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ANALYSIS OF BURIED STEEL PIPELINE MATERIAL DAMAGE UNDER SEISMIC LOADING CONDITIONS

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Steel pipeline systems traverse large geographical areas characterised by a wide variety of soil conditions and environmental hazards such as earthquakes that can induce large inelastic deformations in pipe components leading to fracture with consequent material leakage.
Buried pipelines installed in seismic regions are susceptible to the effects of transient ground deformation (TGD) due to seismic wave propagation and permanent ground deformation (PGD) resulting from earthquake induced soil liquefaction, surface faulting and landslides [1]. Post-earthquake investigations have shown that almost all seismic damages to buried pipelines were due to permanent ground deformation and there were very few reported cases of pipelines damaged only by wave propagation [2].
In fact, buried pipelines are primarily affected by large permanent ground deformations (PGD) which may produce pipe wall rupture due to excessive tension as well as buckling by either excessive imposed bending or uniaxial compression loading.
Therefore it is necessary to perform accurate finite element analysis taking into account the nonlinear soil and pipe interaction as well as the constitutive behaviour of the pipe material subjected to extreme seismic loading.
At the state of art, damage material models for large scale loading are not sufficiently developed and validated due to the complexity of the physical phenomena.
The present paper analyzes the damage evolution in a steel pipe component under critical seismic loading conditions using a suitable damage material model that simulates the pipe material fracture under large scale seismic loading. This model is calibrated utilising the experimental and numerical research conducted during the European Project RFSR-CT-2011-00029: “Ultra Low Cycle Fatigue of Steel under Cyclic High-Strain Loading Conditions” [3].
Specifically, the seismic performance of the buried pipeline has been investigated through a series of parametric studies that permit to assess the structural response of the pipe components in function of various soil and pipeline characteristics (i.e. soil type, pipe steel grade, pipe diameter to thickness ratio, internal pressure, geometric configuration etc.).
The obtained numerical analysis results allow to evaluate accurately the limit ground displacement inducing global failure on the pipeline components due to loss of strength capacity following large scale seismic loading, thus avoiding overconservative factors and optimising the seismic design of buried steel pipelines.

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