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GLOSSARY OF TERRAIN-VEHICLE TERMS AND STANDARD TEST PROCEDURES—PART III

INTRODUCTION

THE STANDARDIZATION Committee of the International Society for Terrain-Vehicle Systems (ISTVS) has been working on a set of standard terms to be used by investigators in the field of off-road operations, so that better communication might result; a list of standard test procedures has been added to the glossary. Terms and procedures will be grouped and presented in categories as follows:

Glossary of terms

- I. Terrain characteristics
  - A. Soils
  - B. Geometry
  - C. Vegetation
- II. Vehicle physical characteristics
- III. Vehicle performance characteristics
- IV. Soil test devices associated with soil-vehicle tests
- V. Standard symbols.

Standard test procedures

Standards for two categories, Terrain Geometry and Vehicle Physical Characteristics, were published in the *Journal of Terramechanics* Vol. 5, No. 2 (1968), and were adopted by the Society in 1969; standards for Vehicle Performance Characteristics were published in the *Journal of Terramechanics* Vol. 8, No. 2 (1971) and were adopted by the Society in 1972. A list of Soil Test Devices Associated with Soil-Vehicle Tests is presented here for comment by members of the Society. All appropriate changes will be incorporated into this list, and the final version will be submitted to the next International Conference of the Society for adoption. The Committee, members of which are listed below, therefore welcomes all suggestions, corrections, or additions.

MARVIN P. MEYER, Chairman
Mobility and Environmental Systems Laboratory
U.S. Army Engineer Waterways Experiment Station
P.O. Box 631
Vicksburg, Mississippi 39180

I. ROBERT EHRLICH
Davidson Laboratory
Stevens Institute of Technology
Castle Point Station
Hoboken, New Jersey 07030

DAVID SLOSS
Stevens Institute of Technology
Castle Point Station
Hoboken, New Jersey 07030

NEWELL R. MURPHY, JR.
Mobility and Environmental Systems Laboratory
U.S. Army Engineer Waterways Experiment Station
P.O. Box 631
Vicksburg, Mississippi 39180

ROBERT D. WISMER
Technical Center
Deere and Co.
Moline, Illinois 61265

TIBOR CZAKO
Land Locomotion Division
U.S. Army Tank-Automotive Command
Warren, Michigan 48090.

SOIL TEST DEVICES ASSOCIATED WITH SOIL-VEHICLE TESTS*

A. *Penetrometers*

166. *Aerial cone penetrometer.* A projectile with a cone-shaped striking point that can be dropped from an airplane or fired from the ground by a mortar or similar gun. By telemetry or ejection of a flare, a signal is sent to the operator to indicate the depth of penetration or the deceleration experienced by the penetrometer upon striking the soil. This information is related to the cone index of the soil and can be interpreted in those terms [10].†

167. *Airfield penetrometer.* A cone penetrometer used to measure the trafficability of landing sites for aircraft. It consists of a 30-deg cone with a 0·20 in.^{2} (1·290 cm^2) base area attached to a spring [11].

168. *Bevameter penetrometer.* See Bevameter under Soil Shear Test Devices.

169. *California Bearing Ratio (CBR) equipment.* Equipment designed to measure the shear strength and bearing capacity of soil. The equipment used to conduct field in-place CBR tests consists of a mechanical screw jack equipped with a special swivel head for applying load to a penetration piston, a calibrated proving ring, a circular penetrating piston 3 in^2 (19·4 cm^2) in area and 4 in. (10·2 cm) high, dial gages for measuring proving ring deflection and piston penetration, a circular 10-lb (4·54-kgf) steel plate, and surcharge weights. The equipment has been modified for conducting tests on compacted samples in the laboratory. The CBR is the ratio of the force per unit area required to penetrate a soil mass with the circular piston at a rate of 0·05 in.

*Soil includes snow, peat, and other unconsolidated surface materials. The procedures in using this equipment will be presented under the category "Standard Test Procedures".
†Reference numbers are compatible with those used in previously published standards.

(1.27 mm) per minute to that required for corresponding penetration of a standard material. The ratio is usually determined at 0.1 in. (2.54 mm) penetration, although other penetrations are sometimes used [12].

170. *Canadian hardness gage.* An instrument for measuring the strength of snow surface. It consists of a spring-loaded plunger on which may be mounted various-sized disks. The disk is pressed against the snow and the load recorded when a definite collapse of the snow surface is observed [13].

171. *Cone penetrometer, WES.** An instrument used to obtain an index of in situ shear strength and bearing capacity of soil. It consists of a 30-deg cone with an 0·5 or 0·2 in^2 (3·23 or 1·29 cm^2) base area mounted on one end of a shaft. The shaft has circumferential bands indicating depths of penetration. At the top of the shaft is mounted a dial indicator within a proving ring which indicates the force applied axially to the penetrometer. The instrument is forced vertically into the soil while records are made of the dial reading for various sinkage depths [14].

The cone penetrometer is associated with the following parameters:

(a) Cone Index (CI)
(b) Remolding Index (RI)
(c) Rating Cone Index (RCI)
(d) Vehicle Cone Index (VCI)
(e) Slope Index
(f) Effective Rating Cone Index (ERCI)
(g) Critical Layer.

172. *Drop-cone penetrometer, snow.* An instrument used to determine the strength of snow. It consists of a sheet-aluminium 60-deg cone weighing 0·5 kgf and having a central spindle, a graduated support rod 80 cm long mounted on a flat base, and a movable, horizontal arm equipped with a bubble level. A trip lever to release the penetrometer is fitted to the spindle. Weights of 0·5, 1·0, and 2·0 kgf are provided to load the penetrometer. In operation the movable arm is set at a preselected height on the support rod. The appropriate weight is then placed on the cone spindle and the cone dropped by releasing the trip lever. The graduated support and movable arm are then used to measure the depth of penetration of the cone into the snow [13].

173. *Proctor needle.* An instrument used to measure the penetration resistance in pounds per square inch of a compacted soil sample. The penetration resistance, wet unit weight, and moisture content are used to estimate the degree of compaction. The instrument consists of a handle and calibrated plunger rod on one end, a barrel with a piston resting on a spring in the middle section, and one of several sized needles, ranging in area from 0·05 to 1·00 in^2 (0·32–6·45 cm^2) on the other end. The needle is forced into the soil at a rate of approximately ½ in. (1·27 cm) per sec to a depth of about 2½ in. (6·35 cm) and the maximum resistance is measured [15].

174. *Rammsonde penetrometer.* An instrument used to determine the relative strength of snow layers to depths of several meters. It consists of several hollow meter tube sections one meter long and 20 mm dia, each weighing 1 kgf and graduated in centimeters. At the end of one of these tubes is a 60-deg cone with a 40-mm dia base

*Waterways Experiment Station.

which is tapered back to the rod. A driving hammer is provided to force the cone into the snow [13].

175. *Taper penetrometer.* An instrument used to measure the strength of soil. It consists of a hollow shaft in the shape of a four-sided, 3-deg pyramid. The shaft is graduated in 1-in. (2·54 cm) increments to 30 in. (76·2 cm), with a spring-type loading device mounted on top. The spring which connects the two arms can be adjusted so that when the arms are depressed to reach a nearly horizontal position a constant force is applied. The depth to which the taper penetrates the soil is a measure of its strength. The remolding effect is determined by measuring the increase in penetration that results from twisting the instrument while the maximum load is maintained [13].

B. *Samplers*

176. *Hvorslev sampler.* A device used to obtain an undisturbed sample from comparatively soft soil. It consists of a $1\frac{7}{8}$ in. (4.76 cm) i.d. tube externally sharpened on one end. A piston within the tube is retracted during penetration in order to maintain a partial vacuum above the soil and thus to prevent soil compression as the cylinder is forced into the soil. The piston also prevents moisture loss by drainage in noncohesive soils. It is primarily used to obtain soil samples for use in the remolding test or for determination of moisture-density [14].

177. *Peat sampler.* A piston-type sampler used to obtain undisturbed samples of unfrozen peat. The sampler consists of a cylinder, open at one end, containing a piston capable of providing suction. Rods are attached to both the piston and cylinder to facilitate manual operation. Peat cores about 2·5 ft in. (0·76 m) length and 2 in. (5·08 cm) dia or 1 ft (30·5 cm) in length and 4 in. (10·2 cm) dia can be obtained (ISTVS).

178. *Oakfield punch.* A device used to obtain small disturbed soil samples. It is a tube with a cutting edge at one end and a handle attached to the other. A considerable length of sidewall is removed along the length of the tube between the cutting edge and the handle. Depth indexes are inscribed on the tube. The tube is pushed into the soil, the handle is turned to break the soil column, and the punch is then withdrawn from the soil. The soil may then be easily removed from the tube by pushing with the fingers through the cut-out in the side wall. Successive soil samples from other depths may be obtained in a like manner [16].

179. *Sans Dimas sampler.* A device used to obtain samples cores (2 in. (5·08 cm) dia by $1\frac{3}{8}$ in. (3·49 cm) length with a volume of 71 cm^3) for the determination of bulk density and moisture tension. The sampler has an outer cylinder equipped with spiral flanges with sharp cutting edges and an inner cylinder with three removable brass sleeves. When the handle attached to the outer cylinder is rotated clockwise the inner cylinder is forced downward into the soil. The design permits the inner cylinders to penetrate undisturbed soil [16].

C. *Soil shear test devices*

180. *Bevameter.* An instrument used to measure the *in situ* soil strength. The instrument consists of two separate devices: one to measure the shear strength and another to measure the bearing capacity. The shear device consists of a grousered annular ring mounted on the end of a shaft. The shear measurements are made by

applying a number of constant vertical loads to the ring which is then rotated at a constant velocity. Records of the torque and angular displacement are used to calculate shear strength. The bearing capacity device is a plate penetrometer. The bearing capacity measurements are made by forcing different sizes of flat plates into the soil. Records of the penetration force and sinkage are used to calculate bearing capacity [17]. The bevameter is associated with the following parameters:

(a) Cohesion (c_b)
(b) Angle of internal friction (φ_b)
(c) Sinkage moduli (k, kc, $k\varphi$)
(d) Sinkage exponent (n).

181. *Cohron sheargraph.* A device used to measure the *in situ* soil shear strength. It consists of a torsional shear plate with a smooth rubber or metal vane head attached to a recording graph by means of a spiral spring. By applying a combination of axial–torsional load a shear stress–normal stress curve is produced. Repeated tests at different loads will trace an envelope of curves which may be used to calculate the soil cohesion, c_c, and angle of internal friction, φ_c [18].

182. *Direct shear box.* An instrument used to measure soil shear strength. It consists of a metal box, open at the top and divided horizontally into two frames and fitted with alignment pins to aid in fitting them together accurately. The bottom of the box is fitted with a porous stone to allow water drainage. The upper frame of the box is provided with a link for applying a horizontal force along the plane dividing the two sections of the box. Usually the shear box is about 3 in. (7·62 cm) square or larger and contains a $\frac{1}{2}$ in. thick (1·27 cm) soil sample. Above the soil sample is placed a porous stone above which is also placed a loading piston. A means is provided for placing a constant, uniform, vertical load on the piston. A means is also provided to apply and measure a horizontal load to the upper frame link by means of a controlled rate of strain (preferred) or a controlled stress device. Usually the device is also capable of measuring the soil deformation during the test [19]. The direct shear box is associated with the following parameters:

(a) Cohesion (c_d)
(b) Angle of internal friction (φ_d).

183. *Penetration-shear device, combined.* A device used to measure *in situ* soil strength. Various designs exist; however, all apply a vertical and a horizontal load at the same time. Records of these loads and their associated sinkages are used to describe soil strength (ISTVS).

184. *Remolding equipment.* In conjunction with the cone penetrometer this equipment is used to measure the remolding index (RI) of soil or the soil strength change experienced during remolding. The remolding equipment consists of a cylinder and a drop hammer. The cylinder, mounted on a steel base, is of the same diameter as the Hvorslev sampler. The drop hammer weighs $2\frac{1}{2}$ lb (1·13 kgf) and travels 12 in. (30·5 cm). Samples of soil are inserted into the cylinder from the Hvorslev sampler. For fine-grained soils the drop hammer is allowed to fall on the soil sample within the cylinder 100 times; for coarse-grained soils with fines the cylinder with the soil is dropped from a height of 6 in. (15·2 cm) on to a firm surface 25 times. After this procedure the change of soil strength is measured by a cone penetrometer [14].

185. *Shear vane.* An instrument used to measure the *in situ* shear strength of soil

at a specified depth. Although a number of shaft and vane sizes have been used, most devices consist of a cruciform vane mounted on one end of a shaft. On the other end is a device to measure the torque required to rotate the shaft about its axis (ISTVS).

186. *Torvane.* A type of shear vane used to measure the surface cohesive strength of soil. The torque required to shear the soil may be measured directly in soil cohesion (c_v) (ISTVS).

187. *Triaxial test apparatus.* An instrument used to measure the shear strength of a soil under undrained or controlled drainage conditions. It essentially consists of a compression chamber containing a relatively incompressible fluid. The bottom of the chamber is fitted with a porous plug while the top is fitted with a vertical loading device. A cylindrical soil sample being tested is encased in a rubber membrane and placed in the chamber. The fluid surrounding the soil sample is subjected to a predetermined pressure while the sample is loaded axially until failure. The porous plug at the bottom of the chamber is connected to the soil sample to allow drainage during testing at a predetermined rate. The instrument is usually used to determine the soil cohesion, c_t, and angle of internal friction, φ_t.

188. *Torque tube.* An instrument used to measure the *in situ* snow cohesion, c_s, and angle of internal friction, φ_s. The equipment consists of a thin-walled tube with a set of thin vanes placed at right-angles to each other inside one end of the tube. The other end is equipped with a torque measuring apparatus and a set of weights [13].

189. *Unconfined compression test apparatus.* An instrument used to measure the unconfined compressive strength of a cohesive soil. A cylindrical soil specimen of known dimensions is placed between the compression members of the apparatus and loaded at a constant rate of strain until failure [19].

D. *Soil density measuring devices*

190. *Gravimetric samplers.* A number of samplers are designed to extract a known volume of undisturbed soil. These may be used directly to measure *in situ* soil density (see Samplers).

191. *Nuclear density devices*

(a) *Backscatter method.* Density values are obtained by measuring the nuclear radiation, reflected by the soil, which has been emitted from a known source. The rate of radiation reflected is proportional to the density of the soil (ISTVS).

(b) *Direct transmission method.* Density values are obtained by measuring the radiation received by a detector which is placed in the soil adjacent to a radiation source. The rate of radiation received by the detector is inversely proportional to the soil density (ISTVS).

192. *Sand cone apparatus.* A device used to measure *in situ* soil density. A sand is calibrated to determine the volume it occupies per unit weight when poured by a specific technique. A sample is extracted from a level portion of the soil and weighed. The calibrated sand is then poured into the void until the surface is again level. The weight of sand will yield the volume of soil extracted [20].

E. *Soil moisture measuring devices*

193. *Electrical probe.* An instrument used to determine the moisture content of

nonsaturated soils. Moisture content may be determined from the electrical resistance of the soil. The instrument must be calibrated for each soil studied (ISTVS).

194. *Gas pressure technique*. The measure of moisture content in a small soil sample derived from the pressure of the gas generated when the water in the soil combines with calcium carbide [21].

195. *Gravimetric technique*. The oven drying of a known weight of soil to determine the weight of moisture contained in the sample [20].

196. *Nuclear technique*. The measurement of neutrons from a known source which are scattered by the soil to determine the number of hydrogen atoms in a given sample. Since there are few hydrogen atoms in soil, this measurement represents the moisture content of the soil (ISTVS).

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