Classification and consolidation test on peat soil of Asahan Regency Sumatera Utara Province

Roesyanto* and F Shakila

Civil Engineering Department, Universitas Sumatera Utara, Medan, Indonesia

*Email: roesyanto@usu.ac.id

Abstract. Defined as land with water-saturated soil, formed from deposits that originate from the accumulation of decaying past plant. Peat soil has poor physical properties for construction purposes, the soil has low shear strength and has a high shrinkage because of a lack of mineral content in it. The research purposes were to find out the index properties and the classification of peat soil and to analyze the compression index (Cv) and the coefficient of consolidation (Cv) of peat soil. The research was carried out by gradual consolidation and immediately consolidation. In gradual consolidation the load was given in step by step of 0.5 Kg, 1 Kg, 2 Kg, 4 Kg, 8 Kg, and immediately consolidation using a load of 1 Kg and 4 Kg for 7 days. Peat soil of Pertahanan Village had high water content (w) of 726.34 %, specific gravity (Gd) of 1.302, moist unit weight (γm) of 0.764 gr/cm³, dry unit weight (γd) of 0.144 gr/cm3, void ratio (e) of 8.06. Based on ASTM D442-84 (1989), the peat soil had 45.032 % ash peat and 54.968 % organic content, and it was classified as High Ash Peat. The acidity of peat soil was 4 and it was classified as Highly Acidic Peat with a pH less than 4.5. Index compression (Cv) of the peat soil was 0.659 and the coefficient of consolidation (Cv) was 0.317 cm²/seconds.

1. Introduction
In various parts of the world has some soil types. This causes differences in existing ecosystems, one of which is the soil element in it. The land is not all suitable for construction activities. One type of soil that is less suitable in construction activities is compost and peat soil [1-6]. Peatlands are defined as land with water-saturated soil from deposits that originate from the accumulation of decaying past plant. The process of forming peat started the presence of the silting-up of the lake that gradually overgrown with by aquatic plants and vegetation wetlands. The process of destruction in soil formation from rocks occurs physically or chemically [7]. If a layer of soil has loading due to the load on it, then the soil load increases hence the ground level settle. This loading results in deformation of soil particles, relocation of soil particles, and the release of pore water from the soil accompanied by reduced soil volume. This is what causes land subsidence [8]. Terzaghi's consolidation theory is generally used to estimate soil compression, but this theory cannot be used because peat soil has highly coefficient permeability and high compressibility [9]. The peat soil research was conducted to know the index properties, to determine the classification, and to analyse the compression index (Cv) and coefficient of consolidation (Cv) of peat soil of Pertahanan Village Sub-District of Sei Kepayang, Asahan Regency, Sumatera Utara Province.
2. Method
This research used an experimental method which was conducted in the Soil Mechanics Laboratory, Civil Engineering Department, the University of Sumatera Utara for index properties. Then for consolidation test was conducted in the CV. Lima Saudara Laboratory. The research samples were peat soil which was taken from Pertahanan Village, Sub-District of Sei Kepayang, Asahan Regency Sumatera Utara Province. These samples were assumed to be representative of peat soil that was in the district of Asahan, Sumatera Utara Province.

One sample was used for the determination of ash content and organic content based on ASTM D2947-87 [10]. Mineral element tests were carried out in Balai Riset dan Standarisasi Industri (BARISTAND) Medan. The gradually loading consolidation used 0.5 kg, 1 kg, 2 kg, 4 kg, and 8 kg while the immediate loading consolidation employed 1 kg and 4 kg for 7 days. All data were analyzed and were presented in the form of tables, graphs, and explanations. The flow diagram of the research could be seen in Figure 1.

---

**Figure 1.** The flow diagram of the research.
3. Results and discussion

3.1. Index properties test
Index properties test of the peat soil was shown in Table 1.

**Table 1. Index properties of peat soil.**

| No. | Test                  | Results  | Index properties of peat Soil  |
|-----|-----------------------|----------|--------------------------------|
| 1   | Water content         | 726.34   | 110 %-1300 %                  |
| 2   | Specific gravity      | 1.302    |                                |
| 3   | Void ratio            | 8.06     | 5-15                           |
| 4   | Mois unit weight ($\gamma_w$) | 0.764 |                       |
| 5   | Dry unit weight ($\gamma_d$) | 0.144 |                       |

3.2. Classification of peat soil
The result of ash content, organic content, and pH of the peat soil were presented in Table 2.

**Table 2. Classification of peat soil.**

| No. | Test       | Results | Classification peat soil based on ASTM D4427-92 (2002) [11] |
|-----|------------|---------|----------------------------------------------------------|
| 1   | Ash content| 45.032  | High Ash Peat                                            |
| 2   | Organic content | 54.968 |                                                   |
| 3   | Acidity (pH) | ↓ 4    | Highly Acidic                                            |

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

**Table 3. Mineral elements of peat soil.**

| Mineral Composition | Unit | Results |
|---------------------|------|---------|
| Calcium (CaO)       | %    | 0.29    |
| Ferrum (Fe₂O₃)      | %    | 0.40    |
| Silica (SiO₂)       | %    | 0.02    |
| Aluminum (Al₂O₃)    | %    | 0.03    |
| Magnesium (MgO)     | %    | 0.16    |
| Potassium (K₂O)     | %    | 1.58    |
| Sodium (Na₂O)       | %    | 0.61    |
3.4. Loading time influence toward water content in immediately loading

The time of loading versus water content curve for immediately loading was shown in Figure 2. It was concluded that if the loading time increased then the water content decreased steeply.

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

3.5. Loading time influence toward moist unit weight in immediately loading

The time of loading versus the moist unit weight curve for immediately loading was displayed in Figure 3. It was deduced that if the loading time and the load increased then the moist unit weight decreased.

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

3.6. Loading time influence toward dry unit weight in immediately loading

The time of loading versus the dry unit weight curve for immediately loading was shown in Figure 4. The dry unit weight increased due to the amount of immediately loading and the length of loading time given so that the dry unit weight of the soil increased.

![Figure 4. The curve of settlement toward dry unit weight.](image)
3.7. Correlation of time with settlement in gradually loading
The correlation of time with settlement on samples 1 and 2 in gradually loading was shown in Figure 5 and Figure 6. Both figures showed the same settlement trends which at early loading produced a large settlement and then produced a very small settlement in the remaining time.

![Figure 5. Curve sample (1) gradually loading.](image)

![Figure 6. Curve sample (2) gradually loading.](image)

3.8. Correlation of time with settlement in immediately loading
The correlation of time with settlement on samples 3 and 4 in immediately loading was shown in Figure 7 and Figure 8. Both figures showed the same trend of settlement which at early loading produced a large settlement and then produced a very small settlement in the remaining time.

![Figure 7. Correlation of time with settlement sample 3 in immediately loading.](image)

![Figure 8. Correlation of time with settlement sample 4 in immediately loading.](image)
3.9. Coefficient of consolidation ($C_v$) in gradually loading

The coefficient of consolidation ($C_v$) in gradually loading was shown in Figure 9.

![Figure 9](image)

**Figure 9.** The curve of $C_v$ from sample 1 and sample 2.

3.10. Correlation of void ratio with effective pressure in gradually loading

The correlation of void ratio with effective pressure in gradually loading was shown in Figure 10. It was concluded in loading condition that the void ratio decreased and in unloading condition, the void ratio was constant which meant no elastic strain at all.

![Figure 10](image)

**Figure 10.** The correlation of void ratio with effective pressure sample 1 and sample 2 in gradually loading.

3.11. Correlation of void ratio with time of loading
The correlation of void ratio with the time of loading was presented in Figure 11 and in Figure 12. It was concluded that $C_v$ value was large in the early loading, then became very small in the later time.

![Figure 11](image1.png)  
**Figure 11.** The curve of void ratio vs time for gradually loading.  

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

4. **Conclusion**

From the research results, it could be concluded that:

1. Peat soil of Pertahan Village Sub-district of Sei Kepayang of Asahan Regency had 726.34% water content ($W_c$), specific gravity ($G_s$) of 1.302, moist unit weight ($\gamma_b$) of 0.764 gr/cm$^3$, dry unit weight ($\gamma_d$) of 0.144 gr/cm$^3$, void ratio ($e$) of 8.06.

2. The peat soil had 45.032% ash content and based on ASTM D4427-92 (2002), the peat soil was classified as High Ash Peat with more than 15% ash.

3. The peat soil had acidity pH of 4 and based on ASTM D4427-92 (2002), the peat soil was classified as Highly Acidic Peat with a pH less than 4.5.

4. The compression index ($C_c$) was 0.659 and the coefficient of consolidation ($C_v$) was 0.317 cm$^2$/sec. The compression index and the coefficient of consolidation in peat soil were relatively very large compared to clay soil.

5. Peat soil of Asahan Regency was poor soil for building construction because it had a high water content and fibrous soil with relatively very large compression index.

**References**

[1] Noor M 2010 *Lahan Gambut Indonesia* (Yogyakarta: Gadjah Mada University Press) 212  
[2] Trisakti B, Lubis J, Husaini T and Irvan 2017 Effect of turning frequency on composting of empty fruit bunches mixed with activated liquid organic fertilizer *IOP Conf. Ser: Mater. Sci. Eng.* 180 012150  
[3] Irvan, Husaini T, Trisakti B, Batubara F and Daimon H 2018 Composting of empty fruit bunches in the tower composter – effect of air intake holes *IOP Conf. Ser: Mater. Sci. Eng.* 309 012066  
[4] Trisakti B, Mhardela P, Husaini T, Irvan and Daimon H 2018 Production of oil palm empty fruit bunch compost for ornamental plant cultivation *IOP Conf. Ser: Mater. Sci. Eng.* 309 012094
[5] Trisakti B, Mhardela P, Husaini T, Irvan and Daimon H 2018 Effect of pieces size of empty fruit bunches (EFB) on composting of EFB mixed with activated liquid organic fertilizer IOP Conf. Ser: Mater. Sci. Eng. 309 012093

[6] Irvan, Rahman M, Anwar D, Trisakti B, and Daimon H 2019 Production of compost from non-shredded empty fruit bunches mixed with activated liquid organic fertilizer in tower composter Malaysian Journal of Analytical Sciences 23 (1) 138-146

[7] Wesley L D 1977 Mekanika Tanah, edition VI (Jakarta: Penerbit Pekerjaan Umum) 1

[8] Das B M 1994 Principles of Geotechnical Engineering Third Edition (Boston: PWS Publishing Company) 177

[9] Terzaghi K 1943 Theoretical Soil Mechanics (Universitas Michigan: Penerbit J. Wiley and Sons, inc.) 266

[10] ASTM D2974-87 1993 Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils (United States of America: ASTM International)

[11] ASTM D4427-92 2002 Standard Classification of Peat Samples by Laboratory Testing (United States of America: ASTM International)