Advances in Cone Penetrometer Technology

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Cone penetration testing (CPT) has been routinely used as a site investigation tool in Europe for almost 75 years and is now recognized throughout the world as a viable method of obtaining soils information. The principal reasons for acceptance and increased use of the CPT in recent years are the accuracy and detailed nature of CPT data, the fact that the test is conducted in-situ eliminating sample disturbance and changed stress conditions, and the relative speed and economy of the method as compared to conventional drilling and sampling.

Static cone penetration testing equipment consists of four major components:
[1] a thrusting mechanism (usually hydraulic) for pushing the cone into the ground,
[2] a thrust reaction system consisting of screw anchors or dead weight,
[3] the electronic cones and associated push rods, and
[4] a resistance measurement system.
The cone penetrometer normally contains two resistance strain gauge load cells for independent measurements of tip and friction resistances. Electric signals from the load cells are transmitted through an electrical cable running inside the hollow push rods and are recorded by a computer acquisition system at the surface. The cone is pushed into the ground at a rate of 2 cm/sec to depths in excess of 100 feet.

The use of in-situ tests to compliment conventional drilling and sampling programs has become a cost-effective means of collecting both geotechnical and environmental data. The continuous profiles obtained with the cone penetrometer allow the user to visualize the stratigraphy, to evaluate soil type, to estimate a large number of fundamental soil parameters, and to directly design shallow and deep foundations subjected to vertical loads. Common geotechnical properties which can be evaluated from cone data include horizontal stress, relative density, friction angle, constrained and Young's modulus, stress history, sensitivity, undrained shear strength, coefficient of consolidation, permeability, and liquefaction potential.

The ability of the cone penetrometer to collect continuous stratigraphic data has also made the equipment an invaluable tool for environmental studies. An entire suite of multi-media sampling tools can also be deployed from the CPT truck in addition to push-in piezometers and placement of well screens. Environmental applications have included hydrogeological soil characterization using a standard cone (tip and friction measurements), evaluation of in-situ permeabilities using a piezocone (tip, friction and pore water pressure), mapping contaminant plumes with a conductivity cone (tip, friction, pore pressure, and electrical conductivity measurements), installation of push-in piezometer/monitor wells using steel and PVC material, and ground water, soil and soil-gas sampling within the contaminate zones. In addition to the above, cone penetrometers equipped with piezo elements, conductivity cells, and natural gamma radiation and seismic capabilities in various configurations have been utilized for geotechnical and environmental studies.

Recent advances include the ROST(TM) technology and GeoVIS (Soil Video Imaging System).

ROST(TM) or Rapid Optical Screening Technology provides real-time, in-situ screening of petroleum hydrocarbons (PHCs) in soils such as gasoline, jet fuel, kerosene, diesel, and creosote. The system consists of a tunable laser mounted in the CPT truck that is connected to a down-hole sensor. The down-hole sensor consists of a small diameter sapphire window mounted flush with the side of the cone penetrometer probe. The laser and associated equipment transmit 50 pulses of light per second to the sensor through a fiber optic cable. As the probe is advanced into the soil, the laser light passes through the sapphire window and is absorbed by the PHCs in contact with the window. This addition of energy (photons) to the hydrocarbons causes them to fluoresce. A portion of the fluorescence emitted from any encountered aromatic constituents is returned through the sapphire window and conveyed by a second fiber optic cable to a detection system within the CPT truck. The emission data resulting from the pulsed laser light is averaged into one reading per one second interval (approximately one reading every 2cm of vertical movement) and is recorded continuously.

GeoVIS provides a capability for collecting in situ video images of the subsurface soil environment. The GeoVIS system uses a miniature CCD video camera coupled with magnification and focusing lens systems integrated into a cone penetrometer probe. Illumination is provided by white light-emitting-diodes (LEDs). The soil environment is imaged through a sapphire window on the side of the probe. The video signal from the camera is returned to the surface where it can be viewed in real-time on a video monitor, recorded on a video recorder, and /or digitized. The present optics system provides approximately a 100x magnification factor when viewed on the standard 13-inch monitor.

GeoVIS provides a powerful new method of characterizing soil properties that are important for estimating subsurface waterflow and contaminant transport. GeoVIS can also be used to image non-aqueous phase liquid (NAPL) contamination in subsurface environment.

These advances in CPT technology often yield significant cost savings over conventional investigation due to [1] the methods do not generate any potentially hazardous soil cuttings or fluids and there are no associated disposal costs, [2] the collection and expensive analysis of soil samples for laboratory analyses are not required for delineation of affected soils, [3] only a limited number of samples and analyses were necessary for confirmation purposes, and [4] the high production rate reduces the field hours of personnel which in turn lowers overall project costs. In addition, since the CPT yields continuous lithologic and contaminant screening data, potential data gaps which often require additional field efforts are minimized.

If you have any questions, please contact **Dr. C.Vipulanandan**