Concerns Surface from Polypropylene Pipe Installations

American Concrete Pipe Association
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An educational document from the American Concrete Pipe Association for users and specifiers

In some U.S. markets, contractors and engineers are being solicited to experiment using polypropylene (PP) pipe in storm water projects. Generally, when compared to reinforced concrete pipe (RCP) and other flexible materials, there are very few PP storm pipe installations nationwide. Civil engineers and underground utility contractors know very little about PP storm pipe, and the history book of successful PP pipe performance is yet to be written. While consistent, successful performance of PP storm pipe remains to be proven, there are published articles available to engineers that are interested in learning more about the PP storm pipe material, design, and installation characteristics.[1] Recently, some interesting reports – stemming from actual installations - have emerged to raise concerns and doubts about PP pipe.

Figure 1. Floatation of 60-inch Polypropylene Pipe at Port Columbus International Airport

PP Pipe Floatation at Columbus Airport

In July 2012, a 60-inch diameter PP storm pipe was discovered to have succumbed to groundwater hydrostatic forces at the Port Columbus International Airport in Columbus, Ohio. The PP storm pipe literally floated out of the ground. Based on photographic evidence, it appears that the PP pipe displaced approximately four feet vertically from its initial line and grade. At the time of initial installation, the owner decided to not use RCP in lieu of the flexible pipe.[2] After the pipe installation failed, the owner ultimately decided to use RCP from Hanson Pipe & Precast to replace the PP storm pipe.

Virginia PP Pipe Deformations

In March 2011, The Virginia Center for Transportation Innovation and Research (VCTIR) published Final Report 11-R14 *Evaluation of Polypropylene Drainage Pipe*.[3] In lay terms, the 11-R14 report, illustrates a relatively poor performance of a flexible pipe product that has been widely touted as robust. The PP pipe also exhibited stress marks (also referred to as "stress whitening"). At less than three feet of backfill, under a low AADT (Annual average Daily Traffic) road, and using quality No. 57 stone embedment (class I material per ASTM D2321), the PP pipe still deformed by as much as 4.5 percent. It should be noted that PP pipe generic design tables suggest that 30- to 48-inch diameter PP storm pipe can be installed to depths of 24 feet or deeper using similar backfill (compacted class I material).[2] However, in the case of the Virginia installations at such low loads and in such high quality embedment material, it is concerning that the PP pipe still barely passed the industry standard 5% deformation rejection criterion.

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[1] *New Product, More Concerns*, Resource # e-009, American Concrete Pipe Association, April 2011, link.

[2] *Engineering Sanitary and Storm Sewers using Polypropylene Pipe*, Advanced Drainage Systems, presented at the South Carolina Engineering and Surveying Conference, Myrtle Beach, SC, June 15, 2012, http://scesconference.org/documents/AGENDA.pdf and http://scesconference.org/documents/ENVIRO%20SESSION%204.pdf.

[3] *Evaluation of Polypropylene Drainage Pipe*, Final Report VCTIP 11-R14, Virginia Center for Transportation Innovation and Research, by Edward Hoppe, Ph.D., P.E., March 2011, http://www.virginiadot.org/vtrc/main/online_reports/pdf/11-r14.pdf

The Virginia 11-R14 report also recommends that Virginia Department of Transportation (VDOT) reject any PP pipe that is mechanically damaged, and it stated that there is no viable technique to assess the long-term consequence of a localized defect. It appears that rejection criteria of PP pipe includes not only deformation and buckling, but also stress marks as evidenced by discoloration, cracks, or indications of distress in the material.

Georgia PP Pipe Deformations

In early 2012, the Georgia Department of Transportation (GDOT) installed approximately 1,500 feet of PP pipe in 12 pipe runs as part of the SR 38 / US 84 project in Donalsonville, Georgia, which is about 60 miles northwest of Tallahassee, Florida. Although PP pipe is not included in GDOT Standard Specifications, Section 550, the use of HDPE pipe is permissible provided that it is installed in accordance with ASTM D2321.[4] The soils were classified as Class II B2, B3, and B4 according to GDOT Supplemental Specification Section 810. According to Section 810, these materials are considered medium- to well-graded sandy clay, sandy silt, and clay with some mica materials with low volume change and good densities (105 – 120 pounds per cubic foot dry density) that serve well as subgrade material.[5] Per review of these specifications, it is assumed that the pipe embedment materials could be considered Class III materials per ASTM D2321, which would require only 90% standard proctor density compaction according to the ASTM D 2321 specification.[6]

An external review of the GDOT project's July 2012 post-installation inspection results indicated that 5 of 12 runs (40 %) had deformation problems:[7]

1. 18-inch diameter PP pipe, 35 feet run, two sections with deformation ≥ 5%, up to 7.5%
2. 36-inch diameter PP pipe, 3 feet installation depth, 60 feet run, with 10 feet section ≥ 5%.
3. 36-inch PP pipe, 7 feet installation depth, 165 feet run, 7 sections with deformation ≥ 5%, up to approximately 8.5%.
4. 36-inch PP pipe, 8 feet installation depth, 165 feet run, approximately one-third to one-half of the run was deformed ≥ 5%, up to approximately 9%.
5. 36-inch PP pipe, 12 feet installation depth, 250 feet run, 5 sections with deformation ≥ 5%, up to approximately 8%.

Orlando-Orange County Expressway Authority Experience

In response to the demands of a partnering municipal agency, the Orlando Orange County Expressway Authority (OOCEA) permitted the use of PP pipe as an alternate pipe material in a small section of a recent bid opportunity for SR 429. Conditional upon permitting the use of PP pipe the OOCEA required the following specification:[8]

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[4] Georgia Department of Transportation, Standard Specifications, Section 550 – Storm Drain Pipe, http://www.dot.state.ga.us/doingbusiness/thesource/Pages/specifications.aspx.

[5] Georgia Department of Transportation, Special Provisions, Supplemental Specification 810 – Roadway Materials, http://www.dot.state.ga.us/doingbusiness/thesource/Pages/special_provisions.aspx.

[6] ASTM D2321-09, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications, American Society for Testing and Materials, 2009.

[7] Review of SR38/US 85 post-installation inspection data for runs A5 to A14, A7A to A7B, A19L to A20L, A19R to A20R, and A24L to A25L, obtained through Open Records Request.

[8] OOCEA Project 429-200D Phase 2, Sheet 19 Drainage Details, Revision 1 Dated October 25, 2012, Included per Bid Addendum, Project No. 429-200D, Contract No. 000886, S.R. 451 Connection to Vick Road – Addendum No. 1, Orlando-Orange County Expressway Authority, October 30, 2012.

If the contractor desires to use flexible, thermoplastic pipe, then the Contractor shall submit for review and approval prior to installation a structural design in accordance with AASHTO LRFD Bridge Design Specifications (2007) and shall be signed, sealed, and dated by a professional engineer licensed in the State of Florida. The structural design shall use AASHTO's long-term material properties, pipe installation depth per the design plans, and shall use groundwater elevations and soil modulus properties based on a certified geotechnical analysis of the project limits. The use of a standard design table for the pipe design is prohibited unless the Contractor provides a certification that the design assumptions used in the design table are representative of the pipe long-term material, cross-section geometry, and site geotechnical conditions (soil type, groundwater elevation, etc.).

The Contractor shall compact backfill to 95% standard proctor density (AASHTO T99) at depth. The pipe structural design shall be based on 90% compaction to account for potential deviation from installation specification requirements. No sooner than 30 days prior to completion of backfill and construction of stabilized subgrade, the Contractor shall conduct a pipe inspection using video and laser ring profiling in accordance with FDOT Section 430-4. Pipe profiler inspections shall indicate the profiler rate on screen. Scans at rates that exceed 30 feet per minute will be rejected. The Contractor shall provide certification that the laser profiling vendor has met the accuracy criteria (http://www.dot.state.fl.us/construction/contractorissues/laser.shtm) in a controlled test conducted at a profiler rate of 30 feet per minute. The Contractor shall provide a certification of one mean pipe diameter for each size of flexible pipe used. Any pipe that is deformed 5% or more than the certified mean diameter shall be rejected, replaced, and reinstalled at the Contractor's expense.

The Engineer shall be responsible for conducting on-site inspections in accordance with ASTM D2321.

Thermoplastic pipe joint gaps shall be inspected an measured. Joint gaps in thermoplastic pipe shall not exceed 0.75 inch. The Contractor shall repair excessive joint gaps, or leaking joints, based on an Engineer-approved method.

Deformation Risk of PP Pipe

Engineers and contractors should consider the risks of experimenting with polypropylene storm pipe. If an engineer or contractor must use PP pipe, even on a small installation, design calculations and installation assumptions should be verified by a licensed professional engineer in that state and the owner may elect to use a performance bond on the PP storm pipe installation in order to offset these risks until a repeatable and successful performance history can be verified.