Tools for Direct-Push Subsurface Environmental Investigation and Remediation

EVS-developed tools improve capabilities of direct-push cone penetrometer methods for subsurface investigation and remediation. One tool provides rotational force and unrestricted air flow for drilling through hard, consolidated subsurface layers. The second tool is an extendable, one-way delivery system for injecting materials to aid subsurface remediation, with improved control over placement and quantity of injected chemical and biological media.

PROBLEM/OPPORTUNITY

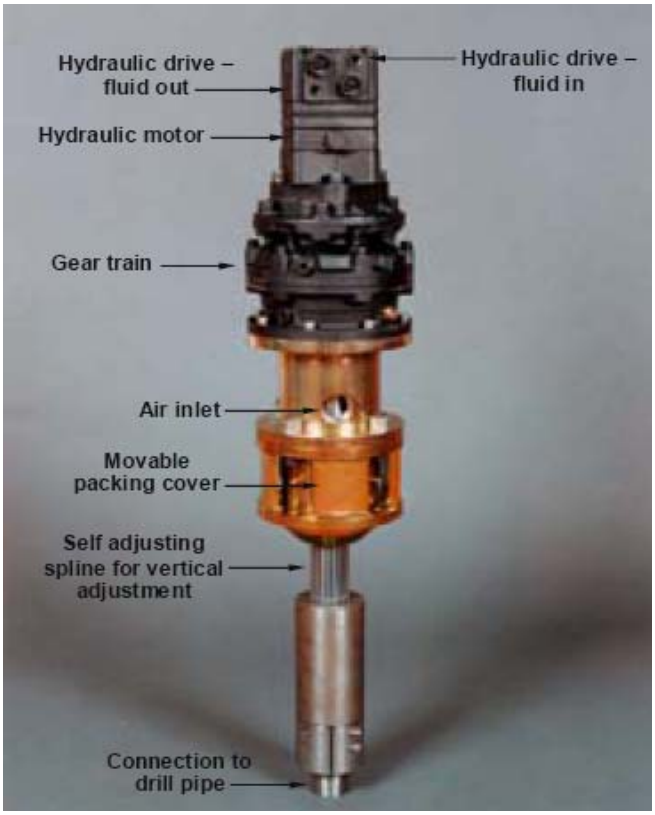
Conventional and sonic drilling rigs can penetrate virtually any material to great depth, but they are expensive and cumbersome to operate in environmental investigations. Contaminated material brought to the surface requires special handling and can be a safety concern for workers.

An alternative, the direct-push cone penetrometer, was developed in the 1930s in The Netherlands. This device uses up to 40,000 pounds of hydraulic force to push a steel instrumented cone or a sampling device into the ground. No material comes to the surface unless soil or groundwater samples are being collected. Direct-push technology eliminates the need for disposal of cuttings and solidification of drilling fluids.

Steel cones equipped with electronic sensors can generate real-time information for subsurface characterization. The cone penetrometer, typically mounted on a truck or a tracked vehicle, is more mobile and less expensive to operate than a conventional drill rig. However, the cone penetrometer is typically limited to depths of 150 feet in unconsolidated or highly weathered material.

APPROACH

Argonne National Laboratory's Environmental Science Division (EVS) has been using direct-push technology routinely in its environmental site investigations since the early 1990s and has continually participated in the development and testing of new equipment and concepts for subsurface environmental investigation and remediation. Included in the Argonne developments are two tools for use with direct-push cone penetrometer equipment. One tool provides rotational force and unrestricted air flow for drilling through hard subsurface layers that conventional direct-push technology alone cannot penetrate. The second tool is an extendable, one-way delivery system for injecting materials to aid subsurface remediation, with improved control over placement and quantity of injected chemical and biological media versus previous delivery systems.



Cone Penetrometer Power Swivel
Developed by Argonne

RESULTS

EVS's direct-push drilling swivel and air delivery system greatly improves the penetration capability of direct-push technology, while retaining its advantages of greater mobility, lower cost, and decreased invasiveness and waste generation versus conventional drilling.

The swivel has a stationary part coupled with a hydraulic motor and a mounting platform, as well as a rotating part coupled with the drill string. In addition, the swivel permits a high-volume, leak-free flow of air into the rotating part.

The direct-push drilling swivel employs a planetary gear to transfer power from the hydraulic motor to the rotating drive shaft. As it is pushed downward with a force up to 5,000 pounds, the swivel spins a hollow-core drill string and drill bit to make a boring, typically of diameter 1.25-6.25 in.

The swivel provides an unrestricted pathway with a cross-sectional area of at least one square inch for the flow of air (or other fluids). Compressed air supplied at the upper end of the air pathway is controlled by pneumatic and solenoid valves. A communications link displays readings from pressure sensors above, between, and below the valves. The operator remotely closes the upper valve and opens the lower valve to bleed the pathway before a new pipe section is added. For safety, the valves automatically revert to this configuration in the event of a power failure.

During operation, the compressed air used for drilling passes through the open valves and into the power swivel. The power swivel turns the drive shaft within a stationary housing, periodically aligning air apertures to create a continuous inner passageway for air to the drill bit. Air exiting the drill bit carries cuttings to the surface through an outer passageway. Near the surface, a pack-off seal and a drilling nipple direct air and cuttings to the desired location above the ground.

A second EVS-developed tool is an extendable, one-way delivery system for injecting remediation-aiding materials into a contaminated subsurfaceenvironment. This ejector/injector tool achieves new control and flexibility in the direct-push delivery of materials for underground, *in situ* biological or chemical remediation of contamination. Previously available tools have lacked the new device's ability to treat a large or small vertical area and to control the amount of treatment material released into soil or groundwater.

EVS's direct-push ejector/injector tool includes a hollow body connected at one end to the push rod string and at the other end to an annular valve body with a central tubular opening. An extendable delivery tube with multiple fluid delivery ports passes through the valve body and into the hollow body. O-rings in the valve body ensure a liquid-tight fit within the delivery tube. The interior end of the delivery tube is coupled to a stop ring providing for a number of optional fluid paths.

The spacing of multiple delivery ports at different radial and linear positions along the extendable delivery tube enables controlled application of selected nutrients and chemicals at specific subsurface depth zones. The valve body can be closed as the ejector/injector tool is passed into the hole and opened at the desired depth. Together, the control systems enable the delivery of one or more materials at a single depth or at desired intervals — at flexible application rates (for example, 0.25-4.0 gpm) and at a range of depths (for example, 5-300 ft below ground level) — without loss of material or unwanted flow-back or backpressure.

COMMUNICATION OF RESULTS

Two patents have been awarded for the design and use of the direct-push drilling swivel and air delivery system developed by EVS, and a third patent is pending for the design of the ejector/injector tool. Efforts toward commercialization are under way.

EVS has hosted conferences of international experts on cone penetrometer testing in geotechnical and environmental practice. Presentations covered theory and practice; soil stratigraphy and engineering parameters; factors influencing test results; problem soils; environmental engineering, geology and hydrogeology; field demonstrations; and equipment exhibits.