Numerical Analysis and Evaluation of Buried Pipeline Response to Earthquake-Induced Ground Fault Rupture

By

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ABSTRACT

Buried pipelines often serve as lifelines in that they may carry resources that are essential to the support of human life (water and natural gas). When such pipelines cross active earthquake faults, there is potential for major damage to the pipeline and thus there is significant interest within the seismic design community in being able to accurately predict their response to such faulting. However, a review of the literature indicates that relatively few full-scale case histories or experimental investigations exist which could be used to benchmark or confirm the applicability of current analysis and design guidelines. Thus, a systematic study, employing advanced computational simulations in parallel with physical testing (small-scale centrifuge testing and full-scale testing), was undertaken to evaluate the seismic response of buried pipelines subjected to ground fault rupture in the form of strike-slip and normal faulting.

This study focuses on the following four major topics: 1) Numerical modeling of pipelines subjected to strike-slip faulting, 2) Numerical modeling of buried pipelines subjected to normal faulting, 3) Local buckling of buried pipelines subjected to fault offsets and 4) Numerical simulation of lateral soil-pipe interaction. For each of these four topics, attempts are made to benchmark the usefulness and relative accuracy of various analytical approaches and numerical models through comparisons with data from physical tests. The numerical models are developed within a finite element analysis framework wherein both simplified two-dimensional models, which can be directly used in the seismic design of buried pipelines, and more complex three-dimensional (continuum) models, which can more accurately reflect the nature of soil-pipeline interaction, are utilized.