Concrete Pipe News

SPRING 2011
Volume 63 No. 2

American **Concrete Pipe** Association

www.concrete-pipe.org

Spring 2011
Volume 63 No. 2

Concrete Pipe News is published four times each year by the American Concrete Pipe Association. It is available in hard copy and digital format posted on the ACPA website. *Concrete Pipe News* content is linked to archived technical information, research and product development, educational products and applications of precast concrete pipe and boxes. Content is linked to archived word and graphic files on the ACPA and other industry-wide websites. Readers include engineers, specifiers, contractors, suppliers, government officials, and members of the American Concrete Pipe Association.

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On the Cover:

Concrete pipe on-site storm water management system to store and slowly release almost 1,000 cubic meters.

American **Concrete Pipe** Association

Editorial

Red Alert – What Else is Needed to Show *There Is a Problem?*

Matt Childs, P.E., President
American Concrete Pipe Association

What is it going to take to convince specifiers, designers, regulators and contractors that there are applications not suitable for HDPE sewers and culverts? Despite claims and estimates of 75 to 100-years service – and more, the physical evidence suggests otherwise. Many engineers are beginning to realize that there is much to consider when specifying HDPE installations[1]. Some are now reluctant to sign design drawings, because they know that flexible conduit products differ, and that installation Standards can be complicated.

Soil dependency is much greater for a flexible system than a rigid structure. Once the fundamental design differences are understood, and a designer has the competencies to design a structure that will perform for the design life of a project, then the public will receive an asset that should perform as expected. This is an important distinction, considering two public policies that affect the selection of sewer and culvert material and products.

The FHWA's SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act – A legacy for Users)[2] states that where products appear to be equal, alternative bidding practices must be used as required by the Federal Code. Where alternative products are determined to have different engineering and economic properties, contracting agencies may select a specific material or product based on the required engineering properties and/or life cycle cost criteria. State DOTs do not have to include all pipe materials in a specification, and do not have to use HDPE conduit products. The purpose of the Governmental Accounting Standards Board (GASB) Statement 34[3] is to place a value on infrastructure assets and report those assets in the municipality's financial report.

Both of these policies should grab the attention of designers and specifiers, because their decisions determine the long-term performance of buried infrastructure and their own professional liability. Considering these policies, a recently completed laser video study by Dr. Abolmaali at the University of Texas Arlington, and publication of one of the nation's largest liability settlements at the John D. Parker East Texas State Fish Hatchery in Jasper, you have to wonder why HDPE continues to be specified for major sewer pipelines and highway culverts.

Dr. Abolmaali's nation-wide study[4] indicates that structural health and integrity of the installed HDPE pipelines tested are generally below structurally acceptable levels of serviceability. The design firm that managed the HDPE pipeline at the John D. Parker East Texas State Fish Hatchery[5] absorbed nearly 100% of the financial liability for the repairs. The design firm eventually agreed to cover $3.2 million of the $3.3 million bill.

HDPE has been in the irrigation, sewer and culvert markets since the 1980s. The accounts of premature failures do to reasons ranging from fires, material and product quality, installations not-to-Standards, buoyancy, and oxidation, among others, continue to mount. Being a low capital cost product does not always result in cost savings or valuable assets. What else has to be shown to have HDPE properly specified?

LINKS

1. http://www.concrete-pipe.org/pdf/InstallationComparisonInspectorsContractors.pdf
   http://www.concrete-pipe.org/pdf/InstallationComparisonOwnersEngineers.pdf
2. http://www.concrete-pipe.org/ysk_pdfs/ysk141.pdf
3. http://www.concrete-pipe.org/news/cpnewsspring06.pdf
4. http://www.uta.edu/ce/abolmaali/hdpe%20report.pdf
5. http://pwmag.com/industry-news.asp?sectionID=760&articleID=1520919

Bridging The Technology Gap

NRCP – Cinderella of the Concrete Pipe Industry

Nonreinforced concrete pipe (NRCP) was used widely in America by the mid 1800s as a product of choice for the construction of sewers and culverts. The famous Mohawk, New York sanitary sewer, that was still functioning 142 years after installation, was a nonreinforced concrete pipeline. One of the earliest railroad culverts near Salem, IL constructed in 1854 was still functioning 100 years later. It was nonreinforced concrete pipe. NRCP has a centuries-old legacy in America's food lands of New England, Ohio, the Midwest, California, and Texas as drainage and irrigation pipe. NRCP is still used today, although it can be successfully argued that it is under-specified for modern-day applications. NRCP is the Cinderella of the concrete pipe industry.

NRCP began to fall from grace in the late 1920s when producer members of the American Concrete Pipe Association and industry officials began to debate the merits of nonreinforced and reinforced concrete pipe. Many city and consulting engineers were specifying nonreinforced concrete pipe in large sizes, because they believed that the reinforcing in the thin walls would corrode and lead to deterioration of the pipe! Some producers were mass-producing NRCP using both the packerhead and the tamping process.

Cities grew, and with them the need for large diameter storm and sanitary sewers. Reinforcing steel became standardized and widely used for large diameter products and low head pressure pipe. This trend carried over into the smaller sizes, and NRCP was specified less and less, although many applications for small diameter concrete pipe did not require reinforcement. That trend continues today and many specifiers are completely overlooking the merits of NRCP, and many more know very little about its production, quality, performance – and cost effectiveness! It's a fact that many producers do not make this product that has modern-day applications.

The most commonly used specification for NRCP is ASTM C14-07[1], *Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe*, that provides for production in sizes ranging from 12-inch (300mm) to 36-inch (900mm) diameter pipe. The specification covers Class 1, 2, and 3 round pipe with A, B, and C wall thicknesses. ASTM C985 - 04(2010) *Standard Specification for Nonreinforced Concrete Specified Strength Culvert, Storm Drain, and Sewer Pipe* covers nonreinforced concrete pipe designed for specified strengths and intended to be used for the conveyance of sewage, industrial wastes, and storm water and for the construction of culverts. AASHTO M 86M/M 86-09 covers nonreinforced concrete pipe intended to be used for the conveyance of sewage, industrial wastes, storm water, and for the construction of culverts. CAN/CSA-A257.1-M92, *Circular Concrete Culvert, Storm Drain, Sewer Pipe, and Fittings* pertains to nonreinforced circular concrete pipe and fittings intended to be used for the conveyance of sewage, industrial wastes, storm water, and for the construction of culverts. The Standard is applicable to manufacture and purchase only. Like the ASTM specification, the AASHTO and CSA Standards cover the pipe sizes 12 to 36 inches in diameter. ASTM C505 - 05a *Standard Specification for Nonreinforced Concrete Irrigation Pipe with Rubber Gasket Joints* covers nonreinforced concrete pipes with rubber gasket joints for use in irrigation water conveyance with working pressure, including hydraulic transients. Sizes covered range from 6 to 24 inches.

NRCP is suitable for a wide range of buries and applications throughout the USA and Canada, especially in average installations from two to 14 feet of cover with highway loadings. The pipe is widely used throughout Europe. The pipe is corrosion resistant, but in soils with a high percentage of sulfates in solution that can be replenished, changes in concrete mix design and backfill must be considered. NRCP will not rust or burn, gets stronger with time, and has a specific gravity of 2.40 to resist buoyancy.

Nonreinforced concrete pipe[2] is a twenty-first century product in every way. It can be mass produced in modern automated and robotic plants, and produced with mixes to suit just about any environmental and site condition. It has a service life known to extend beyond 100 years, is a formidable alternative to flexible pipe, and has a competitive price point. The time is long overdue for lifting a veil on a proven product for today's market demands.

LINKS

Info Links

1. http://www.astm.org/Standards/C14.htm
2. http://www.concrete-pipe.org/brochures/pdfs/Rigid-vs.-flexible-material.pdf

Robotic handling of concrete pipe.

Mass production of small diameter NRCP at The Langley Concrete Group of Companies in Chilliwack, B.C., Canada.

Photos: The Langley Concrete Group of Companies, Chilliwack, B.C. Canada.

Work Through the Math – Selection of Pipe Strength for the Trench Condition

Given A 48 inch circular pipe is to be installed in a 7 foot wide trench with 10 feet of cover over the top of the pipe.

Find The pipe strength in terms of 0.01 inch crack D-load.

Solution

1. Determination of Earth Load (W_E)
From Table B-14A, Sand and Gravel, the backfill load based on 100 pounds per cubic foot backfill is 5,581 pounds per linear foot.
Increase the load 20 percent for 120 pcf backfill material.

$W_d = 1.2(5{,}581)$

$W_d = 6.697 \times 10^3$ pounds per linear foot

Note: Another alternative for calculating the load is to use Equations 4.3 and 4.4 of the *Concrete Pipe Design Manual*.

$$C_d = \frac{1 - e^{-2 \cdot K\mu' \cdot \frac{H}{B_d}}}{2 \cdot K\mu'} \qquad \text{Equation 4.4}$$

where:
$K\mu' = 0.165$ for sand and gravel
$H = 10$ feet
$B_d = 7$ feet

$$C_d = \frac{1 - e^{-2 \cdot (0.165) \cdot \left(\frac{10}{7}\right)}}{2 \cdot 0.165}$$

$$C_d = 1.139$$

$$W_d = C_d \cdot w \cdot B_d^2 + \frac{D_O^2 \cdot (4 - \pi)}{8} \qquad \text{Equation 4.3}$$

where:
$t = 5$ wall thickness of pipe in inches

$$D_O = \frac{48 + 2 \cdot (t)}{12} \qquad \text{pipe outside diameter in feet}$$

$$W_d = 1.139 \cdot 120 \cdot 7^2 + \frac{4.83^2 \cdot (4 - \pi)}{8} \cdot 120$$

$W_d = 6997.71$ pounds per foot

Use the calculated value of 6,998 lbs per foot for weight of earth

$W_E = 6998$ pounds per foot

1a. Determination of Internal Fluid Load (W_F)

$$W_F = \pi \cdot \left(\frac{4}{2}\right)^2 \cdot 62.4$$

$W_F = 784.142$ pounds per foot

2. Determination of Live Load (W_L)
From Table 42, live load is negligible at a depth of 10 feet.

3. Selection of Bedding
A Type 2 Installation is assumed. In actual design, it may be desirable to consider other types of bedding to arrive at the most economical installation.

4. The trench variable bedding factor, B_{fv} is given by the following equation:

$$B_{fv} = \frac{(B_{fe} - B_{fo}) \cdot (B_d - B_c)}{B_{dt} - B_c} + B_{fo}$$

Step 1. From Illustration 4.22 for a Type 2 Installation the minimum bedding factor, $B_{fo} = 1.9$

Step 2. A trench width, $B_d = 7$ feet is given.

Step 3. The transition width, B_{dt}, determined from Table 23 is 8.3 feet.

Step 4. From the interpolation of Illustration 4.21, for a Type 2 Installation, the embankment bedding factor, $B_{fe} = 2.86$

Step 5. $B_c = 4.83$ feet: The outside diameter of pipe.

$$B_{fv} = \frac{(2.86 - 1.9) \cdot (7 - 4.83)}{8.3 - 4.83} + 1.9$$

$$B_{fv} = 2.5$$

Use the variable bedding factor, B_{fv} of 2.5 to determine the required D-load pipe strength.

5. Application of Factor of Safety (F.S.) of 1.0 based in the 0.01 inch crack is applied.

6. The 0.01 inch D-load is given by the following equation:

$$D_{0.01} = \left[\frac{(W_E + W_F)}{B_{fV}} + \frac{(W_L)}{B_{fLL}}\right] \frac{FS}{D}$$

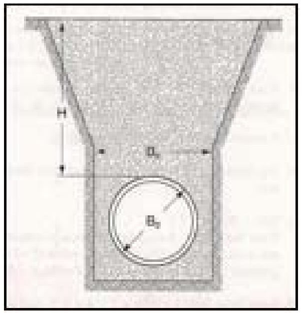
$$D_{0.01} = \left[\frac{(6998 + 784)}{2.5} + 0\right] \frac{1}{4}$$

$D_{0.01} = 778.2$ pounds per linear foot per foot of inside diameter

Answer:
The strength of a pipe which could withstand a minimum three-edge bearing teat load for the 0.01-inch crack would be 778.2 pounds per linear foot per foot of inside diameter.

TAKE THE CHALLENGE - Join ACPA's roster of Math Wizards on our Facebook page.
What is the pipe strength, in terms of 0.01-inch crack D-load, for a 36-inch diameter circular pipe to be installed in a 6-foot wide trench with 20 feet of cover over the top of the pipe?
Email your answer and name to the ACPA at info@concrete-pipe.org and join the Math Wizards.

LINKS
1 to 6 http://www.concrete-pipe.org/designmanual.htm



Concrete Pipe Used for Storm Water Storage

By Stewart Totten, PTech
Strescon Limited
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Four 2100mm diameter manholes supplied to the project.

There is an increasing need to store storm water on developed sites, because of limited sewer access, flooding from more frequent heavier storms, and policies of municipalities to intensify urban development by infilling. Storm water management ponds are becoming less popular as interest grows in storing water below ground[1]. In the City of Saint John[2] New Brunswick Canada, the quantity of the storm runoff from a developed site cannot be any worse after development than it was before, based on the 1 in 100 year return storm, if there is potential to cause or worsen flooding.

When Costco decided to build a new store in the Glen Falls area of Saint John, the runoff from their paved parking lot and roof was a concern and had to be addressed by the designers. Regardless of the storm water management solution, Costco was required to store and slowly release almost 1,000 cubic meters into the local storm sewer system. The designers chose concrete pipe for the on-site storm water management system. The site services contractor, Debly Enterprises of Saint John contracted Strescon Limited[3] (Saint John) to supply the nearly 400 pieces of 1200mm diameter pipe, six concrete Ts, and four 2100mm diameter manholes for the structure. Installation started in mid October, 2009 and lasted approximately two weeks. Access structures were pre-benched, ensuring a smooth flow through the system. Using this size of pipe for larger structures, makes it easy for a pump truck to vacuum the system when maintenance is required. Once backfilled and paved, visitors to Costco will have no idea that they are driving over a large volume of stored water (equivalent to ½ an Olympic-size swimming pool).

400 units of 1200mm RCP used to construct a storm water management structure.

Concrete pipe[4] has been used in North America since the mid 1800s and has numerous advantages over some of the newer pipe materials and products in the market. Concrete pipe does not float, rust, or burn in the case of petroleum spills and wildfires, and is not affected by standard pollutants in storm water or most chemical spills. Joints[5] are the most versatile in the market, since they can be gasketed and water tight, or non-gasketed to allow for ground water infiltration, or storm water exfiltration to recharge groundwater. RCP comes in standard 8-foot or 2.5m sections, so there are more options without cutting pipe when installing the product. RCP is typically produced locally, so suppliers employ area residents and use locally-produced aggregate, which is important if the project is looking for LEED[6] certification. If there is any damage to the product during installation, it is usually cosmetic and can be repaired using standard construction practices and materials, rather than throwing a section away or needing special equipment for repair.

Full Story: http://www.concrete-pipe.org/pdf/ConcretePipeUsedforStormWaterStorage.pdf

Installation of precast concrete pipe structure took two weeks.

LINKS

Info Links

1. http://www.concrete-pipe.org/brochures/pdfs/underground_storm_water.pdf
2. http://www.saintjohn.ca/en/home/default.aspx
3. http://www.strescon.com/drainage.aspx
4. http://www.concrete-pipe.org/why.htm
5. http://www.concrete-pipe.org/pdf/2009%2007%20epipe%20e-07-124%20Concrete%20Pipe%20joints%20brochure%20format%20highrez.pdf
6. http://www.concrete-pipe.org/pdf/2009%2002%20ipipe%20i-003%20Reinforced%20Concrete%20Pipe%20and%20the%20LEED%20Systemipipe.pdf

Learn More About Buried infrastructure

- **Keyword Search on American Concrete Pipe Association Website**
  (Pond, storm, water, retention, detention, hydraulics, SIDD, storage)
  www.concrete-pipe.org
- **Concrete Pipe Design Manual**
  http://www.concrete-pipe.org/designmanual.htm
- **Concrete Pipe News**
  http://www.concrete-pipe.org/cpnews.htm

Photos: Stewart Totten

Century Concrete Pipe Does Exist

By Grant Lee, MCIP, RPP, Manager
Canadian Concrete Pipe Association

It is widely accepted that a 6-inch diameter concrete pipeline, constructed between 1840 and 1842 in Mohawk New York is the oldest recorded sanitary sewer in the USA. It is known that concrete pipe was used for sanitary sewers to control outbreaks of Yellow Fever in the mid 1800s.

There are claims by flexible conduit manufacturers[1] that their products will last 100 years, based on theory, linear regression analysis to determine probability, and limited materials testing. It is important for designers and specifiers to understand that when considering concrete pipe[2], they are working with a well-known material and product that has a proven service life of 100 years[3] and more. It is important for many reasons, that designers and specifiers should be thinking long-term to build public assets that hold value, or increase in value throughout the design life of a project[4].

When developing a confidence level to specify concrete pipe, designers and specifiers may well ask; where are the century concrete pipes and those approaching the century milestone? The concrete pipe industry, municipalities with detailed public inventories because of GASB 34[5], and State DOTs with decades of record-keeping know the location of many century installations.

Some of the Nation's oldest installations of concrete pipeline sewers and culverts can be found in Chelsea Mass, St. Paul Minnesota, Salem IL, Chicago, San Francisco, Appleton WI, Lansing MI, and Oshawa Ontario, Canada.

Concrete drain tile was introduced in the 1840s to improve crop production. The widespread need for tile was recorded in Ohio, where 11 million acres of land were improved with 20,000 miles of drain tile by 1884. The Bureau of Reclamation was instrumental in the development of irrigation installations in Washington, Oregon, California, and Texas. These installations were started and completed between 1925 and 1940. Major irrigation programs included the Central Valley Project in California and the Lower Rio Grande Valley of Texas.

American concrete pipe companies that have remained in continuous service in their communities since the early 1900s also have records of decades-old local concrete pipe installations. The concrete pipe industry and its national and state associations know where century pipe exists. If there is any doubt about the long-term performance and value of concrete pipe sewers and culverts, you may not need to go any further than the records of your own city or town. It can be easily argued that concrete pipe is among the top reasons for the success of your home town.

Full Story: http://www.concrete-pipe.org/pdf/CenturyConcretePipeDoesExist.pdf

LINKS

Info Links

1. http://www.concrete-pipe.org/ysk_pdfs/ysk116.pdf
   http://www.concrete-pipe.org/ysk_pdfs/YSK-142-HDPE-Pipe-Service-Life.pdf
2. http://www.concrete-pipe.org/why.htm
3. http://www.concrete-pipe.org/cp_vs_hdpe.htm
4. http://www.concrete-pipe.org/articles/2006%20Fall%20R%20&%20B%20Stormwater%20supp%20by%20Galloway%20pipesreprint.pdf
5. http://www.concrete-pipe.org/news/cpnewsspring06.pdf

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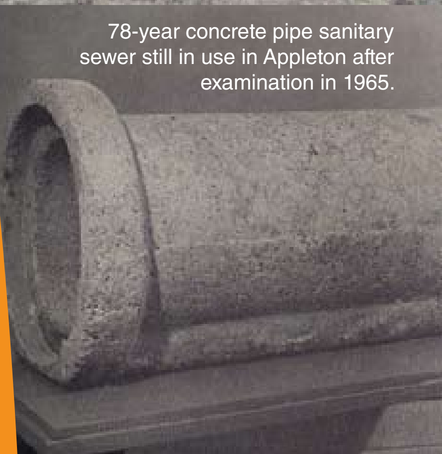
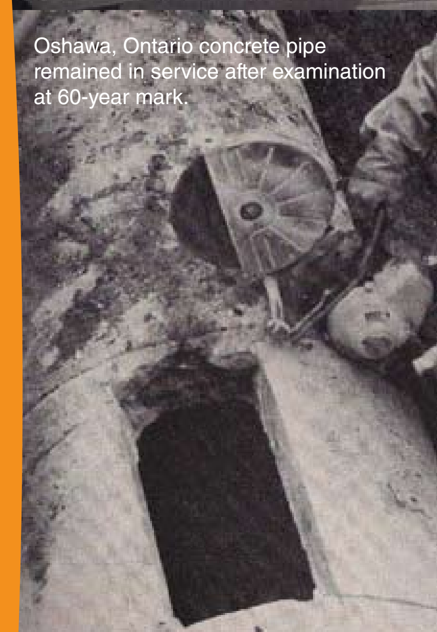
  (Service, design, flexible, rigid, history, performance, GASB, reuse, sanitary, storm, culvert)
  www.concrete-pipe.org
- **Concrete Pipe Design Manual**
  www.concrete-pipe.org/designmanual.htm

6-inch diameter century concrete pipeline constructed between 1840 and 1842 in Mohawk New York.



78-year concrete pipe sanitary sewer still in use in Appleton after examination in 1965.



Oshawa, Ontario concrete pipe remained in service after examination at 60-year mark.

Section of 70-year concrete pipe from San Francisco.

Photos: American Concrete Pipe Association

Selected Effects of Concrete Pipe on the Environment and Climate

By Grant Lee, MCIP, RPP, Manager
Canadian Concrete Pipe Association

Life Cycle Assessment (LCA) can be used to evaluate the potential environmental impact of concrete pipe, and process throughout its entire life cycle by quantifying the use of resources (inputs) and environmental emissions (outputs) to air, water and soil. To complete an LCA, it is necessary to undertake a Life Cycle Inventory (LCI) to reveal consumption in producing a unit of pipe.

ISO 14040-2006[1]*: Environmental Management – Life Cycle Assessment – Principles and Framework*, specifies the general framework, principles and requirements for conducting and reporting life cycle assessment studies. The upcoming ISO 14067 is a Standard for quantification and communication of carbon footprints for products and the development of a greenhouse gas (GHG) protocol for products. The U.S. Green Building Council awards a LEED "Innovation" point to projects using a percentage of Cradle-to-Cradle certified products. Carbon footprint is the overall amount of carbon dioxide (CO_2) and other GHG emissions associated with a product along its supply chain contributing to climate change. The main unit of measurement is kg of CO_2 equivalent (CO_2e)

The results of an LCA study[2] by Concrete Pipeline Systems Association (CPSA)[3] UK show a massive gap between concrete and other types of plastic pipe systems. Work by the CPSA on embodied carbon emissions in gravity pipe suggests that one linear meter of concrete pipe has a lower embodied energy than PVC and PE. Furthermore, greater than 99.8% of inputs into the production of concrete pipe are from local sources indicating that transportation emissions of the inputs to the plant are low ranging from 2.5 to 3.5 kg of carbon dioxide equivalent per tonne of concrete pipe. Data for the production process suggest a low greenhouse gas emission of approximately 22kg of CO_2e per tonne.

Bedding and backfill requirements for concrete pipe reduce transportation of granular imports and the disposal of excavated material. When CPSA compared concrete and HDPE DN2100 pipe per meter to the site, results suggest that the CO_2e/m for concrete is 48 to 84 kg, while HDPE is approximately 143kg. Removal of material from the site is 4 to 10kg CO_2e/m while HDPE is approximately 23kg.

In Europe, concrete pipe has a proven performance for more than 150 years. In America, concrete pipe performs for well over 100 years, with the oldest functioning pipeline being 140 years. Concrete pipe can be recycled as pipe, or as crushed components. The CPSA reports that concrete is carbon negative, since 15 to 35kg CO_2e can be absorbed by $1m^3$ of crushed concrete by carbonation. When the numbers are in, there is little doubt that concrete pipe has the least environmental impact on the environment and the lowest carbon footprint compared to flexible pipe materials and products, especially thermoplastics!

Full Story: http://www.concrete-pipe.org/pdf/SelectedEffectsofConcretePipeontheEnvironmentandClimate.pdf

LINKS

Info Links

1. http://www.iso.org/iso/catalogue_detail?csnumber=37456
2. http://www.concretepipes.co.uk/documents/CPSABrochureINTRONLCAstudy_000.pdf
3. http://www.concretepipes.co.uk/index.php

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- **Concrete Pipe Design Manual**
  http://www.concrete-pipe.org/designmanual.htm

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Randy Wahlen Receives Longfellow Award

The 2010 recipient of the Richard C. Longfellow Award was Randy Wahlen, with Mountain States Concrete Pipe Association. His article, "New Technology, Innovation, and Cost Effectiveness Recognized on UDOT SR 92 Project"1 was published in the Summer 2010 issue of Concrete Pipe News, Page 4.

Each year, a Concrete Pipe News author is honored with the award whose article most effectively demonstrates innovative and effective use of concrete pipe. The award is presented in memory of Richard Longfellow who had an outstanding career with Cretex Companies, Inc. based in Elk River, Minnesota.

LINK TO ARTICLE
http://www.concrete-pipe.org/pdf/2010SummerCPNewsWebEdition.pdf

Save this link www.concrete-pipe.org/cpnews.htm to your favorites list to increase your knowledge about drainage applications and innovative ways to use precast reinforced concrete pipe and boxes to build structures that will last.