Consolidation test on peat soil of Humbang Hasundutan regency, North Sumatera Province

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Abstract: The purposes of this study were to determine the index properties of peat soil, to determine the classification of peat soils and to determine the consolidation coefficient ($C_v$) and compression index value ($C_c$) of peat soil in Nagasaribu Village, Lintong Nihuta sub-District, Humbang Hasundutan Regency, North Sumatera province. This research was conducted through a consolidation test with direct loading of 9.810 Newton and 19.613 Newton and gradually loading of 9.810; 19.613; 39.226; 78.453; and 156.96 Newton. The peat soil in Nagasaribu Village, Lintong Nihuta sub-District, Humbang Hasundutan Regency has a high water content ($w$), of 628.139%, specific gravity (Gs) of 1.301, moist unit weight ($g$) of 10.125 KN/m$^3$, dry unit weight ($\gamma$) of 1.390 KN/m$^3$ and void ratio ($e$) of 8.157. Based on ASTM D4427-92 (2002), the sample of peat soil was classified as low ash peat because it had 0.780% ash content and 26.500% organic content. And according to the acidity level with a pH of 4.000, the sample was classified as highly acidic peat soil. The compression index ($C_c$) of sample 1 was 3.044 and sample 2 was 3.574 and the consolidation coefficient ($C_v$) of sample 1 was 2.155 cm$^2$/sec and sample 2 was 1.818 cm$^2$/sec.

1. Introduction

The widest distribution of peatlands in Indonesia is found in three large islands (Sumatra, Kalimantan and Papua), which covers an area of around 14.9 million hectares, this area does not include the area of peatlands on other islands [1]. Apart from being used for agriculture, peatland is also used as a base for civil construction. Construction on peat soil causes pressure or loads on the land. Loading above the surface of the peat soil causes the subsoil to experience compression (compressibility) where there is a slow volume reduction process on perfectly saturated soils with low permeability due to the draining of some of the pore water. This process is known as a consolidation process. Consolidation settlement is the vertical displacement of the land surface in relation to changes in volume at one stage of the consolidation process. The land subsidence value that is high enough is not good for the construction of the building above it. Therefore, it is necessary to conduct research to find out how much and how fast the subsidence occurs in peat soils. In this case the author examines the consolidation of peatlands in Nagasaribu Village, Lintong Nihuta Sub-district, Humbang Hasundutan Regency, North Sumatra province. The peat soil of Asahan Regency, North Sumatera province had compression index ($C_c$) of 0.659 and coefficient of consolidation ($C_v$) of 0.317 cm$^2$/sec [2]. The peat soil of Paya Pinang Plantation, Batubara Regency, North Sumatera province had compression index ($C_c$) of 0.693 and coefficient of consolidation ($C_v$) of 0.275 cm$^2$/sec [3]. The purposes of this study were to determine the index properties of peat soil, to determine the classification of peat soils and to determine the consolidation coefficient ($C_v$) and compression index value ($C_c$) of peat soil in Nagasaribu Village, Lintong Nihuta sub-District, Humbang Hasundutan Regency, North Sumatera province.
2. Method
This study used peat soil samples taken from Nagasaribu Village, Lintong Nihuta Sub-district, Humbang Hasundutan Regency (See Figure 1). The research was conducted by using an experimental method which consisted of several types of tests obtained from two main tests, namely physical properties testing and peat soil consolidation testing. Testing of physical properties consists of: testing of moisture content, specific gravity, volume weight, pore number, ash content and organic matter, and acidity (pH) which was carried out at the Laboratory of Soil Mechanics, Faculty of Engineering, University of North Sumatra.

![Sample location](image)

Figure 1. Location of peat soil samples

The consolidation test was carried out with two types of loading, namely direct loading and gradual loading. A number of peat soil samples were tested for mineral content and ash concentration using reference ASTM D2947-87 [4]. Mineral element tests were carried out at the Research Center of the Ministry of Industry of the Republic of Indonesia in the Medan area. The consolidation test for the gradual loading method used a load of 9,810 N; 19,613 N; 39,226 N; 78,453 N and 156.96 N, while the direct loading method used a load of 9.810 N and 19.613 N.

3. Results and Discussion
3.1. Index properties test
Index properties test of peat soil were shown Table 1.

| No. | Test                  | Results       | Index properties of peat Soil |
|-----|-----------------------|---------------|------------------------------|
| 1   | Water content         | 628.139 %     | 100 - 1300%                  |
| 2   | Specific gravity      | 1.301         | 1.250 – 1.800                |
| 3   | Void ratio            | 8.157         | 5 – 15                       |
| 4   | Moist unit weight (γw)| 10.125 KN/m³  | -                            |
| 5   | Dry unit weight (γd)  | 1.390 KN/m³   | -                            |
3.2. Classification of peat soil
The result of ash content, organic content, and pH of peat soil were presented in Table 2.

| No. | Test            | Results   | Classification of peat soil based on ASTM D4427-92 920020 [5] |
|-----|-----------------|-----------|-------------------------------------------------------------|
| 1   | Ash content     | 0.780%    | <5% low ash-peat                                           |
| 2   | Organic content | 26.500%   | sapric                                                     |
| 3   | Acidity (pH)    | 4         | Highly acidic                                              |

3.3. Mineral elements of peat soil
Mineral elements of peat soil were displayed in Table 3

| Mineral Composition | Results (%) |
|---------------------|-------------|
| Aluminum Oxide (Al₂O₃) | 5.160       |
| Silicon Dioxide (SiO₂) | 1.720       |
| Ferric Oxide (Fe₂O₃)  | 1.070       |
| Magnesium Oxide (MgO) | 12.000      |
| Natrium Oxide (Na₂O)  | 0.250       |
| Potassium Oxide (K₂O) | 0.270       |
| Calcium Oxide (CaO)   | 1.220       |

3.4. The effect of loading on water content
In the peat soil consolidation test, the seepage that occurs is strongly influenced by the amount of load applied and the length of time to load the sample. The greater the load received by the sample, the higher the seepage that occurred in the soil. The time of loading versus water content curve in directly loading was shown in Figure 2.

![Figure 2. The curve of settlement vs. water content](image)

3.5. The effect of loading on moist unit weight
In the peat soil consolidation test, the decrease in wet volume that occurred was influenced by the amount of load received by the peat soil and the length of time of loading. This was due to the discharge of water due to loads through soil drainage channels, which affected the volume of wet soil.
on peat soils. The time of loading versus moist unit weight curve in directly loading was shown in Figure 3.

![Figure 3. The curve of settlement vs. moist unit weight](image)

3.6. *The effect of loading on dry unit weight*
In the peat soil consolidation test, dry volume weight had increased. The increase in dry unit weight occurred because the load received by the soil caused consolidation so that the pore soil volume got smaller with a fixed weight. The time of loading versus dry unit weight curve in directly loading was shown in Figure 4.

![Figure 4. The curve of settlement vs. dry unit weight](image)

3.7. *Correlation of time with settlement*
There was a large decrease at the beginning of the loading and then produced very small settlement in the remaining time. Time correlation with settlement on sample 1 and 2 were shown in Figure 5 and Figure 6.
3.8. Correlation of time with settlement in directly loading

The correlation of time with the settlement in direct loading were shown in Figure 10 and Figure 11.

![Figure 5](image1.png)

**Figure 5.** Correlation of time with settlement on sample 1

![Figure 6](image2.png)

**Figure 6.** Correlation of time with settlement on sample 2

![Figure 7](image3.png)

**Figure 7.** Correlation of time with settlement on sample (1) in directly loading

![Figure 8](image4.png)

**Figure 8.** Correlation of time with settlement on sample (2) in directly loading
3.9. Coefficient of consolidation (C\textsubscript{v})

The coefficient of consolidation (C\textsubscript{v}) was shown in Figure 9.

![Figure 9. The curve of coefficient of consolidation, C\textsubscript{v}](image)

3.10. Correlation of void ratio with effective pressure

In consolidation test it was concluded that the greater the pressure and loading time applied to the peat soil, the smaller the pore value due to compression. From Figure 13, the sample 1 and 2 gave the compression index, C\textsubscript{c} value of 3.044 and 3.574 respectively. The decrease in pore numbers due to pressure can be seen in Figure 10.

![Figure 10. The correlation of void ratio with effective pressure sample 1 and sample 2](image)
3.11. Correlation of void ratio with time of loading
The correlation between the pore number and the gradual and direct loading time is that the longer the given time and the greater the load given, the smaller the pore number. The curve of void ratio versus pressure shown in figure 11 and figure 12.

![Figure 11. The curve of void ratio vs. time](image1)

![Figure 12. The curve of void ratio vs. time for directly loading](image2)

4. Conclusion
From the results of research, conclusions could be drawn:
1. Peat soil in Nagasaribu Village, Lintong Nihuta Sub-District, Humbang Hasundutan Regency, North Sumatera province had a high water content, w of 628.139%, specific weight, \( G_s \) of 1.301, moist unit weight \( \gamma_b \) of 10.125 kN/m\(^3\), dry unit weight \( \gamma_d \) of 1.390 kN/m\(^3\), void ratio, \( e \) of 8.157.
2. The sample was classified as peat soil with low ash content (Low ash peat) because it had ash content of 0.780% with a high acidic level (pH), which is 4 and has an organic content of 26.500%.
3. The compression index, \( C_c \) of sample 1 was 3.044 and sample 2 was 3.574 and the consolidation coefficient, \( C_v \) of sample 1 was 2.155 cm\(^2\)/sec. and sample 2 was 1.818 cm\(^2\)/sec. The rate of descent depended on the amount of loading applied.
4. Construction on peat soil in Humbang Hasundatan Regency, North Sumatera province was not good for building construction because the peat soil had a high moisture content and was fibrous so that it would experience very large settlement.

5. References

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