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# Penetration Resistance of Bengkalis' Peat From Hand Cone Penetration Test

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**Abstract.** In situ soil investigation on peat is not easy due to its low bearing capacity and high compressibility. Traditional in-situ test such as cone penetration test (CPT) are quite heavy which make movability on peatland difficult and slow. This study described the measurement of peat penetration resistance using portable hand cone penetration (HCP) test. The location of this study is at Bengkalis' Island. Visual observation and laboratory tests show that peat at the site, mainly, can be classified as sapric and low ash. Dry unit weights range from 1.06-1.54kN/m<sup>3</sup> with specific gravity range between 1.19-1.81. HCP test show that penetration resistance range from 84-674kPa with majority of it is at 300kPa. Estimated unconfined compression test suggested soft to medium consistency. Equivalent penetration resistances of full CPT are between 110-910kPa. There is tendency that higher fibre content may increase penetration resistance.

## 1. Introduction

According Indonesia National Standard (SNI) 8460 about geotechnical design, soil investigation is a requirement for a site assessment [1]. In Indonesia mechanical cone penetration test (CPT) is a very common and popular soil investigation tool particularly for low rise building. CPT has more advantages compare to heavier and more expensive standard penetration test (SPT). CPT measurement is also more repeatable than SPT. However, CPT on peatland, which cover almost 60% of Riau Province area, has some problems e.g. moving to and between point of investigation is not easy on very soft and watery peat; need wooden path to help access, require at least three to four persons. This suggests a more portable soil investigation tool to be used on peatland.

There are many portable tools available in the market e.g. dynamic cone penetrometer (DCP), macintosh probe (MP) and hand cone penetration test (CPT). Dynamic cone penetrometer (DCP) and macintosh probe (MP) are based on number of blows require to penetrate a rod (by hammering) at a certain length, as in SPT. Measurement of relative strength using both of them usually give crude and rather meaningless value because of the very soft nature of peat i.e. index values almost the same [2,3]. Hand cone penetration (HCP) is a portable and small version of CPT. HCP weight only about 20 kg for 3m depth test thus it is very portable compare to more than 500kg of full CPT. They are using the same principle i.e. measure stress at certain interval by pushing. HCP have been used widely in



road construction, compaction quality control, agriculture, wood logging, tree planting etc., which usually on mineral soils i.e. clay and sand.

Based on the degree of decomposition peat can be classified as fibric (low), hemic (intermediate) and sapric (high) [4]. This study describes the application of HCP to determine penetration resistance of peat with different degree of decomposition. To the best Author's knowledge there is still limited study on the use of HCP on peat [5, 6]. In addition to HCP, some laboratory tests were also performed to compliment the study.

## 2. Methodology

### 2.1. Location

The site of interest in this study is in Bengkalis Island, Riau Province, -Indonesia. Figure 1a shows Bengkalis island in regional context. Bengkalis Island was selected as the Author's had previous studies on the island [7]. Based on the geological map, the lithology of the location is classified as alluvial composed of clay, silt, clean gravel, vegetation raft and peat swap. Aquifer can be classified as moderate to low transmissivity, depth to water table varies and well generally yield less than 5 litre/sec [8]. Figure 1b present the point of location of the study i.e. 102.008528E 1.595733N.



**Figure 1.** Location of study

### 2.2. Equipment

The main equipment used in this study are peat sampler, laboratory apparatus, hand cone penetration, portable water quality kit. More information about the equipment is described in the following sub section.

**2.2.1. Peat Auger.** “Eijkelkamp” Russian type peat sampler was used in this study (Figure 2). The main parts of it are peat sampler, extension rods and rotating handle. The peat sampler consists of hooked blade(fin) and half cylindrical tube (gouge) that has sharp edge which can cut peat. Initially the gouge is open and when the rod handle is rotated, it close and cover the cut soil sample.



**Figure 2.** Peat auger Russian type

**2.2.2 Laboratory apparatus.** Laboratory apparatus used in this study are laboratory scale to weight oven, furnace to measure ash content.

**2.2.3 Hand cone penetration test.** Hand cone penetration is a portable and small version of CPT. The one used in this study (Figure 3) was manufactured by Marui corporation. The apparatus has tip angle of  $30^\circ$ , a cone diameter of 28.6mm and rod diameter of 16mm. The speed of penetration is 1 cm/s [9]. The force is measured by calibrated proving ring. Penetration resistance then calculated as

$$q_c = \{Q_{rd} + (m_0 + nm_1)9.81\} / 1000 / A \quad (1)$$

where  $Q_{rd}$ =measured cone penetration force (kN);  $m_0$ =weight of cone;  $n$ =number of rods;  $m_1$ =weight of rod;  $A$ =cone area= $0.000645\text{m}^2$ .

Result of portable cone penetration may be used to estimate unconfined compression strength and CPT value with the following equations

$$q_c = 53 + 4.19 q_u \quad (2)$$

$$q_c \approx 4.87 q_u \quad (3)$$

$$q_c \approx 0.741 q_{CPT} \quad (4)$$



**Figure 3.** Hand cone penetration [10]

*Portable water quality kit.* The kit was used to measure pH and water resistivity.

### 2.3. Procedure

Hand cone penetration test was conducted close to the peat boring (about 1m). Sample was collected every 50cm from peat sampler. Unit weight was measured in the field using plastic ring (known volume) and weighted it using pocket scale (before and after filled with peat). The leftover sample is put in the labelled plastic bag for other laboratory test i.e. water content ( $w$ ), dry unit weight ( $\gamma_{dry}$ ) specific gravity ( $G_s$ ), ash content (AC) and fibre content (FC).

### 3. Results

Peat boring was conducted to about 5-meter depth, which mineral soil i.e. clay was encountered. Based on visual observation the peat at the site is predominantly sapric (Figure 4). Measured water pH is 4.02 thus can be classified as **highly acidic** [2]. Water resistivity value is 117ohm which can be classified as **mildly corrosive** [11]. Table 2 shows laboratory test results on the peat physical properties. Water contents ( $w$ ) and specific gravity range from 637-931% and 1.25-1.81 respectively. Dry unit weights ( $\gamma_{dry}$ ) values lie between 1.06-1.54 kN/m<sup>3</sup>. Ash content values (predominantly less than 5%) reveal high organic content, thus can be classified as low ash content. Fibre content is

predominantly less than 33% thus mainly sapric (except hemic at 5m depth). This results in consistent with visual observation.



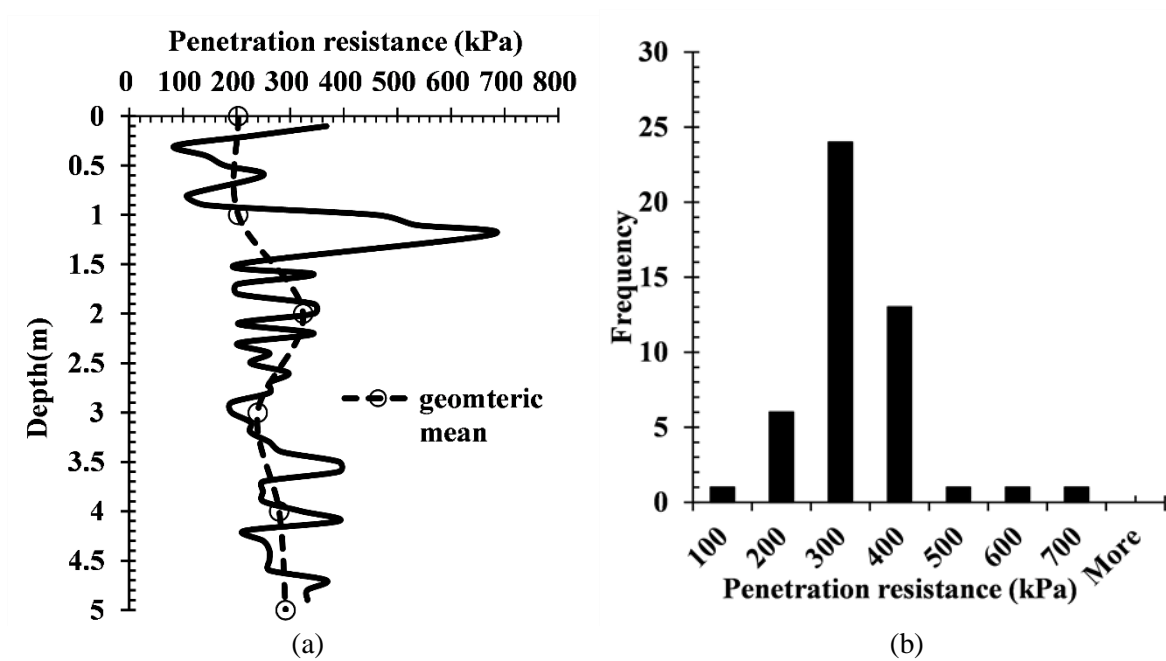
**Figure 4.** Peat sample.

**Table 1.** Laboratory Results.

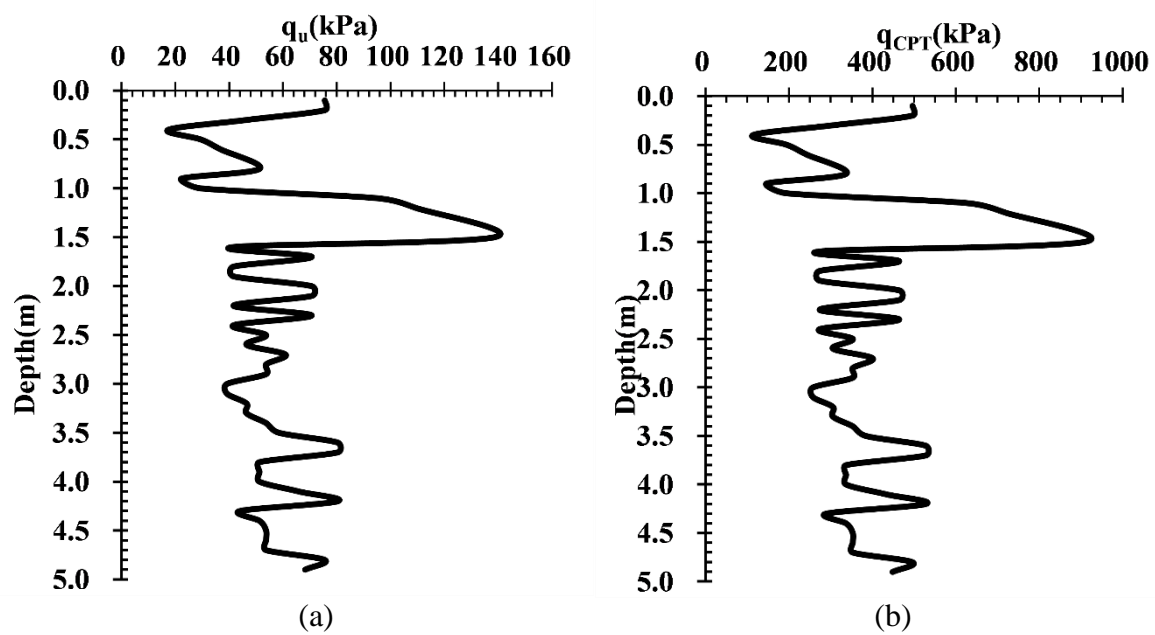
Depth	w (%)	$\gamma_d$ (kN/m <sup>3</sup> )	Gs	AC (%)	FC (%)
1.00 m	637.96	1.34	1.81	0.92	13.33
2.00 m	581.45	1.54	1.21	0.81	12.84
3.00 m	681.98	1.38	1.19	1.77	13.30
4.00 m	721.25	1.32	1.31	1.98	19.55
5.00 m	931.76	1.06	1.25	2.17	35.70

Figure 5a shows penetration resistance up to 5m depth. The penetration resistances range from 84-674 kPa with predominant value of 300 kPa (Figure 5b). kPa. Those values are within the typical value of CPT on peat which is less than 1000 kPa. It was thought that that peat penetration resistance is lower as the degree of decomposition higher. Unfortunately, there is only one data of hemic peat in this study (i.e. at 5m depth) thus it is difficult to draw any conclusion yet. Additional data and investigation are needed.

Figure 6a illustrates correlation between penetration resistance with unconfined (Figure 6a) compression test. The figure generally suggests **soft to medium consistency** [12]. Figure 6b presents equivalent to cone resistance of full CPT (Figure 6b) which gives equivalent full CPT resistance range from 114-910kPa.



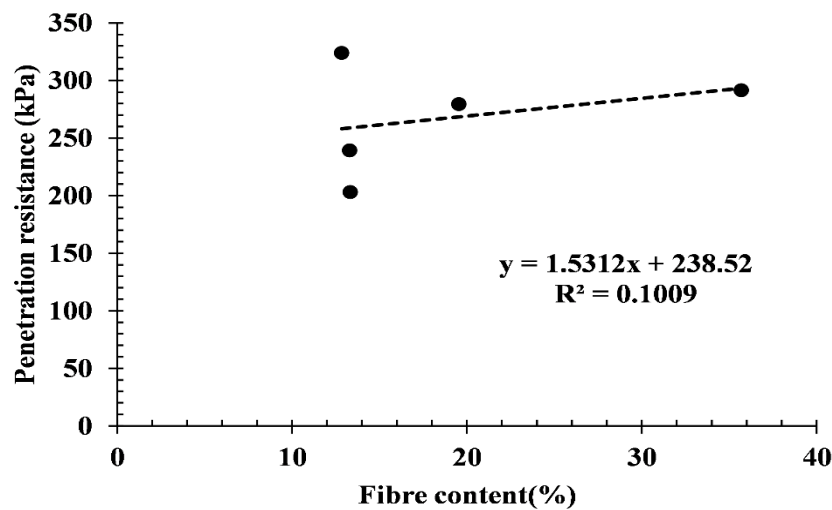
**Figure 5.** Penetration resistance (a) and its frequency distribution (b)



**Figure 6.** Estimated unconfined compression strength and full CPT resistance

Figure 7 shows fibre content and penetration resistance relationship. Although the coefficient of correlation  $r = \sqrt{R^2} = 0.31$  is low [13] the tendency is as expected i.e. higher fibre content result in higher penetration resistance. This trend should be investigated further by conducting more test.





**Figure 7.** Effect fibre content on penetration resistance

#### 4. Conclusions

Initial study on the application of hand cone penetration test on Bengkalis' peat has been conducted. Peat is mainly sapric with low ash content. Penetration resistances range from about 84-674 kPa with predominant value of 300 kPa. Estimated unconfined compression test indicated soft to medium consistency. There is tendency that higher fibre content may result in higher penetration resistance. Hand cone penetration could be peat characterization.

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