Steerable Vibratory System (SVS) For Penetrometer Applications

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Abstract

Penetrometers play an important role in detection, mapping and remediation of underground contaminated sites. At present, penetrometer applications are restricted mainly to vertical pushes. This is due to a technology gap that exists in tracking and steering of the penetrometer tip. In the past six years, UTD Incorporated has worked to close this technology gas by developing an accurate and efficient position location system referred to as the POLO (POsition LOcation) device.

The prototype POLO device was developed under a PRDA contract sponsored by the Department Of Energy (DOE), Federal Energy Technology Center (FETC), Office of Science and Technology. At the completion of this contract, for the first time the penetrometer operator had the capability to know the position of the tip of the penetromer in real-time. Building on this capability, UTD Incorporated was awarded a follow-on three-phase contract under a Research Opportunity Announcement (ROA) program, Contract No. DE-AR21-94MC31178. The objectives of the new contract were to develop a steerable distance enhanced penetrometer delivery system.

The Phase I work was the base year program and was comprised of sub-scale (smaller scale for the purpose of laboratory testing) major sub-systems analysis and design of steering and vibratory penetrometer components. Through the analysis, design work and laboratory and field tests carried out in Phase I, the feasibility of a steerable penetrometer delivery system was demonstrated. In addition, it was shown that vibratory penetration increases depth of penetration by reducing the magnitude of the retarding forces on penetrometer rods.

The work in Phase II was carried out to generate an integrated design of a full-scale steerable/distance enhanced penetrometer delivery system. The integrated Steerable Vibratory System (SVS) is comprised of four major sub-systems. They include the steerable tip, steerable rods, POLO, and the vibratory rig. The steerable tip has two modes of operation for straight or curved pushing. To switch from one mode of operation to another, the rods connected to the tip have to be turned from the surface by at least 180 degrees. The rods used with the SVS are stronger in bending and are equipped with locking joints. This is necessary in order to be able to push along curved paths and to avoid loosening of rod joints when turned from the surface.

Phase III work started in May 1996 and culminated in a field deployable SVS and its field demonstration on August 7, 1997. The demonstration test was performed at a private site in Delmar, Maryland to members of Industry, DOE, and DOD. The demonstration began with a quick introduction to UTD's steerable penetrometer technology and hardware. Than a target point 71 feet underground, 11 feet Southeast of the surface entry location was selected. The initial attitude of the penetrometer was within 1.5 degrees of vertical. Penetrometer rods were pushed straight for about 12 feet. The POLO sensor indicated a penetrometer rod bend radius of about 500 feet. At this point the steering tip was engaged by rotating the penetrometer rod counterclockwise from the surface. This oriented the penetrometer tip to veer in a Southeast direction. The path assumed a radius of 150 feet after only two more rods were pushed.

At 1500 lbs, the Steerable Vibratory System is lightweight. It's static thrust capability is over 6000 lbs., the excess beyond the system's weight is made up with anchors screwed into the earth. The rig hit refusal at a depth of 35 feet, at which time the vibratory head was engaged; the rig continued to advance without incident. At a depth of 71 feet, UTD's POLO navigation system indicated the penetrometer tip was within 2 feet of the underground target location. Past results have shown POLO's positional accuracy to be better than 0.5 percent of the distance pushed or about 4.3 inches at a depth of 71 feet.

Vibratory pushing continued until a depth of 76 feet, at which time the ability to change direction mid-course was demonstrated by rotating the tip to veer in an easterly direction, and advancing four more rods to a final depth of 91 feet. At this point rod pushing was stopped in the interest of time.

Ongoing work related to SVS includes marketing and commercialization. As part of this effort commercial partners are sought for distribution of SVS as a whole or its individual components separately.

Many individuals from DOE, and UTD subcontractors were instrumental in successful completion of this contract. They include Messer. Craig Hustwit (DOE, COR), John Duda (DOE, FETC), John Hall (Ditch Witch of Georgia), John Clarke and Hugh Scott (MPI Drilling), Edward Kelley (Atlantic Coastal Co.), Allen Fisk (Foster-Miller), Joe Rossabi and Brad Pemberton (Westinghouse, Savannah River Co), and Mark Noll (Applied Research Associates).