

## **Development and Testing of Robotically Installed Manufactured In-Place Composite Pipe (MICP) for Pressure Pipe Renewal**

The pressure pipe rehabilitation market is a \$2 billion annual industry and is dominated by traditional intrusive construction methods that involve digging and replacing the pipe from the surface or requiring large ingress/egress footprints. Pressure pipes carry more loads than gravity pipes, renewal methods must be more robust to meet full structural classification (Class IV). Spray-in-Place Pipe (SIPP) lining technology is one of the oldest and most practical methods among all pipe rehabilitation technologies. Most SIPP technologies are currently classified as barrier linings (Class I/II) and only a very few even classify as semi-structural (Class III) per AWWA M28. This paper presents the material and robotic application development/testing of an Manufactured In-place Composite Pipe (MICP) renewal lining system. The robotically applied lining system that uses mechanically reinforced polymer coating that completely overcomes the limitations of SIPP. The patented application devices apply a combination of polymeric (polyurethane) formulations with carbon fiber reinforcement. Each portion of the system assists in the ease of application and long term performance of the full structural (Class IV) renewal system. The MICP incorporates a suspension ductile polyurethane layer that protects the structural liner (also a polyurethane) to mitigate failure events initiated by corrosion, seismic, bending or frost heave events. Carbon fiber reinforcement layer(s) are specifically designed and integrated into the robotic manufacturing to mitigate creep limitations of the structural polyurethane liner material. The MICP is robotically manufactured inside of the pipeline offering real time visual and multi-sensor feedback for application adaption and quality control and assurance. The paper will detail the structural and machine design/development along with laboratory and full scale testing of the material system, field deployable robots and support systems for 48 inch to 144 inch diameter pressure pipes.