Alternative Construction Methods and Pipe Material provide Solutions for Cleveland WWTP Project

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ABSTRACT
The Easterly Wastewater Treatment Plant (WWTP), located on the northeast side of Cleveland between Lakeshore Boulevard and Lake Erie, provides wastewater treatment services for 334,000 residents and various businesses in northeastern Cleveland and the surrounding suburbs. In addition to treating wastewater from homes and businesses, the Easterly WWTP also receives and treats stormwater from combined sewers. Over 94 million gallons of wastewater per day (mgd) are treated at the Easterly WWTP.

The Northeast Ohio Regional Sewer District (NEORSD) awarded the contract to Shook Walbridge Joint Venture. The Sustained Secondary Improvements Project includes expanding the Easterly Wastewater Treatment Plant's 330 MGD capacity to 400 MGD. The project included improvements to the plant's existing aeration tanks and final settling tanks, construction of six additional final settling tanks, improve hydraulics to support the capacity increase, and implement various miscellaneous improvements.

More specifically, as part of the improvements, the project required auger-cast–piles to support new structure foundations, but also to support pipe cradles for the final effluent piping. These piles were part of the original design to support the 60", 72" and 84" diameter effluent pipe, which was designed with Prestressed Cylinder Concrete Pipe (PCCP).

As a way to solve some constructability issues, Shook-Walbridge proposed a pipe material and pipe foundation substitution in lieu of the PCCP pipe and auger-cast–piles. Their substitution included the use for large diameter fiberglass pipe along with a continuous concrete ballast slab to address floatation concerns. As part of the substitution review process, various aspects of the alternative installation method had to be reviewed prior to acceptance of this alternative. This paper will review the different key components considered during the substitution review process.

PROJECT BACKGROUND

The Easterly Wastewater Treatment Plant (WWTP), located on the northeast side of Cleveland between Lakeshore Boulevard and Lake Erie, provides wastewater treatment services for 334,000 residents and various businesses in northeastern Cleveland and the surrounding suburbs. In addition to treating wastewater from homes and businesses, the Easterly WWTP also receives and treats stormwater from combined sewers. Over 94 million gallons of wastewater per day (mgd) are treated at the Easterly WWTP.

This facility was originally constructed in the 1930's and since has undergone various expansions and improvements over the years. Due to the continued growth of the Northeast Ohio Regional Sewer District (NEORSD) expansion of the Easterly Wastewater Treatment Plant Secondary System is required to increase the capacity of the facility by 70 million gallons per day. This will increase the capability of the Easterly Wastewater Treatment plant from 330 MGD capacity to 400 MGD.

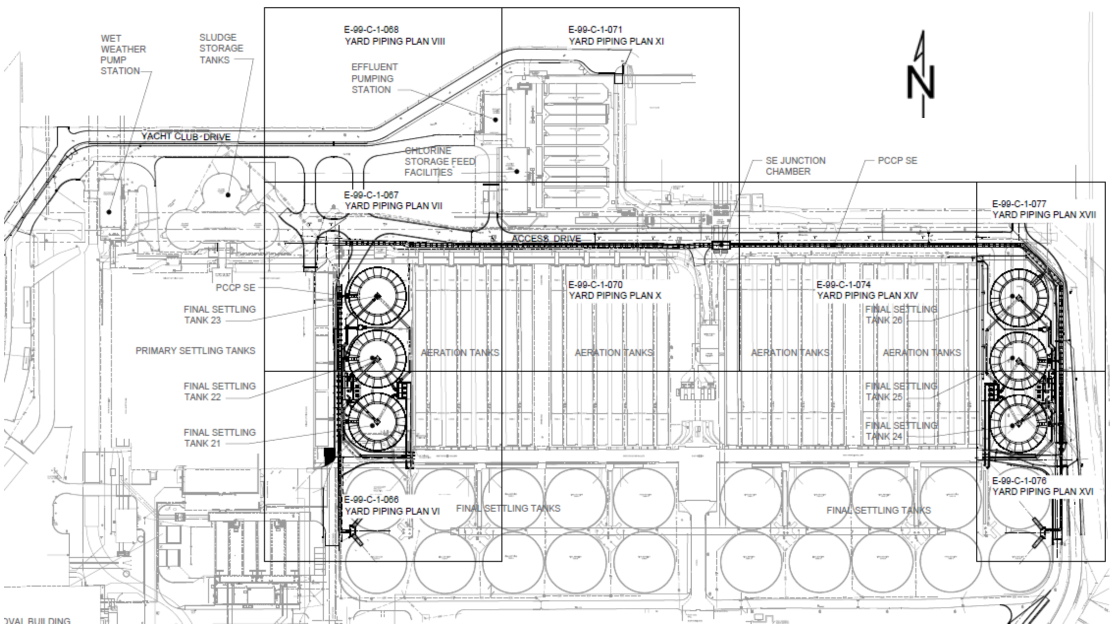

Figure 1 – Proposed Easterly Wastewater Treatment Facility Secondary System Improvements – Cleveland, Ohio

In order to accomplish this, the following list of major activities were required to achieve this capacity increase.

- Improvement to existing aeration tank
- Improvement to existing final settling tank Improvements
- Road Relocations
- Improvements to existing effluent pump station
- Construction of new final settling tanks
- Construction new conveyance conduit and channels
- Construction of new pumps stations

The Construction contract amount for this project is $ 74,350,000.

One of the most significant portions of the improvement to the Easterly Wastewater Treatment Facility was the work associated with the new secondary effluent tanks and conduits. New secondary effluent conduits were to be installed between the existing primary settling tanks and proposed final settling tanks (#21, #22, and #23). In addition, new conduits were to be installed on the northeast side of the proposed final settling tanks (#24, #25, and #26) and along the northwest side of the existing aeration tanks. The conduits would range from 48 to 84 inches in diameter.

In all, 6 new final settling tanks were to be constructed adjacent to the existing aeration tanks. Each tank, 105 feet in diameter, would extend 23 to 27 below grade, with the invert elevations of the conduits being 11 to 16 feet below grade.

SITE CONSIDERATION [1], [2]

Positioned on the south shoreline of Lake Erie, this site has gone through significant changes since its construction in the 1930's. Buried utilities and conduits are located throughout the site from decades of plant expansions and site improvement work. As part of the design process, a geotechnical investigation was performed to set a baseline of subsurface soil conditions, identify buried obstruction and establish ground water conditions which could be encountered during construction. This investigation involved subsurface exploration using traditional borings, laboratory tests, and field tests.

One of the most significant site conditions identified was the existence of fill material placed during the original construction and expansion of the facility. Fill material was used to build out the ground surface of the original shoreline in order to construct the plant and subsequent development further out into the lake. The majority of the existing structures within the project site were placed on timber pile foundations that were installed through the fill and into the underlying native soil.

One additional site condition to be considered was the groundwater surface elevations. Boring logs presented in the subsurface investigation report indicated that groundwater was encountered at the time of drilling in a majority of the structural borings at depths ranging from 8 to 48 feet below grade. The groundwater elevation generally corresponds to the water surface levels in Lake Erie. These levels may fluctuate due to precipitation and wind conditions.

Based on the subsurface site conditions it was recommended that the proposed new clarifier tanks and conduits greater than 60 inches in diameter be supported on a deep foundation system consisting of drilled shafts or 50' to 60' deep auger cast piles. Shallow foundation options were not utilized for these structures due to the potential for excessive hydrostatic uplift forces that could possibly develop beneath the structure foundations. Deep foundations systems consisting of driven piles were also not considered for support of the structures. Driven piles were not considered as the noise of the pile driving operations would be disruptive to the surrounding community.

DESIGN PHASE

The final design and layout of the proposed improvement to the Easterly Wastewater Treatment Facility included the utilization of Prestressed Cylinder Concrete Pipe (PCCP) for the new secondary effluent conveyance conduits. As previously noted, the pipe had to include a deep foundation system to support the pipe, and had to address buoyancy due to high groundwater levels. PCCP, a pipe material traditionally utilized by the NEORSD, appropriately addressed the pipe buoyancy concerns. The weight of the 48 inch through 84" PCCP materials allowed for the pipe to be installed using a traditional open trench method based on the following weights.

- 48 inch diameter PCCP – 900 lbs per foot
- 60 inch diameter PCCP – 1240 lbs per foot
- 72 inch diameter PCCP – 1780 lbs per foot
- 84 inch diameter PCCP – 2390 lbs per foot

The weight of the pipe was a benefit for buoyancy concerns, but required a deep foundation system to address the poor subsurface ground conditions and potential of long-term settlement of the proposed conduits.

As recommended in the Geotechnical Investigation, the PCCP was designed with a deep foundation support system to prevent the potential of long-term settlement. The supports were auger-cast-piles extending through the man placed fill from the original construction of the facility and into the native soils. These piles were designed with a concrete pile cap cradle for which the PCCP would rest. Figure 2 shown below details the pile and pile cap cradle formation.

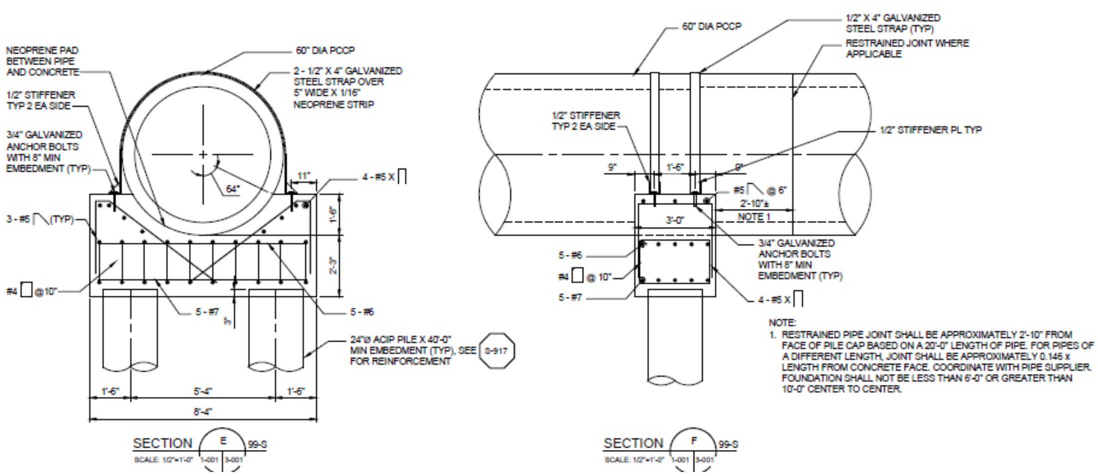

Figure 2 – PCCP Secondary Effluent Conduit Foundation Detail

The spacing of the foundations for the conduits took into consideration the weight of the pipe material, potential buoyancy, beam strength of the pipe in a buried installation intermittently supported on deep foundations. Based on all of these factors, the supports were spaced at a maximum of 10 foot intervals along the horizontal alignment of the proposed secondary effluent conduits. Figure 3 shown depicts a portion of the proposed deep foundation layout for the proposed PCCP.

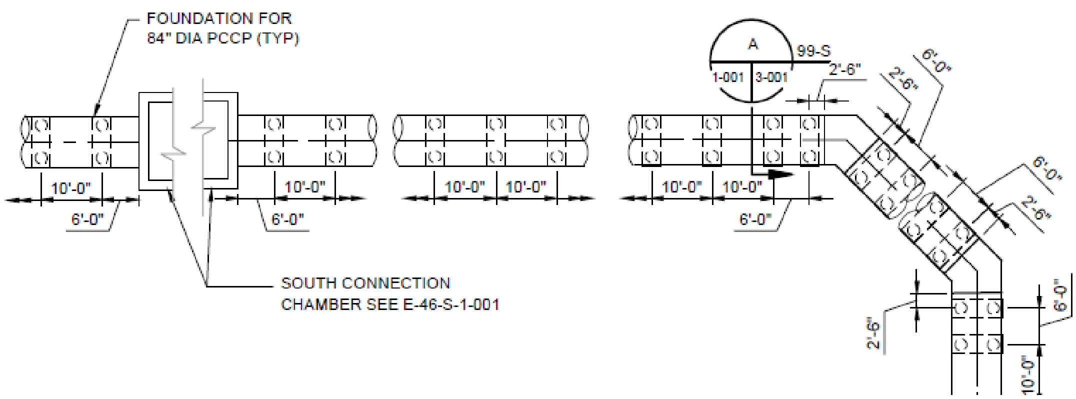

Figure 3 – PCCP Secondary Effluent Conduit Foundation Layout

The final design required auger-cast–piles to support new structure foundations as well as support the pipe cradles for the 60”, 72” and 84” diameter PCCP effluent piping.

CONTRACT PHASE

Base on the bid process, the Northeast Ohio Regional Sewer District (NEORSD) awarded the contract to the team of Shook Walbridge Joint Venture.To facilitate their proposed construction schedule, means, methods and a potential cost savings to the Owner, the Shook Walbridge team explored other pipe materials and construction methods to provide an alternate solution to the secondary effluent conduit piping and deep foundations. This alternate solution would still have to address the primary site considerations which were taken into account in the original design of the project. Thus the alternative would have to address the following:

- Differential settlement due to placement on man-place fill at the site
- Pipe buoyancy due to groundwater
- Pressure capabilities of pipe material
- Joint restraint of pipe material

Shook-Walbridge proposed an alternate pipe material and a pipe foundation substitution in lieu of the PCCP pipe and auger-cast–piles. Their proposed substitution included the use for large diameter fiberglass pipe along with a continuous concrete slab to address floatation concerns.

As part of the substitution review process, various aspects of the alternative installation method had to be reviewed prior to acceptance of this alternative. The proposed change could not affect the construction schedule or the specified warranty requirements of the contract. The added value for the owner over the PCCP is that the fiberglass pipe offers a longer anticipated design life and less maintenance given the resistance to corrosion, improved flow hydraulics, reduced cleaning and sediment build-up. In addition, this substitution offered cost savings to the project.

The contractor proposed the use of Flowtite filament wound fiberglass pipe manufactured by the Thompson Pipe Group. This product offers a minimum design life of 50-year in a corrosive sanitary sewer application.

The filament wound fiberglass pipe proposed weighed only 1/10th the weight of the PCCP. The weight of the 48 inch through 84" fiberglass pipe had the following pipe weights.

- 48 inch diameter PCCP – 127 lbs per foot
- 60 inch diameter PCCP – 179 lbs per foot
- 72 inch diameter PCCP – 247 lbs per foot
- 84 inch diameter PCCP – 424 lbs per foot

The weight reduction provided a benefit during the installation process as smaller equipment could be utilized to install the pipe material.

In order to utilize the lighter weight fiberglass pipe potential buoyancy risk would have to be eliminated. The proposed solution was to ballast the fiberglass pipe down to a reinforced concrete slab as shown in Figure 4. This design offered buoyancy resistance through the weight of the concrete but more importantly took advantage of the soil weigh outside of the pipe due to the extended width of the slab. This slab design would be continuous and be installed everywhere the 60 inch, 72 inch and 84 inch pipes were to be installed.

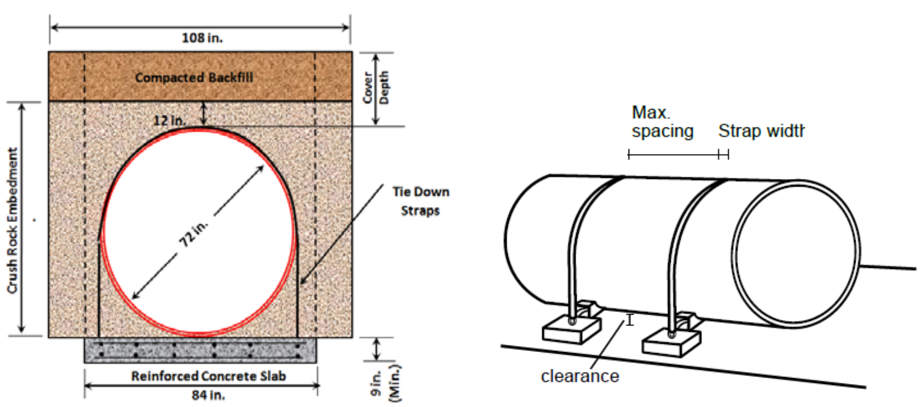

Figure 4 – Proposed Ballasting for Buoyancy Resistance

As the original design for the PCCP included harness restraints, the fiberglass pipe proposal also had to include the appropriate restraints where restraints were required. The proposal included three types on joint systems. The small diameter pipe (36 inch and 48 inch) would be restrained with a fiberglass key-lock system as shown in Figure 5. The larger diameter pipes (60 inch, 72 inch and 84 inch) would be restrained using a fiberglass or carbon fiber laminate on the inside of the pipe as shown in Figure 6. The third joint system was to address the sections of the effluent conduits connected to rigid structures. In order to offer restraint along with a flexibility to account for differential settlement between the rigid structures and the pipe, a harnessed style joint was offered with the Flowtite fiberglass pipe as shown in Figure 7.

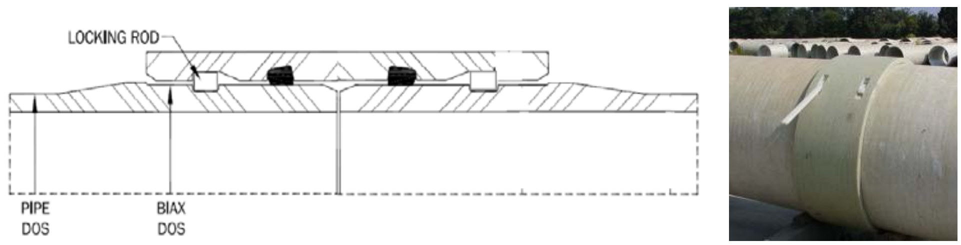

Figure 5 - Fiberglass "Key-lock" Restrained Joint System

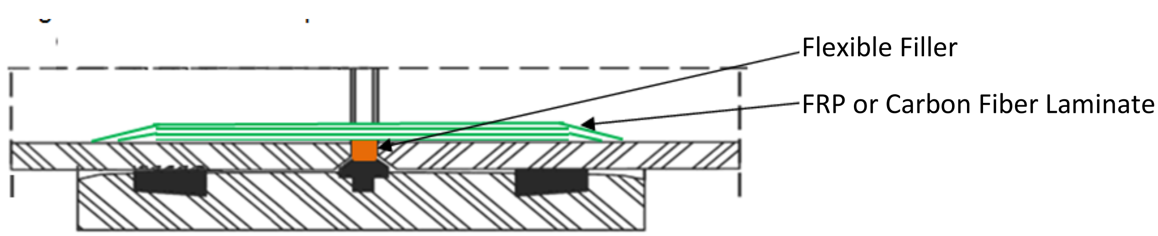

Figure 6 - Fiberglass Pipe Joint with Internal Laminate Restraint

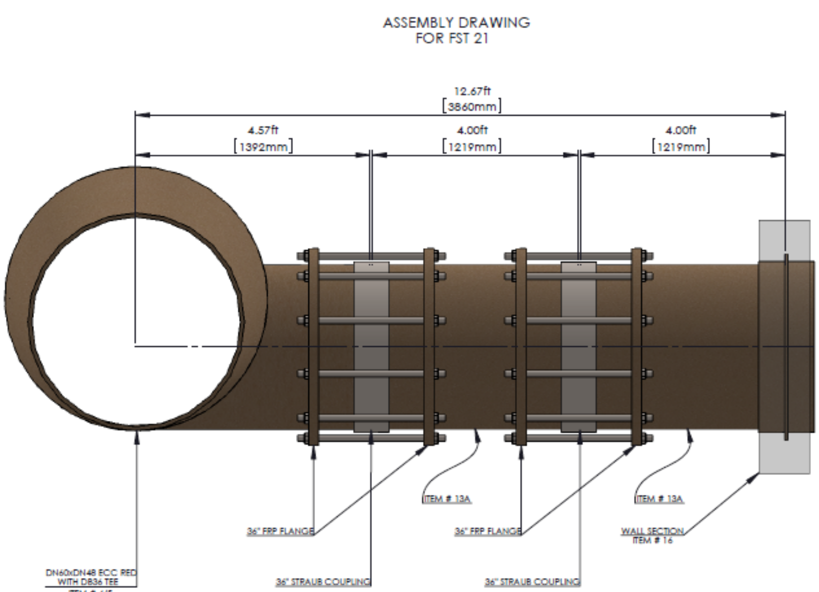

Figure 7 - Fiberglass Pipe Harnessed Restrained Joint

As this substitution was also changing the effluent conduit pipe material from a rigid pipe to a flexible pipe, other aspects of the design needing to be addressed included evaluating the fiberglass pipe. In accordance with the AWWA M45 Fiberglass Pipe Design Manual and specifications, this evaluation included the following:

- Pressure Class
- Working Pressure
- Working Pressure + Surge Pressure
- Pipe Long-term deflection
- Combined Loadings
- Buckling Pressures

In addition to the fiberglass pipe evaluation, the proposed substitution was reviewed by the Design Engineer and Owner to confirm that the alternative slab addressed the design issues previously discussed. With the design issues having been addressed, the substitution was allowed and the project was able to move forward into construction. The following is a summary of the benefits of this alternative pipe material and construction method:

- Significant cost saving to the Owner due to alternative pipe material and construction methods.
- Improved overall constructability of the project with respect to weight of pipe material and crane extension/capacity.
- Improved schedule of construction due to alternative concrete foundation design.
- Anticipated long-term maintenance and operation savings to the Owner with choice of corrosion resistant fiberglass pipe in a sanitary sewer application.

The construction of the secondary effluent conduit began at the start of 2015. The installation of the conduit will take approximately 5.3 months. Without the team work and effort of all parties involved, Northeast Ohio Regional Sanitation District, Brown & Caldwell, Shook Walbridge and Flowtite Pipe this project optimization would have never been possible. All parties involved helped to find a solution which was more economical, provided sound engineering solutions as well as provided long-term benefits to the Owner. This is the goal of every project but without a team effort his could not have been accomplished.

REFERENCES

1. Miller, Michael J. (2013). “Easterly Secondary System Improvements – Geotechnical Baseline Report., MWH.
2. Cimino, Vito. (2012). “Easterly Secondary System Improvement – Technical Memorandum No. 24.” MWH.