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Seismic Impact and Design on Buried Pipelines

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Abstract : Seismic design of buried pipeline systems for energy and water supply is not only important for plant and operational safety, but in particular for the maintenance of supply infrastructure after an earthquake. Past earthquakes have shown the vulnerability of pipeline systems. After the Kobe earthquake in Japan in 1995 for instance, in some regions the water supply was interrupted for almost two months. The present paper shows special issues of the seismic wave impacts on buried pipelines, describes calculation methods, proposes approaches and gives calculation examples. Buried pipelines are exposed to different effects of seismic impacts. This paper regards the effects of transient displacement differences and resulting tensions within the pipeline due to the wave propagation of the earthquake. Other effects are permanent displacements due to fault rupture displacements at the surface, soil liquefaction, landslides and seismic soil compaction. The presented model can also be used to calculate fault rupture induced displacements. Based on a three-dimensional Finite Element Model parameter studies are performed to show the influence of several parameters such as incoming wave angle, wave velocity, soil depth and selected displacement time histories. In the computer model, the interaction between the pipeline and the surrounding soil is modeled with non-linear soil springs. A propagating wave is simulated affecting the pipeline punctually independently in time and space. The resulting stresses mainly are caused by displacement differences of neighboring pipeline segments and by soil-structure interaction. The calculation examples focus on pipeline bends as the most critical parts. Special attention is given to the calculation of long-distance heat pipeline systems. Here, in regular distances expansion bends are arranged to ensure movements of the pipeline due to high temperature. Such expansion bends are usually designed with small bending radii, which in the event of an earthquake lead to high bending stresses at the cross-section of the pipeline. Therefore, Karman's elasticity factors, as well as the stress intensity factors for curved pipe sections, must be taken into account. The seismic verification of the pipeline for wave propagation in the soil can be achieved by observing normative strain criteria. Finally, an interpretation of the results and recommendations are given taking into account the most critical parameters.

Keywords : buried pipeline, earthquake, seismic impact, transient displacement
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