SHAFT CONSTRUCTION IN TORONTO USING SLURRY WALLS

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PROJECT DESCRIPTION

The York Durham Sanitary System (YDSS) Interceptor in the Town of Richmond Hill located just north of Toronto, Ontario, Canada will see the construction of a tunnel extending along 19th Avenue for a length of approximately 3.8 Km from Yonge Street, east to Leslie Street and will have a minimum internal diameter of 2.1 m.

The tunnel will connect into four shafts, for which two of the shafts will be constructed using the slurry wall construction method given the high water table and difficult ground conditions encountered at these locations.

The two shafts noted as Access Shaft No. 2 and No. 3 were designed and constructed to meet regulatory conditions, which required a sealed shaft construction method.

GEOGRAPHICAL PROFILE

The ground conditions in the Toronto region consist predominately of glacial till, glaciolacustrine and glaciofluvial sand, silt and clay deposits, and beach sands and gravels.

The shallow geological formation found in the project area consists of four types of deposits: Oak Ridge Morain deposits, Halton Till, Glacial lake deposits and Organic soils.

The Oak Ridge Morain is the dominant deposit encountered along the tunnel alignment. This formation consists of three deposits: The Upper Till, Middle Sand and the Lower Till. Standard penetration tests (SPT) carried out in these deposits measured N-values ranging from 2 to more than 100 blows/300mm which indicate very loose to very dense soil conditions.

The Middle Sand deposit will be the dominant feature within the slurry wall construction at access shafts 2 and 3.

Access Shaft 3

The base of the slurry wall will be 20.5 M below the ground surface. Slurry wall excavation will be within peat and organic soils found at the upper 3 M, followed by 5 M of the Upper Till. The remainder of the excavation will be within the Middle Sand. The piezometric head elevation is found at the ground surface.

Access Shaft 2

The base of the slurry wall will be 22.5 M below the ground surface. Slurry wall excavation will be entirely within the Middle Sand 2.The piezometric head elevation is found at 7 M below the ground surface.

Figure 1. Slurry wall rig equipped with hydraulic clamshell

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Equipment

The choice of equipment is governed by certain site requirements and tasks. Alignment and verticality are the most essential elements for a successful result. The primary slurry wall construction equipment consists of a hydraulic pile rig equipped with specialized clamshell buckets. This rig will excavate through the overburden material to the required depth. The KRC Casagrande hydraulic clamshell bucket is fixed to a rigid Kelly bar enhancing vertical excavation tolerance through the dense soils. Figure 1 shows slurry wall equipment excavating at Shaft #2.

Slurry Wall

Prior to the construction of any slurry wall, guide walls are constructed to facilitate proper vertical and horizontal alignment for slurry wall excavation. The guide walls also prevent soil loss near the surface and act as containment for the introduction of bentonite slurry. At this site the guide walls will be built in circular fashion as per the required shaft footprint, as shown in Figure 2.

Slurry wall panel layout for both Access Shafts #2 and #3 will be constructed using 8 panels and a wall thickness of 600mm, as shown in Figure 3. The primary panels will be excavated followed by the secondary or closing panels. The first step in panel excavation is to position the digging rig in front of the panel. The hydraulic clamshell will excavate the overburden to required depth.Table 1 illustrates the shaft size and depth.

Throughout the excavation, the excavation progress is monitored for verticality, and stability. The panels will be excavated in two passes. As the excavation proceeds panel verticality is monitored at 3 meter intervals.

At the completion of excavation, panel dimensions, verticality and continuity will be checked. Verticality readings of the same joint obtained from two adjacent panels will be compared and the deviation, if any, the panel dimensions will be corrected. Just prior to placement of concrete, the bentonite slurry is cleaned to achieve a sand content below 5%. The reinforcing cage is then placed into the panel trench and suspended off the guidewalls, see Figure 4 for typical reinforcing cage used. Tremie pipes

Figure 2. Guide walls at Access Shaft No. 3

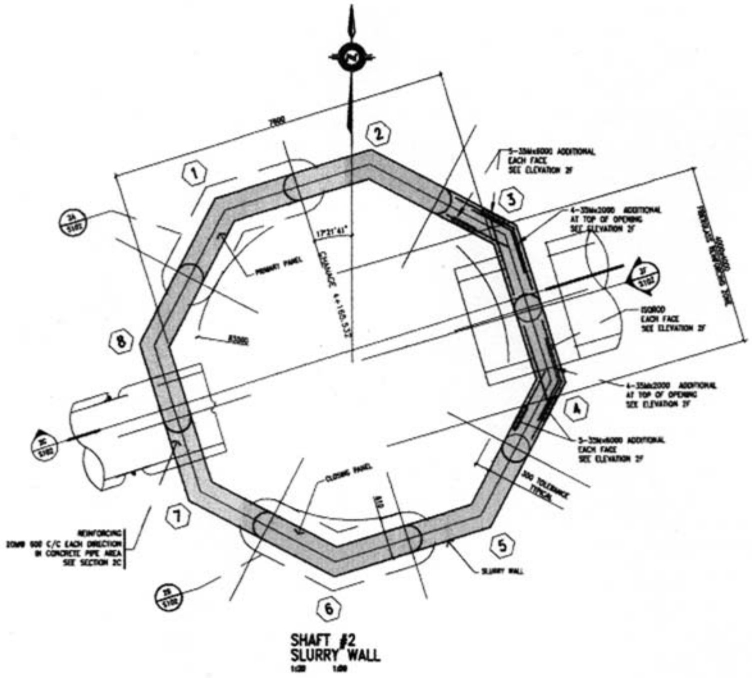

Figure 3. Slurry wall panel layout at Shaft No. 2

Table 1. Shaft sizes and depths

Access Shaft	Outside Diameter (m)	Slurry Wall Depth (m)	Shaft Excavation Depth (m)
No. 2	9.0	22.5	18.0
No. 3	12.0	20.5	15.0

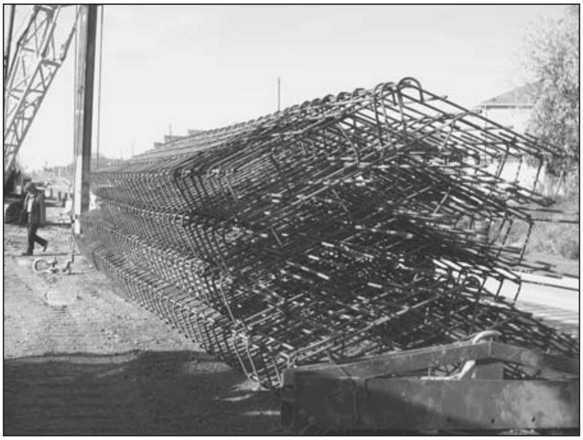

Figure 4. Typical reinforcing cages used for panel construction

will be installed and secured to the top of the guide walls. Each length of tremie pipe installed will be recorded on specific quality control forms. Tremie pipes are 250 mm in diameter, smooth and with watertight joints. The hopper attached at the top of the tremies will be 1.5 M^3 in volume. The bottom tip of the tremie pipe will be positioned 150 mm off the bottom of the panel excavation prior to commencement of the concrete placement.

Concrete will be delivered to the site in transit mixers and discharged directly into hoppers at the top of the tremie pipes. Prior to commencing discharge, the concrete will be checked for slump and air content. Concrete discharge into the hopper at the top of the tremie pipe will be continuous, and controlled. To avoid segregation, a Go-Devil will be introduced into the tremie pipe just prior to concrete discharge. Depth of the concrete will be monitored and sections of the tremie pipe removed regularly, always leaving a minimum 3M and a maximum 10M of pipe embedded in the placed concrete. Concrete volume placed and depth of the placed concrete are recorded and drawn on a chart after the complete truckload discharge of concrete. Concrete is placed continuously until it reaches the cut-off level within the guide walls. Displaced slurry will be pumped off, and stored in ponds for reuse

The slurry wall panel joints will be created using 610 mm diameter joint sectional pipes. These are installed in the open excavation prior to the concreting of primary panels. Once the concrete has set sufficiently they are withdrawn leaving a concave surface into which is poured the next adjacent panel. This provides a watertight joint and continuity given the wider contact between panels.

The general contractor McNally-Aecon JV requested a steel reinforcement free zone in the slurry wall in the areas of TBM penetrations, while assuring the structural integrity of the shaft. Given the TBM cannot mine through a heavily reinforced slurry wall, these areas will be replaced with a fiberglass “soft-eye.” The “soft-eye” is designed with the equivalent strength to replace the steel reinforcement.

McNally-Aecon JV will also perform shaft excavation under water. Once reaching the target depth a tremie concrete plug is placed and left to cure. The water within the shaft is then pumped out and the sealed shaft completed.

CONCLUSION

While completing this paper, the slurry wall at access Shaft #2 was completed. The use of a hydraulic clamshell proved to be very effective through the very dense soils. The Kelly mounted hydraulic clamshell also assured good verticality and panel alignment.

Circular self-supporting shafts are most effective providing safe, stable dry unhindered excavation and access for tunnel construction.