NUMERICAL EVALUATION OF THE STRIKE SLIP FAULT EFFECTS ON THE STEEL BURIED PIPELINES

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ABSTRACT

Pipelines are often referred as "lifelines" and this demonstrates that pipelines play an important role in human's life. Based on the damage mechanism of buried pipelines, seismic effects can be either caused by transient strain and curvature in the ground due to traveling wave effects or caused by permanent ground deformations; such as fault deformation, landslide, and liquefaction-induced soil movements. Among them, the ground movements of active faults can have the most severe earthquake effects on buried pipelines. The traditional method of assessment of a buried pipeline subjected to seismic faulting is initially carried out using analytical methods. Due to the limitations of these techniques for large deformation soil movement associated with fault displacement, non-linear finite element (FE) methods are widely used to assess the pipeline integrity. The FE analysis typically idealises the pipeline using discrete structural beam-type elements and the pipeline-soil interaction as discrete non-linear springs, based on the concept of subgrade reactions proposed by Winkler. Recent research suggested that the use of the discrete Winkler element model leads to over-conservative results in comparison to the coupled continuum model. The principal reason for the conservatism is related to the poor modeling of realistic surrounding soil behaviour for large deformation events. In this paper the effects due to difference in ground motion from surface faulting has been studied using 3D finite element continuum model, winkler model and analytical method. The structural response of steel pipelines under strike-slip fault movement is examined numerically using the general purpose FE program ABAQUS. The nonlinear seismic response of buried pipeline under permanent ground deformation is analyzed using pseudo-static analysis method without considering the fracture of the soil. Some influential factors, such as fault-pipeline crossing angle, backfill type and burial depth are considered in the analysis in order to draw some regular conclusions.

1. INTRODUCTION

Earthquakes may constitute a threat for the structural integrity of buried pipelines. Post-earthquake investigations have demonstrated that the majority of seismic damages to continuous oil and gas steel pipelines were caused by permanent ground deformations such as fault movements, landslides, liquefaction-induced lateral spread, whereas only few pipelines were damaged by wave propagation. Permanent ground deformation is applied on the pipeline in a quasi-static manner, and it is not necessarily associated with high seismic intensity, but the pipeline may be seriously damaged. Such pipeline damages have been reported in numerous earthquakes, such as the 1971 San Fernando earthquake, and, more recently, the 1995 Kobe