TransTech Systems' Soil Quality Indicator™ (SQI) Application Brief

Density of compacted soil is the most important construction variable in the durability of soil sub-base for pavement, fills, and other construction applications. All current methods of measuring soil density have major limitations. The Sand Cone Test (ASTM D1556) is the accepted test for field density measurement. The test requires careful preparation and execution, is subject to a number of error sources and is extremely time consuming. Measurement time is a critical issue for utility cut/repair operations on congested city streets. The alternative, nuclear densitometers, are cumbersome to use, require strict licensing and usage procedures, take several minutes to get data, and have limitations in their accuracy. Many states have initiated, or are in the process of initiating, programs to replace nuclear soil density gauges to eliminate the regulatory and logistical difficulties associated with nuclear gauges. Further, the time required by nuclear devices to obtain useful density data limits their in-process, Quality Control (QC) effectiveness during soil compaction operations.

To meet the need for a fast, accurate, non-nuclear soil density/compaction gauge, TransTech Systems is developing an innovative alternative, the electrical impedance-based Soil Quality Indicator™ (SQI) for use as a QC tool during the soil compaction process. The SQI is based upon the patented, and recent NOVA Award winning, Pavement Quality Indicator™ (PQI).

Using advanced electrical impedance spectroscopy, the SQI is able to make instantaneous, non-invasive, in-situ measurements of soil density and moisture content. The novel approach permits separation of the effects of soil type, density, and moisture content on the response of the soil to electromagnetic probing. The density, or compaction level, is measured by the response of the SQI's electrical sensing field to changes in electrical impedance of the material matrix, which in turn is a function of the composite dielectric constant of the soil constituents and the air trapped in the voids of the material. Since the dielectric constant of air is much lower than that of the other soil constituents, as compaction increases, the combined dielectric constant increases because the percentage of air in the soil matrix decreases. The embedded computer allows the SQI to perform sophisticated calibration and measurement functions and enables the device to store a number of readings for later retrieval and analysis.

The importance of this innovation is that soil density measurements can now be taken instantly, allowing necessary changes to the compaction process to be made immediately. It also makes it possible to take many more readings per hour on the job site, which helps ensure the best possible compacted soil quality. The device is light-weight, easy to use and requires no special licensing. Thus, almost any member of the construction crew can operate it successfully.

Initially, the SQI is being developed to address utility cut/repair operations. Several studies have shown that improper compaction of the fill prior to repaving is the major cause for failures in the street cuts made by utilities during installation, repair, or upgrading of buried equipment. The instrument can also be used in any construction activity where proper soil compaction is critical to ultimate performance of engineered structures, such as pavements, foundations, dams, and fills.

Several operating modes are planned for the SQI to address the needs of the particular job:

1. **Mode 1 (Calibrated Absolute)** - In this mode, pre-stored data for the soil, compaction equipment, and compaction process is used to produce the highest accuracy. The operator enters Soil Identification, Compactor/Process ID, and the approximate cut dimensions and lift thickness. The instrument will prompt the operator to take a set of readings over the compacted lift surface. A computer model of the compaction process calculates the expected density profile using the cut, lift, and process information. A dielectric model of the soil is adjusted using the calibration data for the particular soil being measured. Absolute density and soil moisture content are calculated for each lift. A final density (or density profile) for the multi-lift process could be calculated from the individual lift data to produce a result that could be used for QA purposes.

2. **Mode 2 (Uncalibrated Absolute) –** Mode 2 is provided for the case when the backfilling will use the material originally excavated instead of a controlled, new fill. In this case, calibration data for the soil will not be available. This mode can also accommodate use of compactors or compaction procedures that are not part of the built-in calibration data. For this mode, the operator will enter/select all the data specified for Mode 1 that is applicable. If known, the operator can select the generic soil type. Optionally, the soil moisture can be entered. In this mode a default calibration for the soil type specified will be used. Best accuracy is expected for well-graded, gravely sandy fills without silt, clay, organics, or other debris, such as broken asphalt or concrete. For Mode 2, only a density measurement is produced. A single point Field Proctor Test may be optionally employed to increase the accuracy of Mode 2.

3. **Mode 3 (Relative) –** In some circumstances, there is no requirement for an absolute density reading, or the job specifics (soil, compactor, process) are sufficiently different from the items in the SQI built-in library that an accurate absolute reading would not be produced. In these cases, Mode 3 provides a way of determining when the maximum compaction has been achieved for each lift. In this mode, readings are taken after each compactor pass (usually 4-6 total). Based upon a regression of the readings, and knowledge of the typical densification profile, the maximum density can be estimated and the readings after each pass can be compared to the expected maximum to determine when additional passes would produce little additional compaction. In this mode, no operator-entered data is required.

Preliminary SQI 100 SPECIFICATIONS:

Unit Weight (with battery): under 16 lbs.
Unit Dimensions (with handle): 10 3/4” x 10 3/4” x 11”
Shipping Case Dimensions: 13” x 13 3/4” x 16 1/2”
Operating Temperature & Humidity: ambient 20 to 110°F; RH 95%
Storage Temperature & Humidity: 0 to 150°F; RH 95% noncondensing
Maximum Surface Temperature: 350°F
Power Supply: 12 VDC, 4.0 Amp-hr NiMH
Current Drain: 225 ma

Battery Chargers: fast-charge 120 VAC, 12 VDC, 1 Amp
Recharge Time: 4 hours
Outputs: Density, Percent Compaction, Percent Moisture
Density Linearity: Typical ±2% of full scale or better
Moisture Linearity: Typical ±2% of full scale or better
Display: 4-line alphanumeric, backlit
Keypad: 16 key sealed with tactile feedback
Scale: English lb/cu-ft or metric kg/M^3
Measuring Depth: 3-12 inches (75 to 300 mm)
Continuous Operational Time (fully charged battery): >13 hours
Accessories: Battery Charger, Shipping Case
Data Storage: 99 records by station, location, date and time
RS-232C interface to external computer
Options: GPS locator, Extended Warranty

For more information:

TransTech Systems, Inc.
900 Albany Shaker Rd., Ste 2
Latham, NY 12110
Email: sales@transtechsys.com
R&D: jhewitt@transtechsys.com

Toll Free: 800-724-6306
Phone: 518-370-5558
Fax: 518-370-5538
www.transtechsys.com