Lower Your Risk with Concrete Pipe

Lessons Learned from the East Texas Fish Hatchery Incident

Intro: The engineer's role in any design project is to develop a design that is constructible, meets the desired purpose and ensures the health, safety, and welfare of the user. An installed pipe system is made up of two structural components that work together to resist load. The pipe material itself (concrete, plastic, steel, fiberglass etc.) and the structural backfill work together to provide structural capacity. Depending on the material type the structural unit will depend more on the pipe (rigid) or more on the structural backfill (flexible). Reinforced concrete pipe (RCP) is a drainage product that minimizes the installation sensitivities. The use of RCP allows the engineer a lowered risk because RCP is a rigid structure that is designed, manufactured, and tested to meet the loading requirements before it arrives to the project site.

The result of ignoring the structural design and proper installation was front and center at the East Texas Fish Hatchery in 2009. When designers were forced to replace failed drainage pipe with 795 feet of 60" and 2,344 feet of 48" Class V RCP. The failure occurred as a result of an improper installation design based on the site-specific challenges and the selected pipe material. This failure resulted in a $3.2 million settlement that could have been avoided with proper implementation of the pipe design requirements specific to the selected pipe material in the site-specific conditions.

The Texas Fish Hatchery has now experienced the benefits of RCP over the last 10 years as the RCP line is still serving the Fish Hatchery even with difficult site conditions due to its inherent structural strength.

Protecting Yourself as a Gravity Pipe Designer

- **Fill Height Tables:**

  Fill height tables are created using a specific set of assumptions and parameters. If a design chart is used, the engineer should certify that the assumptions and parameters used to develop the table are consistent with the in-situ geotechnical conditions, the pipe properties, as well as with practical construction specifications. In the Fish Hatchery incident, the Engineer misapplied a standardized design chart.

- **Geotechnical Studies:**

  Geotechnical engineering is often a minor part of an overall project budget, but it can be critical. Meeting the standard of care in the design of pipe-soil systems requires knowledge of in-situ soil conditions. In this case, the Engineer overlooked available geotechnical studies for the East Texas Fish Hatchery site, which should have played a critical role in the design and specification of a suitable pipe material and installation.

- **Groundwater:**

  Pipe is sometimes installed in high groundwater conditions. High groundwater can create pipe buoyancy issues, but groundwater can also impact structural performance of the pipe-soil system. The impacts of groundwater can affect various pipe materials differently. The hydrostatic pressures at the East Texas Fish Hatchery contributed to the excessive deflection and ultimate collapse of some sections of the HDPE pipes. RCP inherently is more capable of withstanding hydrostatic forces and is less bouyant due to its structural capacity and dense material properties and is therefore serving the Fish Hatchery's site conditions today.

- **Following Installation Specifications:**

  The design and installation of any drainage product should be done in accordance with the governing specifications. American Society for Testing and Materials (ASTM) has standard installation specifications available for the various types of drainage products available in the market. Some ASTM specifications place more responsibility on the engineer during the installation process. The benefits of ASTM C1479, the standard installation specification for RCP, is that it provides clear instructions for a contractor to install concrete pipe successfully with little to no responsibility placed on the engineer. ASTM D2321, the standard installation specification for thermoplastic pipe, applies numerous responsibilities to both the contractor and the engineer since the structure of plastic pipe depends heavily on an engineered installation. Therefore, the engineer's liability in the installation process is critical to ensure a successful installation of thermoplastic pipe.

  A forensic analysis performed prior to resolution of the East Texas Fish Hatchery lawsuit determined that many of the project specifications appeared to have been derived from ASTM D2321, therefore leaving the engineer liable for the results of the installation.

- **Communication:**

  The request for information (RFI) phase prior to bidding is an excellent opportunity to clarify concerns about such issues as pipe design, acceptance of in-situ materials as suitable backfill, dewatering, final internal inspection, and laser profiling. In the East Texas Fish Hatchery incident, a failure analysis indicated that excessive deflections could have resulted in the ultimate reverse curvature and collapse of the 60-inch corrugated HDPE pipe. Had there been communication regarding the factors affecting pipe performance prior to the bid, perhaps this incident could have been avoided.

- **Post Installation Inspection:**

  All storm pipe systems should be inspected at various stages after final backfill. Post installation inspection provides opportunity to initially detect any installation errors that can result in potential failures, property damage, or personal injury. The structural integrity of RCP is tested at the plant, and therefore, the same structural testing should be performed on a product requiring an engineered installation. That is why it is especially important to measure shape deformations and deflection in flexible pipes using laser profiling equipment. It does not appear that internal pipe inspections were performed in the East Texas Fish Hatchery project until pipe sections had already collapsed.

ASTM D2321 states that deflection tests should be performed no sooner than 30 days after installation in order to allow for stabilization of the pipe soil system. Soil stiffness of the pipe embedment or native trench soils can change over time. Trench settlement can change loads on the pipe. Such time dependent changes typically add to initial deflections. Public agencies and private owners nationwide are recognizing that the use of final inspection is a cost-effective way to verify proper pipe performance and public safety, particularly when using highly installation-sensitive pipe materials.

- **Preventing Structural Failures on Drainage Projects:**
  The structural success of all drainage pipe designs depend on both the structure of the product and the structure of the installation. The benefit of utilizing a rigid pipe design such as RCP is that the product is designed to handle the majority of the loads itself which allows for less stringent installation requirements. On the other hand, the premise of flexible pipe design is engineered installation. A thermoplastic pipe is essentially a liner that requires a contractor to carefully construct a soil embedment structure in accordance with a geotechnically-based design from the engineer. The replacement of 11,000 feet of corrugated HDPE pipe and a $3.2 million settlement could have been avoided if proper design and installation practices that considered the project-specific requirements were utilized to suite the pipe material that was selected for drainage.The concepts explained in this document and a further understanding of pipe design and installation will result in successful drainage projects.

Lessons Learned at the Texas Fish Hatchery

A third-party Construction Assessment and Failure Analysis cited professional opinions for the failure of the designed installed corrugated HDPE pipe system, including:

- "The corrugated HDPE drain pipes collapsed or deflected excessively because the external forces imposed by soil and hydrostatic pressures exceeded the capacity of the pipe and surrounding soil to resist those forces."[3]
- These external forces should have been foreseen. For instance, geotechnical studies were available.[4]
- Soil boring analysis determined that on site materials were poorly suited for pipeline construction.[4]
- Insufficient compaction of backfill material was a significant factor in the collapse and excessive deformations.[3]
- Sufficient compactive effort was not achieved. The gap between the pipe and trench box wall was too narrow to allow proper compaction. Further, dragging the trench box loosened the backfill around the pipe.[3]
- The Contractor did not comply with the specification requirements for dewatering beneath the pipe trench, which led to difficulty achieving proper compaction of pipe embedment.[3]

- The pipe backfill and compaction specifications contained inconsistencies and were difficult to understand.[3]
- The Contractor should have resolved the specification inconsistencies by asking the Engineer to clarify what type of backfill material and how much compaction was necessary. This could have been done at a pre-construction meeting and/or through RFIs to the Engineer.[3]
- The Engineer had important construction phase responsibilities. However, the Engineer believed that its construction responsibilities were limited to progress assessment, monthly site observations, and responding to questions. Despite its on-site presence, albeit limited in scope, the Engineer was simply not aware of the pipe's failing conditions.[4]
- The Engineer "did not provide per their contract with TPWD sufficient services during construction, including sufficient site observations and review of field compaction and inspection records. As such, [the Engineer] fell below standard of care as the Engineer of Record."[4]
- The Engineer "should have more carefully chosen the type of backfill and degree of compaction. At a minimum, a Class II backfill compacted to a minimum of 95% relative compaction should have been used for pipe embedment for the 30-inch and 48-inch diameter pipelines."[4]
- The Engineer's "approach of designing the pipes solely by using a chart was improper given that the chart did not account for the contributions of groundwater that was known to exist at shallow depths at the site. As such, [the Engineer] fell below the standard of care for pipe design."[4]

References:

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3. Exponent Failure Analysis Associates, Construction Assessment and Failure Analysis, Drain Pipeline System, East Texas Fish Hatchery, Jasper, Texas, TPWD Project No. 101690, Exponent Project No. 0904829.000, December 8, 2009.
4. Exponent Failure Analysis Associates, Design Assessment and Failure Analysis, Drain Pipeline System, East Texas Fish Hatchery, Jasper, Texas, TPWD Project No. 101690, Exponent Project No. 0904829.000, December 4, 2009.
5. ASTM D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications, ASTM International, www.astm.org, 2009