Effect of Water Content on Soil Supportability at Wai Lapu Halong Bridge Ambon City

[1]Vera Th. C. Siahaya, [2]Sely Metekohy, [3]Sjafrudin Latar, [4]Kirana Maranressy

[1,2,3]Lecturer, [4]Student
[1,3,4]Department of Road and Bridge Construction Techniques, [2]Department of Civil Engineering,
Polytechnic Negeri Ambon, Indonesia

***Abstract-* The 25 m-long Wai Lapu Halong Bridge connecting Galala and Passo villages in Ambon City experienced a landslide. The landslide was caused by heavy rain that flushed Ambon city. In addition to the landslide, the retaining wall was also broken and collapsed, due to the heavy water flowing at the bridge. Due to climate change and unfavorable soil structure at this location, the soil was saturated and shifted. The purpose of this study is to determine the amount of bearing capacity and soil settlement that occurs.**

To determine the bearing capacity of the soil and the decline that occurred, testing the physical properties and mechanical properties of the soil using the Indonesian National Standard (SNI) method was carried out. The type of soil used is disturbed or undisturbed soil on the Wai Lapu Halong bridge in Ambon City.

From the test results conducted this soil has a consolidation value of 0.0041 cm. The results of the CBR test without soaking it is known that the greater the moisture content, the smaller the bearing capacity moisture content, and the greater the bearing capacity of the soil.

***Keywords:* Water content, soil bearing capacity, settlement, Wai Lapu bridge.**

I. INTRODUCTION

In bridge construction, it is built with supports that are directly in contact with the ground. Soil is a material that is very influential in various kinds of bridge construction work or where structures are placed. In this case, the soil functions as a load-bearing due to construction. So that whether or not the bridge construction is strong is also influenced by the existing soil conditions. [3] One of the soils commonly found in bridge construction is clay soil. Clay soil is mineral particles smaller than 0.002 mm. [7] Clay soil is a type of soil with low bearing capacity, so the influence of water is very large on its physical and mechanical behavior. For this reason, in the use of clay as a construction material, soil moisture content plays a very important role.

In July 2021, heavy rains that flushed Ambon city caused a landslide on the Wai Lapu Halong Bridge. Apart from the landslide, the soil retaining wall was also broken and collapsed, due to the heavy water flowing in the bridge river [1]. Due to climate change and unfavorable soil structure at this location, the soil was saturated and shifting. Variations in water content in the soil will continue to occur throughout the year, along with the changing seasons. In the soil mechanics point of view, the variation in water content results in variations in soil parameters and variations in soil stress. The variations that occured certainly have an influence on foundation structures and others that interact directly with the soil. [2]

Research objectives: a) Knowing the amount of soil bearing capacity and b) Knowing the decline that occured. Compaction testing, CBR [9], and consolidation testing were carried out in order to determine the amount of bearing capacity and the decline that occurred in the soil. With various percentages of water content (w), the effect on the bearing capacity of the soil will be obtained with varying results or values. So that it can be known whether the soil in the area requires improvement or not.

The findings of this research will be useful for future stakeholders, especially in planning the work of Wai Lapu Halong Bridge in Ambon city effectively and efficiently based on Indonesian national standards.

II. METHODS

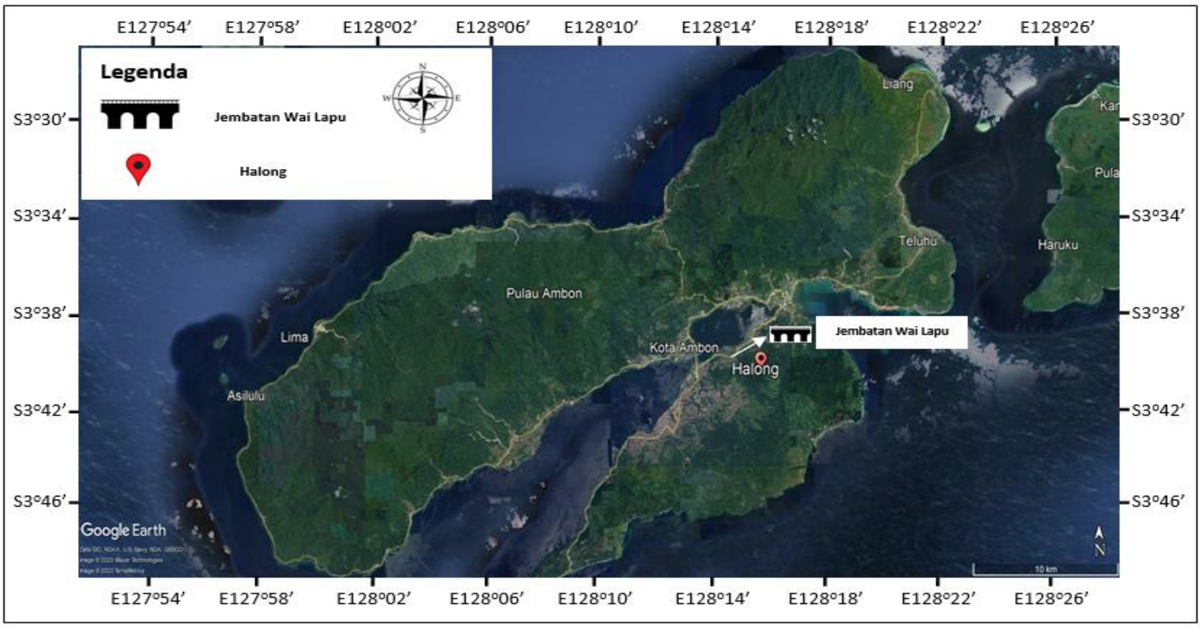
Sampling and Test

Primary data were obtained from tests conducted in the laboratory. Experimental methods obtained from laboratory testing results. Sampling and preparation methods consist of a) soil collection at the Wai Lapu Halong bridge in the form of disturbed soil filled in plastic soil wrappers and labelled, b) soil compaction testing carried out at the ITS soil laboratory of Politeknik Negeri Ambon, measuring the diameter and height of the molt and weigh the molt, mix water with soil and mash 25 times in 3 layers, flatten the surface of the molt then weighed; c) CBR, differentiated in soaking and unsoaking CBR with variations in moisture content of 5%, 10%, 15%.20%, and 25%, with a soaking period of 4 days (96 hours) [13] which was carried out at the Maluku BPJ laboratory in Ambon; d) Consolidation testing was carried out using Geostarr "the Geothecnical software for testing".

Secondary data was obtained from various procedures and the use of soil testing tables obtained from SNI.

Research Site

The location of soil sampling at Wai Lapu Halong bridge, Ambon City, as well as the location of testing at the soil laboratory of the Civil Engineering Department of Politeknik Negeri Ambon, and the Maluku National Road Laboratory.



Data collection

Primary data is the main data directly obtained from the collection of soil data in the laboratory, the value of CBR and consolidation test results.

Secondary data is information or data that already exists and is collected by researchers to complement research data needs, secondary data in the form of various procedures and the use of soil testing tables obtained from SNI

Experimental methods obtained from laboratory test results

1. Soil sampling disturbed soil was placed in plastic wrap and labelled.

Figure 2 Soil Sample

2. Soil Compaction: a) preparatory work; b) weigh the molt and the base; c) measure the diameter and height of the molt; d) Mix water with soil and make 3 layers of compaction; e) each layer is pounded 25 times; f). remove the neck of the molt, level the soil surface parallel to the surface of the molt, then weigh it; g) the soil is taken enough to determine the moisture content [14].

Figure 3 Soil Compaction

3. Laboratory CBR: a) the three test specimens shall be compacted such that the dry density ranges from 95% (or less) to 100% (or greater) of the maximum dry density; b) install the CBR mold on the base chip, locked and weighed to the nearest 5g.

Insert the separator puck into the mold and install coarse filter paper on the surface of the separator puck. Attach the neck to the mold surface and lock it to the stem of the base chip; c) mix each prepared sample material with an appropriate amount of water to achieve the optimum moisture content; d) determine the moisture content of the compacted material (pre-soaked moisture content). The minimum moisture content sample mass is 100 g for fine-grained materials and 500 g for coarse-grained materials. Determination of moisture content must be carried out in accordance with SNI 1964: 2008 [12]; e) open the connecting neck, cut off the excess test specimen with a cutting knife and flatten the surface until it is flat with the surface of the mold using a levelling tool. Irregular or hollow surfaces must be filled with fine material, then compacted and levelled; f) remove the separation puck from the mold, install coarse filter paper on top of the multi-hollow base puck, then the mold containing the test object that has been turned over and placed on top of the filter paper so that the compacted test object lies on top of the filter paper. Attach the multi-hole base puck to the mold and then attach the connecting neck and lock it. Weigh the mold containing the test specimen (to determine the mass of the test specimen) to the nearest 5 g; g) perform compaction for the second and third test specimens according to steps d) to g), except that for the second test specimen 30 impacts per layer are required and for the third test specimen 65 impacts per layer are required [13].

Figure 4 CBR test

4. Consolidation; This test is carried out using *Geostarr "the Geotechnical software for testing,* by means of property data that has been tested and will get consolidation results.

Evaluation Method

After obtaining the test results, data analysis will be carried out to determine the behavior of the soil towards the bearing capacity of the soil with variations in the value of the specified moisture content and the decrease in soil.

1. Compaction testing aims to determine the relationship between moisture content and soil density by compacting a soil sample in a cylinder of a certain size using a mold. The soil sample used is soil that passes sieve no. 4.
2. In this research, CBR testing is divided into two parts, namely unsoaked CBR and soaked CBR. For each sample, the variation of water content is 5%, 10%, 15%, 20%, 25%. In addition, the samples used use the same maximum dry weight, and use a mold with the same diameter and height. For CBR soaking the test specimens were soaked for 96 hours (4 days).

III. DATA AND ANALYSIS

Compaction

Compaction testing aims to determine the relationship between moisture content and soil density by compacting a soil sample in a cylinder of a certain size using a mold. The soil sample used is soil that passes sieve no. 4.

Compaction has the purpose of finding the Optimum Moisture Content value and the maximum dry weight value. In the compaction test, the results are shown in Table 1.

Table 1 Compaction test results

Experiment	1	2	3	4	5	6
Water Content (%)	10.34	11,79	14,70	15,97	19,98	21,47
Dry Fill Weight (gr)	1,22	1,40	1,54	1,59	1,11	0,97
ZAVC (t/m^3)	2,10	2,03	1,92	1,87	1,74	1,70

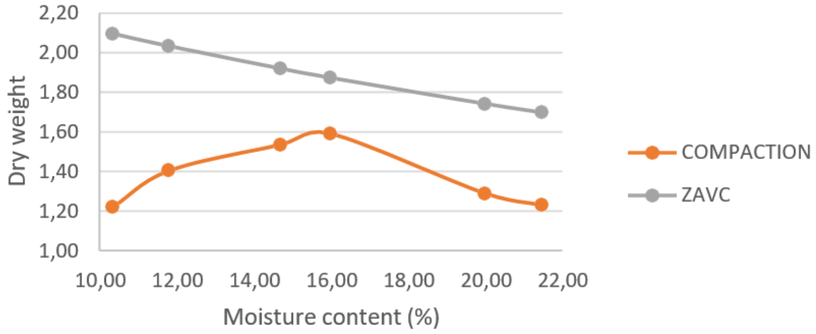


Figure 5 Compaction graph

From Figure 5, it can be seen that the Wai Lapu Halong Bridge soil in Ambon city has an optimum moisture content of 16% with a maximum dry weight (γd max) of 1.6 gr/cm3. This optimum moisture content (OMC) and maximum dry weight (γd max) will later be used as a reference for making research plan samples. This maximum dry weight (γd max) will be used as the dependent variable (controller) in making CBR samples with varying water content.

1. Consolidation

This test aims to determine the speed of consolidation and the amount of soil settlement. Based on the root value of time (t90), the value of the Coefficient of Consolidation (Cv) of the soil sample can be calculated as shown in Table 2. The average CV is 0.0227 cm^2/sec.

Table 2. Compaction test results

Pressure	Ht	t90	CV=0.848Ht^2/t90 cm^2/sec
0,25	0,551	7,51	0,034
0,50	0,551	8,35	0,031
1	0,551	14,44	0,017
2	0,551	14,21	0,018
4	0,551	14,44	0,017
8	0,551	30,25	0,009
4	0,551	7,84	0,033
Average			0,0227

Table 3. Calculation of pore number

Pressure (KN/m^2)	Voltage (KN/m^2)	Watch Reading (mm)	ΔH (m)	Δe = ΔH/Ht	Pore Number
0,25					
0,5	0,354	9,785	0,0979	0,178	0,5224
1	0,707	9,558	0,0956	0,173	0,5265
2	1,415	9,170	0,0917	0,166	0,5336
4	2,829	8,540	0,0854	0,155	0,5450
6	5,659	7,650	0,0765	0,139	0,5612
8	1,451	6,590	0,0659	0,120	0,5804
4	0,354	6,60	0,0660	0,120	0,5802

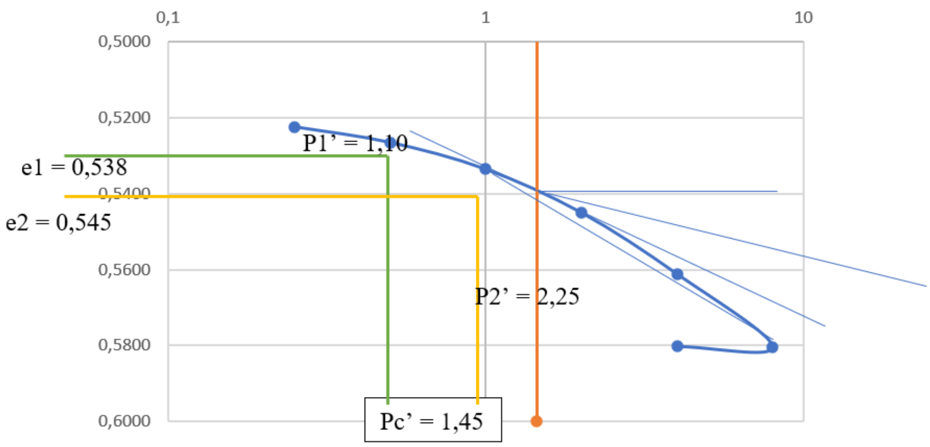


Figure 6 Graph of the relationship between Pressure and Pore Number to determine Preconsolidation Pressure (Pc')Calculation of

Overburden Pressure (Po'):
Po' = (½ H x γb) = (½ x 1 x 1.70) = 0.85
Pc'>Po' value is obtained. Based on OCR calculation
Pc'/Po' = 1.45/0.85 = 1.71 > 1
then the soil belongs to over-consolidated clayCompression index:
Cc= 0.009 (LL-10) = 0.009(55.25-10)= 0.407

$Cr = \frac{\Delta e}{\Delta \log P'} =$ = (0,545 – 0,538) / (log (2,25 – 1,10) = 0,115

From the test results that have been carried out, the amount of decline is calculated as follows:Sc = Cr (H0/1 + e0)(log P2'/P1') = 0.115 (1/1 + 0.70)(log 2.25 - 1.10) = 0. 0041 cm

2. CBR

a. Unsoaked CBR and Soaked CBR Results

In CBR testing without soaking produces a greater soil bearing capacity compared to soaking CBR. In the immersion CBRtest it takes 96 hours (4 days) of soaking time.

Table 4. CBR Results

Variation of moisture content (%)	Submerged CBR Value(%)	Moisture content (%)	Unsubmerged CBR value (%)	Moisture content(%)
5	0,68	51,800	10,68	5,012
10	0,97	42,066	6,12	10,311
15	1,26	35,701	3,01	15,169
20	1,46	30,646	1,94	20,103
25	1,55	27,849	1,65	25,440

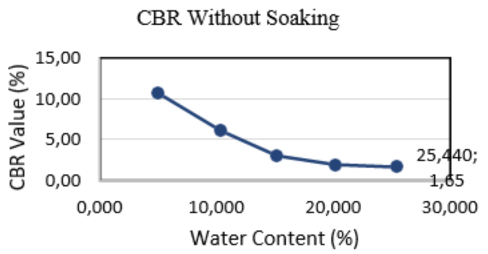


Figure 7 Relationship between moisture content and CBR without soaking

From Table 4 and Figure 7, it can be seen that the largest unsoaked CBR value is 10.68% at 5% moisture content, and the smallest CBR value is 1.65% at 25% moisture content. So it can be seen that the higher the water content in unsoaked CBR, the smaller the CBR value.

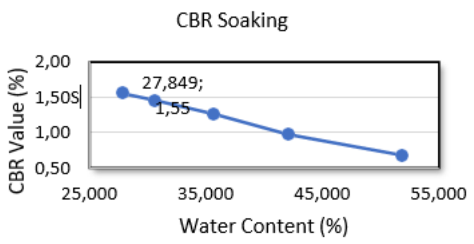


Figure 8 Relationship between water content and submerged CBR

Table 4 and Figure 8, for CBR with soaking is 1.55% at 25% moisture content and the smallest CBR value is 0.68% at 5% moisture content. So it can be seen that when the water content is higher, the value of CBR by immersion is greater.

b. Comparison of Unsoaked and Soaked CBR Values

It can be seen in table 4.12 that the soaking CBR value has decreased when compared to the CBR value without soaking. The following are the results of the comparison of the CBR value of soaking and without soaking:

Table 5 Comparison of soaked and unsoaked CBR values

Variation of Moisture Content(%)	Submerged CBR Value (%)	Unsubmerged CBR Value (%)	Decrease (mm)

5	0,68	10,68	10,00
10	0,97	6,12	5,15
15	1,26	3,01	1,75
20	1,46	1,94	0,49
25	1,55	1,65	0,10

From Table 5, it can be seen that the decrease in CBR value between unsoaked CBR and soaked CBR is the highest at 10.00% which occurs when the water content is 5%. The higher the water content, the smaller the decrease in CBR value between unsoaked CBR and soaked CBR will be, namely 0.10% at 25% water content.

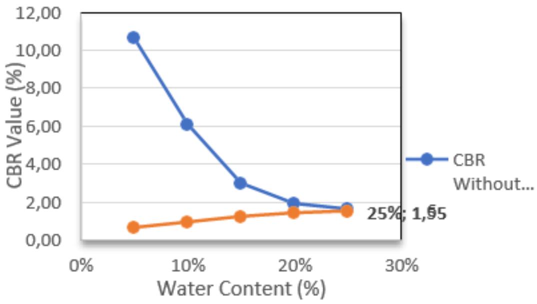


Figure 9 Relationship between unsoaked CBR and initial water content soaked CBR

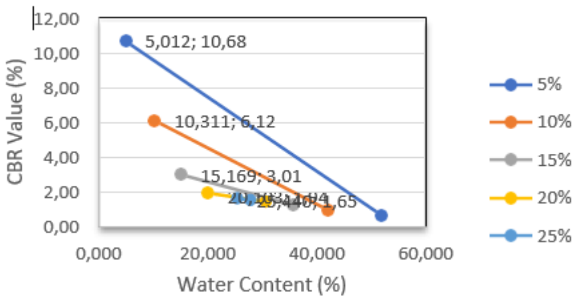
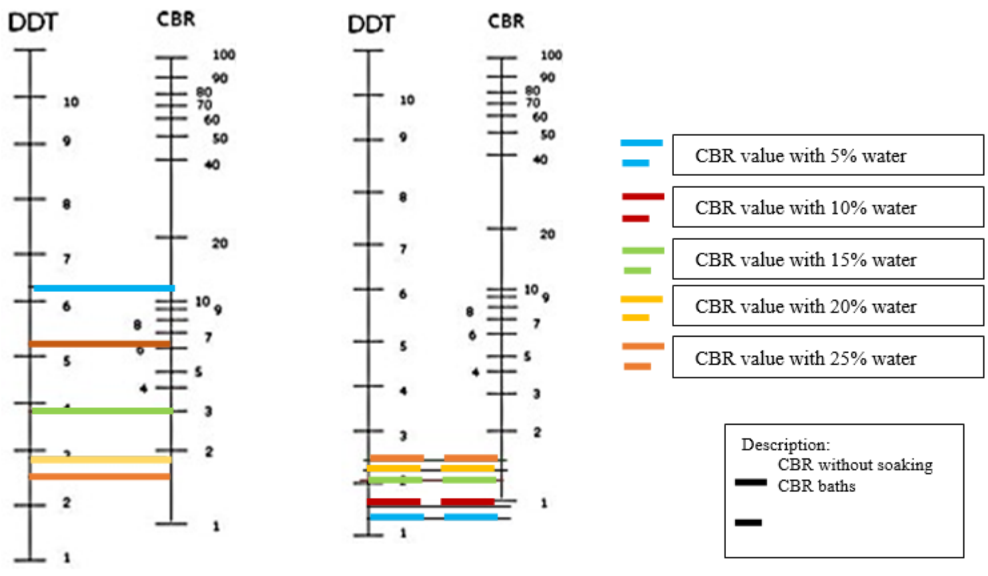


Figure 10 Relationship between unsoaked CBR and final water content soaked CBR

B. Determination of Soil Support Value



(a) (b)

Figure 11 Graph of the relationship between (a) unsoaked CBR and soil bearing capacity, (b) Soaking CBR with soil-bearing capacity

From the CBR value data obtained by connecting to the graph of the relationship between CBR and soil bearing capacity, theresults are shown in Table 6.

Table 6 Relationship between unsoaked CBR values and soil bearing capacity values

Variation of Water Content(%)	Unsubmerged CBR Value(%)	Soil Support Value(%)
5	10,68	6,42
10	6,12	5,25
15	3,01	3,93
20	1,94	2,87
25	1,65	2,53

Table 7 Relationship between soaking CBR value and soil bearing capacity value

Variation of Moisture Content(%)	Submerged CBRValue (%)	Soil Support Value(%)
5	0,68	1,36
10	0,97	1,68
15	1,26	2,08
20	1,46	2,25
25	1,55	2,39

From Table 7, it can be seen that the greater the CBR value, the greater the bearing capacity of the soil, and vice versa. In addition, the relationship between moisture content and soil bearing capacity value can also be seen in Figure 12.

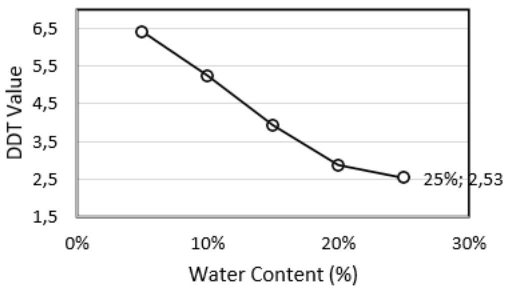


Figure 12 Relationship between moisture content and soil bearing capacity

IV. CONCLUSIONS

1. The unsoaked CBR value will decrease with the addition of excess water content, the highest soil bearing capacity value is 6.42% at 5% water content, while the soaked CBR will have a greater CBR value with the addition of water content, the highest bearing capacity value is 2.39% at 25% water content.
2. In testing consolidation it can be seen that the soil at Wai Lapu Halong Bridge, Ambon has a value of Cv = 0.0227 cm²/sec, Cc = 0.407, Cr = 0.115 and a consolidation value of 0.0041 cm .

V. ACKNOWLEDGEMENTS

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