

SCHNABEL PROVIDES LOW OVERHEAD ACCESS FOR DEEP SEWER REPAIR IN MICHIGAN



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GEOSTRUCTURAL DESIGN & CONSTRUCTION

Drilled shafts inside a shaft: Constructing secant piles under low overhead power lines

On Christmas Eve of 2016, a section of the Macomb County Interceptor Sewer collapsed, which led to a massive sinkhole at the ground surface. This dramatic event caused an evacuation of nearby residents as well as an emergency repair. After the localized repair was performed, design work started on re-lining approximately 7,000 feet of the sewer to avoid future problems with the aging tunnel, which was originally constructed in 1973.

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DEEP SEWER REPAIR | STERLING HEIGHTS, MI

Authors: Stanley L. Worst, P.E., Michael Grimm, Parthiv Brahmbhatt, Allen Stanton



GENERAL CONTRACTOR



DESIGN/BUILD SPECIALTY CONTRACTOR



BACKGROUND

Located in Sterling Heights, Michigan, the sewer tunnel was 11 feet in diameter and approximately 50 feet below grade along a stretch of 15-Mile Road.

The original sewer was constructed with unreinforced concrete, up to 18 inches in thickness. As part of the re-lining project, it was decided to locate construction activities in a utility corridor to minimize disruption to traffic. The utility corridor contained multiple overhead high-voltage power lines and was located off to the side of 15-Mile Road. Ground conditions dictated the use of a cutoff wall; however, the overhead power lines restricted the equipment which could be used. The resulting design consisted of an access shaft with two different wall types.

The upper 42 feet was composed of ring beams and wood lagging, while the lower section included reinforced concrete secant piles. Conceptually, a large rotary drill rig could fit within the upper shaft in order to construct the lower circular secant pile shaft.

Schnabel Geostuctural Design & Construction was hired by Oscar Renda to install the 34.5 foot inside diameter secant pile shaft. This work consisted of 60 overlapping secant piles ranging from eight feet to 51 feet in depth. Shallow drill depths of 8 to fourteen feet followed the top radius of the tunnel. Once clear of the tunnel to the sides, 38 feet deep primary shafts and 51 feet deep secondary shafts were drilled below subgrade to ensure basal stability of the excavation. Reinforcing steel consisting of W21x182 wide flange sections were placed in secondary shafts.

ASSEMBLY & JOB PREP

Months of planning from an equipment and safety standpoint went into this project. The unique construction technique of low-overhead secant piles had many obstacles to plan around. First was lowering a 200,000 pound drill rig in sections into the upper shaft. Second was assembling the rig with a 70 foot tall mast inside of a 45 foot wide shaft. Third was constructing the secant piles with limited access for people, support equipment and material installation.

Lifting the rig into the upper shaft of ribs and lagging required a detailed lift plan to be created with the crane company.

Connelly Crane was employed to assist with and execute the plan. There were very unique conditions that would affect the crane size and setup. First, the crane could not sit closer than 15 feet from the edge of the shaft to restrict excessive surcharge pressures per the design.

Second, a maximum crane boom height was enforced due to limitations set forth by the International Transmission Company (ITC), the owner of the power lines. The power lines were approximately 63 feet above the ground surface, although this fluctuated with both the ambient temperature and the power draw on the lines themselves. A proximity limit of 20 feet was imposed, which meant any work located beneath the power lines could not be more than 43 feet off the ground surface.

Based on the lifting weight, horizontal distance and height restrictions, it was determined that a 400-ton crane would be used for the operation of hoisting the drill rig. The critical lift would be the base of the Bauer BG-26 drill rig, which weighed 82,000 lbs.

Maintaining a low boom angle with a 50-foot swing radius allowed for staying under 75% of the crane's capacity.

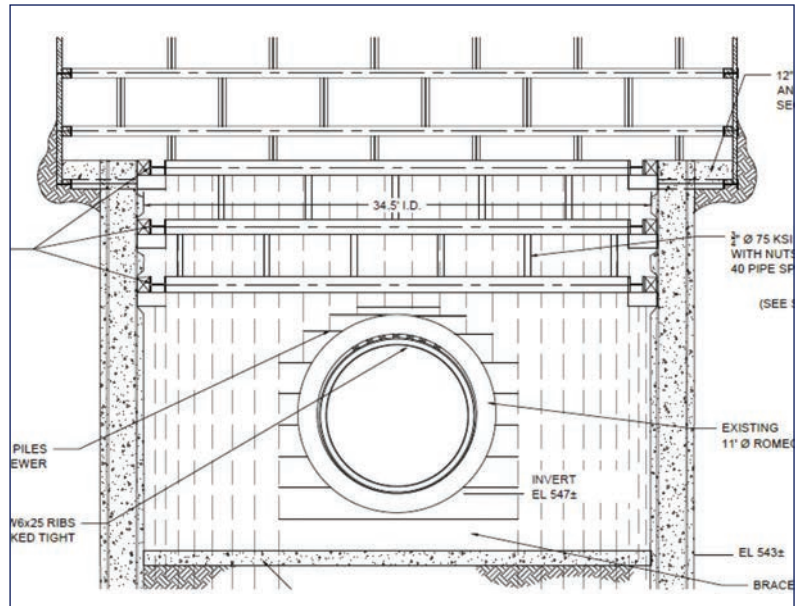


Fig. 2 Elevation view of secant piles around sewer



Fig. 3 Lowering base of rig into shaft



Fig. 4 Lowering lower mast into shaft

After the base was set, the next step was to connect the lower mast to the base of the drill rig. Under normal circumstances this would require one hundred feet of space, the mast would be lifted in a horizontal position on the ground and connected to the rig base prior to being tilted vertical. The inside diameter dimension of the upper shaft prevented this from happening. Complicating things even more, the lower mast was not designed to be lifted in the vertical position.

The only possible assembly scenario remaining was a series of two lifts for the lower mast: the first lowering it into the upper shaft horizontally; the second, lifting it on a seventy-degree angle and connecting it to the base. This required adjustable chain slings to be used and took multiple shifts to assemble.

Schnabel performed test lifts at their equipment yard to ensure that the rigging made just for this one lift was sufficient, minimizing potential downtime on site. After pinning the lower mast to the base, the rest of the components of the drill rig including counterweights, upper mast, rotary, etc., were relatively easy to assemble, yet still took more time than usual due to the site constraints.

For any circular secant pile wall, a guidewall is first constructed. The guidewall serves the purpose of initially aligning the piles so that adequate overlap is achieved per the design. It also aides in maintaining verticality of the piles during drilling, pinning the casing in place at the ground surface.



Fig. 5 Connecting upper and lower mast

The design of the secant piles is predicated on what is referred to as effective thickness. This thickness dictates the dimensions of a

compression ring beam which resolves the lateral earth, water and surcharge pressures acting on the overall shaft. Schnabel used circular Styrofoam cutouts set on a mud mat as the template.

The guidewall was poured with concrete surrounding the Styrofoam. A one-foot thick concrete working pad was also poured inside the guidewall, which allowed for the drill rig to situate itself in the center of the shaft without tearing up the ground surface and potentially disturbing the guidewall.



Fig. 6 Assembled rig below power lines

DRILLING & CONSTRUCTION

Once assembled, the drilling was similar to other jobs with the main difference being that it took place inside of a 45-foot diameter cell at a depth of 42' below ground surface.

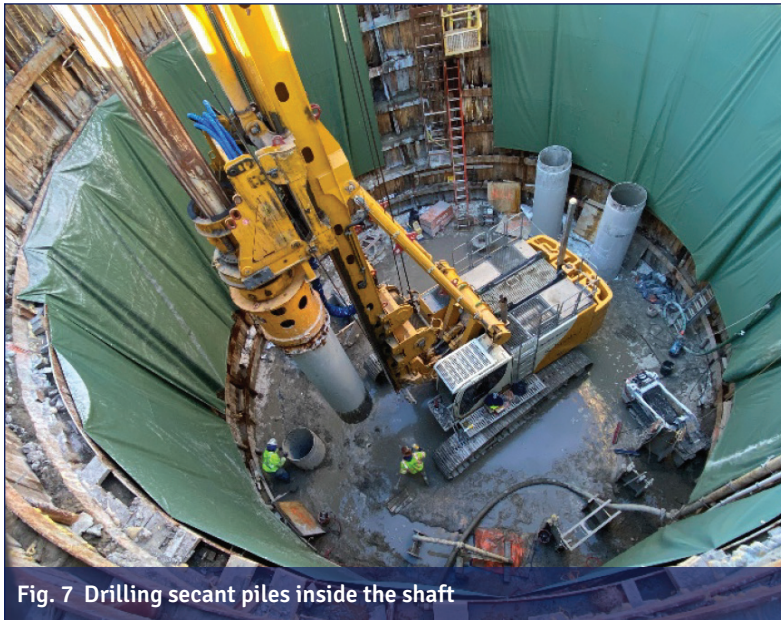


Fig. 7 Drilling secant piles inside the shaft

Careful planning was implemented to overcome the operational challenges. Drill tooling was kept to a minimum to allow as much room as possible within the shaft. A self-dumping box to spin spoils into and then lift out of the upper shaft with a service crane was utilized. There was inherently some drill spoil which did not get into the spoil box by mechanical means. This was addressed with ground workers who had to shovel any extra spoil by hand. Due to safety concerns, only two people were allowed on the ground inside the shaft at a time.

No other normal support equipment, such as a skid steer, loader, forklift or manlift were allowed inside the shaft as there physically was not enough room.

Three main soil layers were encountered while drilling. The upper 25 feet consisted of a silty clay, which was dry and stayed on the auger flights. Some of the shallow secant piles above the sewer stayed in this layer and were drilled relatively easily. From 25 to 45 feet, sand below the water table was encountered. To effectively excavate this material, the drill hole was kept flooded during drilling.

This, in addition to advancing the casing ahead of the drill tooling, kept the sand from heaving up into the casing and losing ground. A muck bucket was used to drill in this layer to remove the sand, as granular material does not stay on auger flights when submerged in water. Water alone had enough weight to prevent the sand from heaving at the bottom of the drill hole; therefore, a drilling slurry such as polymer was not needed. At 45 feet below grade, a stiff, impermeable clay layer was encountered.

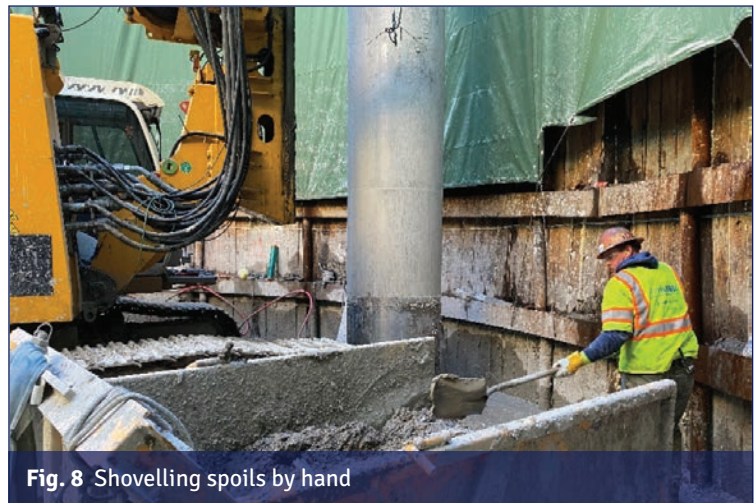


Fig. 8 Shovelling spoils by hand

The method Schnabel chose to drill the secant piles consisted of flush-joint casing extending full depth. Due to extending the casing full depth and the water-tightness of the casing joints, once the lower clay layer was encountered, flooding the hole was no longer required. The casing was able to seal off the water and the bottom of the hole could be drilled conventionally with augers.

After drilling an individual secant pile, an inclination measurement was taken using the PRAD system by Jean Lutz.

This measures any deviation of the shaft from top to bottom in both the X and Y axis, and can be seen in real time by the driller in the cab of the rig. Based on the specifications and a minimum effective wall thickness to be maintained, a tolerance of 0.9% deviation for the shaft length was imposed and achieved. Once the pile was confirmed to be in compliance, the shaft was concreted.



Fig. 9 Taking verticality reading in the cab

The concreting operation was setup to be pumped from the top of the shaft down to the bottom using a trailer pump. To guide the concrete, a hard-line pipe was secured to the inside of the upper shaft, which transitioned to a rubber line at the bottom. During concreting of the 38-foot deep shafts, which would have to stay flooded, a sectional tremie pipe was used to fill the secant pile. On the 51-foot deep shafts which were sealed into the lower clay

layer, ground water was pumped prior to pouring the shaft.

With the limitations of the overhead power lines, setting the steel soldier beams were very challenging. The crane was set up in the only location possible, which was between the two sets of power lines that ran overhead. With this configuration, there was a 6-foot wide window in which to lift the beams vertical and lower them into the shaft.

Once the beam was lowered into the upper shaft, the crane would boom horizontally while staying under the ceiling height imposed by the power lines and place the beam in the secant pile where it was needed.

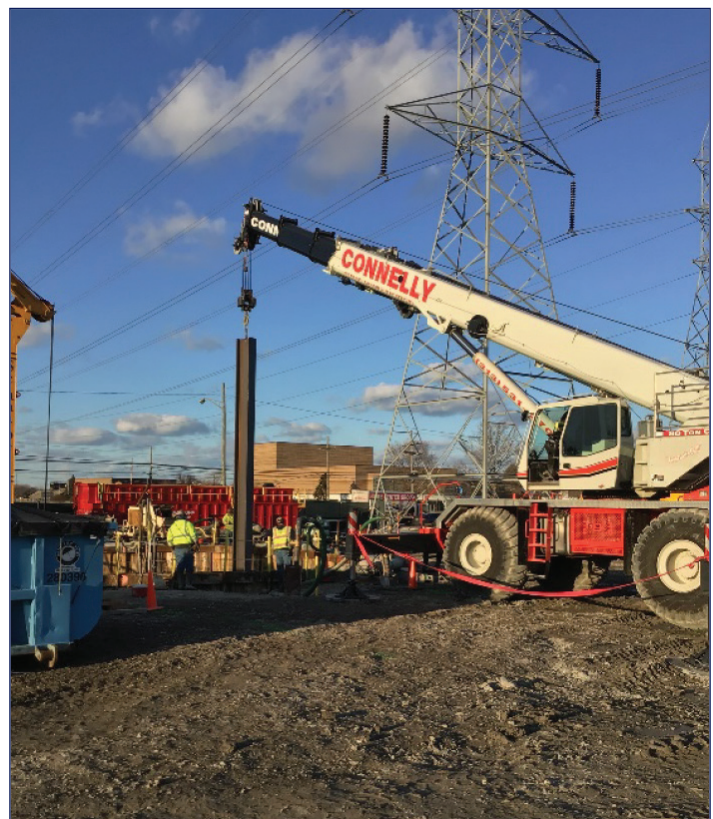


Fig. 10 Setting a pile below power lines

CONCLUSION

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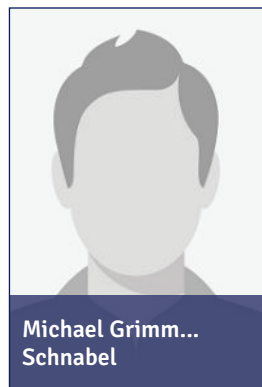


Fig. 11 Completed access to existing sewer

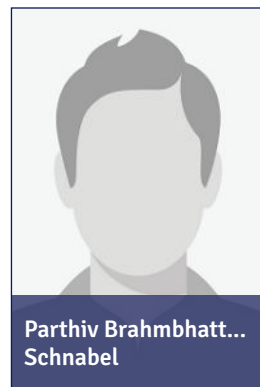
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