

BUCKLING AND POST-BUCKLING BEHAVIOR OF BEAMS ON ELASTIC FOUNDATION MODELING BURIED PIPELINES

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Keywords: Winkler beam, buried pipeline, upheaval buckling, buckling mode cross-over, buckling mode interaction, nonlinear analysis

ABSTRACT

Buried pipelines transporting oil products are structures of great financial, environmental and social importance. Such structures must adapt to eventual deformations of the surrounding soil, thus they may be severely damaged by large imposed permanent ground displacements triggered by landslides or seismic fault activation, causing combined axial and bending actions along the pipeline. Possible failure modes are tensile fracture at the welds between adjacent pipeline parts, local shell wall buckling in regions of high compressive stresses and upheaval buckling, which may be critical for relatively shallowly buried underground pipelines with low diameter to thickness ratio.

The latter issue is investigated here, both analytically and numerically. The mathematical model used is that of a beam on elastic foundation, commonly referred to as Winkler beam. The case of a simply-supported beam with uniformly distributed transverse springs subjected to constant axial force over its length is addressed, as a first step towards more realistic modeling of actual buried pipelines crossing active faults.

Linear buckling analysis is first carried out analytically, yielding critical buckling loads and corresponding buckling modes. The results are verified by means of comparison to finite element results, and indicate buckling mode cross-over depending on the stiffness of soil springs. Then, geometrically nonlinear analyses with imperfections (GNIA) are performed, indicating buckling mode interaction and descending post-buckling paths, thus unstable post-buckling behavior. The effects of material nonlinearity of both pipeline steel and soil springs are evaluated. Subsequent steps of this investigation will include more realistic boundary conditions, different soil resistance for upwards and downwards motion of the pipeline, as well as axial force distribution representative of the one along buried pipelines subjected to fault activation and corresponding bending moments.