Construction starts at Lake Ontario’s Ashbridges Bay
Shaft construction and support methods

The importance of minimizing public impact and the need to avoid interfering with other structures and utilities in the area often requires the design and construction of vertical shafts during a tunnelling project.

Shaf.ts can be permanent for elevator access, ventilation, utility pipelines, storage, etc., or operated temporarily to provide access during construction. Temporary shafts are typically backfilled when the tunnel is completed.

Two of the most important elements in design and construction of shafts are the method of excavation and the technique used to support the shaft against different design loads, such as earth pressure, groundwater, and live and seismic loads.

Shaft excavation in soft ground is normally done with a crane using a clamshell bucket to hoist the muck from the shaft and drop it into a hopper/stockpile or directly into a truck on the surface. Shaft excavation in rock is usually performed by the drill-and-blast method.

Liner plates provide a relatively lightweight, easy-to-handle, safe support for soft ground excavation (typically for smaller shafts). The liner plate assembly distributes and transmits the load to the surrounding earth. The plates can be galvanized or coated, and holes with plugs can be included to facilitate the grouting between plates and the ground.

Caissons are relatively watertight retaining structures and an ideal concept for shafts in wet ground or underwater situations. When creating the caisson shaft, typically cast-in-place or precast concrete sections/segments are constructed from the surface. Once the caisson reaches a set height, the concrete forms or segments are added to the top to create the next section (lift) of the caisson. Precast segments are used more widely in Europe. The segments are like the ones used in the TBM tunnels, bolted and gasketed together to form a ring. Rings are added at the top when used as a caisson or at the bottom when the ground has a safe stand-up time.

Rock dowels/bolts (+ shotcrete/mesh) are used for the construction of shafts in rocky ground conditions. Typically dowels or bolts are drilled radially from the shaft in calculated horizontal and vertical distances to provide reinforcement for the rock. It is common to use shotcrete (strengthened with wire mesh or fibres) to further secure the rock face.

Sheet pile walls are constructed by driving prefabricated sections of sheet materials with an interlocking edge into the ground. Soil conditions may allow for the sections to be vibrated into the ground instead of it being hammer driven. The full sheet pile wall is formed by connecting the joints of adjacent sections in sequential installation. Sheet piles are most commonly made of steel but can also be formed of timber or reinforced concrete.

Secant piles are a series of drilled columns constructed in such a way that the columns overlap to form a continuous wall for the shaft structure. The construction sequence involves drilling every other column (primary) and then returning after the concrete has partially returned to drill and pour the overlapping column (secondary) between the primaries. The concrete in the columns can be all low strength, all high strength, or a combination of low strength primary and high strength secondary. Steel piles or reinforcing steel are typically placed in the secondary columns.

The slurry wall method is typically used to build shafts through a series of reinforced concrete walls typically in areas of soft earth close to open water, or with a high groundwater table. Before the construction of slurry walls, it is common to use guide walls 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. Care is generally required to obtain acceptable verticality (~0.5 per cent is typical).

Ground freezing is a shaft construction technique used to provide temporary earth support and groundwater control when other conventional methods, such as dewatering, shoring and grouting, or soil mixing, are not feasible. The ground freezing process involves drilling and installing a series of closely spaced pipes and circulating a coolant through them. The refrigerated coolant extracts heat from the ground, converting the soil pore water to ice resulting in an extremely strong and impermeable material.

CONCLUSION
Regardless of what method of construction is employed, there are numerous other issues to be considered before the design of the shaft is finalized. From the logistics point of view, for example, the location of the shaft in relation to tunnel alignment, muck transportation routes, and sensitive buildings in the area, all need to be considered. Technical challenges include the estimation of groundwater seepage and methods of dealing with water inflow, such as excavation of sump and the use of a water pump with enough capacity to handle the maximum anticipated flow.

References

40 | April ~ May 2019 | www.tunnelsandtunnelling.com