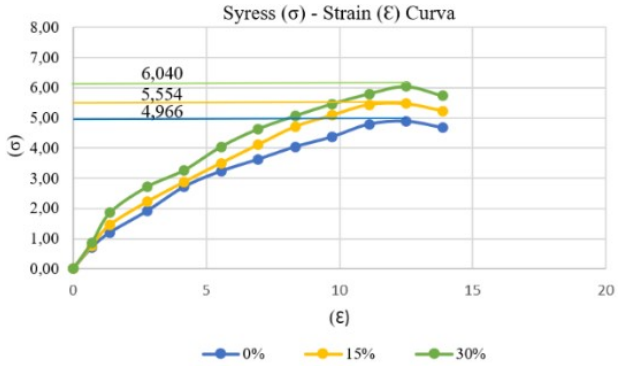

Figure 10: Graph Results Test Strong Pressure Free during 28 days of incubation

Figure 5. – Figure 10. Illustrates the relationship between stress (σ) and strain (ε) in variations of sea sand mixtures of 0%, 15%, and 30%. Based on the data obtained, it can be seen that the addition of sea sand increases the stress value required to achieve the same strain level. This indicates that the sea sand content in the clay mixture affects the soil strength, where the mixture with 30% sea sand shows the highest stress compared to the mixture without sea sand (0%) or the one containing 15% sea sand. The increase in stress along with the increase in the amount of sea sand indicates a change in the elastic characteristics of the material. Although the addition of sea sand has a positive effect because it can increase soil strength, it is also necessary to pay attention to the optimum limit for adding beach sand because if the proportion of beach sand exceeds the optimum limit, the soil strength will weaken because the structure cannot bind together. The optimum value of the compressive strength was obtained at 3,040 kg/cm 2 at a proportion of 30% sand. sea with ripening during 28 day mark This experience increase from 2,200 Kg/cm 2. So that can it is said that addition sand sea on clay soil on the Banggai – Lakotoy road section can be done based on the tests that have been carried out because the research results show that adding sea sand can improve the road subgrade

CONCLUSION

Based on results testing physical and classification USCS system, land base in Lelang Village, Regency Banggai Laut, categorized as clay with plasticity high (CH) which has index significant plasticity (PI). The addition of sand sea as material stabilization on the section road Banggai – Lakotoy proven change characteristics physical and mechanical land linearly. The original land that was originally own heavy content dry maximum (γd) of 1.623 gr/cm³ with optimum water content (*wopt)* 22.35% as well CBR value 11.23%, experienced improvement optimal performance in proportion 30% sand mixture sea. At the level said, γd increase up to 1,848 gr/cm³ and wopt decrease to 17.35%, which shows that grains sand sea effective fill in cavity inter-particle clay so that create more structure solid and stable. Improvement this was also followed by an increase CBR value is 24.07% and mark strong press free (qu) average reaching 6,040 kg/cm² after a 28-day fermentation period, increasing from mark initial 4.966 kg/cm². Findings This confirm that use of 30% sand the sea is very effective in increase Power support and stability land base the road, making it solution ideal technical for handle problem land clay soft in the area them.

REFERENCES

1. *Dialihudien ; Muhtar. (2021). Influence Effect of Sand Addition on CBR Value and Sifa – Properties of Clay Soil.*
2. *Afriani, Lusmeilia. 2016. "The Influence Sand Fraction in Clay Soil Mixture Against CBR Value and Index Plasticity For Increasing the Bearing Capacity of the Subgrade." Journal Engineering 20 (1).*
3. *Aprian Eko Susilo, Rismalinda, Alfi Rahmi. 2024. "The Influence " Addition of Sand to the Density Level and Bearing Capacity of Soft Clay Soil." Taxiway Journal 3 (2): 11–22.*
4. *Darwis. 2017. "Basics of Soil Improvement Engineering."*
5. *Das, Braja M. 2014. "Principles Of Geotechnical Engineering." Cengage Learning 8th.*
6. *Das, Braja M. 1995. Soil Mechanics (Principles of Engineering Geotechnical). Volume 2. Jakarta: Erlangga.*
7. *Fathonah, Woelandari, Rama Indera Kusuma, Enden Mina, and Agustia Tridasa Ningsih. 2022. " The Use of Beach Sand as a Subgrade Stabilization Material and Its Effects Against the Unconfined Compressive Strength Value." Foundation : Civil Engineering Journal 11 (2).*
8. *Hadisaputra, Aboerisal, Winarno Arifin, Mukti Maruddin, and Muhammad Arief. 2019. " Analysis Use of Sand Against Land Stabilization in the Tempe Lake Area for Made into As Fill Material" 1 (April): 226–35.*
9. *Hardiyatmo. 2002. " Soil Mechanics I." Gadjah Mada University Press 4 (1): 1–23.*
10. *Hardiyatmo, hary Christady. 2003. " Soil Mechanics II." Gadjah Mada University Press 91 (5): 1–398.*
11. *Hardiyatmo, Hary Christady. 2007. Soil Mechanics 2nd Edition Third. 3rd ed. Yogyakarta: GADJAH MADA UNIVERSITY PRESS.*
12. *Khotima, Andi Khusnul, and MT Tatag Yufitra Rus., ST, M.Sc, Totok Sulistyo., ST 2021. "Clay Soil Stabilization With Using Monpera Sand Balikpapan and Its Effects On the Value of Soil Bearing Capacity (Case Study at Km 8 Direction of Oil and Gas Stt Towards Manggar Beach Breakthrough)." Journal Civil Engineering Final Project 5.*
13. *Kusuma, Rama Indera, Enden Mina, and Rosa Hasibuan. 2017. "Sea Sand and Its Effect on CBR Value" (California Bearing Ratio) (Study Case: Mangkualam Village Road Subdistrict Cimanggu – Regency Pandeglang)." Journal Foundation.*
14. *Marga, Bina. 2020. "General Specifications 2018," no. Revision 2.*
15. *Mina, Enden, Rama Indera Kusuma, and Jamatul Ridwan. 2017. "Clay Soil Stabilization Using Sea Sand and Its Effect on Unconfined*
16. *Compressive Strength (Case Study: Mangkualam Road) Subdistrict Cimanggu – Banten)." Journal Foundations 6 (2): 13–23.*
17. *Purnawan, Syahrul, and Sofyatuddin Karina. 2014. "Characteristics and Mineral Content of Lhok Beach Sand" Mee, Beureunut And Leungah, Aceh Besar Regency: The Characteristics and Mineral Content of Coastal Sand from Lhok Mee, Beureunut and Leungah, Aceh Besar District." Depik 3 (3): 263–70.*

18. *Silaban, Tarsan. 2024. "The Influence Addition of Sea Sand to the CBR Value of Tarsan A-7-6 Clay Soil." Journal of World Education 4: 1112–24. https://jurnal.stokbinaguna.ac.id/index.php/JURDIP.*
19. *Density test method heavy For land. Indonesian National Standard.*
20. *SNI 1744. (2012). National Standardization Agency laboratory CBR test method. Standardization Agency, 1–28. www.bsn.go.id*
21. *SNI 1964. (2008). Indonesian National Standard for Weight Test Methods type Land Back to list. National Standardization Agency.*
22. *SNI 1965. (2008). Test Method for Determining Water Content for Soil and Rock in the Laboratory. SNI 1965:2008, 1–16.*
23. *SNI 1966. (2008). SNI 03-1966:2008 Plastic Limit and Index Plastic.*
24. *Analysis Test Method Size Soil Grains. Analysis Test Method Size Soil Grain, 1–27.*
25. *SNI 3637. (1994). SNI 3637 - 1994 CONTENTS WEIGHT.pdf.*
26. *Trias Widorini, Ngudi Hari Crista, Bambang Purnijanto. 2020. " Analysis Comparison Stabilization of Native Soil with Pre-Boring Results on the Semarang University Tower Project With Sand and Lime Mixture For Increasing Soil Bearing Capacity " 06 (2019).*
27. *Wahyu Santoso, Hasrullah. 2022. "Tarakan City Sea Sand as Soft Soil Stabilization Material " 1 (2): 86–97.*