Blue Plains Tunnel Shaft Design and Construction – Description of Innovation

TSJD, a joint venture of Traylor Bros., Inc., Skanska USA Civil Northeast, and Jay Dee, with CH2M HILL as lead designer, is currently working on the tunnel construction phase of the design-build Blue Plains Tunnel project for DC Water. The project is a 24,000-foot-long, 26-foot-diameter CSO tunnel constructed in soft ground under and adjacent to the Potomac and Anacostia Rivers. The project involves the construction of five shafts, two of which are a 132-foot finished diameter dewatering shaft and a 76-foot-diameter screening shaft, both between 180 and 198 feet below ground. The innovative design and construction techniques required to construct these two massive shafts is the reason why our team should be nominated for a NOVA Award.

World class size and depth. The 132-foot cell was specified by DC Water to accommodate a future pump station. Based on the space requirement for launching the TBM, the team designed the smaller cell to have an oversized internal diameter of 76 feet. By designing the two shafts to be back-to-back with a common section of wall between them (in the shape of a figure eight), the team eliminated the need for a separate interconnector tunnel between the shafts. This configuration also allowed the essential components of the TBM to be assembled and launched within the one large space rather than requiring start up mining and assembly to occur simultaneously.

Composite design. Due to the mandatory requirements for the earth and hydrostatic pressure for both the temporary and permanent design, the project utilizes a composite design, where the diaphragm walls will become part of the permanent structure. With excavation depths between 180 and 198 feet and DC Water's mandatory design loads, there was a very high verticality tolerance (0.12 percent, or 1/800 foot) which required the use of state-of-the-art equipment and monitoring processes to ensure the extreme tolerances were met: final design mandated that the panels maintain a minimum continuous wall of 54 inches using a nominal 60-inch-thick diaphragm wall. Panels for the connecting walls of both shafts are a minimum thickness of 96 inches and maximum thickness of 217 inches. To our knowledge, these panel dimensions and size had not been achieved before.

Unique design. In addition to the unique figure eight design of the shafts, the team also designed five large diameter foundation mats using radial and circumferential reinforcement instead of the typical square grid reinforcement mats. Both unique designs saved critical time and cost.

Large-scale construction. Many of the panels required concrete pours of more than 1,000 yards. Before pouring, the team placed instrumentation in the slurry wall to monitor earth pressure for the future shaft excavation. The team also installed nearly all of the TBM tunnel utility pipes directly into one of the secondary closure panels, which was faster and safer than hanging utilities during shaft excavation. Reinforcement of the slurry walls consisted of rebar tied together to form rebar cages. Approximately 1,250 tons of rebar was installed at the two shafts. The cages, weighing up to 50 tons, were horizontally constructed on the ground in two sections.

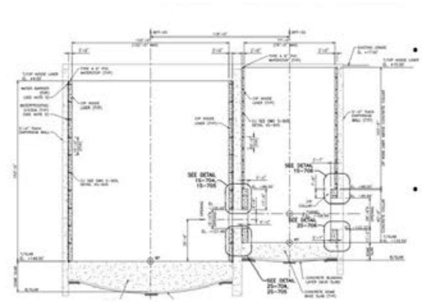
Significant time and cost savings, plus reduced risk and improved safety, were achieved through:

a) The elimination of a separate interconnector tunnel between shafts
b) The ability to assemble and launch the TBM within one large space rather than requiring start up mining and assembly to occur simultaneously
c) The ability to more easily construct the five radial and circumferential rebar mat foundations at the base of the shafts
d) Placing instrumentation into the walls and installing nearly all of the TBM tunnel utility pipes directly into one of the secondary closure panels before pouring concrete
e) The state-of-the art, automated monitoring system that provides a continuous review of the structural performance of the system

The lessons learned from the design and construction approach developed for this project will be taken forward and implemented on future projects requiring large, complex shaft arrangements in challenging ground conditions. The partnering approach required to successfully complete this most challenging part of the project is also proving to be beneficial for completion of the remainder of the Blue Plains Tunnel contract.

Links to recent Blue Plains Tunnel publicity:

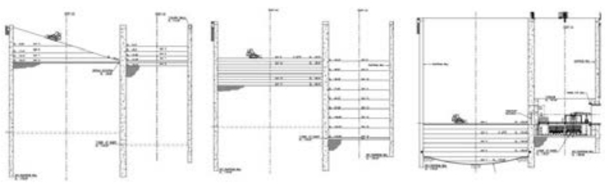
http://www.usatoday.com/story/news/nation/2014/03/09/sewer-overflow-tunnel/5808615/
http://www.washingtonpost.com/local/trafficandcommuting/meet-lady-bird-a-massive-machine-digging-out-a-solution-to-dc-wastewater-woes/2014/02/15/e20b1c60-8dc3-11e3-98ab-fe5228217bd1_story.html
http://www.wusa9.com/story/news/local/georgetown/2014/02/19/lady-bird-tunnel-boring-maching/5615657/
http://thekojonnamdishow.org/shows/2014-02-18/dc-water-proposes-green-infrastructure



- Shaft wall consists of 5ft diaphragm wall and 3ft cast-in place final liner (DS side) and 2ft cast in place final liner SS side.
- Base slabs have a curved invert with a total thickness of 25 ft in the DS shaft, and 16 ft in the SS shaft.

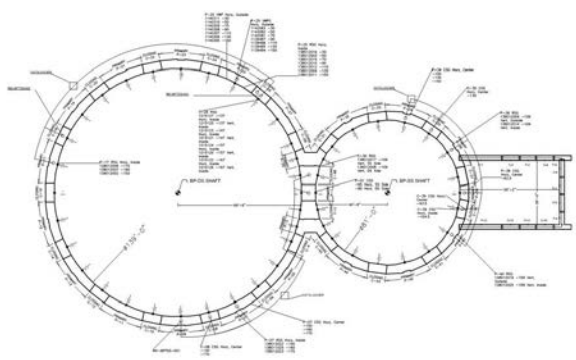
Shaft Cross Section

Rebar placement



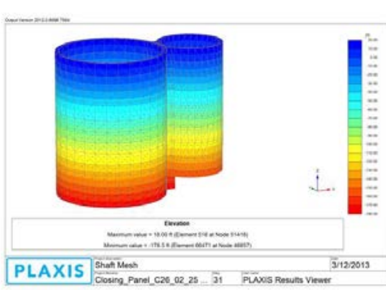
Construction Stages

132-foot-diameter dewatering shaft excavation



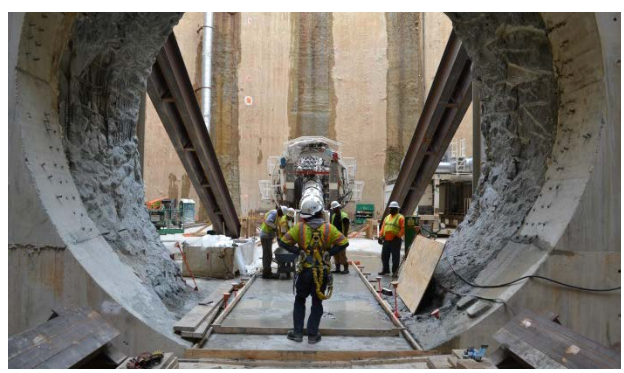
Structural Monitoring

Aerial Overview



FE MESH SHAFT WALL

Advanced Engineering



TBM assembly in shaft