International Journal of Integrated Engineering: Special Issue 2018:
Innovations in Civil Engineering, Vol. 10 No. 9 (2018) p. 48-52
© Penerbit UTHM
DOI: https://doi.org/10.30880/ijie.2018.10.09.009

Influence of Damping Ratio and Dynamic Shear Modulus for Different Locations of Peat

Siti Nurul Aini Zolkefle[1], Adnan Zainorabidin[1*], Syuhada Fatim Harun[1], Habib Musa Mohamad[1]

[1]Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia.

Received 22 April 2018; accepted 29 December 2018, available online 31 December 2018

Abstract: In recent years, geologist and soil scientist have increasingly sought out organic soil, including peat in tropical regions to study their characteristics and agricultural potential for new development area. However, few studies had been made to analyse the consequences of cyclic loading onto peat. The aim of this study is to determine and analyse the behaviour of dynamic parameters on different locations of peat using cyclic triaxial test. Sample preparations and testing methods on analysing the dynamic parameters are briefly explained. Results on Index Properties test and Cyclic Triaxial test are presented for all peat locations. It has been concluded that the behaviour of damping ratio, D and dynamic shear modulus, G in PNpt, POpt and SBpt are influenced by the basic physical and chemical properties like moisture content, organic content and fibre content which affected by its site condition and environmental growth. The percentage of fibres and its sizes that contained in each peat samples also could be the major causes pertaining to the Malaysia's peat dynamic parameters behaviour.

Keywords: Damping Ratio, Cyclic Shear Modulus, Peat, Cyclic Triaxial, Dynamic Loading

1. Introduction

In recent years, geologist and soil scientist have increasingly sought out organic soil, including peat in tropical regions to study their characteristics and agricultural potential for new development area. However, few studies had been made to analyse the consequences of cyclic loading onto peat [1]. Cyclic loading or so-called as the dynamic loading exemplify as loading conditions which vary both in its magnitude and frequency. These loadings sources are depending on the nature of the source producing it, for example, an earthquake, blasting, pile driving, construction operations, traffic and wheel loads, wind or the tidal actions of water [2-3]. Therefore, it is essential to deeply understand the knowledge of dynamic loading on peat and its behaviour, particularly on the parameters of damping ratio, D and cyclic shear modulus, G [4].

Peat contains an organic residue formed through the decomposition of plant and animal constituents under an aerobic and anaerobic condition with basically no measurable strength [5]. According to Kazemian et al. [6], peat would have a very high percentage of organic content which is made of carbon and usually occurs in the area of wetland condition. Moreover, Kalantari & Prasad [7] also indicated that peat in Malaysia was found in the coastal areas of the east and west coasts. As the matter of fact, the shape of particles for peat in Malaysia has been often elongated and irregular, rather than the ideal round bog shape [7]. Due to the process of peat formation, properties of peat would indicate remarkable anisotropy as different plants are mixed in both the horizontal and vertical direction [8]. Besides, peat also has been said as a homogeneous appearance according to Noto [8] but displays very complicated and diverse properties depending on the organic matter and the process of formation. Therefore, the characteristics of this natural peat would altered the properties of dynamic loads including damping ratio and cyclic shear modulus in this research.

Based on previous literature, there was approximately 124,000 ha of peat areas in the state of Johor [9]. Prior researchers have been investigated on the road construction in Muar, Batu Pahat and Pontian and stated that the improvements for road on peat are quite challenging for engineers [10]. This is happening because of peat in Pontian had a highly non-uniform settlement and low shear strength which had undergone a surcharge of vertical drainage [10]. The consequences of these loadings were effected by the behaviour of peat underneath this road.

Due to that, the aim of the study is to investigate and analyse the behaviour of dynamic parameters on different locations of peat by using the cyclic triaxial test.

*Corresponding author: adnanz@uthm.edu.my

2. Sample Preparations and Testing Method

This research focused on peat samples from Parit Nipah (PNpt), Pontian (POpt), Johor and Beaufort (SBpt), Sabah. The undisturbed peat samples are collected by using PVC tube sampler sized 50mm diameter and 100mm height at a depth of 0.3 metres from the top soil. The end of the tube samplers was edged to ensure that the features of the samples were protected and maintained before testing. During laboratory testing, great care has been taken on sample preparations. The procedure of samples preparations was done as fast as possible to reduce any disturbance of moisture and structures.

Fig. 1 illustrated a sample arrangement for the cyclic triaxial test. The procedure was checked based on the standard and has been found to be satisfactory. The machine used for the cyclic triaxial test is called the Enterprise Level Dynamic Triaxial Testing System (ELDYN) manufactured by GDS Instruments. The performance specification of the test corresponds to the requirements of ASTM Designation D3999-91, "Standard Test Methods for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus". This machine is available for testing at high speed direct cyclic with control from the axial load, constant cell and back pressure. The main components of this ELDYN machine are the dynamic axial force or displacement controller, a back pressure controller and a radial pressure controller.

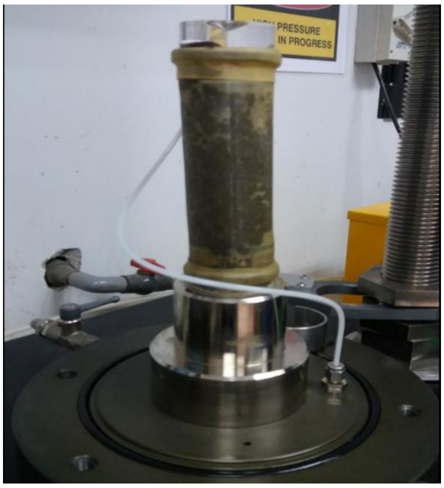

Fig. 1 Sample Setup for Cyclic Triaxial Test

A sample was firstly saturated by the increments of 50kPa to ensure that the sample is fully saturated with no pore entrapped. Then, the sample was consolidated to 24 hours consolidation at the effective stress of 100kPa according to the standard. The cyclic stage starts by applying an axial load to at least half of its maximum deviator stress in order to limit the amplitude. Then, the sample was dynamically loaded up to 100 number of cycles and specifically used only one-way loading with a stress-controlled condition at 1Hz loading frequency.
Results are collected by using GDSLAB Software and Microsoft Excel. A representative data of cyclic deviator stress (kPa) versus cyclic axial strain (%) for PNpt was developed as illustrated in Fig. 2. Meanwhile, Fig. 3 explained the analysis of a cycle for dynamic parameters in this research. Basic calculations for the dynamic test in cyclic triaxial have been used in this study. The cycles of 1 to 100 by the intervals of 10 are proposed and calculated in this research. The equations are as follows:

$$E = \frac{\Delta\sigma_d}{\Delta\varepsilon_a} \quad (1)$$

$$G = \frac{E}{2\,(1+\mu)} \quad (2)$$

$$D = \frac{1}{4\pi}\left(\frac{Loop\ Area}{Area\ of\ AOB}\right) \quad (3)$$

Where $\Delta\sigma_d$ is the differences of cyclic deviator stress and $\Delta\varepsilon_a$ is the differences of cyclic axial strain. Poisson's ratio, μ of 0.4 was used in all calculations of G. Each cycle is calculated by using the Auto Computer Aided Design (AutoCAD) Software to calculate the area as well as to obtain the parameters of G and D.

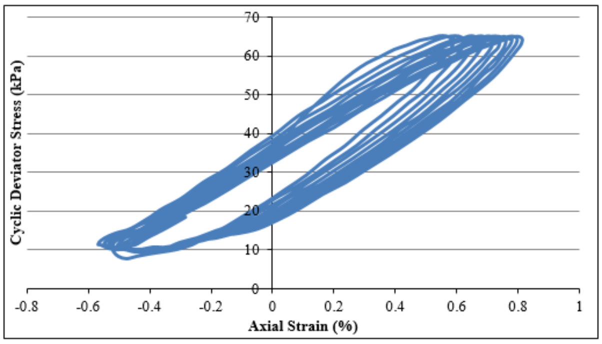

Fig. 2 Hysteresis Loop Results from Cyclic Triaxial Test

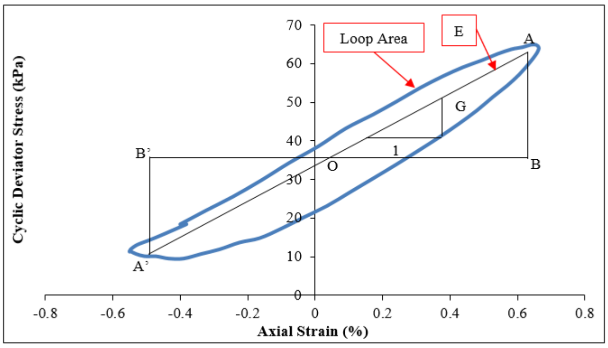

Fig. 3 Hysteresis Loop of the Third Cycle

Loop area shown in Fig. 3 was calculated by using the AutoCAD. The young modulus, E was calculated by using the triangle shown in Fig. 3 which defines as the differences of cyclic deviator stress and axial strain.

3. Results and Discussion

The first step in evaluating the potential ground failure in organic and peat soils during cyclic loading is to determine the characteristic behaviours of the soil [11]. The natural characteristics of peat in this study are implemented in the index properties test which includes the degree of humification test, moisture content test, organic content test and fibre content test. Research results are divided into two categories; Index Properties Test results and Cyclic Triaxial Test Results.

3.1 Index Properties Test Results

The results of index properties test for PNpt, POpt and SBpt are shown in Table 1. The level of decomposition of peat is classified according to the degree of humification which is known as the Von Post Scale. The degree of humification test is done based on the appearance of soil water that is extruded when a sample of soil is squeezed in the hand.

Table 1 Index Properties of Peat

Parameters	PNpt	POpt	SBpt	References
Moisture Content (%)	710.44	898.91	491.16	BS 1377: Part 2: 1990: 3.2
Organic Content %)	78.77	76.55	55.82	BS 1377: Part 3: 1990: 4
Fibre Content (%)	40.97	43.65	66.0	ASTM D1997-91 (2001)
Degree of Humification	H6 (Hemic)	H5 (Hemic)	H4 (Hemic)	Von Post Scale

In this study, PNpt, POpt and SBpt are classified as Hemic peat at the degree of H6, H5 and H4 respectively. Loss on ignition test has been conducted on the disturbed samples to obtain the organic content by maintaining the temperature of 440^{o}C until constant mass achieved. Meanwhile, the moisture content tests are done in the oven of 105^{o}C for 24 hours. The fibre content tests are conducted for determining the fibre contained in peat samples by dry mass. Based on the table, Sabah and Johor peats demonstrate a great distance of index properties results even though the level of decompositions are in the same grade. SBpt indicates low moisture content and organic content but high in fibre content compared to both POpt and PNpt.

The utmost reasons of this behaviours are the fibre elements that contained in each sample could be varied based on its sizes and quantities which may influence the basic characteristics of peat. Site condition and temperature changes during the peat sampling in each location also altered the results of index properties test in this research. Pontian site sampling area was surrounded by palm oil trees and some bushes. Meanwhile, Parit Nipah peat area was experienced the agricultural activities for the past 5 years. These consequences would affect the characteristics of peat in each location. Therefore, the properties of peat are significantly varied based on this condition.

3.2 Cyclic Triaxial Test Results

Dynamic parameters of soil particularly damping ratio, D and shear modulus, G plays an important role towards the exclusive behaviour of soil and the crucial design method. In this study, the results of D and G of peat in Parit Nipah, Pontian and Beaufort are compared in order to analysed its characteristic behaviours.

Based on previous literature, D would behave increasingly with the increased of shear strains and G would decrease when the shear strains increased [12][13]. Fig. 5 and Fig. 6 show the results of D and G behaviours for PNpt, POpt and SBpt in this research study.

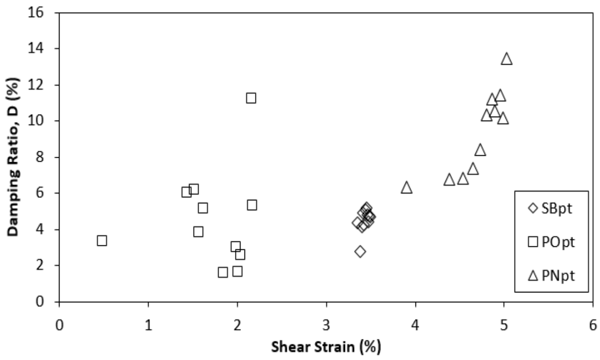

Fig. 5 Relationships between Damping Ratio and Shear Strain for PNpt, POpt and SBpt.

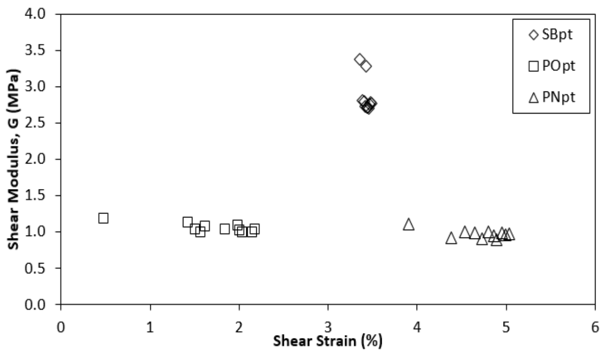

Fig. 6 Relationships between Shear Modulus and Shear Strain for PNpt, POpt and SBpt.

Scattered results are presents all around in less than 14% in Fig. 5. Locusly, the outcomes pointed out that SBpt indicated 2% to 6% of D at 3% to 4% of shear strain. Meanwhile, the D of POpt and PNpt lies between 1% and 12% and 6% and 14%, respectively. On the other hand, Fig. 6 shows that both G for PNpt and POpt are in the same pattern and almost at the same range but in different shear strain level. PNpt and POpt are both resulted in the range of 0.5 MPa to 1.5 MPa. Meanwhile, SBpt pointed distinctive results which are in the range of 2.5 MPa to 3.5 MPa at the shear strain approximately between 3% and 4%.

To be exact, Fig. 7 and Fig. 8 are the enlargement graph for both D and G for SBpt, respectively. Parameters of D are resulted in increasingly and a vice versa for the parameters of G.

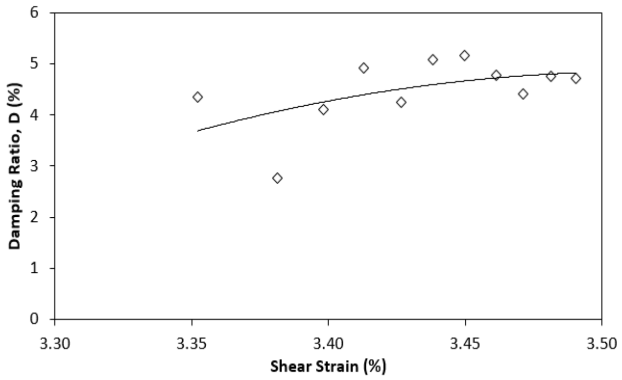

Fig. 7 Results of Damping Ratio for SBpt

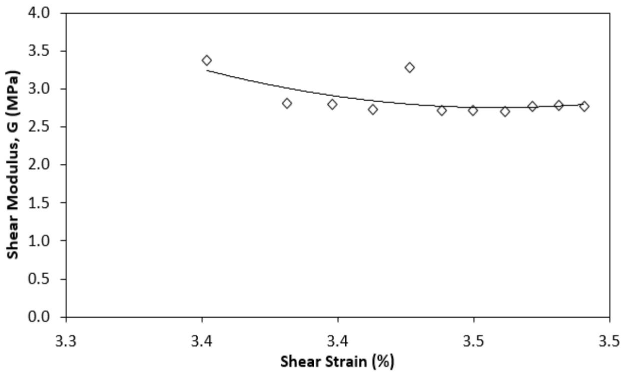

Fig. 8 Results of Shear Modulus for SBpt

Damping ratio and cyclic shear modulus of Johor and Sabah peat indicated insignificantly different behaviours. However, both peat locations show the same pattern of dynamic loading parameters. The differences of behaviours for both peat locations may due to the natural characteristics of that particular soil. In this study, the index properties results for both Johor and Sabah peats show distinctive results. Percentage of moisture content, organic content and mostly the fibre content in each peat sample would affect the behaviour of dynamic loading parameters in this study.

Comparisons have been done at the end of this study with past researchers Kishida et al. [12] and Boulanger et al. [13]. Results are shown in Fig. 9 and Fig. 10.

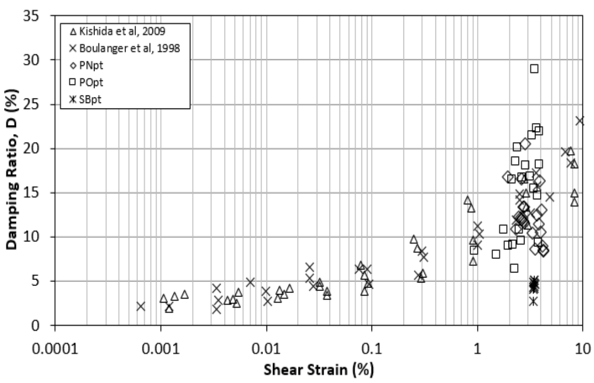

Fig. 9 Correlations of Damping Ratio versus Shear Strain

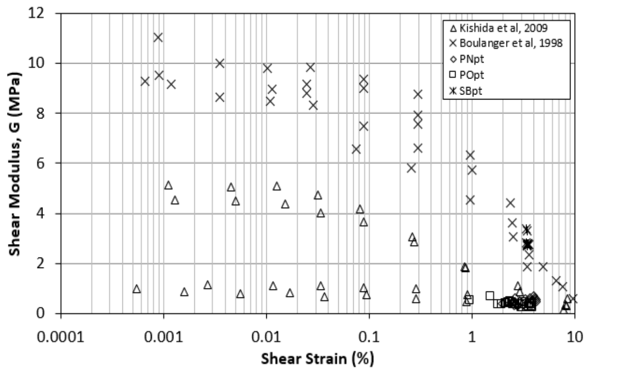

Fig. 10 Correlations of Shear Modulus versus Shear Strain

PNpt, POpt and SBpt indicated the same range as past researchers with minimum differents. Results are also pointed a high strain compared to past researchers.

This is proved that Johor and Sabah peats behaved dynamically unique in the cyclic triaxial test. Numerous reasons can be pointed in this study as per behaviour of this peat such as the morphology characteristics which influenced by its basic physical and chemical properties like the moisture content, organic content and fibre content in this study. It happened may be due to the fields area and environmental growth since Parit Nipah, Pontian and Beaufort peats are located in the coastal area of Malaysia. The morphology of peats in different areas controls the structural arrangements, fibres, moistures and pore structures of each sample. Thus, provide varied behaviour in D and G. Meanwhile, the percentage of fibres and its sizes that contained in peat samples also dominates the results of both D and G in this study.

4. Conclusions and Recommendations

Peat originates from decomposed soil and vegetation. The composition and morphology of peat are crucial to understands and interpret physically especially in its engineering properties. Based on the laboratory testing, it has been proved that the peat in Malaysia would have varied textures based on their decomposition level. After analysing the results, conclusions have been made in this research study.

The index properties test shows distinctive results for each peat location. Moisture content test, fibre content test and organic content test pointed different ranges even it was in the same group of von post scale. The utmost reasons of this behaviours are the fibre elements that contained in each sample could be varied based on its sizes and quantities which may influence the basic characteristics of peat. Site condition and temperature changes during the peat sampling in each location also altered the results of index properties test in this research.

On the other hand, scattered results presented in D for all peat in less than 14%. Meanwhile, SBpt indicates higher results in G compared to PNpt and POpt at the same shear strain level. All peats resulted increasingly in D and decreasing in G as the percentage of shear strain increased respectively. However, the behaviours pattern show insignificantly different. The differences of behaviours for both peat locations may due to the natural characteristics of that particular soil. In this study, the index properties results for both Johor and Sabah peats show distinctive results. Percentage of moisture content, organic content and mostly the fibre content in each peat sample would affect the behaviour of dynamic loading parameters in this study.

Comparison of D and G with past literatures has been made in this study. PNpt, POpt and SBpt indicate the same range as past researchers with minimum differents. Results also pointed a high strain compared to past researchers. It can be concluded that basic physical and chemical properties like moistures, organic and fibre content influence the results of D and G which may affected by its fields area and environmental growth. The structure arrangements which also altered the behaviours of dynamic parameters D and G. Meanwhile, the percentage of fibres and its sizes that contained in peat samples also dominates the results of both D and G in this study.

Further research study on D and G should be done in order to magnify the influences of these parameters reflected to the natural characteristics of peat. The results could be varied depends on its degree of humification and properties behaviours. The main structural element of peat such as its fibres probably is the major consequential to these dynamic loading parameters. Fundamental study is needed to deeply highlight this problem.

Acknowledgement

The writers acknowledge the following contributions and supports by Universiti Tun Hussein Onn Malaysia to the work reported herein: Research Centre for Soft Soil (RECESS), UTHM, Research on Peat Station (REPEATS) and Malaysian Higher Education (MYBRAIN15) in finishing the laboratory testing.

References

[1] Zolkefle, S.N.A., Zainorabidin, A. and Saedon, S. An overview of the cyclic behaviour of peat soil. *Soft Soil Engineering International Conference, Sarawak*, (2013).

[2] Saran, S. *Soil Dynamics and Machine Foundations*. New Delhi Suneel Galgotia for Galgotia Publications (P) Ltd. (1999).

[3] Zainorabidin, A. *Static and Dynamic Characteristics of Peat with Macro and Micro Structure Perspective.* University of East London: PhD Thesis. (2011).

[4] Ansal, A.M. and Erken, A. Undrained behaviour of clay under cyclic shear stresses. *ASCE Journal of Geotechnical Engineering*, (1989). Volume 115 (No.7), 968-983

[5] Zainorabidin, A., and Wijeyesekera, D.C. Geotechnical challenges with Malaysia peat. advance in computing and technology conference, University of East London, Crowne Plaza Hotel, Docklands, London. *2nd Annual Conference.* (2007).

[6] Kazemian, S., Huat, B.K., Prasad, A. and Barghchi, M. A State of the art review of peat: geotechnical engineering perspective. *International Journal of the Physical Sciences*, Volume 6 (No.8), (2011). pp. 1974-1981

[7] Kalantari, B. and Prasad, A. A study of the effect of various curing techniques on the strength of stabilized peat. Retrieved November 11, (2014), doi:http://dx.doi.org/10.1016/j.trgeo.2014.06.002

[8] Noto, S. *Peat Engineering Handbook*. Japan. The civil engineering research institute of Hokkaido development bureau, (1991).

[9] Hassan, A. Extent of peatlands and 'c' contents of soils in peninsular Malaysia. *Workshop on Vulnerability of Carbon Pools of Tropical Peatlands in Asia*. Pekan Riau, Sumatra, Indonesia. (2006).

[10] Talib, Z.A. and Chan, C.M. Laboratory-based remedial study of a road embankment on peat soil. *Geotropika Conference*. Malaysia, (2009).

[11] Boulanger, R.W. and Idriss, I.M. Evaluation of cyclic softening in silts and clays. *Journal of Geotechnical and Geoenvironmental Engineering*, Volume 133 (No. 6), (2007), pp 641-652

[12] Kishida, T. Wehling, T.M. Boulanger, R.W. Driller, M.W. and Stokoe II, K.H. Dynamic properties of highly organic soils from Montezuma Slough and Clifton court. *Journal of Geotechnical and Geoenvironmental Engineering*. Volume 135 (No. 4), (2009), pp 525-532

[13] Boulanger, R.W. Arulnathan, R. Leslie, F.H.J. Torres, R.A. and Driller, M.W. Dynamic properties of Sherman island peat. *Journal of Geotechnical and Geoenvironmental Engineering.* Volume 124 (No.1), (1998), pp 12-20.