

21st Century Infrastructure - Sustainable/Resilient/Legislated

The construction of sustainable pipeline systems is desirable within the notion of sustainable development¹ and its three pillars of social, economic and environment. Conversations about critical infrastructure suggest that not only should materials and products be sustainable, they must also be resilient to both natural and man-made catastrophic events due to changing climate and weather patterns, carelessness, vandalism and deliberate attacks on a system. Acts of terror, like starting fires in thermoplastic sewers and culverts, can easily close vital thoroughfares used by first responders or during evacuation. It can be challenging for designers and specifiers to recommend materials and products for pipeline systems, if there are questions about the resiliency and sustainability of those materials and products that are required to perform at least as long as the design life of a project. Federal, state and local agencies will confirm that it is easier to obtain funds to organize a job properly in the beginning than to obtain funds for repairs, later.

The term resilience, used in the context of urban infrastructure, is rooted in ‘resilience theory’ that was coined in the early 1970s by the Canadian ecologist C. S. ‘Buzz’ Holling (Emeritus Eminent Scholar and Professor in Ecological Sciences at the University of Florida). “He hoped to find the hidden laws that underpin disturbance – whether out of the blue, like fires or explosions, or occurring more slowly, while being similarly transformative. The use of resilience in terms of the urban environment has evolved to take prominence over the discussion of sustainability. This could be partly due to the sense within the word (resilience) that ‘jeopardy’ is increasingly more likely than not. Sustainability suggests that ‘if we do this we might avoid disaster.’ Resilience is more realistic and says, if and when disaster occurs, how well will we bounce back (Hollis).”²

Politics and legislators have no place in the bidding/tendering process for materials, products, and services. Low-bidding and political interference is deeply rooted in government purchasing practices. Any variance from the bidding/tendering system is viewed with suspicion by the public and its elected representatives. But the value of many purchases for engineered projects cannot be determined on price alone. Box culverts, bridges, and drainage pipeline systems are structures. The design engineer must make the decision on the materials and products to use that will provide not only project functionality but also protect the safety of the public. This is an obligation in the Order of the Engineer and in an Engineer’s Code of Ethics. It is the design engineer who is ultimately responsible for the performance of the structure throughout the design life of the project. It is the engineer who accepts liability each time he or she stamps plans and specifications.

State autonomy for culvert pipe selection is confirmed by Section 1525 of MAP-21 (Moving Ahead for Progress in the 21st Century Act) that “directed the U.S. Secretary of Transportation to ensure that States have the autonomy to determine - without any federal interference - the type of culvert pipe material to be used for highway projects within their borders.” The passage of the Fixing America’s Surface Transportation Act (FAST) by Congress on December 3, 2015, signed by President Barack Obama on December 4, accommodates Section 1525 of MAP21. State DOT design engineers and specifiers have autonomy for culvert pipe selection.

¹ What is sustainable development? www.worldbank.org/depweb/english/sd.html

² What do we mean by ‘resilience’? <http://citiesaregoodforyou.wordpress.com/2014/02/18/what-do-we-mean-by-resilience/>

Many state DOTs across the Nation with standard specifications and policy like Vermont and Texas, facilitate the construction of critical culverts and sewers that are resilient to changing climate and weather patterns, carelessness, vandalism and deliberate attacks. MAP 21 and the FAST Act have mitigated potential liability of state and municipal design engineers and specifiers by giving them the autonomy to choose pipe material.

Concrete Choices

Forces that impact the specification of concrete pipe are wide and varied. Within this complex public and private sector marketplace there is a constant that concrete pipe used for critical buried infrastructure systems performs as designed for a long, long time with little unplanned maintenance and low professional and corporate risk to designers, specifiers, and contractors. Contrasted to the low risk of concrete pipe and precast concrete box culverts and sewers is the specification and approval for construction of thermoplastic conduit systems. Such systems do not become pipelines until there is an engineered design interface with surrounding soils that form a continuous structure.

Evidence of the high professional liability risk to design engineers, along with the high risk to the health and safety of the general public (a situation that the professional engineer is sworn to prevent), is found in recent natural and manmade fires that have caused the failure of culverts on critical access roads.

Stoneburg, TX

Brushfires in April, 2009 northwest of the greater Dallas/Fort Worth area sparked debate regarding the use of certain drainage materials under roadways. This is where the entire town of Stoneburg was burned by a 25,000-acre fire. The town with about 100 residents was designed with two thoroughfares for evacuation: FM 1806 and US 81. A section of FM 1806 collapsed when three plastic culverts, used for drainage and support for the road, ignited and melted. An unsuspecting driver drove into a crater on the road caused by the resulting void from incinerated HDPE pipe and sustained severe injuries and a wrecked truck. In addition, the crater broke the axle of a fire truck, leaving one main evacuation route out of the region.

“I cannot believe that plastic pipe (high density polyethylene pipe or “HDPE”) can be used in this setting,” said Jason Ratliff of FX5 Construction and Excavation, the truck driver who fell into the ditch. “I do not understand how a product that catches fire and continues to burn can be used in an area so receptive to brushfire.”

HDPE can be substituted for conventional concrete culverts in roadway construction where storm water pipelines serve as underground support. HDPE is a petroleum-based plastic that is combustible. Since Stoneburg, TxDOT revisited its specifications for culvert materials and to minimize the chance of fire-related damage on future installations, modified the criteria for use of thermoplastic pipe on TxDOT projects. The criteria superseded criteria for use of thermoplastic pipe issued dated September 17, 2002. The special provision notes that when thermoplastic pipe is included in a contract, it should be set up as an alternate to another pipe type.³

³ TxDOT Memorandum dated January 4, 2010, signed John A. Barton, P.E. subject Thermoplastic Pipe

Tucson, Arizona



A fire believed to have been started at the outfall of an HDPE storm sewer installed in a residential subdivision by a private developer melted 60% of approximately 50 feet of 36-inch diameter storm drain. The street was closed until the storm drain system could be inspected, evaluated structurally and repairs made to ensure safe use of the road. What exacerbated the impact of this fire was evacuation of residents due to the large amount of fire and smoke and the uncertainty associated with the fire that buried gas lines in the area were or could be compromised. When HDPE burns, the combustion products include hydrogen cyanide, formaldehyde, carbon monoxide and acrolein in levels that exceed the National Institute for Occupational Safety and Health (NIOSH) Immediately Dangerous to Life or Health (IDLH) concentrations. The health and safety of nearby residents was at risk.

The first fire crew arriving on the scene entered the wash to extinguish the fire that was extending outside of the pipeline with the flames shooting well above the 7-foot wall of the wash. A second fire crew investigated the smoke that was rising from a manhole and storm drain inlet in the housing development. While the crew worked to extinguish the fire from the wash, the second began pumping water into drain inlet and then the manhole to dissipate the smoke and extinguish the fire inside the pipeline.

The developer had installed the cheaper HDPE conduit material although there are restrictions to using HDPE by the local municipality.⁴

Diamond Valley (Prescott), AZ



In May 2011, the Central Yavapai Fire Department arrived at the scene of a fire inside of a plastic storm culvert located at the intersection of Diamond and Emerald Dr. As the fire crew extinguished the flames from both the inlet and the outlet, they noticed the roadway pavement giving way and called the police to close traffic. The 48-inch diameter HDPE culvert pipe had only 2 feet of cover. The total culvert length was 250 feet. Twenty feet of HDPE was burned. Since the residential area was sparsely populated, the fire chief decided that no evacuations were necessary, but it was considered due to the potential of toxic fumes. The fire was determined to be intentionally set.⁴

New Jersey

In the early 2000s, accidents involving fuel spills on NJ highways had increased at an alarming rate. Over a five-year period, nearly 300 accidents involved fuel spills as a result of tanker truck accidents or other highway incidents. In the year 2000, the Department of Community Affairs' Division of Fire Safety accounted for 11 incidents. A Rutgers University engineering group studied the risk and documented the economic consequence of combustible conduit under the state's highway system: "The performance of roadway pavement is significantly affected by the integrity of buried pipes underneath. It is important that these pipes remain structurally sound during the life of the roadway for better performance and uninterrupted service."

⁴ Where There's Smoke There's Fire – e-Pipe Resource # e-016 0 7 /12 – American concrete Pipe Association

Although concrete conduit supports most of NJ's highways, there have been inroads made to substitute HDPE that sell at a discount compared to traditional concrete pipe and manufacturers at that time had not utilized flame retardant additives to reduce or eliminate its propensity to burn. Large underground pipe could present a significant fire hazard by literally carrying a fire from one location to another. Moreover, the collapse of the conduit adjacent to or crossing under the highway would result in highway collapse and catastrophic expense and loss of use for transport.

The New Jersey Department of Transportation is fully aware of specifying appropriate pipe and conduit material for its thousands of miles of highway.⁵

Herriman City, UT

While the outfall of a 42-inch diameter HDPE storm drain was heavily grated, it was not enough to prevent children from crawling under the grate and into the storm drain where they placed hay to build a fort. They started a fire and the conduit contained enough petroleum to catch fire and spread. The children were nowhere to be found, causing great concern. First responders spent over 4 hours searching the site.

The fire moved rapidly up the pipe, burning the invert and melting the crown. Firefighters wanted to enter the upper end of the pipe, but the fumes were too dangerous. The city poured water from fire hydrants into the storm drain, but by then over 800 feet of the storm sewer was lost.⁶

HDPE Conduit is Flammable and Toxic

Fire is an issue with HDPE conduit, even if the pipe meets AASHTO specifications. The HDPE industry is aware of the fire potential, but has apparently chosen to downplay the risk. The owner of the culvert or pipeline assumes responsibility for the risk of fire. So why take that risk?

The American Concrete Pipe Association and one of its members used samples of polypropylene (PP), reinforced concrete pipe (RCP), and high density polyethylene pipe (HDPE) to demonstrate comparative flammability. Dry hay was ignited in three 18 in. by 18 in. pipes and allowed to burn. In 22 min. 30 sec. the thermoplastic samples had incinerated.⁷

It is vital in these times of fiscal responsibility, uncertain weather patterns and man-made catastrophes that critical buried infrastructure be specified by engineers who have the choice to design resilient structures that are protected by legislation.

⁵ www.prnewswire.com/news-releases/increases-in-fuel-spill-accidents-raise-concerns-about-nj-roadway-infrastructure-55780782.html

⁶ What Positive Lessons can be Learned from an HDPE Fire? – You Should Know – Bulletin No. 134 – American Concrete Pipe Association

⁷ www.youtube.com/watch?v=z34KNQWS2Ds – American Concrete Pipe Association