Shaft Collar Construction Through Quicksand Ground Conditions

Location: **Ontario, Canada**

Sector: **Mines**

Case Description

A mining contractor was constructing a surface collar for a new ventilation shaft that was being developed by shaft sinking methods through approximately 15 m of saturated granular unconsolidated soil conditions.

Solution

The contractor's initial attempt at shaft collar excavation was to install conventional pre-formed liner plate as excavation was underway. This method of shaft collar construction was abandoned after a few meters of excavation due to lack of standup time of the unconsolidated soils and associated sinkholes that were occurring adjacent to the shaft perimeter.

The second attempt was to install a cylinder of vertical interlocking sheet piles within the previously placed rings of liner plates. As excavation proceeded within the sheet pile shaft lining, problems with sinkholes continued as granular soil migrated through openings between the sheet piles and the underlying bedrock.

Due to the solid nature of the bedrock underlying the site, it was not possible to embed the sheet pile toes. In addition, the bedrock profile was smooth and sloping at a shallow angle, resulting in openings beneath each of the individual sheet piles.

The contractor then installed 2 inch diameter steel pipes adjacent to the sheet piles and undertook cement grouting to construct a grouted toe at the interface between the sheet piles and underlying rock. This cement grouting program provided sufficient improvement to the surrounding ground conditions to enable the shaft to be excavated down to the top of the sloping rock interface.

At this point, the contractor observed continuous inflow of quicksand and unsuccessfully attempted to use rags and wooden wedges to control these inflows. Shaft collar excavation work was at a standstill when the contractor called Peter White for assistance.

Peter quickly determined that the required solution was chemical grouting outside the toe of the sheet piles to completely consolidate an external ring of soil at the bedrock interface.

Shaft Collar with sheet piles

Chemical grouting was required to permanently stop all of the residual quicksand inflow as the remaining soil was excavated from within the shaft and to construct an adequate external barrier that would withstand subsequent blasting during shaft excavation in rock.

Chemical grouting work commenced at the highest point along the rock - sheet pile interface and gradually proceeded down-slope around both sides of the shaft excavation.

Small diameter holes were drilled through the sheet piles about 50 to 75 cm above the bedrock interface and spaced about 10 cm apart using an electric drill with a magnetic base. Holes typically encountered flowing quicksand immediately after penetrating the steel sheet pile, so plastic injection packers were quickly installed to close the drill holes.

Cement grouting through external grout pipes

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After drilling a horizontal line of drill holes over a distance of 1 to 2 m, approximately 2 to 4 liters of water-activated chemical grout was initially injected at each packer location.

The systematic process of packer removal, gradual deepening of drill holes and injection of additional chemical grout was undertaken until approximately 1 m of consolidated soil had been achieved beyond the sheet pile perimeter.

It was then possible for the contractor to excavate additional soil from the shaft bottom and expose more ungrouted sheet piles for chemical grouting. Drilling and chemical grouting work was labour-intensive, since all of the work was undertaken at the bottom of the excavation using hand-held equipment.

After 10 days of chemical grouting work that consumed over 1,500 kg of chemical grout, all of the shaft bottom had been excavated down to solid rock with no further water infiltration.

Sealing quicksand inflows at sheet pile – rock interface

Quicksand inflow at the bottom of the shaft

Sealed sheet piles at bedrock contact

Peter White, P. Eng., is a senior engineer and grouting specialist with over 25 years of experience working on many different types of pressure grouting operations at hundreds of project locations around the world.