Durability and Reliability of Large Diameter HDPE Pipe for Water Main Applications [Project #4485]

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Due to leaks and breaks, U.S. water utilities, in aggregate, lose more than a quarter of processed water between treatment plants and the tap every day. Potable water pipe rehabilitation costs may reach more than $1 trillion in the coming decade. Previous research shows that there is a need for a reliable and durable pipe material. High Density Polyethylene (HDPE) pipe is one such material to consider. The large diameter (16 in. and larger) water pipe market in the United States mainly includes steel pipe (SP), prestressed concrete cylinder pipe (PCCP), ductile iron pipe (DIP), and PVC (Polyvinyl Chloride) pipe. Currently, HDPE pipe comprises only a small portion (estimated to be 2 to 5%) of the large diameter potable water pipe market.

The main objectives of this project were:

- To explore North American water utilities’ experiences with durability and reliability of large-diameter HDPE pipes in water applications.
- To identify features and characteristics of HDPE pipes in municipal water applications, such as design, installation, maintenance, etc., as well as any limitations or issues.
- To develop a protocol for fatigue (cyclic surge pressure) testing of large diameter HDPE pipe as recommended by water pipeline professionals during the initial phase of this study.

The project approach was divided into six main tasks as summarized below:

1. Search existing publications regarding durability and reliability of HDPE pipe
2. Survey of water utilities to document their experiences regarding HDPE pipe use
3. Conduct a workshop with water professionals to identify issues and corrective measures
4. Perform experiments on a 16-in. diameter HDPE pipe sample
5. Collect case studies of past HDPE pipe projects
6. Prepare a Final Report

The literature search presents an overview of past research on HDPE pipe. While this research validates HDPE as a suitable material for use in municipal piping systems, more research may help users maximize their understanding of its durability and reliability. Overall, corrosion
resistance, hydraulic efficiency, flexibility, abrasion resistance, toughness, fused joints, and long service life are among the advantages listed for HDPE pipes. Permeability, repair and maintenance, long term viscoelastic growth, slow crack growth (SCG), and susceptibility to attack by strong oxidizers are issues mentioned in the literature. Proper design, specifications, installation, and operation typically mitigate any reduction in durability and reliability due to these issues.

The survey of water utilities indicated that the majority of respondents were satisfied with the durability and reliability of large diameter HDPE pipe, while 5% were unsatisfied. Survey respondents expressed concerns about tapping, repairs, and joints. They considered permeation and oxidation to be minor concerns. There were no failures reported due to oxidation or permeation in large diameter HDPE piping systems. They mentioned that some measures, such as improvements in tapping, repairs, are joints are required to improve construction techniques, as are described in this report.

The three project workshops provided valuable input to the project team and helped improve upon the project scope and experimental approach. The innovative and structured approach utilized for the workshops allowed the critical topics to be identified and discussed in an efficient manner. The workshops enabled the project team to explore different perspectives and identify several studies and experiences brought up by the project participants.

This project developed a methodology and designed the testing setup for cyclic pressure testing and fatigue evaluation of large diameter pipes. The pipe sample selected for this project was a 16-in., DR 17, PE4710 pipe containing a butt-fused joint in mid length. The pipe sample was pressurized to its pressure class (125 psi) and then cycled to 1.5 times its pressure class (188 psi) for two million times without failure. Two million pressure cycles is the equivalent number of surges applied to a pipe over 100 years of service at the rate of 50 surges per day. After completion of the two million cycle test, the same pipe sample was cycled from its pressure class (125 psi) to 2 times pressure class (250 psi) for an additional 50,000 cycles without failure. The testing protocol developed in this project can be used to evaluate other types of large diameter pipes.

The case studies collected by the project team and presented in this report provide details on successful installations of large diameter HDPE pipe. Information regarding the challenges and solutions developed during the construction operations are included in these case studies.

Overall, this project shows that large diameter HDPE pipe is a suitable pipe material for large diameter water transmission applications. This report provides strategies to address perception issues preventing wide use of large diameter HDPE pipe, and provides recommendations regarding HDPE pipe joining, fittings, specifications, design, installation, and maintenance.