Proceedings of the 19th Japan-Korea-France-Canada Joint Seminar on Geoenvironmental Engineering

Geo-Environmental Engineering 2021

May 20-21, 2021
ESITC Caen - Caen National University, France

Organized by
ESITC Caen, France
Kyoto University, Japan
Fukuoka University, Japan
Hokkaido University, Japan
Seoul National University, South Korea
Concordia University, Montreal, Canada
University of Normandy, Caen National University, France

Normandie Université
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Former refinery of Petit-Couronne (France) beyond rehabilitation; the industrial activity started in 1929 and stopped in 2013. Since 2014, VALGO is dismantling the units (superstructures up to 170m and underground piping networks), remediating the soils from the hydrocarbon pollutions and welcoming new industrial activities. Depending of the subzones, the LNAPL layer is pumped, the soil is cleaned or removed and replaced with recycled materials. A clean layer of soils coming from Grand Paris' huge works is compacted to finalize the new industrial zone.

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Preface

Like anyone, the GEE2021 conference has suffered from the covid19 pandemic. Originally planned for May 2020, it had to be postponed when the pandemic was at its worst. Postponed to May 2021 in a less pronounced but still active pandemic situation, this conference turned into a virtual conference. This is how the GEE2021 conference came about.

Geo-Environmental Engineering 2021 (GEE2021 or 19th Japan-Korea-France-Canada Joint Seminar on Geo-Environmental Engineering) was held on May 20-21 at the ESITC High school for civil and construction engineers of Caen in the campus 2 of Caen Normandy University. This annual seminar was organized under the auspices of the French National Center for Scientific Research CNRS, the International Geosynthetics Society IGS, the Pole Mer which is a French Sea Innovation and Business Cluster. It was supported by the ESITC Caen for local organization, the Centre Français du Littoral Association for the editorial work, Caen La Mer Urban Community, VALGO company (Paris and Petit-Couronne agency near Rouen) and the Laboratory "Continental and Coastal Morphodynamics - M2C" of Caen.

The first Korea-Japan Joint Seminar took place in Seoul in 2001. Prof. Junboum Park from Seoul University and Prof. Masashi Kamon from Kyoto University initiated it. For the fifth seminar in 2005, the Korean Institute of Construction Technology has joined the seminar group. And the seventh seminar was for the first time held in France, at University of Grenoble with the cooperation of Prof. Jean-Pierre Gourc. One year after, in 2008, the joint seminar held in Kyoto University with the Canadian cooperation through the venue of Prof. Loretta Li from University of British Columbia and then with the participation of the Prof. Catherine Mulligan of Concordia University. Then, it took place continuously in these 4 countries Japan-Korea-France and Canada: Nantes (2016), Seoul (2017), Fukuoka (2018) and Montreal (2019). To ensure the continuity of the joint seminar, with the both cooperation of Prof. Jean-Pierre Gourc (Grenoble University) and Prof. Daniel Levacher (Caen University), the 19th joint seminar was the fourth one held in France, in Caen at ESITC with cooperation of Caen Normandy University. Previously prepared for May 2020 it was postponed in 2021, May 20-21 as a virtual conference.

And so far from Japan and Korea, we highly appreciate the papers coming from overseas and particularly from Brazil and India, these both countries could follow the GEE in the future. During the 2 days, the symposium has provided interesting discussions and participants have debated on updated questions relative to the waste and landfill management, the geotechnical reuse of solid waste, the remediation of contaminated sites, the environmental risk assessment and about lessons from the field and case studies. The exchange of ideas on research and experience in these fields was rich. For these reasons, the Geo-Environmental Engineering 2021 has demonstrated that the symposium should continue in 2022 and in future.

While the virtual conference was well suited to the pandemic situation, it could not provide the traditional technical field visits, which participants regretted. But the hope that the pandemic will end in the near future should reassure all participants for the next GEE.

The symposium would not have been possible without the full contribution of Em. Prof. Daniel Levacher (Caen University), member of GEE committee and Dr Mohamed Boutouil (ESITC Caen) for the local organization. All the GEE committee members, greatly appreciate their efforts.

Daniel Levacher, Civil Engineering Emeritus Professor, Caen University

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ABSTRACTS

Analysis of soil subsidence from the loading cycle using a concrete mattress with woven bamboo reinforcement

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Abstract:
The water content of soft clay soils and organic clay soils is very large, their weight is greater than the soil grains, so that when the soil is given a load, it will experience a problem of land subsidence which causes the pore water pressure to rise, exit and experience a decrease in consolidation. Therefore, it is necessary to conduct soil subsidence research in the laboratory using a test box and a bamboo concrete mat as a means of lowering the soil. The amount of land subsidence is detected by data acquisition.

This research was conducted on a box-shaped test instrument measuring 80 x 90 x 100 cm^3. Soil is put into the box and soil subsidence test is carried out with a concrete slab using bamboo mats, after which a pressure of 0.2 kg/cm^2 is applied; 0.3 kg/cm^2; 0.4 kg/cm^2 and 0.5 kg/cm^2. This test is carried out until it is no longer reduced. The results of the clay soil subsidence test using the test box modeling and bamboo concrete mats show that the soft clay soil is experiencing the reduction rate (C_v) is faster than organic clay soils. The amount of reduction (Cc) in soft clay soils is smaller than that of organic clay soils. Soft clay soils also experience volume changes (M_v) which are faster than organic clay soils. The compressibility (A_v) of soft clay soils is also faster than organic clay soils. The amount of total soil subsidence in a period of 20 years in soft clay soils is smaller than in organic clay soils.

Keywords:
Soft clay soil, Soil organic clays, Consolidation, Concrete mattress.

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1. Introduction

Clay has a weak grain structure. One of the causes is the high-water content and the fine grain size. Therefore, if the soft soil is used as a construction foundation, the soil must be compacted. If the soil is not compressed, there will be a settlement. In other cases, the soil supporting the foundation has been consolidated before loading, but there will still be the settlement. It is probably because of excessive load factors or unstable soil conditions.

It is recommended, before carrying out any construction work, compaction of the soil and calculation of its settlement should be carried out. The subsidence occurs in loam soils and organic or semi-organic soils, significantly reducing their magnitude compared to loam soils. Therefore, this study will use soft clay soil as an experimental sample to obtain the reduction coefficient. Compaction will occur because the weight of the structural load above the soil will compact and destroy the soil grains in each layer of soil and push water out of the soil layer due to the shrinkage of soil pores (TERZAGHI & PECK, 1987). The structural weight here is assumed to be the concrete mattress and the working floors and wood reinforcement. This wood is used to reduce soil problems. The research will use land from Belimbing Sari Village, Jabung Regency, East Lampung, Indonesia.

If the soil carries a load above it, the soil will increase vertical stress, horizontal stress, shear stress, and pore water pressure. The result of this increase in tension will cause a decrease in subgrade elevation. This loading causes particle deformation, particle relocation, and the release of air from the soil pores will reduce the volume of the soil. It can cause soil displacement if it is on a slope, (DAY, 2006). Soil subsidence, *i.e., loss of soil thickness*, is for either clay or organic soil after drainage. It is a widespread phenomenon in Southeast Asia (WÖSTEN *et al.*, 1997; HOOIJER *et al*., 2012) and New Zealand (PRONGER *et al.*, 2014). In the United States, the best-known cases of subsidence are the Sacramento-San Joaquin Delta in California and the Florida Everglades (GALLOWAY *et al.*, 1999). Several environmental factors such as type of peat, decomposition rate, density and thickness of peat, climate, water table depth, temperature, and land use history affect subsidence (ARMENTANO, 1980; WÖSTEN *et al.*, 1997). Water table depth is considered the dominant factor controlling soil subsidence because it regulates peat growth and formation (CLYMO, 1984). In the EAA, studies with subsidence lines established in 1913 indicate that rapid subsidence rates (ca. 9 cm yr^{-1}) followed the initial drainage of the Everglades (STEPHENS, 1956). After this rapid rate, subsidence remained constant at 3 cm yr^{-1}, dominated by the oxidation process (STEPHENS, 1956; STEPHENS & SPEIR, 1970). During the past few decades, subsidence rates have decreased to 1.45 cm yr^{-1} (SHIH *et al.*, 1998). Possible causes for this decrease in subsidence rates include increases in the water table, possibly due to best management practices, in the mineral content of the soils, and in recalcitrant forms of organic carbon (C) (SHIH *et al.*, 1998; GALLOWAY *et al.*, 1999).

Peat soils will rapidly decline in sustainable soil surface due to densification (shrinkage and consolidation) and oxidation of the peat substrate. Shrinkage occurs when water leaks from the soil layer. This settlement rate is consistent with the literature synthesis of moderate zone subsidence rates reported for the same period since drainage occurred. This settlement rate is consistent with the literature synthesis of reasonable zone subsidence rates reported for the same period since drainage occurred (STEPHENS *et al*., 1984; PRONGER *et al*., 2014). Shrinkage, consolidation, and oxidation have been the dominant processes controlling subsidence in the Everglades Agricultural Area (EAA). STEPHENS (1956) and STEPHENS *et al*. (1984) showed that subsidence accelerated after installation of water pumps that quickly lowered the water table in the EAA. Soil subsidence in the EAA is currently dominated by oxidation (TATE, 1980). Before drainage, EAA soils had limited oxygen availability due to their saturated condition and low oxygen diffusion rates in water (REDDY & DELAUNE, 2008). Following drainage, oxygen became available to aerobic bacteria that decomposes organic matter more rapidly, resulting in subsidence due to oxidation (STEPHENS & JOHNSON, 1951). VOLK (1973) found that carbon dioxide (CO_2) efflux from EAA soils accounted for 58% – 73% of the average soil subsidence estimated by field studies with subsidence lines, while STEPHENS & SPEIR (1970) found that oxidation losses accounted for 75% of field subsidence estimates. Higher water tables result in lower subsidence rates (STEPHENS & SPEIR, 1970; SHIH *et al*., 1998). Furthermore, lowering the water table depth by a factor of two in the EAA doubles the subsidence rate (SNYDER *et al*., 1978). Increases in bulk density due to compaction and shrinkage increased subsidence rates, particularly during the initial years after drainage. The estimated bulk density of EAA peats before drainage ($0.1 g/cm^3$), (AICH *et al.*, 2013) doubled 10 years after drainage (STEPHENS & JOHNSON, 1951). Studies in the EAA show that oxidation of these soils is affected by soil temperature with a Q10 of 2 (KNIPLING *et al.,* 1970; VOLK, 1973), where Q10 is the factorial increase in decomposition for every 10°C increase in temperature.

Consolidation will not only occur in the soil layer, but the pile foundation will also undergo settlement. Some analysis to see the decline in the pole. One of them is the numerical method. They also provide a relatively fast way of carrying out a parametric study of the effects of soil characteristics. This article will also examine the numerical settlement of the pile. They also provide a relatively fast way to perform parametric analysis of the effects of pile and soil characteristics and prepare various solutions, which design purposes can use.

Damages resulting from settlement can range from total structural failure to minor damage. Damage due to settlement in buildings causes cracks in the structure and frequent cracks in partitions such as windows and doors, which do not stand in their original position. It can be overcome if there are no more settings.

Settling can create problems in loam soils, so a large drop in numbers will occur when the soil is loaded. The issue of subsidence will continue after the construction period has been completed, often for several years. It happens because there is an immediate or elastic settlement of soil in which there is no water flow. It was at that time when clay soil deforms to accommodate the imposed shear stress. Based on the stress history of saturated cohesive soils, they are considered either under consolidated, ordinarily consolidated, or over consolidated. The over consolidation ratio (*OCR*) is used to describe the stress history of cohesive soil, for under consolidated soil *OCR* <1, (DAY, 2006).

The primary use of this research is to design a large-scale consolidation tool. It is a square box. This innovative tool is made for the benefit of consolidated research with a field-scale approach. This tool is called the modification consolidation tool. Inside this tool will be filled with soil samples, above which are given a load. This tool will be linked by data acquisition during the research process, which will record all the research processes. The parameters recorded are vertical subsidence due to concentrated load and even loading. This tool made it easier for planners from the government and the private sector to determine the magnitude of deterioration in the soil type of clay and organic clays when given a load. In building planning, a consolidation test is required. The consolidation tool in the laboratory is small in size. Later, it will correlate the laboratory scale consolidation value and the approach scale in the field. So that when the research uses a small tool, the researcher can estimate and correct the actual consolidation value in the area.

2. Materials and method

This research uses one type of soil, namely soft clay soil. The sampling location is 2 - 3 hours from Bandar Lampung, Lampung Province, namely. Belimbing Sari Village, Jabung District, East Lampung Regency, Indonesia. The test is carried out in 3 stages. The first is physical properties testing. Second, the consolidation test using standard laboratory equipment. The third stage uses the design of a large consolidation test instrument. This tool is made to resemble the original conditions in the field. The testing phase was carried out at the Laboratory of Soil Mechanics, Faculty of Engineering, University of Lampung. Figure 1 shows the location for taking soil samples.

Previously conducting experiments in the third stage, researchers had made a new consolidation tool. The size is quite large, 90 cm long x 80 cm wide x 100 cm high. This tool is made of 0.5 cm and 0.1 cm thick steel plate, equipped with glass that is 1.2 cm thick and 100 cm high. This new consolidation device is added with a water tap which is located at the bottom. It has the function of removing water when the experiment is carried out. Testing procedures of physical properties in accordance with standardization by the American Society for Testing Materials (ASTM), (GOGOT, 2011; HEAD, 1994; BOWLES, 1991). As an alternative to bamboo matting, the researcher can also use other fibers such as raw or processed coconut fiber, such as local coconut fiber research showing natural fibers such as coconut fiber mixed with mortar for its construction (BUI *et al.*, 2020).

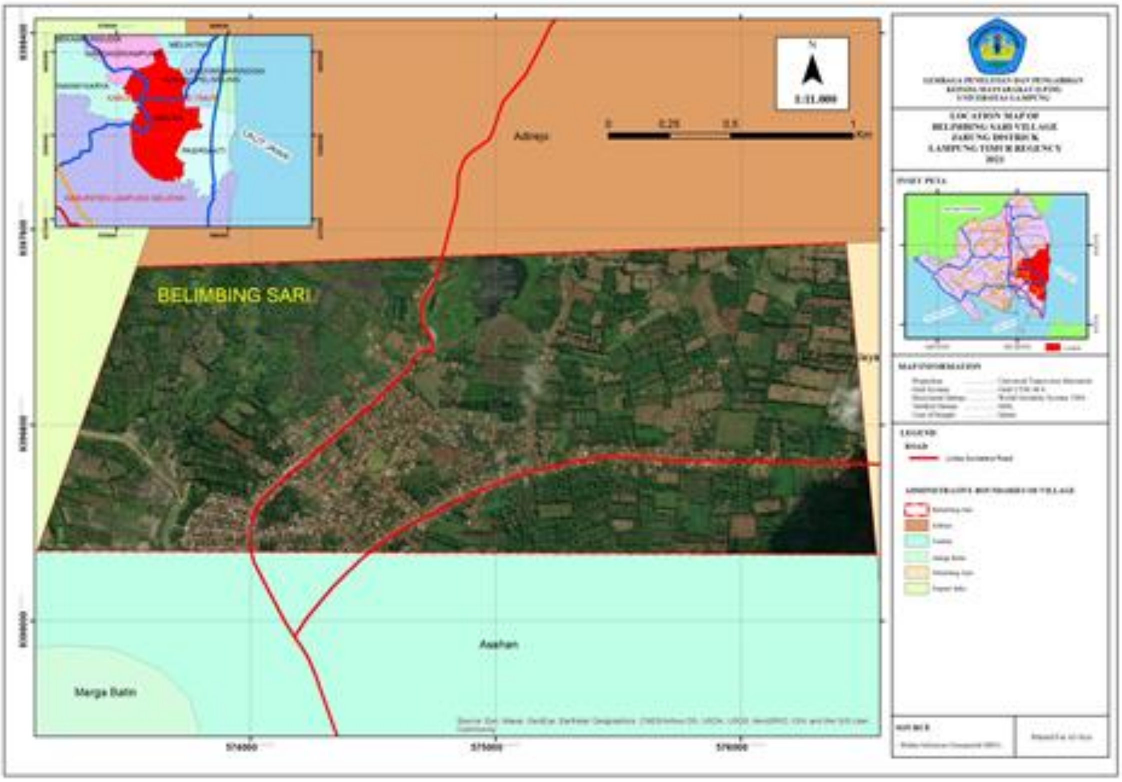

Figure 1. Location for taking soil samples.

Figure 2 is a plan of the working process, and vertical loads are placed in the middle of the bamboo concrete slab. At the same time, the measuring instrument for vertical displacement (strain gauge/sensor) is installed on four sides (ISWAN *et al.*, 2016, NAWAWI *et al.*, 2017). They have done the same tests but used the *gelam* wood reinforcement. *Gelam* wood is the name of a type of wood that is widely available in Indonesia. Its nature is that the longer it is immersed in water, the wood is strong and not rotten.

This study used a modified consolidation test instrument with a concrete mat reinforced by 80 mm thick bamboo wire. The quality of the concrete used was K-225, see Figure 2. As a validation experiment, a concrete mat with wire mesh reinforcement was also carried out. The test procedure is as follows :

1- The physical and mechanical properties of the soil were tested before and after the consolidation test. The soil samples were tested for their property index.

2- Soil is put into the consolidation test instrument, then saturation and soaking for 24 hours, soaking so that the soil is homogeneous.

3- After soaking, the water content is tested. The water content used is the same as the water content in the field. All tests used the same moisture content.

4- Consolidation testing using standard laboratory consolidation tools is also used as data validation, (HEAD, 1994).

5- The placement of vertical loads, sensors is as in the design Figure 2.

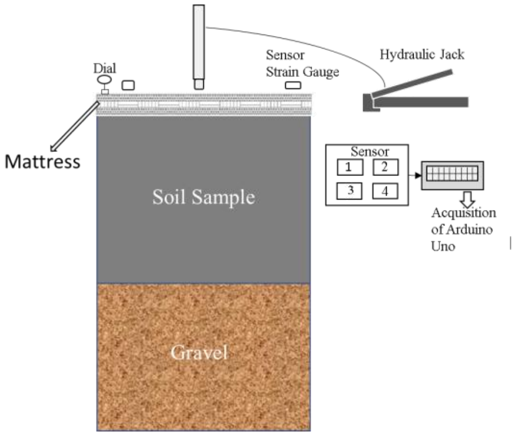

Figure 2. Design of test equipment size.

From Figures 3 and 4, a concrete mattress is placed and then on the mattress the load is placed with a gradual load, namely: 0.2 kg/cm^2; 0.3 kg/cm^2; 0.4 kg/cm^2; 0.5 kg/cm^2. Take measurements of the decline in bamboo mats with a proximity sensor measuring device.

Record settlement yields and makes comparisons of subsidence between soft clay soils and organic loam soils. The data obtained from the laboratory results in the laboratory are processed according to the data classification by using valid equations and formulas. The results of the data processing are described in tables and graphs. Then analyzed and compared the results with previous research.

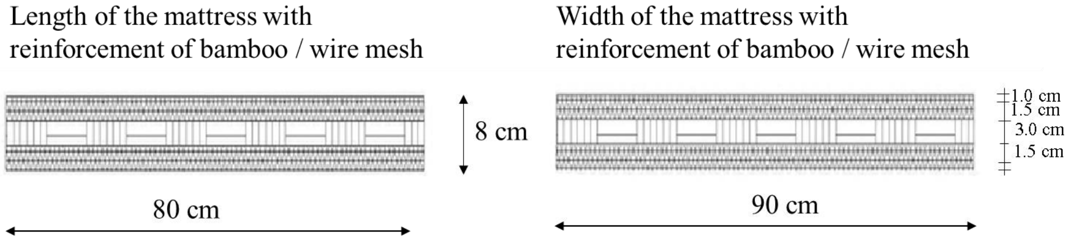

Figure 3. Size and shape of a concrete mat with bamboo / wire mesh reinforcement.

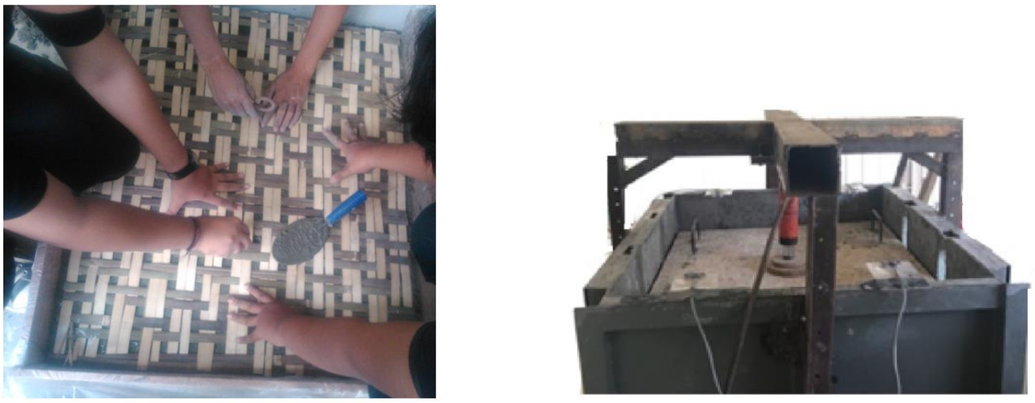

Figure 4. a). The bamboo mat is ready to be cast; b) Placement of strain gauge and pressure / hydraulic jack, (ISWAN et al., 2016; NAWAWI et al 2017).

3. Results

3.1. Results and discussion of physical soil test

Testing the physical properties of soil is a consideration in planning and implementing a construction. The results of this test are also used in papers from ISWAN *et al.*, (2016) and NAWAWI *et al.*, (2017). The results obtained from the physical properties test of the water content in the Belimbing Sari Village, Jabung Timur District, East Lampung, amounting to 64.48%. The water content contained in the Belimbing Sari soil is relatively high. The water content is greater than the soil grains. The level of water content in the soil dramatically affects other soil properties (SOSRODARSONO & TAKEDA, 2016). Based on the Unified Soil Classification System (USCS) soil classification system, the percentage value of soil grains that pass the analysis number 200 is 82.77%. The value of soil grain content, which gives a sieve n° 200, is superior to 50%, according to the USCS soil classification table, generally categorized as fine-grained (loam) soils. In this case, the soil samples were taken from Belimbing Sari Jabung Subdistrict, East Lampung Regency, are fine-grained soil, and the water content is greater than the soil grains. Apart from being fine-grained, the properties of the two soils are different. The soil from Benteng Sari village can be semi-organic soil because it still contains soil grains even though it is very fine. Soil conditions are taken in a location near the rice fields. Visually, the soil contains a lot of crude fiber derived from plants. Previous research has also been carried out in the exact location (SETYANTO, 1992).

While the weight of the soil volume of Belimbing Sari is 1.56 gr/cm^3, the dry weight of the soil will decrease with the addition of water. It will reduce the concentration of solid soil particles per volume. The following things are obtained from the specific gravity test of Belimbing Sari Village 2.54. Figure 5 shows the type of soil as a sample of the consolidation study. DAS (1995) states that soil has a GS value ≤ of 2.68 - 2.75 is soft clay soil.

Figure 5. Soil types at the sampling location in the Belimbing Sari area.

The water content in the two soil samples shows that the soil will expand, and the effective stress of the soil will decrease along with the increase in pore water tension. Likewise, when there is a process of shrinkage on the ground. Soil that loses water suddenly will experience shrinkage in pore volume due to water loss. This will cause the soil to experience large shrinkage. To improve the properties of expansive soil, generally, expansive soil is stabilized with materials that are by the properties of clay to become better and qualify as a construction material. Clay soils are mainly composed of microscopic particles in flat plates and are particles of mica and fine-grained soil minerals or colloidal grains with the size of soil particles (DAS, 1995). The original soil image in the Belimbing Sari area is given in Figure 5.

3.2 Consolidated test results

Soil shrinkage conditions will cause soil subsidence when loaded. It can occur, for example, on the road; thus, there will be soil development. This research looks for a solution by placing a plate on the ground with a concrete plate but with bamboo reinforcement and validated with steel fiber reinforcement. After the test is complete, a graph is made with the time root method used to determine Cv by describing the consolidation test results on the time root relationship to the decline. The characteristic of this time root is to assess the degree of consolidation U = 90%, and T90. The graph's results are used to determine the values of C_v, Cc, M_v and A_v, see Table 1. This study obtained the following products:

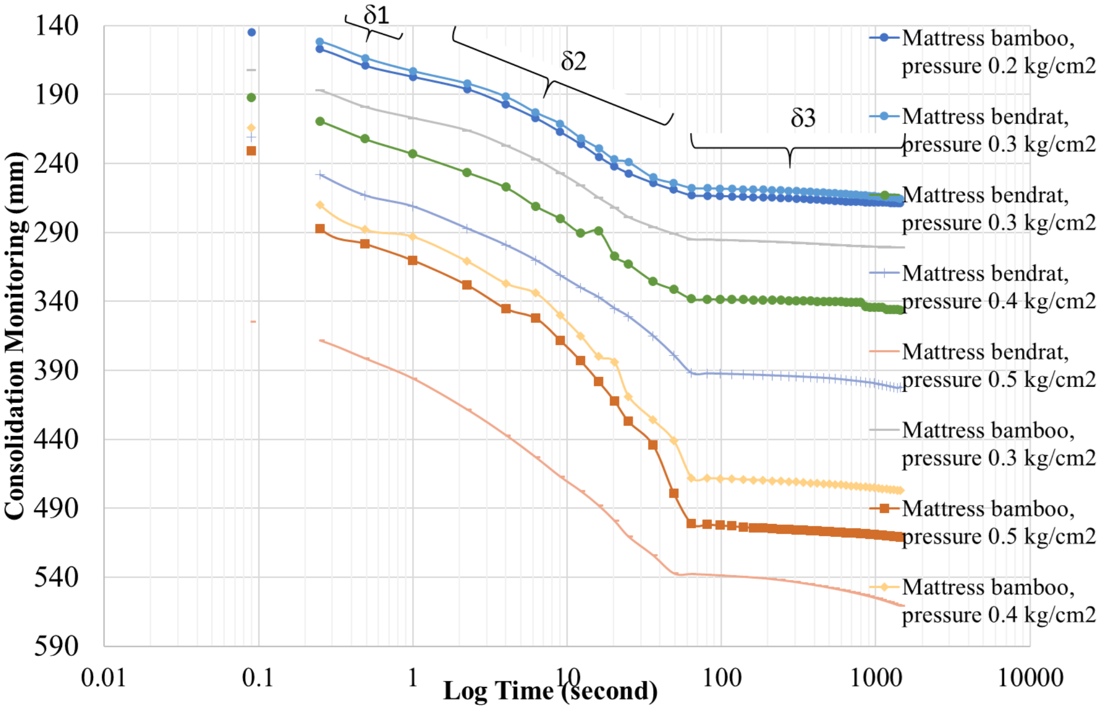

Figure 6. The relationship between time and settlement with 6 trials using concrete mats with bamboo and wire mesh (bendrat) reinforcement with variations in pressure.

The graph in Figure 6 shows that the different descent stages for each are different. From the chart above, starting at 0.2 kg/cm^2; 0.3 kg/cm^2; 0.4 kg/cm^2; 0.5 kg/cm^2 shows a steeper decline in the initial minutes at all loading stages, this is because in the early minutes there is an immediate decrease. After all, the soil is not too dense, and there are still many pore cavities, and the water content is still high so that the time to accept the initial loading of the soil is significantly reduced. After that, there is a gradual decline (consolidation completion). After that, the land consolidation occurs gradually (consolidation completion). This condition applies to all types of soil and concrete mattress.

At $\Delta\delta 1$, the initial drop on the graph looks steep because this is an immediate settlement caused by the initial loading of the specimen. For $\Delta\delta$-initial on soft clay soil, there is an average decrease of 46 - 55%. In the middle, there has been a consolidation settlement. This process depends on the time it occurs in saturated fine-grained soils and has a small permeability coefficient. This condition causes the subsidence to appear not so steeply, but there is still a gradual decline because the soil has begun to harden and compress. For $\Delta\delta 2$ or $\Delta\delta$, the middle subsidence in soft clay soil is 75% - 86%. In the final $\Delta\delta$, you can see the graph starting to slope. This happens because in this part, the soil has undergone secondary compression, at a loading of 0.2 kg/cm^2; 0.3 kg/cm^2; 0.4 kg/cm^2 and 0.5 kg/cm^2. The soil has not decreased anymore, meaning that the soil has consolidated. For $\Delta\delta$-end subsidence in soft clay soil is 2%- 4% from the initial loading.

Table 1. C_v, Cc, A_v and M_v values.

Testing	Mattress Bamboo		Mattress Bendrat	
	Testing with standard laboratory equipment*	Testing using a large box-shaped tool	Testing with standard laboratory equipment	Testing using a large box-shaped tool
Cv (cm2/det)	0,00035	0,0019	0.00044	0.00039
Cc	0,7997	0,8018	0.8300	0.8500
Av (x10-4 m2/kN)	0,0861	0,0857	0.0812	0.0824
Mv (x10-4 m2/kN)	0,0746	0,0745	0.2965	0.3009

*: Head, K.H., 1994.

4. Conclusion

Consolidation experiments conducted in the laboratory have used 2 testing instruments (see Table 1). The consolidation tool in the form of a box measuring 900 x 800 x 1000 mm^3 is an innovation of a large consolidation device to resemble field conditions and a standard consolidation test tool which is often used for practicum and laboratory scale testing. The samples chosen were soft clay soil samples from Belimbing Sari, East Lampung. The location was chosen because the area contains a lot of soft clay and organic soils.

From the study results, the values of M_v, C_v, C_c, and A_v in soft clay soil samples using all consolidation tools get the importance of M_v, C_v, C_c, and A_v almost the same from all consolidation tests. At the beginning of loading, the soil immediately receives a big load and undergoes a significant consolidation so that the soil becomes denser.

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