Dynamic Analysis of Buried Steel Pipelines with Elbow Under Wave Propagation

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Abstract

Pipelines are often referred to as "lifelines" and this demonstrates they play an role for human life and safety. If such facilities are damaged in an earthquake, it will result in both spoiling of products and services and also threatening health and environment. Due to considerable length and wide geographical distribution of pipelines in comparison to other types of structures, they are subjected to different seismic hazards and various soil conditions. As a result, evaluation of pipeline plays a key role in engineering.

Seismic wave propagations and its incidence affect operation of buried pipelines which influences safety of pipeline systems during and after earthquakes. This subject has been studied in the presented research. For this purpose, shell and beam models have been employed and connector elements are used for simulation of buried pipelines and soils, respectively. The connector elements are employed due to their more accuracy in simulation of soil hardening behavior in cyclic loadings, in comparison with spring elements. Moreover, a boundary condition has been used at the end of each branch of pipe that simulates their infinite length more closely. Also, spatial variation of the incident waves was regarded as a certain incidence angle causing time lag in vibration of different points and it was studied as an influencing parameter on pipeline system. The elbow angle is an important factor in response of pipeline systems. Generally, elbow angles in the range of 112.5 and 157.5 degrees are subjected to higher strains. The horizontal propagation of waves and parallel to one of branches, has the most influence on response of pipelines. Thickness and buried depth of pipes are other important parameters that influence the elbow strain. However, soil type should be considered as a factor which could increase or decrease the effect of thickness and buried depth.

Pipelines in condensed soil have less slippage and higher axial strain. Results of shell models do not have a significant difference with beam models; however, shell models are preferred because of their ability to show response changes in cross section of pipes. Finally, maximum strain in buried pipeline as a result of wave propagation leads to plastic deformations and local buckling that are not as much to reach the failure point.

Key Words: Buried Pipeline, Wave Propagation, Elbow, Numerical Model, Pipe-Soil Interaction