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Durability and longevity of concrete pipe determined through an evolution of production and product design

It would be ideal if underscoring the value of concrete pipe was as simple as pointing to legacy pipelines and culverts that have performed as designed for decades and even centuries. That is not the case, because new specifiers, designers, regulators and contractors are entering the market continuously while veterans in the industry leave, taking their experience and knowledge with them. Documented evidence of successful specifications and installations, along with reminders about Standards has to be told and retold. The durability and longevity of concrete pipe is a good story that continues to build confidence in specifying concrete pipe throughout the world.

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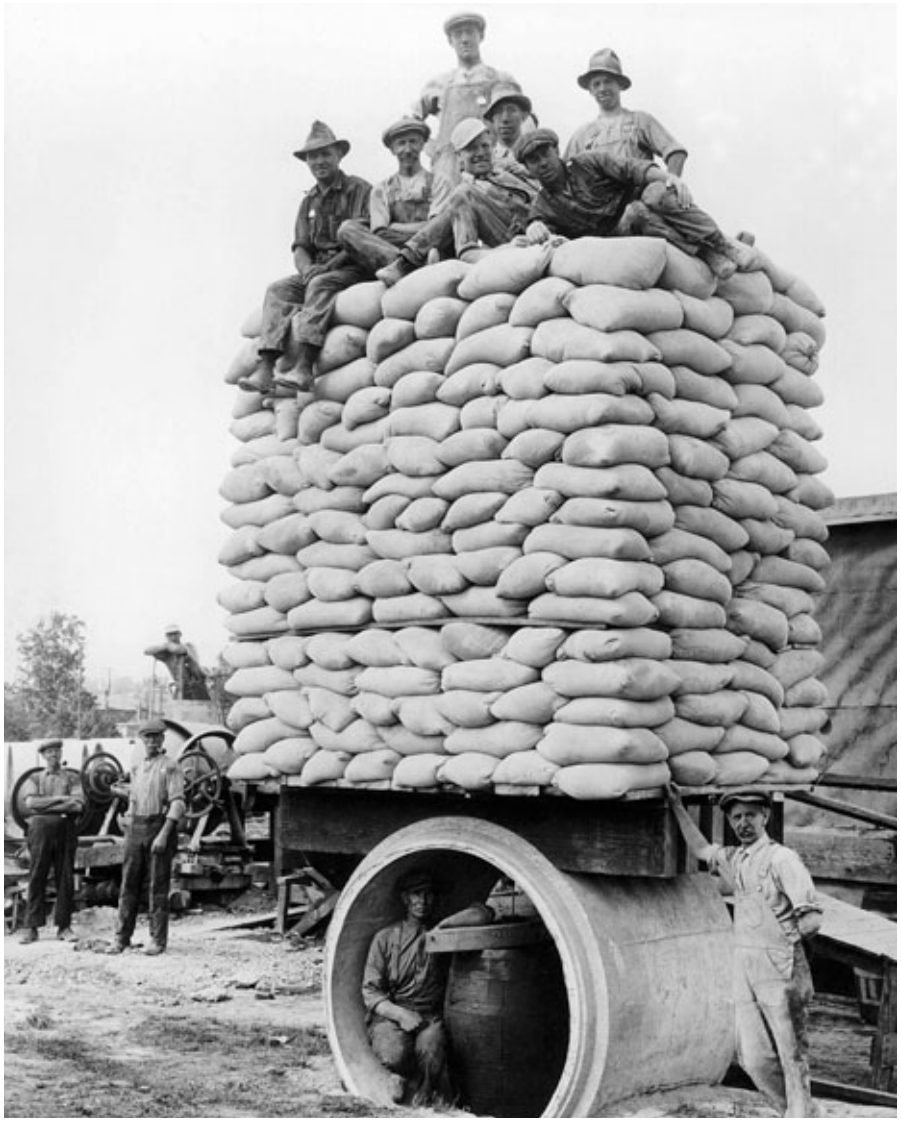
Rome's Cloaca Maxima or "Greatest Sewer" initially constructed around 600 BC by the Romans was built to drain marshes and remove waste. Although not precast concrete pipe, Romans used natural cement concrete to create conduits. Sections of the Cloaca Maxima were installed as buried sewers becoming examples of some of the world's earliest pipeline systems. Some of these systems are in use today after more than 2,600 years of service.

With the urbanization of America and the need for mechanized agriculture to feed a quickly-growing urban populous, concrete drain tile was introduced in the 1840s to carry access water from low-lying areas to improve crop production. During the same period, the oldest known concrete sanitary sewer in the United States, a 6-inch diameter pipe, was installed in 1842 in Mohawk, New York.

It is said the pipeline still functions after 173 years of service. In Chelsea Massachusetts, a concrete pipe sewer installed in 1869 was functioning satisfactorily in 1980, 111 years after installation. There were numerous concrete pipelines installed in New England during the latter half of the 19th century, that were still in use during the 1980s.These are concrete pipe industry examples that reinforce the legacy of durability and longevity of concrete pipeline systems.

When considering the term durability in the context of concrete pipelines, "service life" is a notion that is understood by specifiers, owners and contractors. Durability of a pipeline is the capability of the system to



Workers loading large diameter concrete pipe with sand bags for load bearing test. The photo strongly suggests that pipe producers were aware of the need for long-lasting durable pipelines and culverts constructed with their pipe. Legacy pipelines and culverts attest to the quality of the pipe. Photo: Courtesy of American Concrete Pipe Association

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continue to perform its engineering (structural and hydraulic) functions for an economically acceptable period. The American Concrete Pipe Association (ACPA) expresses durability as: Durability = Economic + Structural + Hydraulic Performance.

Designed to modern Standards, reinforced concrete pipeline systems will provide a 100-year plus service life. It is important, however, to understand the issues that can affect the service life of reinforced concrete pipe to ensure that the service life of the pipeline is achieved.

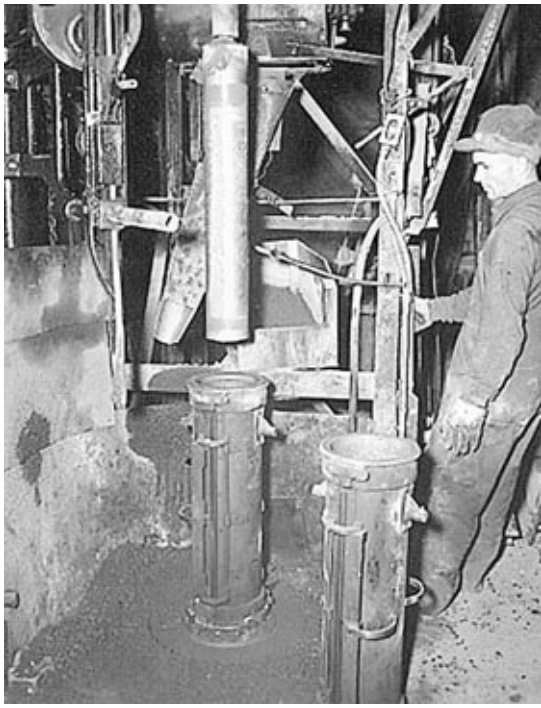
Although durability of concrete pipe is defined; what about longevity of concrete pipe? Culverts and pipeline systems should be designed so that their service life does not adversely impact pavement, bridges or any other component of an engineered highway system or municipal sewer network that have an engineered design life that exceeds 100 years. A modern long-lasting concrete pipeline or culvert rarely requires rehabilitation or reconstruction. In addition, the strength of concrete pipe used for a pipeline or culvert tends to increase over time, contributing to longevity, while autogenous healing of designed cracks strengthens performance.

Longevity plays a crucial role in the Life Cycle Cost Analysis (LCCA/LCA) of a pipeline. The proper way to compare pipe materials for longevity is to perform a Life Cycle Cost Analysis to evaluate overall long-term economic efficiency for competing alternative investment options. The concrete pipe industry's PipePac® software includes an LCA program that compares the longevity of concrete pipe to that of alternative pipeline materials. PipePac helps select the right material for buried infrastructure systems and helps designers to determine the real cost of materials over the design life of the project. PipePac is characterized by three integrated programs: three-edge bearing (3EB) to select pipe class, CAPE (Cost Analysis of Pipe Envelope) and LCA (Life Cycle Analysis).

To achieve modern expectations of durability and longevity, concrete pipe production had to steadily evolve in applied science and technological improvements of production equipment. At the beginning of the 20th century concrete pipe was commonly produced by tamping. ACPA's historical records suggest that the first reinforced concrete culvert pipe was made by Frank Wilson of Wilson Concrete Company, Red Oak, Iowa in 1905 by placing circular rings of reinforcement into the forms as the dry mix was tamped by hand. Through the century leading to modern times, pipe producers used methods that included centrifugal, dry cast, packerhead and wet cast to produce pipe. Today, these methods are automated and many plants have taken the next technological leap to fully-robotic facilities.

The history of specifications and Standards used to produce durable pipe that lasts a long time began in the early 1900s when both Dr. A. Marston and Professor W. J. Schlick (Drainage Engineer of the Engineering Experiment Station at Ames, Iowa), were very active in the work of the Joint Concrete Culvert Pipe Committee of ASTM. In 1909 a proposed specification for plain concrete drain tile was introduced. This is the first indication of a tentative specification for any kind of concrete pipe in America. The recommendation for a specification for the manufacture of plain concrete drain tile was adopted March 30, 1910.
The pioneers of concrete pipelines and culverts knew that specifications were vital to the success of selling their products. They tested their products for durability and performance to be able to compete with clay and the emerging steel pipe industry. Concrete pipe producers of the early 20th century were producing long-lasting durable concrete pipe long before being challenged by manufacturers of existing and alternative pipe materials that were entering the market.

The quality of concrete pipe continues to set benchmarks for durability and longevity of sewers and culverts while production equipment improves along with the quality of accessories like gaskets and lifting devices triggered by design challenges to better compete with low cost alternative products and materials. ACPA has retooled its organization as producers advanced their design of concrete pipe. ACPA has well-established education programs and a network of trained engineers and production personnel to tackle the challenges of its next 100 years which will no doubt include questions about durability and longevity. The concrete pipe industry continues to advance its knowledge of pipe materials and production techniques to make sure that these questions can be answered at any time ■



Early production of small diameter concrete drainage tile using a mechanized process. Photo: Courtesy of American Concrete Pipe Association

FURTHER INFORMATION

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