Bonded or Unbounded Liners? How Longitudinal Bending Impacts Pipe Lining Design and Performance

Since its inception in 1989, ASTM F1216 non-mandatory design Appendix X1 has been widely used across the industry to determine minimum CIPP wall thickness requirements for gravity-flow and low-pressure pipe applications. Although it has served the industry well, it was developed around homogeneous materials and does not incorporate axial checks nor address critical aspects of pressure pipe design.

A variety of water main renewal technologies are commercially available, ranging from Class I (corrosion barrier), to Class II-III (interactive) to Class IV (fully structural). Although some design objectives of each structural classification are clear, others are left open for interpretation. An example of this is the concept of bonded and unbounded liners. By definition, Class II liners (and some Class I) rely on adhesion to the host pipe to prevent collapse when subjected to negative pressures. This design feature may also carry over to Class III and Class IV systems even though they each have the inherent hoop stiffness necessary to survive vacuum or external loads when a pressure pipe is decommissioned.

A critical component to pipe lining design is maintaining hydrostatic integrity, which is often enhanced by obtaining reliable adhesion between liner and host pipe. This is particularly important where robotic service reinstatement methods are utilized. For water distribution systems, the utilization of mechanical end seals in combination with reliable adhesion offers an attractive design alternative, assuming that the buried system maintains equilibrium with its surroundings and future external corrosion does not adversely affect performance.

Recent discoveries on pipe lining projects demonstrate the need for unbounded liners on certain applications. CIPP installed on separate projects in ductile and cast iron gravity-flow sewer and water main pipes exhibited cracking at joints. In each case, the CIPP was bonded to the host pipe and issues were initially determined to have been caused by longitudinal bending due to frost heave, expansive soils or settlement.

Subsequent demonstration testing of bonded and unbounded CIPP liners was conducted. Results showed that a bonded liner has limited ability to withstand joint misalignment while the unbounded liner can accommodate significant joint deflection up to and beyond the laying tolerance for unrestrained ductile iron pipe joints. This testing demonstrates the inherent benefits of using unbounded liners on pipe lining projects where longitudinal bending is a design consideration.