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"Geotechnical Solution in Indonesia to Respond the Challenge of Urban, Industry, Infrastructure and Mining Development"

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KATA PENGANTAR

Assalamulaikum Wr. Wb.

Para undangan, para pengurus Pusat dan Daerah Himpunan Ahli Teknik Tanah Indonesia, para pembicara dan peserta Pertemuan Ilmiah Tahunan HATTI yang kami hormati,

Pertemuan Ilmiah HATTI tahun ini mengambil tema **"Geotechnical Solution in Indonesia to Respond the Challenge of Urban, Industry, Infrastructure and Mining Development"**. Saat ini pemerintah dan swasta semakin giat melakukan investasi pada sektor konstruksi, baik untuk bangunan pekantoran, apartemen, MRT, pelabuhan, jalan bebas hambatan maupun infrastruktur untuk pertambangan. Hal ini berhubungan dengan program pemerintah dalam konteks percepatan pembangunan ekonomi Indonesia. Terobosan baru dalam menjawab masalah geoteknik berkembang semakin pesat dan menjadikan keterlibatan serta peran *Geotechnical Engineers* semakin penting.

Selain mengangkat topik seminar yang berkaitan dengan aspek geoteknik dan perkembangan riset serta teknologi terbaru sebagai pendukungnya, PIT XVII ini juga menggelar Workshop satu hari tentang GROUND IMPROVEMENT FOR DIFFICULT SUBSOIL CONDITIONS. Kegiatan seminar dan workshop ini diharapkan dapat memberi kesempatan kepada seluruh peserta untuk berbagi informasi dengan para praktisi konstruksi khususnya di bidang geoteknik.

Pada kesempatan ini, atas nama seluruh anggota panitia penyelenggara, kami mengucapkan terima kasih kepada *GEOHARBOUR GROUP* sebagai sponsor utama seminar dan workshop Pertemuan Ilmiah HATTI tahun 2013. Ucapan terimakasih juga kepada para pembicara, penulis makalah, para sponsor dan para peserta yang telah berpartisipasi untuk suksesnya PIT-XVII ini. Kami mohon maaf apabila dalam penyelenggaraan pertemuan ini ada kekurangan yang tidak berkenan.

Selamat berdiskusi dan semoga Pertemuan Ilmiah Tahunan ini dapat bermanfaat bagi perkembangan profesi Geoteknik di tanah air.

Wassalamualaikum Wr Wb,
Panitia PIT - XVII

Dr. Ir. Wiwik Rahayu, DEA
Ketua

SAMBUTAN KETUA UMUM

Assalamu'alaikum Wr. Wb.

Salam Sejahtera bagi kita semua.

Bapak Wakil Menteri, Bapak Dirjen, para undangan, para pembicara, dan saudara-saudara peserta Pertemuan Ilmiah Tahunan XVII HATTI yang saya hormati, atas nama Pengurus Pusat HATTI saya ucapkan terima kasih atas kedatangan Bapak/Ibu sekalian di acara ini, yang merupakan event tahunan HATTI. Secara khusus perkenankan saya menyampaikan terima kasih dan penghargaan yang setinggi-tingginya atas kesediaan Bapak Wakil Menteri Perhubungan dan PU meluangkan waktu untuk menghadiri Pertemuan Ilmiah Tahunan ini.

Hadirin yang saya hormati, dalam PIT kali ini diusung tema "Geotechnical Solution in Indonesia to Respond the Challenge of Urban, Industry Infrastructure and Mining Development". Tema ini diharapkan dapat mengantisipasi perkembangan yang makin pesat dan dibutuhkan pada sektor infrastruktur dan pertambangan di Indonesia. Bagaimanapun, perkembangan kedepan akan membawa kita pada kebutuhan pembangunan dengan konstruksi skala besar seperti jembatan dan terowongan. Untuk dapat mewujudkan ini, bagaimanapun tidak dapat dihindari suatu tahap yang kritis dimana masalah-masalah geoteknik harus diselesaikan terlebih dahulu. Para ahli geoteknik diharapkan dapat memberikan solusi yang terbaik. Dalam kerangka inilah para ahli geoteknik dituntut untuk secara terus menerus dapat meningkatkan kompetensinya agar dapat mengikuti perkembangan dan kebutuhan di lapangan.

Para anggota HATTI yang saya cintai, perkenankan saya untuk mengingatkan kembali bahwa tahun 2015 tidak terasa semakin mendekat, dimana akan dimulai pasar bebas ASEAN. Mulai tahun tersebut, pekerjaan jasa konstruksi termasuk geoteknik akan dipasarkan secara bebas di seluruh negara-negara ASEAN, artinya setiap orang atau badan usaha akan memiliki kesempatan yang sama untuk memperebutkan lapangan pekerjaan geoteknik di negara-negara ASEAN termasuk di Indonesia.

Para anggota HATTI yang saya cintai, sungguh akan sangat ironis apabila pekerjaan geoteknik di Indonesia justru dikerjakan oleh orang-orang bukan Indonesia. Adalah menjadi tanggung jawab kita semua untuk mempertahankan eksistensi profesi geoteknik di Indonesia sehingga mampu menjadi tuan rumah di negeri sendiri dan bukannya tamu di negeri sendiri. Oleh karena itu marilah kita persiapkan diri kita masing-masing dalam menghadapi pasar bebas ASEAN 2015 nanti.

Sebagai penutup, saya ucapkan banyak terima kasih atas kehadiran Bapak/Ibu semua, khususnya saya tujukan pada sponsor utama kali ini, GEOHARBOUR, dan sponsor-sponsor lainnya yang telah turut berpartisipasi sehingga PIT ini dapat berlangsung dan berakhir dengan sukses dari mulai hari ini sampai besok. Selamat mengikuti PIT.

Wassalamu'alaikum Wr. Wb.
Jakarta, 13 November 2013

Prof. Ir. Masyhur Irsyam, MSE., Ph.D
Ketua Umum

Other Session :

Session II :

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Shear Strength and Long Term Compressibility of Tropical Peat

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ABSTRACT : Almost 1.5 million hectare (20.60 %) of South Sumatra is covered by peat overlaying soft cohesive soil. Thus, the knowledge on the compression behavior of peat soil is essential for the design of infrastructures in the area. This paper discusses the shear strength and long term compression behavior of peat. The shear strength is assessed by field vane shear test and laboratory direct shear test while the long term compression behavior is analyzed based on data obtained from consolidation test performed in Rowe cell with excess pore water pressure measurement. Study shows that the peat has very low shear strength indicated by low cohesion while the high internal friction angle was derived from the fiber content. Furthermore, the results indicate that the peat has a significant secondary compression stage which is not constant with the logarithmic of time. The secondary compression started as early as 65 % degree of primary consolidation. The consolidation test with pore water pressure measurement using Rowe cell enables the observation of the large deformation and better assessment of the long term compression behavior of fibrous peat.

Keywords: *peat, shear strength, compression behavior, pore-water pressure measurement*

ABSTRAK : Hampir 1.5 juta hektar (20.60%) luas propinsi Sumatra Selatan ditutupi oleh tanah gambut di atas tanah lempung lunak. Oleh karena itu pengetahuan mengenai sifat kompresibilitas tanah gambut sangat penting bagi perencanaan infrastruktur di daerah ini. Artikel ini membahas kekuatan geser dan kompresibilitas tanah gambut. Kekuatan geser diukur dengan uji geser baling di lapangan dan uji geser langsung di laboratorium, sedangkan kompresibilitas dianalisis berdasarkan hasil pengujian konsolidasi menggunakan sel Rowe dengan pengukuran tekanan pori. Hasil studi menunjukkan bahwa tanah mempunyai kekuatan geser berupa kohesi yang sangat rendah dan sudut geser dalam yang cukup tingi yang disebabkan oleh serat sehingga tidak dapat diperhitungkan. Kajian juga menunjukkan bahwa tanah gambut jenis ini mempunyai sifat rangkak yang dominan dan tidak linier terhadap waktu. Penyusutan akibat rangkak dimulai seawal 65 % derajat konsolidasi primer. Pengujian dengan menggunakan alat konsolidasi Rowe dengan pengukuran tekanan air pori sangat berguna karena memudahkan dalam memprediksi sifat kompresibilitas tanah gambut dalam jangka waktu lama.

Kata Kunci : *gambut, kuat geser, sifat kompresibilitas, pengukuran tekanan pori*

1. INTRODUCTION

Peat is considered as problematic soils due to low strength characteristics, large deformation, high compressibility, and high magnitude and rates of creep. Moreover, there is some difficulty in accessing the sites with peat deposit because water table can be at, near or even above ground surface.

The poor characteristics cause construction on peat subjected to problems of instability such as local sinking and development of slip failure, as well as very large primary and long term settlement under an even moderate increase in load. In addition, bearing capacity is affected by the high water table and the presence of woody debris in the soil. The soft water logged soil and peat takes a long time to settle when loaded due to embankment or soil fill. Under this condition, the embankment will settle continually into the ground below, even if the soils do not fail by displacement.

This paper presents the results of the study on engineering characteristics of peat in terms of the shear strength and long term compressibility behavior.

2. METHODOLOGY

Undisturbed samples for this study were obtained by block sampling method. The samples were retrieved from a shallow depth by digging up the soil to a depth of 1 m and then a tube of 200 mm diameter and height of 200 mm was pushed into the soil and the soil was cut at the base. The quality of samples was maintained by ensuring the sharpness of the tube and knife used to cut the sample. Field vane test was performed for the assessment of in-situ undrained shear strength of the peat.

Physical and chemical properties such as natural moisture content, specific gravity, initial void ratio, unit weight, and acidity were determined to establish the basic characteristics of the soil. The soil was classified based on von Post degree of humification, fiber content, organic content, and ash content. All tests were performed in accordance with the British (BS) and U.S. (ASTM) Standards.

Twelve sets of shear strength test containing three soil samples were tested using Direct shear apparatus. The samples are 60 mm diameter and 20 mm high. Each set contains three samples was subjected to normal load of 8 kPa, 16 kPa and 32 kPa respectively. The test was performed according to BS 1377: Part 7: Shear strength tests (total stress).

Large strain consolidation tests were performed using Rowe consolidation cell (Figure 2) with internal diameter of 151.4 mm and height of 50 mm. Each sample was subjected to large strain consolidation pressures of 25, 50, 100, and 200 kPa or load increment ratios (LIR) of one. Drainage was allowed at the top and bottom plates, while pore-water pressure was measured at the center of the base. The tests were performed according to the procedure suggested by Head (1982).

The time-compression and excess pore water pressure curves derived from Rowe consolidation test were analyzed using method proposed by Robinson (2003) in order to develop the compression-degree of consolidation curve to identify the beginning of secondary consolidation (t_p). The primary consolidation and secondary compression were separated in order to assess the coefficient of consolidation (c_v) and secondary compression index m as proposed by Robinson (2003).

Besides the time-compression curve, a graph relating the void ratio at the end of each loading stage with the effective pressure on logarithmic scale (e-$log\ p'$) was plotted for a complete set of consolidation test data. In this case, the curve was plotted for primary consolidation only whereby the void ratio is corrected by eliminating the creep occurred after the completion of primary consolidation. The curve was used to obtain compression index, cc and pre-consolidation pressure (σ'_c). The effect of initial compression was minimized during the preparation of the test specimen and the consolidation test by Rowe cell.

3. RESULTS AND DISCUSSION

3.1. Peat Classification

Visual identification indicates that the peat is dark brown, very soft, and laboratory test shows that the peat contains a large amount of fiber (90%). Thus, according to ASTM 4427, the peat is classified as fibrous with degree of decomposition (von Post scale) H_4. The texture is coarse which results in high initial permeability. The peat is acidic with pH = 3.2. The natural water content is 608 % while the initial void ratio is 9 which yields in high compression index. Specific gravity is 1.47 which is very low.

3.2. Shear Strength of Peat

Shear strength is considered as one of the most important parameters in engineering design and decision when dealing with soil as foundation material. Peat usually has very low shear strength and the determination of shear strength is difficult due to some factors such as the origin of the soil, moisture content, organic matters and also on the degree of humification. During the sampling stage, the sample disturbance will also affect the evaluation of shear strength of peat. In general, shallow peat is more likely to have greater strength than more humified peat at depth (Culloch, 2006).

Mostly, peat is considered as frictional or non-cohesive material due to the fiber content and the spatial orientation of the fibers. However, the high friction angle of peat will not actually reflect high shear strength due to the fact that the fiber's are not always solid and may be filled with water and gas. The presence of fibers will modify the strength behavior of peat since the fibers can be considered as reinforcement and the fibers can provide effective stress where there is none and it induces anisotropy.

The determination of undrained shear strength of peat is important because of the presence of peat is always below the groundwater level. Thus, in-situ test such as field vane shear and cone penetration test are very useful to evaluate the shear strength of peat. The undrained shear strength of peat (c_u) obtained from field vane shear test on the peat used in this study is 10 kPa with sensitivity of 9. The high sensitivity value shows a tendency of decreasing shear strength upon remolding.

Sampling of peat is very difficult due to the nature of peat, thus laboratory testing can only give indicative results (Culloch, 2006). The most common laboratory test is usually aimed at determining the drain shear strength by direct shear test. Result obtained from the direct shear test on twelve sets of sample is shown in Figure 1. The mean values indicate the average cohesion is 6.4 kPa while the internal friction is 22°.

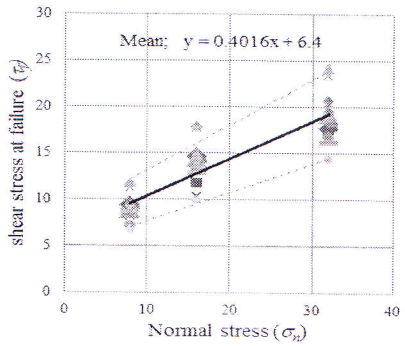

Figure 1. Results of Direct Shear Test

3.3. Long Term Compression Behavior

In general, the compressibility of a soil consists of three stages, namely initial compression, primary consolidation, and secondary compression. While initial compression occurs instantaneously after the application of load, the primary consolidation and secondary compression are time dependent. The initial compression is due to the compression of small pockets of gas within the pore spaces and the elastic compression of soil grains. The one-dimensional theory of consolidation developed by Terzaghi in 1925 carries an assumption that primary consolidation is due to dissipation of excess pore water pressure caused by an increase in effective stress whereas secondary compression takes place under a constant effective stress at a slower rate after the completion of the primary consolidation. Thus the time-compression curve derived from consolidation test follows the Type 1 ("S") curve as shown in Figure 2.

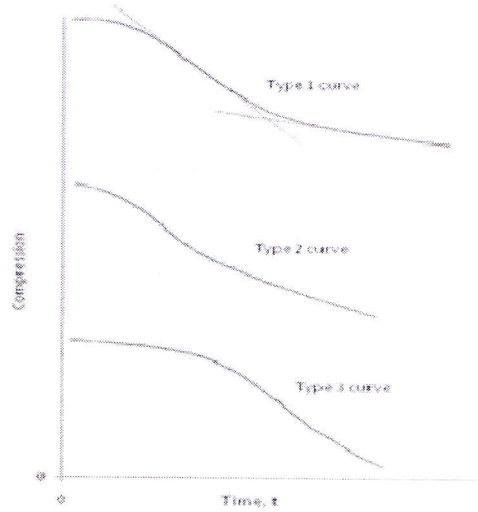

Figure 2: Types of Compression Versus Logarithmic of Time Curve Derived from Consolidation Test (Leonards And Girault, 1961)

The compression behavior of peat is different from that of clay soil. It occurs in three stages: primary consolidation, secondary and tertiary compression. The secondary compression occurs due not only to the compression of particles, but also the plastic yielding of solid material (Samson and La Rochelle, 1972). Some researchers including

Fox and Edil (1994) argued that the tertiary compression can be neglected because it generally started after the design life of structures.

The time-compression curves derived from results of one-dimensional consolidation test on peat usually resemble the Type 2 curve (Figure 2) in which the primary consolidation is very rapid and secondary compression does not vary linearly with logarithmic of time. Therefore the quantification of secondary compression based on conventional compression–logarithmic of time method proposed by Cassagrande (1936) which was later extended by Dhowian and Edil (1980) frequently under-estimates the settlement.

In some cases, the time compression curve of peat follows Type 3 curve (Figure 2) where no inflection point was identified, thus the end of primary consolidation (t_p) cannot be predicted by Cassagrande method.

Robinson (1999) pointed out that the end of primary consolidation is actually the time when full dissipation of excess pore water pressure is achieved; thus, measurement of excess pore water pressure during consolidation test is required. His observation showed that the excess pore water pressure dissipation is completed earlier than the time predicted from the inflection point of the settlement curve. Further analysis by Robinson (2003) supported the argument made by previous researchers that the secondary compression of some soils actually starts during the dissipation of excess pore water pressure from the soil.

Terzaghi's one dimensional consolidation theory stated that the compression during primary consolidation is linearly correlated with the dissipation of excess pore water pressure. Conversely, the actual curve derived from laboratory consolidation test on peat soil was not actually follows a straight line because the settlement was actually due to the combination of excess pore water pressure dissipation on primary consolidation and creep or secondary compression. A method for separating the primary consolidation and secondary compression that occur during the consolidation process based on time-compression and the time-excess pore water pressure curves was proposed by Robinson (2003).

If the primary consolidation and secondary compression were separated in the time-compression curve, the e-log p' curve can be constructed for primary consolidation only (Fox, 2003). The curve is required for the determination of compression index (c_c) and pre-consolidation pressure (σ'_c) of the soil.

The typical time-compression curve obtained from consolidation test on soil used in this study is shown in Figure 3. The shape of the compression curve resembles the Type 2 curve (Figure 2) which is typical of compression of peat soil. The shape of the time-compression curve indicates that the deformation process of the peat deviates from the simple model used in Terzaghi's consolidation equation, which is the basis for the Cassagrande and Taylor's evaluations of primary consolidation and the estimation of the coefficient of consolidation.

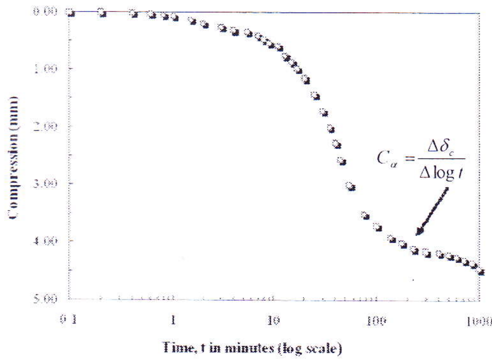

Figure 3 Typical Time Compression Curve from Consolidation Test

The curve indicates that the primary consolidation is dominant in term of magnitude and the rate is high. The secondary compression occurred at a slower rate and is non-linear with logarithmic of time. This part of the compression, even though less significant than the primary consolidation in term of magnitude, could be very important in term of the design life of a structure. The secondary compression may have started during the process of excess pore water pressure dissipation.

Method suggested by Robinson is used in evaluating the time compression curve in Figure 3. The procedure is as follows:

1. Plot the compression versus log time (in minutes)
2. Plot the degree of consolidation U % vs log time, the time where at U reach 100% is the end of primary consolidation (t_{100})
3. Plot the compression versus degree of consolidation.
4. Draw a curve and a straight line through the points. The point where the curve deviates from linearity is identified as degree of consolidation where secondary compression begin (U_p)
5. Separate the primary consolidation curve from the secondary compression
6. Evaluate c_v and c_c based on primary consolidation curve only (Figure 4)
7. Evaluate δ_α based on secondary compression curve which start at t_p (Here the secondary compression curve is drawn on linear or log scale in both axes.

The results of the analysis of time compression curve are presented in Table 1. The results indicate that cv decreases with increasing consolidation pressure. This finding is in agreement with the theory of consolidation, which stated that the coefficient of rate of consolidation decreases with increasing consolidation pressure (Leonards and Girault, 1961). As shown in Figure 3, the secondary compression index c_α is not constant. However, the curve can be linearized by plotting both δ_s and time in linear scale as suggested by Robinson (2003). The linear form enables the determination of m value which increases with increasing consolidation pressure.

Table 1. Compression Characteristics Obtained from Robinson Procedure

p' (kPa)	t_{100} (min)	t_p (min)	U (%)	c_v (m^2/year)	$m = \Delta\delta_s/\Delta t$
25	27.67	19.83	61.67	5.689	0.0109
50	25.83	17.67	65.00	4.947	0.0124
100	23.50	15.83	69.00	4.179	0.0157
200	23.00	14.33	70.50	3.259	0.0211

Figure 4 shows that the compression index (cc) for primary consolidation is 3.15 which slightly lower than the slope evaluated based on total settlement i.e 5.0.

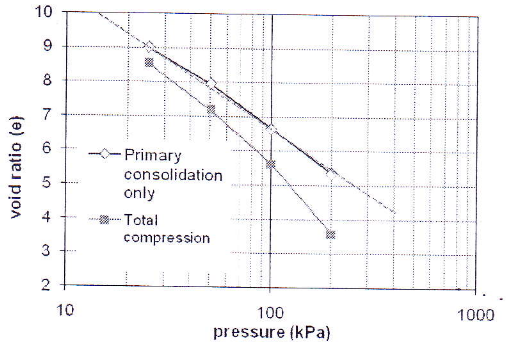

Figure 4: Typical e-Log P' Curve for Determination of Compression Index

4. CONCLUSIONS

The peat used in this study is of fibrous type. The undrained shear strength obtained from field vane test is 10 kPa, while drained shear strength measured by direct shear test is c = 6.4 kPa and $\phi' = 22^o$. It should be noted that the high internal friction angle was derived from fiber content and not reliable. Evaluation of time settlement curve by Robinson (2003) method indicates that the secondary compression started as early as 65 % degree of consolidation. The beginning of secondary compression (t_p) is 18 minutes while the completion of primary consolidation (t_{100}) is 26 minutes. The primary compression parameters c_c = 3.5 while the coefficient of rate of consolidation (c_v) obtained ranges from 5.69 to 3.26 for a range of pressure from 25 to 200 kPa. The secondary compression index m increases from 0.0102 to 0.0304 for consolidation pressure of 25 to 200 kPa. Consolidation test with pore water pressure measurement is very useful for the evaluation of compression behavior of peat. The separation of primary and secondary consolidations is very important for the evaluation of long term compressibility behavior of peat because the conventional evaluation of settlement based on the time-compression curve may result in over-prediction of primary consolidation and under-prediction of secondary consolidation.

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