



*Journal of Advances in
Science and Technology*

*Vol. IV, No. VIII, February-
2013, ISSN 2230-9659*

A COMPARATIVE STUDY ON EFFECTIVENESS OF SOIL STRENGTH

A Comparative Study on Effectiveness of Soil Strength

Sebok

Research Scholar, CMJ University, Shillong, Meghalaya, India

Abstract – In many cases, changes in the water contents were not a significant factor in the prediction of soil strength. This may be a reflection of the limited capabilities of the equations, the uniform equilibration of soil-water potential of the soils, or the fact that the slope of the strength vs. bulk density curve is independent of water content over the range of samples considered. Nevertheless, it does simplify the equations and may suggest that a series of several equations for different soil types would be better than a single equation that requires soil-water content.

Research results have shown that both approaches to describing vehicle trafficability of cohesive soils describe the soil strength of forest wilderness in a similar way and provide a good basis for developing a trafficability evaluation system, as a future task of forest engineering.

The soil cone index and shear strength values calculated in this research do not concur with the classes of EcoWood soil strength classification and indicate that the limits and ranges of these parameters are questionable. The problem of defining the threshold values of soil strength parameters covered by this research will be the subject of future investigations.

The shear strength of a soil mass is the internal resistance per unit area that the soil mass can offer to resist failure and sliding along any plane inside it. One must understand the nature of shearing resistance in order to analyze soil stability problems such as bearing capacity, slope stability, and lateral pressure on earth retaining structures.

INTRODUCTION

Soil strength is a complicated geotechnical concept to simplify due to the inherent complexities of different soil types. Frictional strength, cohesive strength, and porewater pressure relationships are all integral to the effective strength determination of a soil but are only easily identified in the most select granular materials.

For the purpose of this brief discussion, all soils are assumed to be drained with no pore pressure considerations. Cohesion is typically neglected in the simplified design methods and a frictional strength relationship is utilized to determine driving and resisting forces.

Soils are essentially frictional materials. They are comprised of individual particles that can slide and roll relative to one another. In the discipline of soil mechanics it is generally assumed that the particles are not cemented.

One consequence of the frictional nature is that the strength depends on the effective stresses in the soil. As the effective stresses increase with depth, so in

general will the strength. The strength will also depend on whether the soil deformation occurs under fully drained conditions, constant volume (undrained) conditions, or with some intermediate state of drainage.

In each case different excess pore pressures will occur resulting in different effective stresses, and hence different strengths. In assessing the stability of soil constructions analyses are usually performed to check the short term (undrained) and long term (fully drained) conditions.

Soils are essentially frictional materials. They are comprised of individual particles that can slide and roll relative to one another. In the discipline of soil mechanics it is generally assumed that the particles are not cemented. One consequence of the frictional nature is that the strength depends on the effective stresses in the soil. As the effective stresses increase with depth, so in general will the strength.

The strength will also depend on whether the soil deformation occurs under fully drained conditions, constant volume (un-drained) conditions, or with

some intermediate state of drainage. In each case different excess pore pressures will occur resulting in different effective stresses, and hence different strengths. In assessing the stability of soil constructions analyses are usually performed to check the short term (un-drained) and long term (fully drained) conditions.

Soil strength is a measure of the capacity of soil to resist deformation and refers to the amount of energy that is required to break apart aggregates or move implements through the soil. It is measured in megapascals (MPa) which indicate penetration resistance. With regard to grapevine growth, soil strength affects the ability of the roots to penetrate the soil. Vine root growth appears to become limited at 1.0 MPa, and severely retarded at more than 2.0 MPa.

Soil strength can be modified by inputs of organic matter such as mulches, composts or cover crops which cause aggregate macro-structure to become more stable. The application of gypsum to soil stabilises aggregate micro-structure and prevents clay dispersion. Excessive tillage can break down both the macro- and micro-structure of aggregates leading to hard setting and crusting of surface soils.

SOIL STRENGTH MEASUREMENT

Soil strength is a measure of the capacity of soil to resist deformation and refers to the amount of energy that is required to break apart aggregates or move implements through the soil. It is measured in megapascals (MPa) which indicate penetration resistance. With regard to grapevine growth, soil strength affects the ability of the roots to penetrate the soil. Vine root growth appears to become limited at 1.0 MPa, and severely retarded at more than 2.0 MPa.

Soil strength is influenced by several factors:

- Soil water content - as the soil becomes drier, soil strength increases and more force is required to break up aggregates;
- Texture - dense fine textured soils (i.e. soils with high clay content) stick together more than sands;
- Structure - small firm granular aggregates are more easily tilled than large solid slabs; aggregates with a stable macro- and micro-structure neither slake nor disperse by wetting.

Soil strength can be modified by inputs of organic matter such as mulches, composts or cover crops which cause aggregate macro-structure to become more stable. The application of gypsum to soil stabilises aggregate micro-structure and prevents clay dispersion. Excessive tillage can break down both the macro- and micro-structure of aggregates leading to hardsetting and crusting of surface soils.

There are several types of tools and methods used to measure soil strength. They all rely on determining the resistance of the soil to penetration and are best used when the soil is sufficiently moist.

- Penetrometer - This tool has a stainless steel cone on the end of a shaft. It is inserted into the soil and pushed through the profile at a steady rate. A pressure sensor records the pressure (units of kPa or MPa) needed to push the rod through the soil.
- Bronzing rod - This device is simpler but less accurate than a penetrometer. The ease with which the 2.4mm diameter smooth rod is pushed into the soil with the palm of the hand gives an estimate of soil strength.

As the cost of a field penetrometer with pressure sensor may be prohibitive for many growers, the method described below is for the bronzing rod.

Equipment: Bronzing rod (300 mm long x 2.4mm diameter manganese bronze rod), \$1 coin, recording sheet and pen.

Timing: The best time to carry out the estimate of soil strength is when the soil is at field capacity. This is when the soil moisture tension is approximately 10 kPa. This can be measured using a tensiometer. As a general rule, field capacity usually occurs approximately 24-48 hours after soaking rain or penetrating irrigation.

Method: It is important to assess the soil strength of each soil layer that will impact on root growth and water penetration. Ideally you should measure soil strength in each soil layer and at 3 positions in a soil pit. Alternatively, dig a trench adjacent to the middle 4 vines at a site so as to expose a face of soil in the vine line to at least 50cm depth.

Using the bronzing rod: With the palm of the hand, push the rod into the side wall of the soil pit or trench, making sure that it moves horizontally. Repeat for each soil layer in the exposed profile.

STRENGTH TESTS

The engineering strength of soil materials is often determined from tests in either the shear box apparatus or the triaxial apparatus.

The Shear Box8 Test: The soil is sheared along a predetermined plane by placing it in a box and then moving the top half of the box relative to the bottom half. The box may be square or circular in plan and of any size, however, the most common shear boxes are square, 60 mm x 60 mm.

A load normal to the plane of shearing may be applied to a soil specimen through the lid9 of the box. Provision is made for porous plates to be placed

above and below the soil specimen. These enable drainage to occur which is necessary if a specimen is to be consolidated under a normal load, and if a specimen is to be tested in a fully drained state. The soil specimen may be submerged, by filling the containing vessel¹⁰ with water, to prevent the specimens from drying out. Undrained tests may be carried out, but in this case solid spacer blocks rather than the porous disks must be used.

The Triaxial Test: The triaxial test is carried out in a cell and is so named because three principal stresses are applied to the soil sample during the test.

A cylindrical soil specimen as shown is placed inside a latex rubber¹² sheath¹³ which is sealed to a top and base cap by rubber O-rings. For drained tests, or undrained tests with pore pressure measurement, porous disks are placed at the bottom, and sometimes at the top of the specimen. For tests where consolidation of the specimen is to be carried out, filter paper drains may be provided around the outside of the specimen in order to speed up the consolidation process. Pore pressure generated inside the specimen during testing may be measured by means of pressure transducers.

EXPERIMENTAL PROCEDURE

The procedure was similar to that of Taylor and Gardner. Soil cores, 2.54 cm. in final height and 4.02 cm. in diameter, were compressed (initial soil suction was % bar) to known bulk densities in steel retainer rings rewetted, and equilibrated to known soil suctions ranging from % to 1 bar. For each soil, 22 compressed cores of each bulk density and soil suction were prepared. Twelve of the cores were used to determine root penetration and ten were used as controls to determine soil strengths and moisture contents at the time of planting. There were never more than two cores of a particular soil series and bulk density on any one pressure plate during an equilibration period.

CONCLUSION

Regression equations were developed that related the change in soil strength associated with the change in bulk density and water content between some measured value and the critical rooting conditions for soils equilibrated at -100 kPa soil-water potential.

Relationships among these changes were simplified in many cases by the elimination or estimation of water content at a soil strength of 2 MPa and soil-water potential at -100 kPa. Calculated CRDB agreed closely with experimental values. This may be because all soils used were similar in texture and physiographic origin. Nevertheless, it did make the calculations easier and demonstrated at least a limited range of

usefulness for the regressions with and without the inclusion of changes in water content.

Of course, inclusion of more soil types in the analysis would improve the accuracy and applicability of the equations. A method of estimating the water content at 2 MPa soil strength and -100 MPa soil-water potential from easily-measured or calculated soil parameters such as CRDB or texture would be useful (Gupta and Larson, 1979).

The hypothesis, that a specific change of soil strength will cause a specific response of underground plant parts, provided some other growth factor does not become limiting, is presented. Data to evaluate this hypothesis were collected by studying the relation between soil strength and cotton taproot penetration through cores of four medium- to coarse-textured soil materials.

REFERENCES

- Barley, K. P. 1963 Influence of soil strength on growth of roots. *Soil Sci.* 96: 175-180.
- Parker, J. J., Jr., and Taylor, H. M. 1965 Soil strength and seedling emergence relations: I. *Agron. J.* 57: 289-291.
- Taylor, H. M., and Gardner, H. R. 1963 Penetration of cotton seedling taproots as influenced by bulk density, moisture content and strength of soil. *Soil Sci.* 96: 153-156.
- Taylor, H. M., and Burnett, E. 1964 Influence of soil strength on root-growth habits of plants. *Soil Sci.* 98: 174-180.
- Taylor, H. M., Locke, L. F., and Box, J. E. 1964 Pans in Southern Great Plains soils: III. *Agron. J.* 56 : 542-545.
- Fredlund, D.G. and N.R. Morgenstern, 1977. Stress state variables for unsaturated soils. *J. Geotech. Engg. Div., ASCE.* 103: 447-466.
- Fredlund, D.G., N.R. Morgenstern and R.A. Widger, 1978. The shear strength of unsaturated soils. *Can. Geotech. J.*, 15: 313-321.
- Hilf, J.W., 1956. An investigation of pore pressure in cohesive soils. US Bureau of Reclamation, Technical Memorandum. No. 654.
- Little, A.L., 1969. The engineering classification of residual tropical soils. *Proc.*

7th Intl. Conf. Soil Mechanics Foundation Engineering, Mexico, 1: 1-10.

- Escaro, V. and J. Saez, 1986. The shear strength of partially saturated soils. *Geotechnique*, 36: 436-436.
- Gan, J.K.M. and D.G. Fredlund, 1988. Determination of shear strength parameters of an unsaturated soil using the direct shear box. *Can. Geotechn. J.*, 25: 500-510.
- Abdullah, A., F. Ali and Chandrasegaran, 1994. Triaxial shear strength tests on partially saturated residual soils. *Geotropika*: Malacca.
- Corey, A.T., 1957. Measurement of water and air permeability in unsaturated soils. *Proc. Soil Sci. Soc. America*, 21: 7-10.
- Hilf, J.W., 1956. An investigation of pore pressure in cohesive soils. US Bureau of Reclamation, Technical Memorandum. No. 654.
- 8. Little, A.L., 1969. The engineering classification of residual tropical soils. *Proc. 7th Intl. Conf. Soil Mechanics Foundation Engineering*, Mexico, 1: 1-10.
- Raj, J.K., 1985. Characterization of the weathering profile developed over porphyritic biotite granite in Peninsular Malaysia. *Bull. Intl. Assoc. Engg. Geol., Paris*, 32: 121-127.
- Escaro, V. and J. Saez, 1986. The shear strength of partially saturated soils. *Geotechnique*, 36: 436-436.
- Gan, J.K.M. and D.G. Fredlund, 1988. Determination of shear strength parameters of an unsaturated soil using the direct shear box. *Can. Geotechn. J.*, 25: 500-510.
- Abdullah, A., F. Ali and Chandrasegaran, 1994. Triaxial shear strength tests on partially saturated residual soils. *Geotropika*: Malacca.
- Corey, A.T., 1957. Measurement of water and air permeability in unsaturated soils. *Proc. Soil Sci. Soc. America*, 21: 7-10.