Abstract

The plans for eliminating the off-site migration of a non-aqueous phase liquid (NAPL) from a refinery into a nearby river included the installation of a High Density Polyethylene (HDPE) curtain wall and an underdrain system.

A 640 m (2100 lineal feet) HDPE Curtain Wall was installed along the river boundary, tying into an existing sheet pile wall on both ends. The wall varied from approximately 4.5 m (15 feet) deep at the northern end to about 7 m (23 feet) deep at the southern end, running approximately 3 to 3.6 m (1 to 12 feet) inland of an existing wooden bulkhead. The curtain wall was successfully installed through a slurry supported trench.

A 930 m (3050 lineal feet) interception/collection trench was installed parallel to the HDPE Curtain Wall, continuing on beyond the curtain wall on the southern end. The depth of the trench varied approximately 3 to 4 m (10 to 13 feet) deep. A 20.32 cm (8 inch) diameter perforated HDPE header pipe was placed in the trench to convey groundwater and product to two sumps. The trench is 53.34 cm (21 inches) wide and contained aggregate to approximately 0.9 m (3 feet) below ground. This work was accomplished using the bio-polymer slurry drainage trench (BP Drain) technique.

This paper briefly describes the construction methods utilized during this project, specifically HDPE curtain wall installation thru a bentonite slurry and tie-in to the existing sheet pile wall.

Introduction

At the site of an active refinery, NAPL was entering a river, via groundwater, adjacent to the facility property line. The area of flow was concentrated to a 640 m (2100 lineal feet) stretch. Existing sheet pile walls along the river, upstream...
and downstream of this open section, directed the NAPL to this area. An HDPE curtain wall was selected to contain the flow because of its excellent resistance to the contaminants found on site.

The challenges presented by this project were the attachment of the curtain wall to the existing sheet piles walls and the selection of an installation method for the curtain wall panels through soil conditions present, which were known to contain various construction debris and rubble.

Curtain Wall Panel Installation

The curtain wall was installed through a slurry using frames. This method was selected because of the soil conditions along the wall alignment, and the presence of the construction debris and rubble along centerline. By installing the panels through a slurry supported trench, the integrity of the HDPE could be assured.

Although there were no set procedures to install the wall, standard slurry wall techniques and equipment were used. The initial step was taken to excavate a 0.6 m (2 feet) wide trench, using a bentonite slurry to support the side walls. The slurry produced at a mix plant which consisted of a 3.82 cubic meter (5 cy) colloidal mixer, and two 15.24 cm (6 in.) trash pumps. A nearby fire hydrant supplied the water used to fill the 3,785.4 L (1000 gallon) mixer. Approximately 181.5 kg (400 lbs.) of bentonite powder was introduced into the water-filled mixer and agitated. Once a fully hydrated slurry was produced (typically after 5 minutes of mixing) it was then transferred to the trench using one of the trash pumps and polyethylene pipe. As the excavator, a CAT 330L, removed the material from the trench, it was replaced with the hydrated slurry from the mix plant.

The excavated spoils were cast to the inside of the trench, away from the river, and spread out. A combination of a trackhoe and a rubber tired loader sorted through the spoils to remove the abundance of construction debris. The debris included items such a brick clusters, wooden lagging, wire, plywood sections and various other construction waste materials. This was a critical step which required thorough removal of all foreign matter which could have possible adverse effects on the integrity of the curtain wall. This debris was transferred to dumpsters in close proximity to the trenching area for proper disposal. Once the debris was separated from the spoils, the remaining material was mixed with a dozer to form a homogenous mixture of spoils and slurry. To accomplish this, the dozer tracked back and forth through the spoils, using the tracks and blade of the dozer, to blend the materials. At times, additional bentonite slurry was added to the spoils to form a slump which was adequate for proper backfilling of the trench, typically 5.1 to 10.2 cm (2 to 4 inches). Although this is a standard process to construct a low permeability soil-bentonite cutoff wall, the makeup of the contaminants were not completely compatible with bentonite as indicated by
the trial mix program which was completed prior to the job startup. Thus, the addition of a curtain wall provided the added impermeability necessary to stop the flow of contaminated groundwater into the river.

Once a lead-in slope was excavated, normal slurry trenching continued. Due to several areas along the centerline of the trench, which contained large pieces of debris, the top of the trench became wider at those sections. Also, at several stations along the trench alignment, abandoned utilities were encountered. All utilities were removed and plugged, prior to panel installation, to avoid interference with the continuity of the curtain wall. This also resulted in portions of the trench becoming wider at the top. In those areas where trench width was increased, portable walkways were utilized to allow for easier access while installing the curtain wall in the trench.

Another item which had to be considered during trenching, was the influence of the nearby tidal river. Tidal influence caused fluctuations in the groundwater elevation, which varied from 0.6 to 1.8 m (2 to 6 feet) below the working platform. As the groundwater elevation rose, the stability of the trench became a greater concern. Trench stability was controlled by the rheology of the bentonite slurry, level of slurry in the trench, soil conditions, and by limiting the amount of open excavation (portion of trench filled with slurry) prior to the panel installation procedure.

After approximately 21.3 m (70 lineal feet) of trench was excavated to full depth, the initial panel of HDPE curtain wall, which had previously been secured to its frame, was lowered into the slurry filled trench to the proper elevation. The panel was moved into place using a 35 ton, rough terrain crane. Each panel was 12.2 m (40 feet) wide and as deep as required for each section of trench in which it was installed. The geomembrane itself was 80 mil thickness. Attached to the geomembrane were 160 mil interlocking channels on both edges. These channels were used to connect the series of panes together to form a continuous curtain wall (Figure 1).

Once the panel was lowered to the bottom of the trench, it was positioned with the crane towards the outside wall of the trench, nearest the river. The panel and its frame were stabilized and left in place. Excavation of the trench continued until there was sufficient open trench (trench supported by slurry) to install the next panel. Once this was accomplished, the succeeding panel was attached to a second frame. The panel was elevated, using the crane, and interlocking channels on both panels were aligned to connect the HDPE. A small diameter, hydrophilic, high swelling gasket material was placed between the connections to assure that the joint is watertight. The gasket material was a rubber joint seal which expands up to five times its volume when exposed to liquid. During panel interlocking, the bentonite slurry was used to aid in the lubrication of the HDPE joints and the gasket material to ensure that the gasket would not be broken as the panels slip together.
At several instances during panel installation, wind became a concern. At all times, taglines were utilized to guide the elevated panel into place. Due to the large area of each panel, small amounts of wind would cause interference with typical installation, and create unsafe conditions for employees attempting to restrain the taglines. In several instances, the taglines were tied to equipment to stabilize the panel before lowering it into the trench. On a few occasions, all installations had to cease because the sheets became uncontrollable in higher winds, creating a safety concern.

Once the second panel was successfully installed and stabilized, backfilling of the trench could begin. Previously sorted and mixed backfill was lowered into the trench via the lead-in slope. Due to the low slump of the material, the slope of the backfill was maintained between 2:1 and 4:1. Backfilling continued until the toe of the backfill reached the far end of the first panel, at a minimum. This was determined by regularly sounding the trench with a weighted tape measure. To allow for the backfill volume, slurry trench excavation continued at the opposite end. Once sufficient backfilling was complete, the frame on the initial panel was released and removed from the trench, allowing the HDPE panel to remain in place (Figure 2). Another panel was secured to the frame and prepared for installation. Once adequate trench was excavated, the third panel was connected to the second and submerged under the slurry. This process was repeated until the entire length of trench was complete with the interlocking, nonstructural HDPE wall. At both ends, the curtain wall was tied into an existing metal sheetpile wall.

**HDPE Curtain Wall To Sheetpile Tie-In**

The most unique feature of this project was the HDPE curtain wall to sheetpile tie-in. It was decided to leave the existing sheetpile in place as a barrier wall. The existing sheetpile effectively cut off groundwater flow from the site to the river, except for a 636 m (2100 lineal foot) section where the sheetpile was not installed in lieu of an existing wooden bulkhead. Over time, the wooden bulkhead deteriorated and came to disrepair. The sheetpile, however, remained in fair condition. The challenge was in coming up with a means of creating a watertight connection between the existing sheetpile and the HDPE curtain wall.

After entertaining numerous ideas and connection variations, a connection using both a mechanical joint and the manufacturers standard curtain wall joint was employed. The manufacturers' HDPE joint (SLT Curtain Wall Interlock™) as shown in Figure 1 was attached to the sheetpile by means of a mechanical joint (Figure 3). To make the attachment, the ending sheetpile panel was removed using an excavator. A section of interlock was cut to the length of the removed sheetpile section. The edge of the sheetpile where the connection was to be made was thoroughly cleaned, using a wire brush attachment on a
hand drill. Once the sheetpile was cleaned, the HDPE interlock was ready to be mechanically attached.

Standard mechanical attachments are most frequently used to attach HDPE liner to an existing concrete structure. The major component of the mechanical attachment is the batten strip. The most commonly used batten strip is made from stainless steel type 301 or 34. Typical dimensions are 5.08 cm (2 inch) wide by 0.64 cm (1/4 inch) thick, coming in lengths of 3 to 3.6 m (10 to 12 feet). They can be cut to the desired length. To facilitate installation, the batten strip is slotted with 0.95 cm (3/8 inch) wide by 1.11 cm (7/16 inch) long slots on 15.24 cm (6 inch) centers. These slots receive the anchor bolts which hold the batten to the concrete structure. The anchor bolts which are most frequently used are 0.95 cm x 9.53 cm (3/8 inch x 3 3/4 inch) anchor length stainless steel bolts. To install, the concrete is drilled and the anchor bolts are set on 15.24 cm (6 inch) centers. A 5.08 cm (2 inch) wide by 0.32 cm (1/8 inch) thick neoprene gasket with an adhesive backing is then applied continuously along the length to be battened. The geomembrane being attached is then pulled into place, cutting undersized holes at the anchor bolt locations, and forcing the membrane down over the anchor bolts. The stainless batten is then positioned with the anchor bolts through the 0.95 cm (3/8 inch) by 1.11 cm (7/16 inch) slots and tightened down to create a watertight seal.

This standard mechanical attachment, with slight alterations, was used to attach the manufacturers’ HDPE joint to the sheetpile panels. A standard head 0.95 cm x 5.08 cm (3/8 inch x 2 inch) stainless bolt was used in place of the anchor bolts. Then, upon review of the chemical resisitivity properties of the neoprene gasket, it was decided to use a nitrile gasket instead. While neoprene offers moderate resistance to petroleum oils and gasoline, nitrile offers excellent resistance to these products. To attach the interlock, the sheetpile panel and the HDPE interlock were drilled on 15.24 cm (6 inch) centers. The nitrile was then applied continuously along the edge of the sheetpile panel. The bolts were then fed through the sheetpile panel from back to front. The interlock was next placed over the bolts, followed by the stainless steel batten strip. The nuts were then tightened down on the bolts until the nitrile was compressed enough to create a watertight seal.

Now, the section of sheetpile with the HDPE interlock attached to it was complete. The next obstacle which had to be overcome, was driving this sheetpile panel back into the ground without destroying the interlock itself. In order to do this, the next two adjacent sheetpile panels were also removed with the excavator. The sheetpile alignment was then excavated to depth back to the next sheetpile panel section which remained in place. Care was taken not to damage the sheetpile joint with the excavator bucket during excavation. This excavation was done under a slurry to support the trench due to the depth of excavation (approximately 5.45 m (18 feet) deep), groundwater elevation (approximately 0.9 m (3 feet) below ground surface), and soil conditions. The
sheetpile panels were then re-installed through the slurry supported trench, using a vibratory hammer. This method allowed the sheetpile panels to be easily installed with no damage to either the sheetpile joints or HDPE interlock. The curtain wall installation then proceeded as previously described.

Summary

The completed curtain wall, which tied in on both ends to an existing steel sheetpile wall, proved to be a very effective way to control the off-site migration of contaminated groundwater. The addition of a soil-bentonite backfill, in conjunction with the curtain wall, amplified the effectiveness of the cutoff system. After the wall was completed, an interceptor/collection trench was installed approximately 4.6 to 6.1 m (15 to 20 feet) off of the centerline of the curtain wall. This system was used to collect the groundwater which was cut off by the barrier wall. The combination of curtain wall backfilled with soil-bentonite backfill, and the collection trench, was a very successful combination.

Groundwater infiltration into the river has been deferred to the collection trench, therefore, eliminating any future problems for the refinery in this location. The collected groundwater was transferred to a treatment facility where it was conditioned and disposed of properly. This system was installed efficiently and operates as intended.
CurtainWall INTERLOCK DETAIL

FIGURE 1

GEOMEMBRANE CurtainWall INSTALLATION

FIGURE 2
STEELE
SHEET
PILES

CurtainWall.
INTERLOCK

FOR SHEET PILE
CONNECTION SEE
DETAIL THIS SHT.

JOINT

CurtainWall
INTERLOCK

STEEL BATTEN

NEOPRENE GASKET
3" WIDE x 1/8" THICK
x LENGTH TO SUIT

SHEET PILE

SHEET PILE CONNECTION DETAIL

FIGURE 3