Geo-Strata Magazine
ASCE – Geo-Institute
October/September 2005

Beans Help Build Deep Drainage Trenches

by Christopher R. Ryan, P.E. and Steven R. Day

Today's geotechnical engineers are fortunate to enjoy a wide range of construction technologies that can be applied to nearly any problem encountered in the field. For example, in situations where dewatered and sheeted excavations are not feasible or cost-prohibitive, Bio-Polymer (BP) slurry technology may provide the most effective solution.

BP technology has been used for the installation of aggregates, drain pipes, geotextiles and wells for groundwater extraction systems, and reactive media for permeable reactive barriers. BP drains have also been installed to collect and treat contaminated groundwater, to maintain inward gradients at contaminated sites, and for slope stabilization. The process has been in use in the United States since the mid-1980's in about 100 to 200 applications.

Overview

Bio-Polymer (BP) slurry trenches are a variation of the slurry construction method where biodegradable slurry is substituted for bentonite slurry to support deep trench excavations beneath the groundwater table. The resultant trench is backfilled with a drainage medium, forming a relatively deep "French drain" or planar well. This technology represents a small but growing fraction of the total slurry wall installations in the U.S.

BP trenches are used for a variety of applications including:

- Groundwater collection/extraction for pump & treat systems,
- Reactive barriers for insitu groundwater treatment,
- Funnel and gate systems for plume intersection and treatment,
- Groundwater treatment systems using air-sparging,
- Toe drains in earthen dams,
- Leachate collection systems around waste sites and landfills,
- Slope stabilization for highway and railroad cuts,
- Dewatering trenches for mass excavations, and
- Product recovery trench systems.

BP trenches are sometimes combined with slurry walls that create barriers that redirect or contain groundwater to take advantage of the economic benefits of using the same basic construction technology to both divert and collect groundwater. In some cases geomembranes are installed in BP trenches to combine groundwater collection and groundwater barriers in the same trench.

The BP method has several significant advantages over conventional excavation methods such as sheeting piling, trench boxes, dewatering and mass excavation including:

- Faster construction rates,
- Reduced excavation volumes and reduced volumes of backfill,
- No dewatering or liquid disposal,
- No sheeting or shoring,
- Serves as an important environmental engineering control for reducing odors and toxic emissions during installation,
- Reduces physical safety concerns since workers cannot enter the trench,
- Enhanced trench stability, and
- Significantly reduced construction costs.

Guar Gum and the BP Trenching Method

The bio-polymer slurry trench drain is a modification of the conventional slurry trench. A narrow trench is advanced with a hydraulic excavator to typical depths of 5 to 25 meters. While conventional slurry trenches use bentonite slurry to stabilize the trench walls, the BP method uses biodegradable slurry. But unlike bentonite, bio-polymer will not permanently plug the trench walls, so that drainage through the trench walls can be achieved. As the trench is excavated, slurry is pumped in so that the trench remains full of slurry at all times while the excavator digs under and through the slurry (Figure 1). The BP slurry stabilizes the trench walls and excludes groundwater from entering the trench. The support provided by the slurry maintains the trench at essentially the same width as the excavator bucket.

Figure 1: Trenching under BP Slurry

The most common polymer for BP trenching is guar gum, a naturally occurring carbohydrate polymer derived from the bean of the guar bush that is relatively low in cost, can be maintained with additives and is easy to break down. Guar gum slurry is constantly in a state of degradation because it serves as a preferred food source for natural soil microorganisms, therefore, additives are used to slow biological activity and maintain the slurry's useful properties. The guar gum slurry formulation is more complex than bentonite slurry (up to 10 additives may be needed) and the slurry can be broken down by naturally occurring microorganisms and/or by introducing chemicals or enzymes. When properly made and maintained, BP slurry will retain a high viscosity and remain effective for about two weeks. Residual by-products (prior to consumption by soil micro-organisms) are simple sugars (mannose and galactose) and water. Guar gum is generally regarded as safe and is a FDA-approved food additive used in products like ice cream. There are also synthetic polymers used in some applications.

The challenge when using BP slurry in construction is to keep the slurry active long enough to complete the required construction. Without additives, the slurry may lose its viscosity and ability to support the trench. With additives (biocides and/or pH control), the active life of the slurry can be extended to about two weeks. While BP slurry is resistant to most chemical contaminants, hot weather and concentrated microorganisms (such as from a septic field) can create a situation where slurry stability is more difficult to control.

While the slurry makes it impossible to visually inspect the trench during the work, it is possible to install a variety of drainage features and lining materials the trench through the slurry. Light-weight drainage materials such as pipes, wells, geo-membranes and geo-fabrics must be weighted with ballast so they can sink through the slurry (Figure 2). Temporary wells are also placed in the trench to provide access for later degrading of the BP slurry.

Figure 2: Placing geotextile filter

Backfill is placed in the trench after the drainage features have been installed. The most common backfills are aggregates such as pea gravels and graded sands, but reactive materials such as zero valent iron or activated carbon can also be installed. Depending on the type and gradation of the backfill, it can be simply dumped into the trench (Figure 3), or placed via slope displacement or by tremie. As the backfilling progresses, BP slurry is pushed forward along the trench alignment while excavation and backfilling proceed simultaneously. This process limits the amount of slurry that is required.

Figure 3: Placing a well and backfilling

After backfill material is placed in the trench, the last steps are to break the slurry and develop flow into the trench. The slurry is broken down by adding enzyme breakers through the backfill by pumping from temporary wells. Pumps withdraw slurry from near the bottom of the wells and discharge the slurry over the surface of the backfill, circulating it through the backfill. The polymer is converted to simple carbohydrates, which the native soil microbes can then consume.

Proper trench development ensures a free flow of groundwater through the trench. When the slurry is degraded or “broken the viscosity is reduced to that of water so that groundwater can pass freely into the installation.

The BP slurry is considered broken when the liquid in the trench has a Marsh Funnel viscosity less than 30 seconds and a pH within background range for the site. The

degraded slurry should show greatly reduced turbidity, but may retain a “sticky feel” which will later be consumed by natural microbes. Cold weather, variable groundwater chemistry, and sterile conditions may reduce the efficiency of the slurry breakdown, thus requiring additional methods. Finally, the degraded slurry can be “polished” to reduce potential odors by adding oxidizers such as chlorine or hydrogen peroxide. Oxidizers are not added to backfills such as zero valent iron, where they could reduce the reactivity of the backfill.

Complex Installations

BP slurry drainage trenches can be used for applications such as groundwater collection trenches, enhanced well fields, air-sparging lines, permeable reactive barriers, and toe drains on earthen dams. The technique is flexible and enables the installation of combinations of features in the drains.

Figure 4: Placing a geomembrane in a BP drain

Vertical sumps or wells can be installed through the slurry with minimum effort and cost. When installing horizontal pipes, materials suited to this application, such as butt-fusion welded HDPE pipe, should be specified. Pipes with joints (e.g., PVC sewer or water pipe) and corrugated HDPE pipe can easily bend or crush when installed through slurry. When manholes are required, it may be better to install the pipe using BP slurry and then use a shored excavation to install the manhole.

Geo-membranes (or liners) and geo-textiles (or filter fabrics) can also be installed in BP trenches. Lining the down-gradient wall of a trench will permit the installation of a combination drain and barrier in a single trench. Interlocking joints are available for HDPE liners, or, overlapping panels can be used to provide barrier continuity (Figure 4).

Bio-degradable Products….A Proven Alternative

BP slurry technology allows engineers to provide deep drains on projects where groundwater collection, relief or treatment is required. Two advantages of this technology are that no shoring or dewatering is needed during installation and that drains of almost any depth can be constructed.

Using a natural, safe, bio-degradable product offers a proven alternative for drainage trench construction compared to traditional methods, which can be difficult, dangerous, expensive and time-consuming trenching projects.