ABSTRACT

Pipe liner design is currently performed considering buckling as the controlling performance limit. Preliminary laboratory testing demonstrates that when the repaired pipe is subjected to disturbance, local contacts between the host pipe and the liner can develop, resulting in significant local bending in the liner. This local bending can be a performance limit of the flexible liner. To date, there is no design approach available to account for this earth load effect. The primary objective of this study has been to: (a) investigate the flexural stiffness of the fractured sewer pipe under earth loads, without the liner, and identify key parameters that influence its behaviour; (b) examine the static response of the repaired pipe system to earth loads to identify a performance limit of the pipe liner besides buckling; (c) develop a numerical model that captures the kinematics of the repaired pipe system to study its response to earth loads; (d) introduce a new liner design approach that accounts for the earth load effect; (e) assess whether it is conservative or unconservative to design liners for earth load by neglecting the host pipe.

Both full scale laboratory testing and finite element analysis have been performed. Results from the laboratory tests reveal that the flexural behaviour of the repaired sewer pipe is similar to a flexible pipe, in that the deformation is controlled by the surrounding soil. It was found that the static response of the repaired pipe to earth loads had induced a significant increase in circumferential tensile strains in the liner; therefore, ignoring the presence of the host pipe in liner design can be unconservative. Both laboratory measurements and finite element analysis results have demonstrated that the liner

responds in almost pure bending, as the fractured host pipe provides most of the hoop stiffness when the host pipe segments are in direct contact with each other. As a result, liner buckling cannot occur under the action of earth loads. A ring under parallel plate load analogy has been used to represent the response of the liner, and a design equation developed to quantify the local strains in the liner.

Keywords: trenchless technology, sewer rehabilitation, flexible pipe liners, laboratory testing, local strains, finite element analysis, liner design, realistic liner geometry, geosynthetics