BEHAVIOUR OF BURIED PIPELINES SUBJECT TO NORMAL FAULTING

by

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Abstract

One of the most severe hazards for buried pipelines, which are sometimes referred to as lifelines due to their essential role in delivering vital resources, is the hazard due to Permanent Ground Deformation (PGD). Earthquake induced PGD can be caused by surface faulting, landslides and seismic settlement. In this thesis, the behaviour of buried pipelines subject to normal faulting has been experimentally investigated through a series of centrifuge tests performed on both continuous and jointed pipelines. Both pipe and soil displacements were measured using image analysis. Signal processing techniques were then developed to filter this data so as to enable the calculation of curvature and other aspects of the response from the observed pipe deformations.

First, a series of centrifuge tests was conducted on continuous pipelines of varying materials, representing a wide range of pipe stiffness relative to the soil and investigating the effect of pipe stiffness relative to the soil on soil-pipe interaction. The experimentally derived p-y curves at different locations along the pipe were compared to the recommended soil-pipe interaction models in the relevant guidelines. These p-y curves showed that the central shearing region was not captured well with independent soil springs. The response of the pipelines predicted by the ALA (2001) guideline, however, was shown to match the experimental data within 50%.

Two new simplified design approaches were then developed. The first features calculations based on simplified pressure distributions. The second featured peak curvature normalized using a characteristic length, i_{pipe}, the distance from peak to zero moment.

A series of centrifuge tests using brittle pipes was also performed. The pipes were buried at three different depths, and the post-failure fracture angle of the pipe was measured to be used as an input for design of liners. Based on the experimental data, a computationally efficient approach

was developed to estimate the initial fracture angle which occurs immediately after the pipe breaks.

The last series of centrifuge tests was conducted on jointed pipelines with five different joint stiffnesses to investigate the flexural behaviour of jointed pipelines under normal faulting. Based on the observed pipe response, a simplified kinematic model was proposed to estimate the maximum joint rotation for a given geometry, pipe segment length, and the magnitude of the imposed ground displacement.