STUDY ON THE POSSIBILITY OF USING OTHER METHOD THAN SEDIMENTATION METHOD TO DETERMINE PARTICLE SIZE DISTRIBUTION OF ORGANIC SOIL

Lenny Saulia

Department of Mechanical and Biosystem Engineering
Faculty of Agricultural Technology
Bogor Agricultural University

A. Introduction

Approximately 20% of Indonesian land area (39 million hectares) is organic soil, where a mat of living vegetation on the surface with a layer of saturated peat beneath it. Since the saturated peat beneath the mat is often weaker than the mat, a number of problems of trafficability and mobility arise due to this kind of soil. Mechanical land preparations for agricultural farming also almost failed in several locations in Indonesia.

Satisfactory analysis of the tractive performance parameters (rolling resistance, drawbar pull and tractive efficiency) of off-road vehicles, especially farm machinery, depends on accurate prediction of the forces between the soil and the tractive elements of the vehicles. Off-road vehicles are now expected to attain a high level of energy efficiency and not to cause undue damage to the environment, especially to the soil. Establishment of functional relationship of pressure-sinkage becomes one of fundamental tasks that may be improving the tractive performance of off-road vehicles.

Soil physical and mechanical properties may govern the sinkage as well as load and dimensional contact area properties. Cohesion and friction as soil mechanical parameters were also indicated in prior empirical models to predict the sinkage of off-road vehicles, e.g. Bekker's equation and Reece's equation (Wong, 2001). These parameters are responsible to the strength properties of soil which considered may influence the sinkage-pressure relationship. However, according to the previous research, several soil parameters (particle size distribution, moisture content, density, *etc*.) also considered being the dependent factors which influence the strength properties of soil and indirectly may role the sinkage-pressure relationship (Saulia *et al*, 2007).

Particle size distribution (PSD) is an important characteristic of soils to determine its engineering properties. It was reported also that the characteristic also makes it possible to predict hydraulic conductivity (Hwang and Powers, 2003, Arya *et al*, 1999), density (Gupta and Larson, 1979).

General method for determining PSD of soil is sieving and sedimentation-based procedure, *e.g.* hydrometer analysis. The sieving method is useful for fractionation of soil in size range of 70 to 2000 μm, while hydrometer method can fractionate less size. However, hydrometer method may have a major error that is inaccuracy in hydrometer reading. A new method to determine PSD is using laser diffraction (LD). However, Shein *et al* (2006) and Eshel *et al* (2004) reported that there is difference in volume percentage of the clay-size fraction and silt-size fraction obtained by LD and the sedimentation-based procedures. Moreover, Shein *et al* (2006) mentioned that the difference between the two methods may be due to several reasons,

including the non-round shape of the particles subjected to sedimentation and the development of colloidal structures and gel films on the surface of soil particles.

The assumption about the constant solid phase density of soil particles independently from their origin and composition, may lead to errors in determination of PSD of soils with a high content of organic matter (Shein *et al*, 2006). While McCarthy (2007) mentioned that the presence of organic material in soil should be carefully considered. Organic material mixed with the non-organic soil can have striking detrimental effects on the strength and compressibility properties of material. In order to provide accurate data of the engineering properties determination to predict the sinkage of off-road vehicles on organic soils, it is necessary to evaluate another method to separate organic soil particles based on its size.

B. Research Method

The samples used in this study were taken from the A horizon (10-20 cm) of a peatland virgin forest (sample A) and rural area (sample B) at Lamunti, Central Kalimantan. Organic compounds analyzer MT-6 CHN corder was employed to analyze soil organic matter (SOM). Table 1 presents the result of the percentage of organic matters in both soil samples.

Table 1. Percentage of organic matters of Lamunti peat soil

Soil sample	H	C	N
A	1.83	9.26	0.6
B	2.49	17.5	0.98

The samples were air-dried and powdered to pass through a 2 mm sieve. Standard PSD test was conducted on the organic soil samples. This standard test is mechanical analysis to determine the range size of particles in the soil and the percentage of particles in each of the size between maximum and the minimum. Two methods are in common use, *i.e.* sieving and sedimentation procedure. Sieving is the most direct method for determining soil particle sizes, but there are practical lower limits that this procedure is generally used for coarse-grained soils. The procedure commonly used for obtaining PSD for silt and clays is the sedimentation method. In this method, the soil is placed into solution with distilled water, and the soil particles are permitted to settle out of the solution. As setting occurs, the average specific gravity of the solution decreases. Readings of specific gravity by use of a hydrometer, made at different time intervals, provide an indication of the weight of the soil remaining in solution and also information on the sizes of particles.

C. Results and Discussion

Figs. 1 and 2 show the results of PSD test using sedimentation method of sample A and B, respectively. The result of particle-size distribution is presented by a relationship curve of soil particle size and its percentage. Both methods, sieving and hydrometer, should generate one smooth and continue line curve. As the hydrometer analysis is wide-use to obtain reasonable approximation of the PSD for fine-grained soils (less than 0.075 mm), while sieving method is aimed to determine particle size of soil more than 0.075 mm, however, both kind of soil samples demonstrate the line of sieving method not come to an end to the line of

hydrometer method. The PSD tests might not consider the presence of organic particles which have low solid-phase density as mentioned by Shein *et al* (2006). The organic particles that have the size of the fine and medium silt fall into the category of the clay fraction upon the hydrometer analysis.

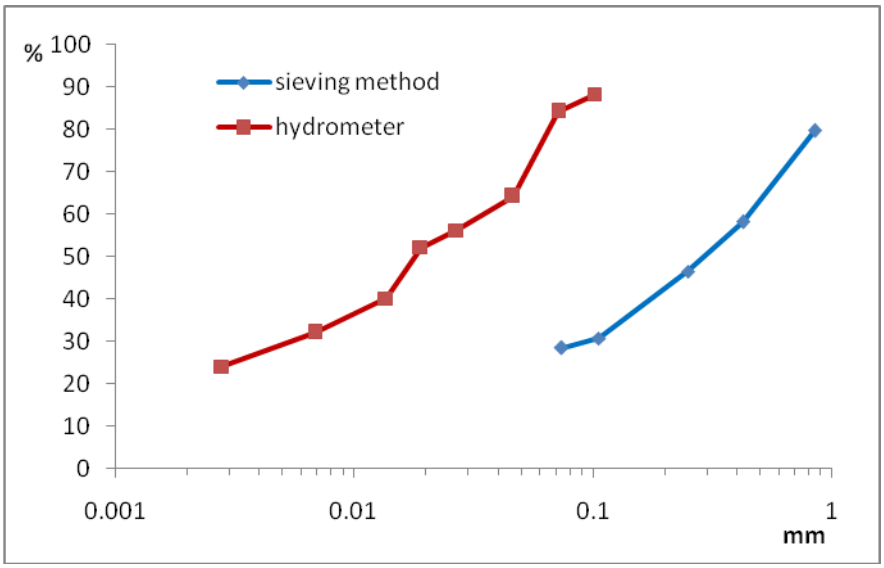

Fig. 1 Particle-size distribution of peat soil (sample A) determined from sedimentation analysis

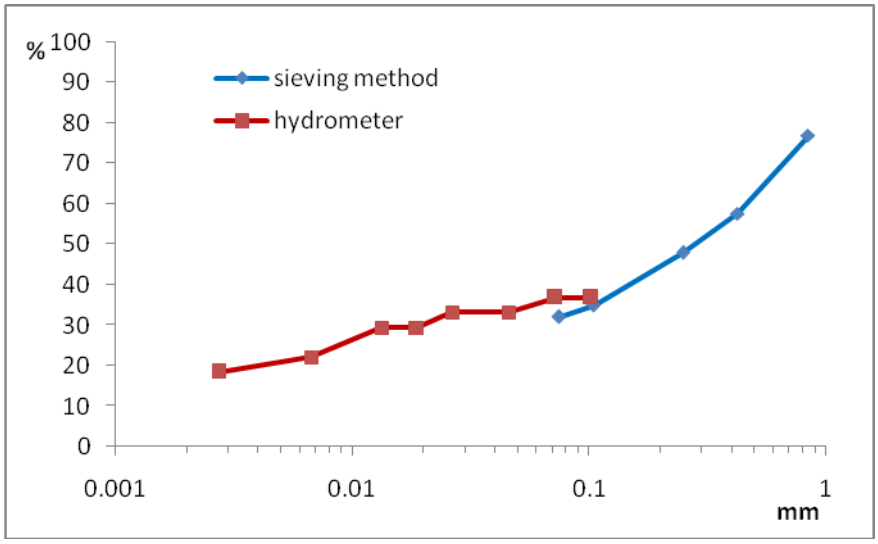

Fig.2 Particle-size distribution of peat soil (sample B) determined from sedimentation analysis

Observation under scanning electron microscope (SEM) provided the information that the soil samples were not only consist of plate-shaped particles. Spherical shaped particles also were found as presented in Fig. 3. This soil particle geometry considered might have effect on sedimentation process of hydrometer analysis on organic soil.

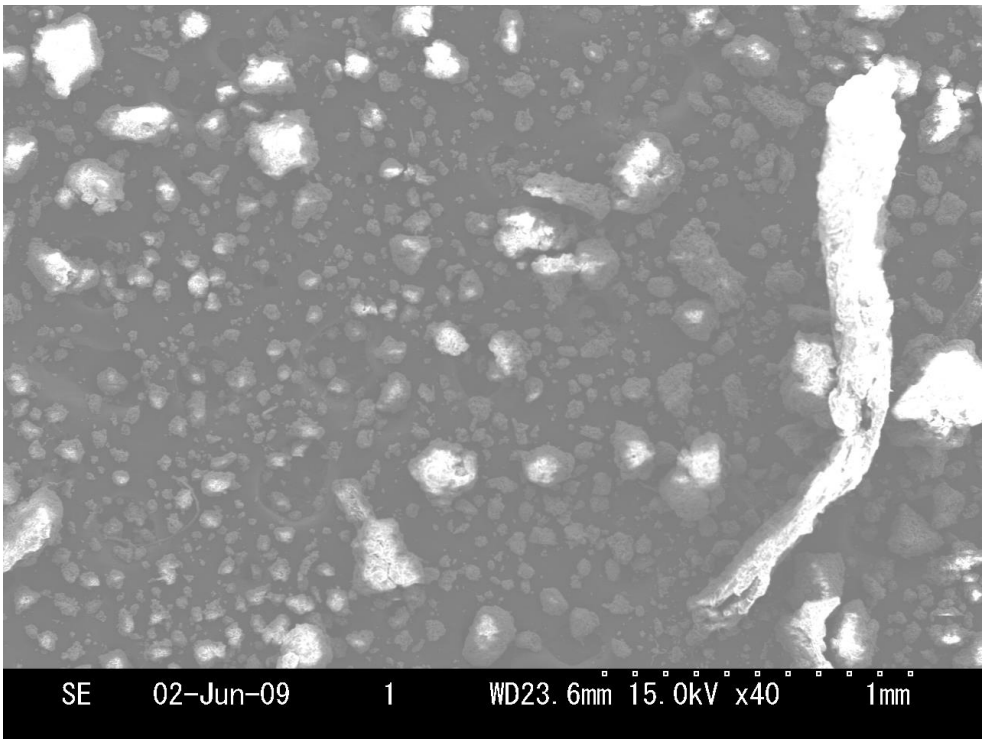

Fig. 3 Lamunti peat soil particles under scanning electron microscope

Fractionating organic soil particles based on its size is necessary to obtain information about the structure and properties of the organic soil. Separation using sedimentation analysis is considered may provide unreliable data. Among the chromatographic methods, there is a techniques based on a size-exclusion effect, *i.e.* gel permeation/size-exclusion chromatography (GPC/SEC). However, SEC covers analytes smaller than 100 nm, while soil particle may range to the larger size. In case of the organic soil sample in this study (detected by sedimentation analysis), soil particles less than 3 μm were around 20 percent. Moreover, separation method using SEC is based rather on differences in particle size than on differences in particle mass. Hence, it is not suitable to use SEC for determining PSD of organic soils. Other technique that might be possible to try is field-flow fractionation (FFF), which is the common method to measure molecular weight distributions. The possibility of using this method can be tried as the future plan.

D. Conclusions

Sieving and hydrometer analysis method to may have a shortcoming in determination of PSD of organic soil. Field-flow fractionation may be used as an alternative method for determining the PSD of organic soil.

REFERENCES

Arya L.M., F.J. Leij, M.Th. van Genuchten and P.J. Shouse. Scaling Parameter to Predict the Soil Water Characteristic from Particle-Size Distribution Data. Soil Sci. Soc. Am. J. 63:510-519 (1999).

Arya L.M., F.J. Leij, P.J. Shouse and M.Th. van Genuchten. Relationship between

the Hydraulic Conductivity Function and the Particle-Size Distribution. Soil Sci. Soc. of Am. J. 63:1063-1070 (1999).

Bolanća, T., Ŝ. Cerjan-Stefanović, M. Lusâ, Ŝ. Ukić, S. Leaković, 2006. Determination of Inorganic Ions in Fertilizer Industry Wastewater by Ion Chromatography. Chromatographia 63:395-400Eshel, G., G. J. Levy, U. Mingelgrin, and M. J. Singer. Critical Evaluation of the Use of Laser Diffraction for Particle-Size Distribution Analysis. Soil Sci. Soc. Am. J. Vol.68, May-June 2004 p.736-743

Gupta S. C. and W. E. Larson. A Model for Predicting Packing Density of Soils Using Particle-Size Distribution. Soil Sci. Soc. Am. J. 43:758-764 (1979).

Hwang, S.I and S.E. Powers. Using Particle-Size Distribution Models to Estimate Soil Hydraulic Properties. Soil Sci. Soc. of Am. J. 67:1103-1112 (2003)

L. Saulia, N. Ito, K. Kito, Wang X.L., and Ho J. Investigation of Effect of Shape Contact ratio on Sinkage for Tracked Vehicles using New measurement System. WSEAS Trans. On Applied and Theoretical Mechanics. ISSN: 1991-8747, Issue 1, Vol. 2, pp. 16-23, January 2007.

McCarthy, D.F. Essentials of Soil Mechanics and Foundations. Pearson Education, Inc., New Jersey, 2007.

Shein, E.V., E. Yu. Milanovskii, and A.Z. Molov. The Effect of Organic Matter on the Difference between Particle-Size Distribution Data Obtained by the Sedimentometric and Laser Diffraction Methods. ISSN 1064-2293, Eurasian Soil Science, 2006, Vol. 39, Suppl. 1, pp. S84–S90.

Wong, J.Y. Theory of Ground Vehicles. 3rd ed. New York: John Wiley & Sons, Inc., 2001