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Numerical Analysis and Laboratory Test of Concrete Jacking Pipes

Summary

Pipe jacking is a trenchless construction technique for the installation of underground pipelines. Although pipe jacking is widely used, fundamental research is still needed to understand fully the factors affecting the process and to prevent unexpected failure. With the time and financial limitation, it is difficult to explore all aspects of these factors with experiments; and it is also difficult to study them by analytical methods because of the complexity of the problem. This thesis describes the use of the finite element technique to study the pipe performance under different environments and the laboratory tests of several different joint designs.

The emphasis of the current research is on the performance of the concrete pipes during jacking under working conditions and to seek possible improvements in the design of pipes and pipe joints by numerical modelling. In the finite element modelling, a simplified two-dimensional model is used for a preliminary study, then the analyses are carried out with three-dimensional models A, B and C representing a complete pipe, a pipe with surrounding soil and a symmetric three-pipe system respectively. Several factors affecting the pipe performance have been examined, for example, the properties of the packing material, the stiffness of the surrounding soil, the misalignment angle at the pipe joint, and the interaction between the pipe and surrounding soil.

The numerical results show that the misalignment of the pipe is the dominating factor inducing both tensile stresses and localized compressive stresses in the concrete pipe, especially with a high misalignment angle which results in sepapation between packing mataerial and the pipe. The packing materials with high Poisson's ratio and high stiffness also induce higher tensile stresses in the pipe, and the influence of Poisson's ratio is significant. Under 'diagonal' loading, both the stiffness of the surrounding soil and the interaction between the pipe and the surrounding soil have a significant effect on the stresses within the concrete pipe. Under 'edge' loading, the greatest potential damage is at the pipe joint due to the tensile stresses in the hoop direction; while under 'diagonal' loading, the damage is most likely the cracking on the external surface of the pipe along a line connecting the two diagonal loaded corners. The results show that the Australian model gives somewhat good prediction about the maximum normal stress and thediametrical contact width at pipe joint.

Based on the numerical results, several different joint designs for improving the pipe strength have been proposed and testsed in the laboratory. Both the laboratory tests and the back analyses suggest that the local reinforcement and the local prestressed band at the pipe joint will improve the pipe strength.