Pipeline Crossings (Asce Manual and Reports on Engineering Practice)

Assessment of the Behavior of Buried Concrete Pipelines Subjected to Ground Rupture: Experimental Study

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Abstract: Rapid assessment of damage to buried pipelines from earthquake-induced ground deformation is a crucial component to recovery efforts. This paper reports on the first year of a four-year study aimed at developing rapid, reliable, and cost-effective sensing systems for health monitoring and damage detection for buried concrete pipelines subjected to ground deformation. A custom-designed sensing strategy was implemented in a ground rupture experiment with a scaled-down concrete pipeline. The behavior of the pipeline, including the failure modes and damage inflicted to the pipe segments, was monitored during the test. Two modes of failure were identified in the test: (1) compression associated with telescoping-type deformation and (2) bending at the pipeline joints closest to the fault plane. Consequently, future research toward advancing sensing technology for concrete pipelines will likely focus on the behavior of the joints. **DOI: 10.1061/(ASCE)PS.1949-1204.0000088.** *© 2012 American Society of Civil Engineers.*

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Introduction

The assessment of damage to lifelines after natural disasters, such as earthquakes, is crucial for management of an effective emergency response and recovery efforts. Of particular importance are water supply systems because water is an important survival resource; even minor damage to water pipelines may result in contamination and epidemic outbreaks. Buried water pipelines are one of the most vulnerable systems to damage from ground motion (e.g., as a result of earthquakes; Eidinger 1996). In particular, pipelines in the vicinity of permanent ground displacements near faults are most susceptible to damage.

A fair amount of research has been performed on the system performance of pipelines (e.g., Isoyama and Katayama 1982; Markov et al. 1994). Earthquake-induced damage of buried pipelines can be classified as being caused by wave propagation or by permanent ground deformation (PGD). This distinction was first made by Eguchi (1983), who correlated pipe-break rate as a function of Modified Mercalli Intensity (MMI) of shaking for different earthquakes. Barenberg (1988) established an empirical correlation relating damage of cast iron pipes caused by wave propagation to peak horizontal ground velocity. Subsequently, O'Rourke and Ayala (1993) developed a correlation relating damage rate to peak velocity for pipes made of different materials. The study presented in this paper, however, focuses on damage caused by PGD, which is widely accepted as the most serious damage mechanism for pipelines (O'Rourke 2005). As discussed in O'Rourke (1998), the distribution of permanent ground displacements varies as a function of intensity and duration of earthquake shaking at a site, site grade, soil type, and location of groundwater table. From post-earthquake investigations, various correlations between pipe damage rate and PGD have been proposed (expressed in terms of number of breaks per given length of the pipeline). Typically, the correlations are categorized based on the types of pipe (e.g., iron or asbestos cement) and the characteristics of PGD. For instance, Porter et al. (1991) report four breaks per 300 m (1,000 ft) for the pre-1960 cast-iron pipes subjected to PGD of 50 cm (20 in.) More examples and appropriate charts can be found in Porter et al. (1991), Heubach (1995), Eidinger et al. (1995), and O'Rourke et al. (1998).

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