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Seismic analysis of underground pipelines subject to dynamic loading

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ABSTRACT

Seismic damage to buried underground pipelines was observed in the Canterbury 2010-2011 earthquakes, New Zealand. The post earthquake reconnaissances of these failures provide useful information about the failure modes and failure mechanisms of buried pipelines. The earthquake safety of buried pipelines has attracted a great deal of attention after the Christchurch earthquakes. Several studies have been carried out to investigate the earthquake response of the underground pipeline network in Christchurch, New Zealand. However, little numerical studies have been done to assess the influence of pipe properties and soil conditions.

In this paper, the failure mechanisms of pipelines under dynamic loading were reviewed. Numerical modeling of dynamic responses of buried pipeline was carried out using finite element software package Plaxis. The responses of a pipeline with and without internal pressure were evaluated and compared. Parametric studies of the pipe sizes, buried depth, embedment, and internal pressures were conducted. The factors influencing pipeline behaviors of pipes were summarized. The results and methods in this work can be referred in the design and assessment of pipeline working conditions.

Introduction

Underground pipelines are essential infrastructure supplying the urban and rural area with indispensable services (e.g. sanitary and drainage networks, power, telecommunication, water mains and natural gas). Underground pipelines are buried pipes by earth filling and/or covering, with all loads on top of the pipe supported by the pipe soil formation below the pipe.

Between September 2010 and July 2011 two large earthquakes occurred in the Christchurch area in New Zealand, including (1) the Mw 7.0 September 4, 2010 Darfield earthquake and (2) Mw 6.1 February 2011 Christchurch earthquake. The Christchurch earthquake is regarded as an aftershock of the Darfield earthquake (GNS 2011). The two major earthquakes have caused extensive catastrophic damages to Christchurch underground pipelines (CERA 2014; Cubrinovski et al. 2012, 2014; Giovinazzi et al. 2012; Milashuk et al. 2012; O'Rourke et al. 2014). Facility and utility owners, and providers faced the huge task of assessing and repairing the damage. The sub main pipeline (pipe diameter < 800 mm) system repairs were reported at 400 and 2000 locations during

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