Temporary Structures

Slurry Trench / Diaphragm Walls
Overview

The sixth lesson provides an overview on the Slurry Trench / Diaphragm Walls method. The slurry trench method is used for creating impermeable groundwater barriers or cutoff walls; they are also used to contain contaminated ground water. Diaphragm walls are used in cases of troublesome dewatering and excavation support problems, which involves constructing an impervious barrier beneath the ground surface utilizing tremie concrete method.

Lesson Objectives

By the end of this lesson you will be able to:

- describe slurry trench method and its application;
- describe diaphragm wall design considerations and applications;

Reading Assignment

Class notes.

Optional Reading - Ratay, Chapter 9 “Diaphragm/Slurry Walls”
Introduction

In recent years, the slurry trench method has been successfully developed to deal with particularly troublesome dewatering and excavation support problems. These methods involve constructing an impervious barrier beneath the ground surface.

Slurry Trench Method

The slurry trench method is used for creating impermeable groundwater barriers and has been used for decades to create economical and positive cutoff walls in the core or foundation soils beneath dams and dikes of many types and sizes. Slurry walls are also used to contain contaminated ground water, divert contaminated ground water from the drinking water intake, divert uncontaminated ground water flow, and/or provide a barrier for the ground water treatment system.

The bentonite or drilling mud clays are generally formed from volcanic mineral (montmorillonite) clays, the highest grade being found in Wyoming. The bentonite is supplied to the site in a powdered form. When added to water in its dry powder form the bentonite is blended to form a viscous (thick and sticky) fluid. When the clay particles are thoroughly mixed and hydrated or soaked, this causes the particles to bond to each other evenly and swell to form a gel. If the bentonite is left to stand for a period of time it forms a gel or bonding of the swollen clay particles. This increases the stabilizing quality of the fluid in the excavation. One could imagine a freshly mixed jelly poured into a mould which then gains strength over a period of time. However, bentonite once in motion again reverts back to its fluid state a process that can be repeated indefinitely. Bentonite is sensitive to many chemicals and has different qualities when blended with each. Just raising or lowering the pH (acidity/alkalinity) can cause the thickening of the fluid till it becomes almost a solid, or on the other hand it can be made to separate into a sludge on the bottom of the tank with clear water on top. By manipulating viscosity the designer of the mix can suspend particles e.g. sand in the mud. Further into construction concrete is used to displace the bentonite.

These subsurface barriers consist of a vertically excavated trench that is filled with slurry. The slurry hydraulically shores the trench to prevent collapse and forms a filter cake to reduce ground water flow. The slurry trench technique uses an engineered fluid for support of trench walls. Usually the fluid is bentonite slurry that coats the trench walls and permanently blocks the free flow of water.

Most slurry walls are constructed with a mixture of soil and bentonite that provides an impermeable, but non-structural barrier. The bentonite slurry is used primarily for wall stabilization during trench excavation. A soil-bentonite backfill material is then placed into the trench (displacing the slurry) to create the cutoff wall. Walls of this composition provide a barrier with low permeability and chemical resistance at low cost. In some cases, a material with moderate structural strength is desirable. A mixture of soil, cement and bentonite (SCB) has recently seen increasing acceptance. SCB is stronger and more impermeable than cement-bentonite grout, but flexible enough to allow for deformation, and usually less costly. Other wall compositions, such as cement/bentonite, pozzolan/bentonite, organically modified bentonite, or slurry/geomembrane composite,
may be used if greater structural strength is required or if chemical incompatibilities between bentonite and site contaminants exist.

Slurry walls are typically placed at depths up to 100 feet (30 meters) and are generally 2 to 4 feet (0.6 to 1.2 meters) in thickness. The most effective application of the slurry wall for site remediation or pollution control is to base (or key) the slurry wall 2 to 3 feet (0.6 to 0.9 meters) into a low permeability layer such as clay or bedrock. This "keying-in" provides for an effective foundation with minimum leakage potential. Figure 1 depicts construction sequence of a slurry trench.

Figure 1 - Construction sequence of a slurry trench

Diaphragm Walls

Diaphragm walls, which are common in the construction industry, are used in cases of troublesome dewatering and excavation support problems. It involves constructing an impervious barrier beneath the ground surface. They are constructed from the surface level by excavating a long deep trench. After the excavation is completed, a reinforcement cage is inserted in the trench and concrete placement follows using tremie concrete method (explained in the next section), from bottom to the top. Similar to the slurry trench method, to prevent the sides of the excavation from collapsing before the concrete is placed, it is filled with a thick bentonite slurry, which bonds to the walls and holds the soil material together.

To construct the diaphragm walls, deep trenches are excavated in long sections using a special equipment commercially known as Hang Grab, which is shown in figure 2. At the same time the bentonite mix is pumped in to stabilize the walls of the trench. Hang Grab is designed for excavating soil continuously until it reaches in a certain depth
providing bentonite in order not to let the wall break down and not to inflow underground water.

The procedure of underground diaphragm wall method is that the soils are excavated continuously. This is followed by the lowering of steel reinforcement cages, which are prefabricated on site. Concrete is then placed into the slurry filled trench. A pump is set up at the surface of the excavation and as the bentonite is being displaced with tremie concrete, it is pumped back to the bentonite plant, cleaned and stored for construction of the next panel. A PVC (polyvinyl chloride) waterstop joint is placed between each panel. Structures such as below grade facilities should have a waterstop system in place. These waterstops are made of PVC and are formed into Concrete joints during the actual concrete placement. The PVC waterstop then bridges the joint between the concrete sections to prevent water from coming through the joint. Waterstops are typically used in large foundation work, bridges, and Dams.

Each panel is deliberately overfilled with concrete so that the top section, which gets contaminated with bentonite and sand, can be removed back to the finished height of the walls. When the concrete is cured, the construction site is enclosed within a rigid, impervious barrier. This method has been employed to depths exceeding 200 feet.

Figure 3 shows the construction of an underground concrete diaphragm wall.
Placement of the concrete seal is by tremie concrete
For placement of tremie concrete method, refer to Lesson 3.

Lesson Summary
The diaphragm wall technique is a tried and true construction method, which provides very good support of existing foundations, during adjacent construction operations. The method has many civil applications. Diaphragm walls are commonly used in congested areas for retention systems and permanent foundation walls. They can be installed in close proximity to existing structures, with minimal loss of support to existing foundations. In addition, construction dewatering is not required, so there is no associated subsidence.