Soil-pipeline interaction on slopes under earthquake loading

Exchange-Risk Workshop
Resilience of natural gas pipeline networks to natural hazards
Bristol, 1 September 2016

Amir M. Kaynia
Discipline Lead, Vibration and Earthquake Engineering, NGI
Adjunct Professor, Norwegian University of Science and Technology, NTNU
OUTLINE

- Background
- Developed computational model
- Special features
- Application
- Representative results
- Developed model vs typical models used in practice
- Typical results
- Effect of special features of developed model
- Conclusions
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Pipelines on slopes – Case study
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Region of large displacement

Edge of escarpment

19 points (every 40 m)

20 points (every 25 m)

10 points (every 50 m)

6 points (every 100 m)
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Results of 2-D FEM analyses of slope
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(a) Horizontal displacements
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(b) Vertical displacements
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(c) Shear strains
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- Typical results – acceleration time histories at several points: large variations along slope
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Maximum axial forces and bending moments in pipeline
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Maximum axial forces and bending moments in pipeline
Pseudo-Static Approach

- In practice, pipelines are often analyzed by pseudo-static method.

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Disadvantages: 1) need for analyses at many time steps, 2) excluding inertial force in pipe is not conservative.
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- Strain softening helps reduce forces in pipeline; positive feature in design.
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• Largest forces often occur at places on the slope which experience largest displacement gradients.

• Consideration of strain softening behavior of soil springs often reduces earthquake-induced forces in pipelines.

• Common analysis methods based on pseudo-static method are not conservative.
Thank you for your attention