Use-Pole Bamboo Raft Foundation With Full-Scale Model Test Of Deformation Causeway Makassar New Port

Yance Kakerissa, Muh. Akbar, Chitra Utary

Civil Engineering Department, Faculty of Engineering, Musamus University, Jl. Kamizaun Mopah 99611 Merauke Papua, Indonesia.

kakerisa@unmus.ac.id

Abstract. The number of buildings or constructions which are at the planning or implementation stage can not be allowed to avoid land base in the form of clay, then, of course, it takes geotechnical engineering to solve the problem by improving the native land so hopefully not happen settlement or deformation. Awareness of the importance of the soil remediation process before building construction on it be an idea to use bamboo as a material provision of soil reinforcement. This research was conducted with the full-scale reinforcement and the raft bamboo poles on the ground with a mounting base plate and observations settlement every day. From the results of modeling on the field at the U-50% condition waiting period ranges from 10-14 days, on the condition of the U-90% the waiting time ranges from 40-55 days, on the condition of the U-95% the waiting time ranges from 53-72 days and the condition of the U-99% the waiting time ranges from 83-115 days. Based on observations in the field, the final drop-readable embankment around 545 mm with a time of consolidation U-90% for 59 days. The results showed that retrofitting with bamboo raft poles can reduce the decline to 60.70%.

1. Introduction

Generally, the type of soil is experiencing excessive consolidation of saturated soft clay. There are several methods that can be done to repair soft soil against excessive settlement (settlement) and can be broadly grouped into three categories: the first can be done by installing the vertical drain, both using cerucuk or corduroy, and the third using pile foundations [1] [2].

Bamboo Raft foundation is one kind of plate-shaped shallow foundation were very wide and massive with a certain thickness. In one building the raft foundation into one unit so that the giant plate-shaped. the bamboo raft made of bamboo which serves to carry the burdens of building on it and passed on to the hard ground. [3]

Awareness of the importance of the soil remediation process before building construction on it be an idea to use bamboo as a material provision of soil reinforcement. Today, bamboo is considered to be used as a soil reinforcement material like wood. Modelling and testing of bamboo as a soil reinforcement material are interesting to investigate look in terms of mechanical characteristics of bamboo has a tensile strength and compressive pretty good. Modelling and micropile bamboo raft as
soil reinforcement is intended to determine the extent of the foundation raft and bamboo micropile reduce the decline (settlement) as well as the effect of the decline of the surrounding soil caused by the axial force (loading test) and horizontal deformation occurring. [4]

2. Theoretical basis
2.1. Clay Soil Software Distribution In Indonesia
Soil is a collection of materials and is made up of a collection of items that make up the compound and into the mass coating on the surface of the earth. An area with soft clay and swamps are often found in low-lying areas and around the coast, especially in large river estuary as sediment alluvial or delta. Gambar 1 shows the distribution of soft ground in Indonesia [5]. Details of soft soil distribution in Indonesia, namely:

- Sumatran Coast east, around the mouth of the Sei. Sigli, Muara Sei. Kuala Tanjung, Muara Sei Belawan.
- The central part of Sumatra, among others, around Dumai, Pakning Sei, Sei. Kampaar, Sei. Batang Pekanbaru.
- In South Sumatra, among others, in the area Sei. Musi, the region around Palembang, and so on.
- The western part of Sumatra, among others, around the city of Meulaboh, City Tapak Tuan, Sibolga, Air Bangis, and so on.
- The north coast of the island of Java, among others, around the area of Tanjung Priok, North Jakarta, Muara Angke, Muara Karang, Sunter, Cirebon, Semarang Regional, Sluke, and so on.
- In Kalimantan, among others, in the surrounding area of Pontianak, Ketapang, Sebamban, Pulo Laut, Samarinda, Tarakan, and so on.
- In Sulawesi, among others, around the Maros, the coastal city of Makkasar, Barru, Watampone, Malili, Poso Kolonodale Luwuk, and so on.
- In the Papua region, among others, in the area around Sorong, Biak, Serui, Kaimana, Nabire, Ewer, Merauke, and so on.

Figure 1. Distribution of soft ground in Indonesia
2.2. Karakteristik dan Soft Soil Problems

To build an on-site construction needs to be held laboratory field testing and testing of soil samples [6]. Field test lot is a standard penetration test (Standard Penetration Test) and a penetration test static cone. gives the relationship between $N$, Free compressive strength ($qu$) and consistency in Table 1 and the relationship between $N$ with relative density ($Dr$) for sand in Table 2.

Clothes defined as soft clay soil (clay) or silt (silt) having a standard penetration test price (Standard Penetration Test) is less than or equal to 4. Similarly, the sandy soil layer in a loose state has $Nyng$ price is less than 10. Typically layer soft soil formed by natural processes. Thick, wide and stratification depending on the style of the topography and geology which forms the coating. [7]

Table 1. Relationship $N$, consistency, and free compressive strength ($qu$) for saturated clay soil

| N Value | consistency   | unconfined Compression (Qu) (kN/m²) |
|---------|--------------|-------------------------------------|
| <2      | Very soft    | <25                                 |
| 2-4     | soft         | 25-50                               |
| 4-8     | Medium       | 50-100                              |
| 8-15    | Stiff        | 100-200                             |
| 15-30   | Very Stiff   | 200-400                             |
| >30     | hard         | >400                                |

Table 2. Relationship $N$ with relative density ($Dr$) for pushing sand soil

| N Value | Relative Density (Dr) |
|---------|-----------------------|
| <4      | Very Loose            |
| 4-10    | Loose                 |
| 10-30   | Medium                |
| 30-50   | dense                 |
| >50     | Very Dense            |

2.3. Decrease conception Land

A layer of soil that is under tension, then the land will experience strain. A strain is caused by changes in the composition of the soil and reduced pore cavities in the ground. A strain is a statistical accumulation of deformation in the direction reviewed. Integrasi of strain (deformation per unit length) along under the influence (total length) is decreased. [8]

The decline in the load due to an accumulation of decline in immediate and consolidation settlement. The decrease immediately which is the form of reduced elastic stress occurs immediately after the work on the ground coarse-grained and fine-grained soil is dry or saturated partially without involving changes in water content (moisture content). The working voltage on fine-grained soil that is saturated (and almost saturated) will produce a strain that depends on time. Decrease depending on the time called consolidation reduction. The decline in consolidated (consolidation settlement) occurring divided into primary consolidation settlement (primary consolidation settlement) and secondary consolidation settlement (secondary consolidation settlement). Primary consolidation settlement is the result of changes in the volume of saturated cohesive soil pore water discharge due to occupy the cavities in the ground. Secondary consolidation is a continuation of the consolidation process of the primary, with a very slow process. The decrease occurred as a result of secondary consolidation...
deformation action of soil particles is plastic. Large secondary consolidation very significant reduction in organic soil. [8]

2.3.1 Decrease Instantly
The decrease immediately (Immediate Settlement) occur in undrained conditions (no change in water content). This decrease occurred immediately after the voltage work. The amount of reduction depends on the amount instantaneous modulus of elasticity of the soil and the amount of heap given load.

2.3.2 Decreased Consolidation Primer
Primary consolidation settlement (Primary Consolidation Settlement) is one of the processes that occur in a decrease in saturated fine-grained clay with a small seepage speed and depending on the time. The process of reduction of primary consolidation caused by the dissipation of pore water pressure and the discharge of air in the cavity of the landmass. The primary consolidation process is based on a mechanism that the addition of the voltage on water-saturated clay soil will be forwarded to the granular soil pore water and the proportion of each.

2.3.3 Decreased Consolidation Sekunder
At the end of primary consolidation, the decline in soil still occur as a result of the action of soil particles deformation is plastic. This consolidation phases of consolidation are called secondary (Secondary Consolidation Settlement). Secondary consolidation settlement is very small and insignificant on the type of clay overconsolidated.

2.3.4 Soil Improvement and Reinforcement Strategy
Repair and reinforcement soil is the work done with the aim to improve the quality characteristics of the soil, especially soil shear strength parameters that will support a structure so as to support the weight of the structure to be built by deformation allowable. Broadly speaking the improvement and reinforcement of land intended for:

- Raise the carrying capacity and shear strength.
- Raising modulus.
- Reducing compressibility.
- Controlling volume stability (shrinking and swelling).
- Reduce susceptibility to liquefaction.
- Improving the quality of material for construction materials.
- Minimize environmental influences.

Various types of ground improvement techniques have been developed. The following are some of the ground improvement techniques that are commonly used, namely:

- Mechanical repairs, the provision of mechanical force from outside for a while, for example with compaction.
- Repair hydraulically, namely the reduction of the pore water pressure, for example, preloading; dewatering, pumping, wells, ditches, and the vertical drain.
- Repairs are physically and chemically, ie by administering a mixture of chemicals, grouting, changes in temperature.
- With the inclusion and restraint (reinforcement), for example with the installation of geosynthetics, anchors, etc.
• The use of lightweight materials, the basic principle of burden reduction heap (backfill) using a very light material (0.02 g / cm3), water-resistant, and environmentally friendly, for example by EPS, etc.

3. Research methodology

3.1 Research sites
Tests carried out by the trial embankment full scale (full scale) by strengthening the gravel-geotextile composite columns conducted in Makassar New Port Development Project, located in Jalan Sultan Abdullah Kingdom Kelurahan Buloa Kecamatan Tallo, Makassar South Sulawesi Province, is located at coordinates 05° 06’09.53” latitude and 119° 26’05.11” E as shown in Figure 1.

3.2 Data collection
All data collected for this study uses data Makassar New Port Construction Project, owner of the job is PT Pelabuhan Indonesia IV (Persero). The data in question is location map, the results of field and laboratory investigation of soil, water tide conditions and the material characteristics geotextile sea.

3.3 Research design
• Stratigraphy Profile Geotechnical Research Site
• Interpretation of Physical Properties and Profile Land
• UjiSifat Materials and Bamboo Raft
To be able to take advantage of a substance/material, it is necessary to know and understand a variety of physical and mechanical properties of the material. Physical properties such as density, fireworks shrinkage, fire resistance, acoustic properties and insulator/conductor of heat. Mechanical properties of materials that need to be understood, among others modulus of elasticity, proportional limit, elastic limit, tensile strength, compressive strength, shear strength and the relationship between stress and strain [10] [11].
3.4 Embankment Structure Model Test Development

Model embankment structures such as width and height of the right embankment greatly affect the accuracy of the proper research to produce a corresponding deformation prediction in the field. [12]

Testing the trial embankment construction has a planned length of 10 m, width 10 m, slope 1 Horizontal: 1 Vertical and tinggi3.50 m. Dasardan soil embankment between the separator given in the form of a bamboo raft (raft bamboo) thereon covered with geotextile type UNW 125 products teknindo Geosistem PT Unggul. For comparison in this study was made 2 types of embankment structures, namely:

- Subgrade did not wear retrofitting
- Subgrade by retrofitting pile of bamboo with a diameter of 60 cm long by 300 cm by 180 cm distance between piles. [13]

Bamboo pile installation process using excavators with a steel pipe as the referrer. Hoarding is done in stages where each stage carried out after the subgrade stabilized. The rate of decline was measured every day using the settlement plate mounted in the middle of each embankment [14]. Model structure embankment settlement and position plate are shown in Figure 5.
4. Results and Discussion

4.1. Soil Characteristics and Profile Geotechnical Software

Based on the results of exploration and laboratory testing, structural design and foundation soil parameters are formulated. From the results of this test in the identification of that land base in the research area generally consists of two formations formation, the first is very soft clay that is always submerged in seawater with a thickness of about 5 m and the second is the bedrock formation that consists of data clays.

4.2. Cone Penetration Testing Data Interpretation Static

Sondir testing results obtained from soil depth up to 5 m from the existing ground surface, the cone penetration value ranging between 3-5 kg/cm².

4.3. Physical Characteristics and Technical Bamboo

Figure 5.c. Pile placement plan details bamboo

Figure 5.d. Pile details bamboo

Figure 6. Curve Bamboo Raft Strong Bending Modulus of Elasticity

Figure 7. Graph Bamboo Raft
4.4. Imposition patterns Decline Model Embankment
4.4.1. Embankment Dengan Perkuatan Bamboo Raft
Field observations of the decline embankment performed continuously from the preparation stage, the initial accumulation until the waiting period, it is done so that the data readout reads daily decline. Until this research ends embankment construction has decreased by 796 mm for 120 days which is still ongoing.

4.4.2. Strengthening Embankment With Bamboo Raft-Pole
As with the embankment without reinforcement, observing a decrease in the embankment reinforced with gravel-geotextile composite columns were observed continuously until the reduction is not significant. Until this research ends embankment construction has decreased by 869 mm for 100 days which is still ongoing.

4.5. Empirical Aprokasi Decline End Model Embankment
4.5.1. Embankment With Bamboo Raft Retrofitting
The prediction results by the method Asaoka final drop of 1388 mm while the basic prediction of land subsidence in the construction of embankment without reinforcement approached by the formula consolidation of one-dimensional (1-D) from Terzaghi, where the results of the analysis made in the graph like Figure 8.

![Figure 8](image-url)

**Figure 8.** The relationship between time and degree of consolidation

On the condition of the consolidation of the U-90% is obtained within settlement around 7.6 tahun (2774 days). This prediction is close to the results of measurement when using the data when reading more.

4.5.2. Strengthening Embankment With Bamboo Raft-Pole
The prediction results by the method Asaoka final drop of 545 mm while the basic prediction of land subsidence in the construction of embankment approximated by the equation consolidation of three-dimensional (3-D), where the results can be seen in Figure 9.
Figure 9. Relationship Between Degrees Timeout And Consolidation

Table 3. Time consolidation for various conditions and Ch U / Cv

| The degree of consolidation combined | Ch / Cv | time consolidation |
|-------------------------------------|---------|--------------------|
| U (%)                              | (-)     | t (months) | t (days) |
| 50                                 | 1.00    | 0.48       | 14       |
|                                   | 1.20    | 0.40       | 12       |
|                                   | 1.40    | 1.35       | 10       |
| 90                                 | 1.00    | 1.82       | 55       |
|                                   | 1.20    | 1.54       | 46       |

Continued table 3

| The degree of consolidation combined | Ch / Cv | time consolidation |
|-------------------------------------|---------|--------------------|
| U (%)                              | (-)     | t (months) | t (days) |
| 95                                 | 1.40    | 1.33       | 40       |
|                                   | 1.00    | 2.41       | 72       |
|                                   | 1.20    | 2.03       | 61       |
|                                   | 1.40    | 1.75       | 53       |
| 99                                 | 1.00    | 3.82       | 115      |
|                                   | 1.20    | 3.20       | 96       |
|                                   | 1.40    | 2.77       | 83       |

From the table above, it can be concluded that the condition of the U-50% the waiting time ranges from 10-14 days, on the condition of the U-90% the waiting time ranges from 40-55 days, on the condition of the U-95% the waiting time ranges from 53-72 days and at U-99% condition waiting period ranges from 83-115 days.
Figure 10. Based on observations in the field

Based on observations in the field, the final drop-readable embankment around 545 mm with a time of consolidation U90% around 59 days.

5. Conclusion

In the field of analysis we concluded that strengthening the embankment with a bamboo raft on the embankment construction has decreased by 796 mm for 120 days which is still ongoing. The prediction results by the method Asaoka final drop of 1388 mm. for embankment reinforcement raft with bamboo poles until the Count with this research ends embankment construction has decreased by 869 mm for 100 days which is still ongoing. The prediction results by the method Asaoka final drop of 545 mm. In the U-50% condition waiting period ranges from 10-14 days, on the condition of the U-90% the waiting time ranges from 40-55 days, on the condition of the U-95% the waiting time ranges from 53-72 days and the condition of the U-99% the waiting time ranges from 83-115 days. From observations in the field,

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