Numerical Modeling of Soil-Pipe Interaction in Landslides

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CeIBA


Ground
movement
direction

Questions

- Which variables affect the soil-pipe interaction phenomenon in unstable slopes ?
- Is it possible to determine the effect of combined loads on the pipeline, such us lateral ground movement,internal pressure, geostatic stresses,etc..?
- **Is it possible to determine the maximum soil displacement in a landslide at which the pipe overpasses the allowable strains ?**

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Outline

Depending on the Landslide Speed

Figure: Slow Landslide

Depending on the Failure Mechanism

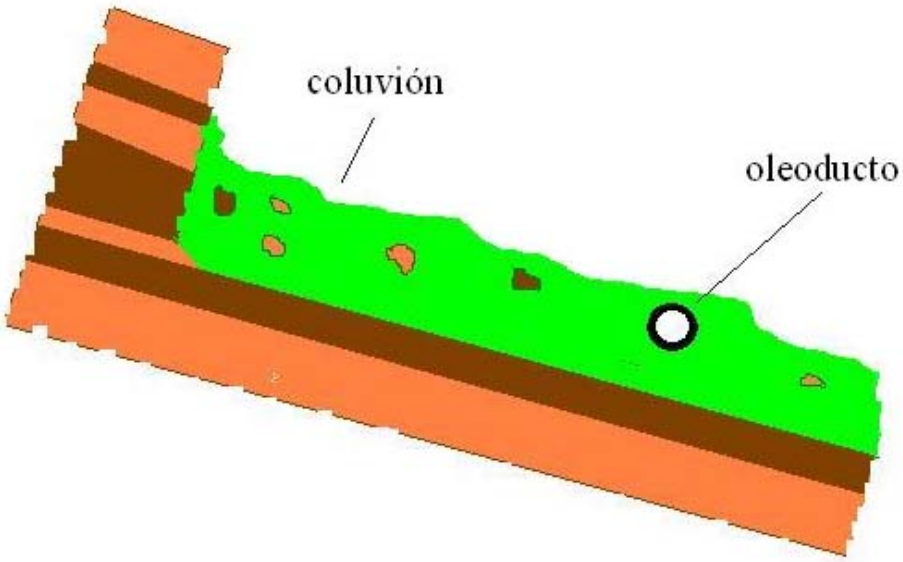


Figure: Translational Landslide

Depending on the Pipe Alignment

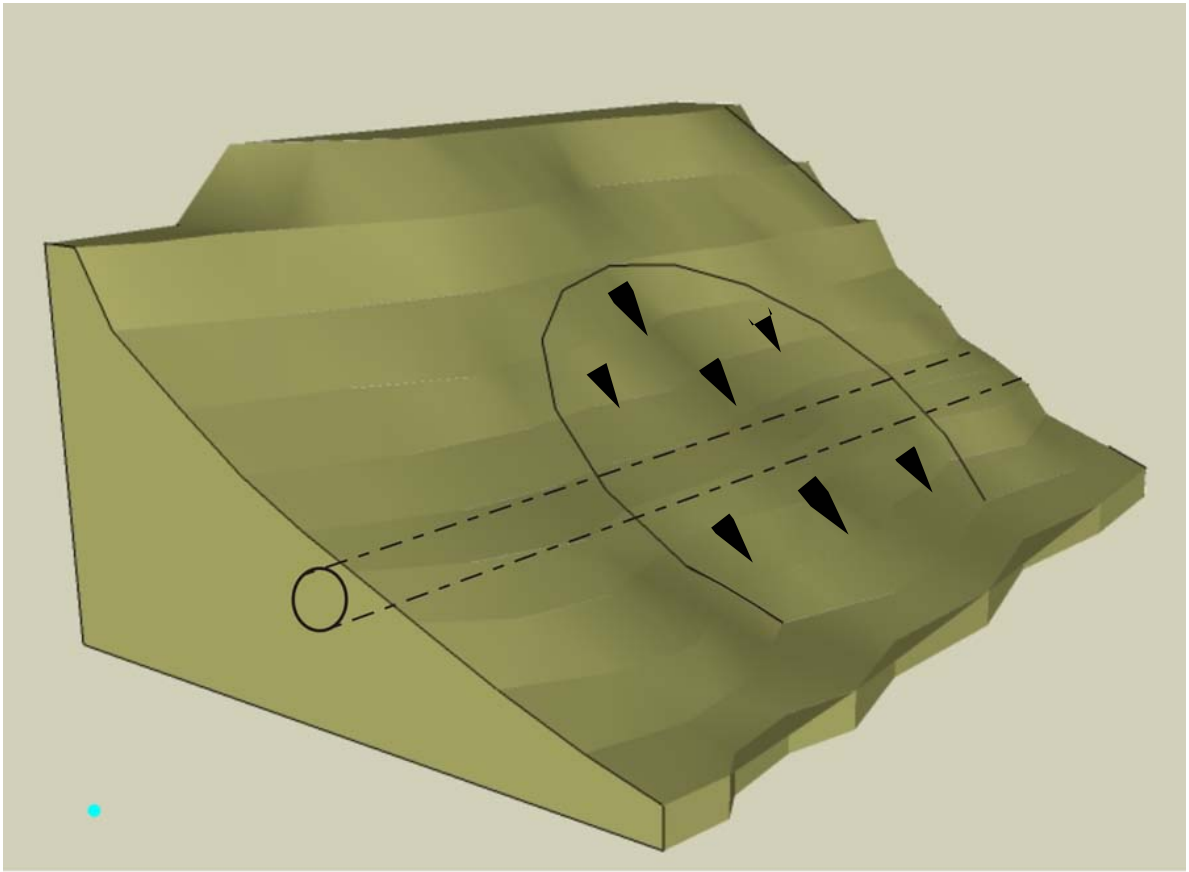


Figure: Transverse Landslide

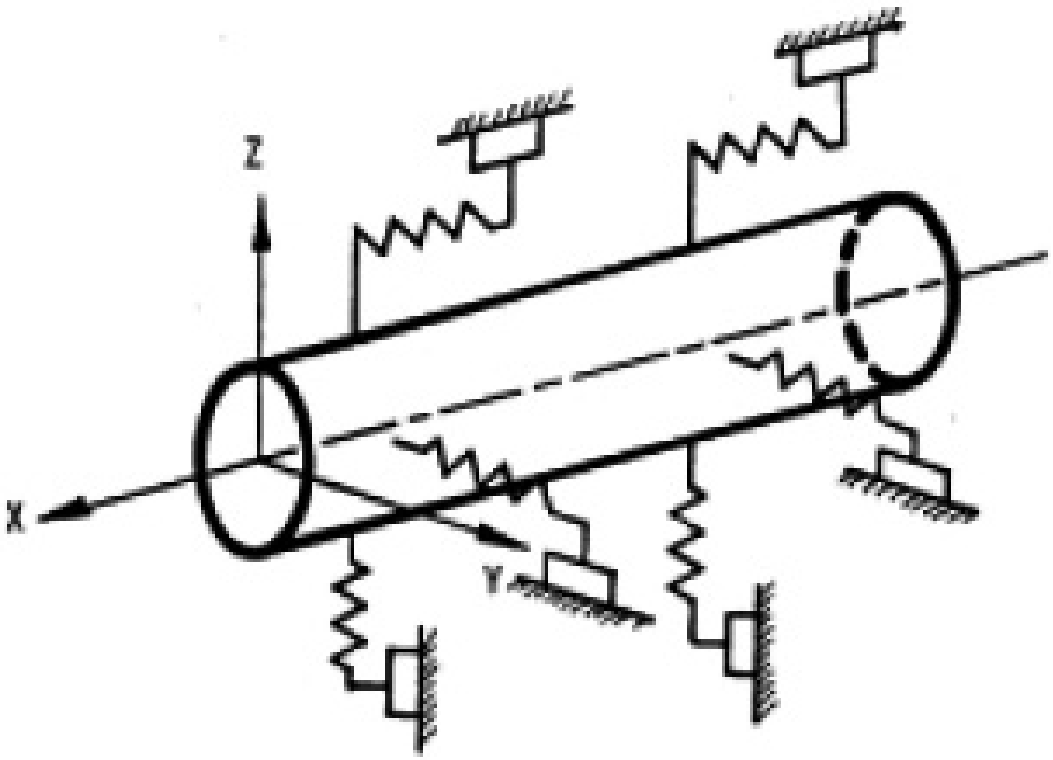


Figure: Winkler Type Models (ALA 2001)

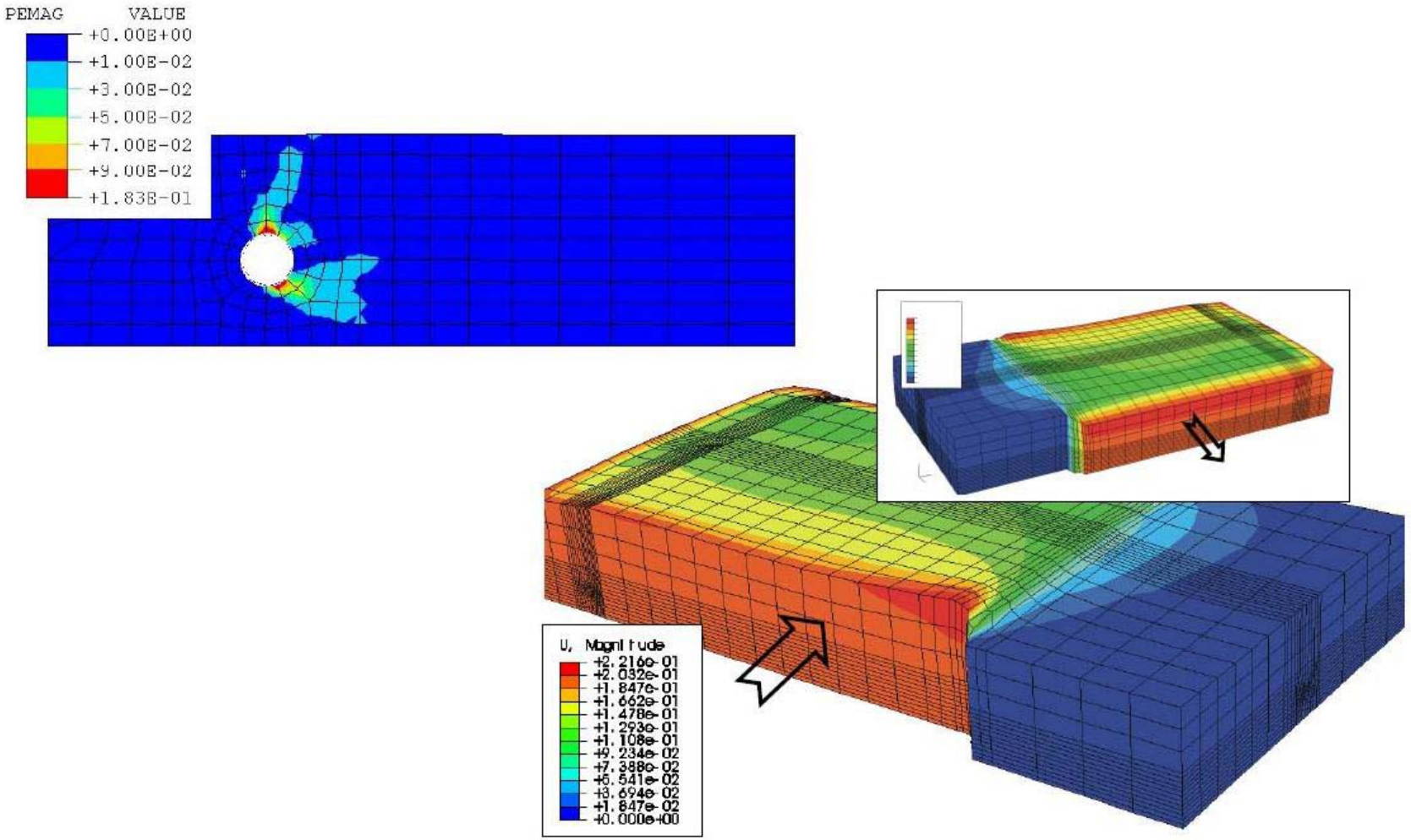
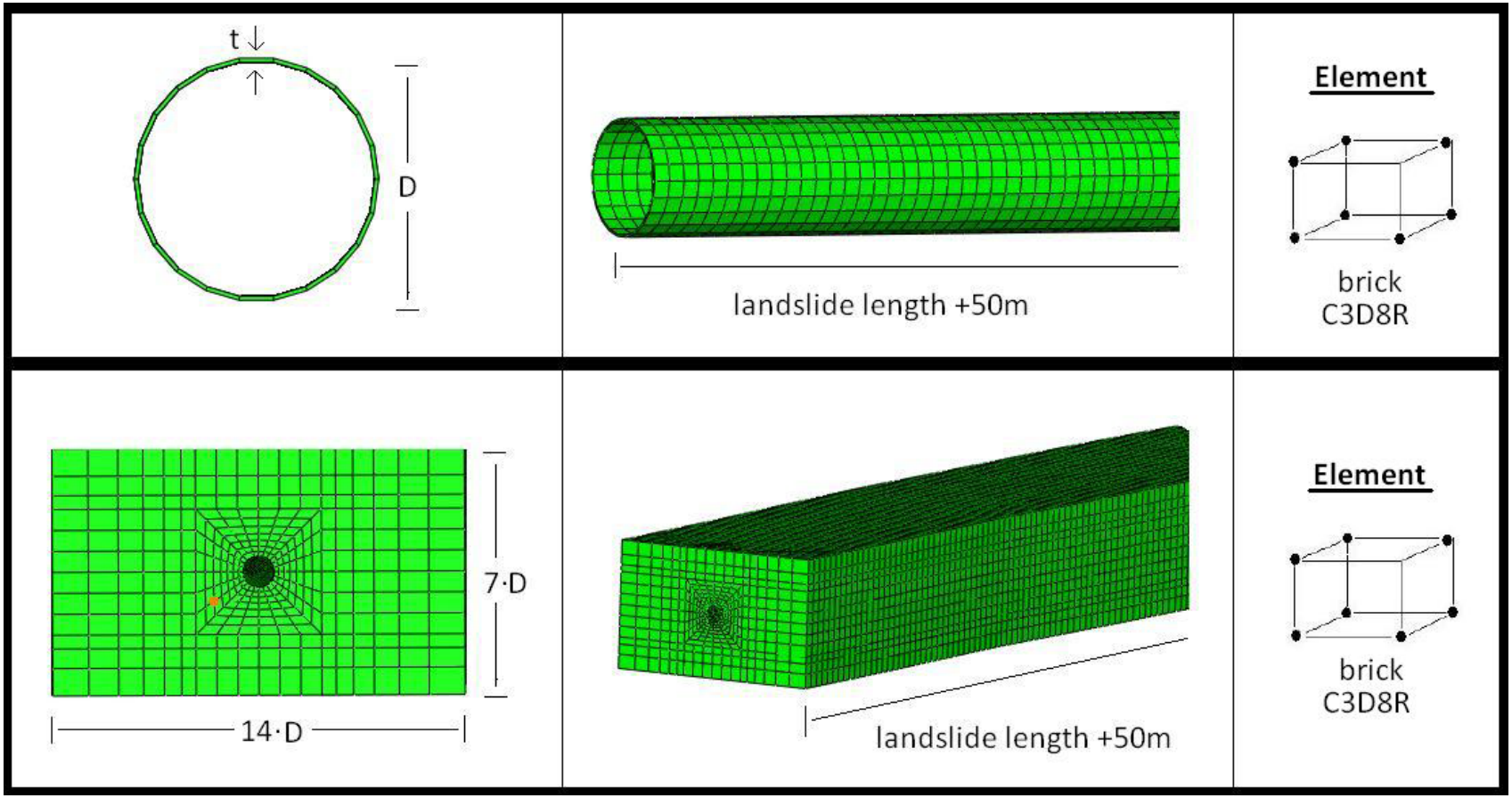


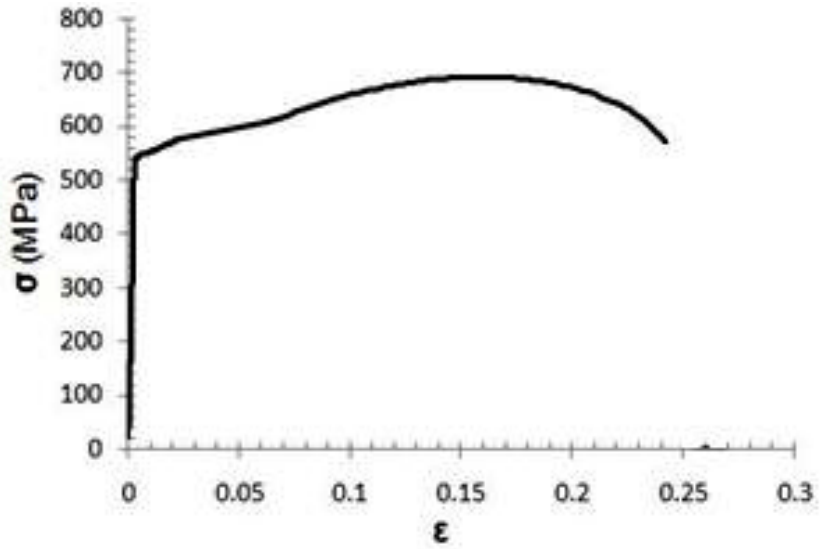
Figure: 2D and 3D FEMs

geometry


t
D
landslide length +50m
Element
brick
C3D8R
7·D
14·D
landslide length +50m
Element
brick
C3D8R

Constitutive models

- Pipe:



- Soil:
  -Elastic
  -Elasto-Plastic (Mohr Coulomb Failure Criteria)
  -Visco-hipoplastic

Constitutive models

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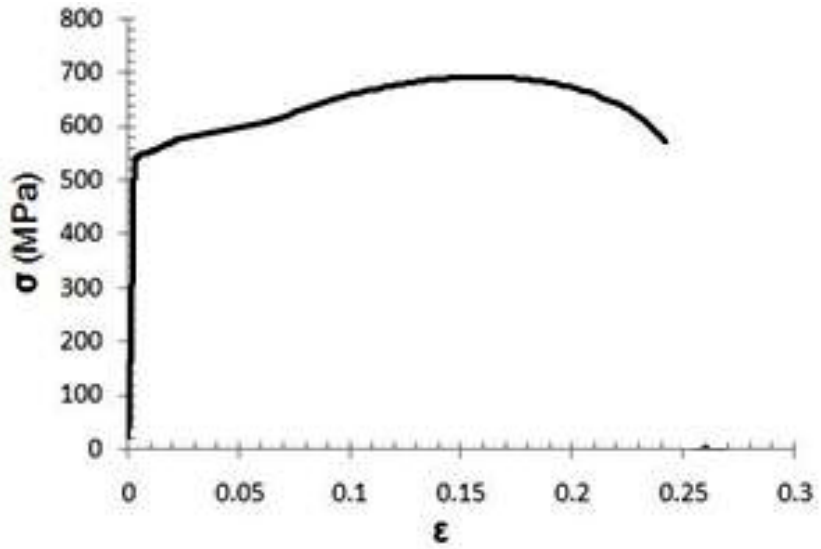

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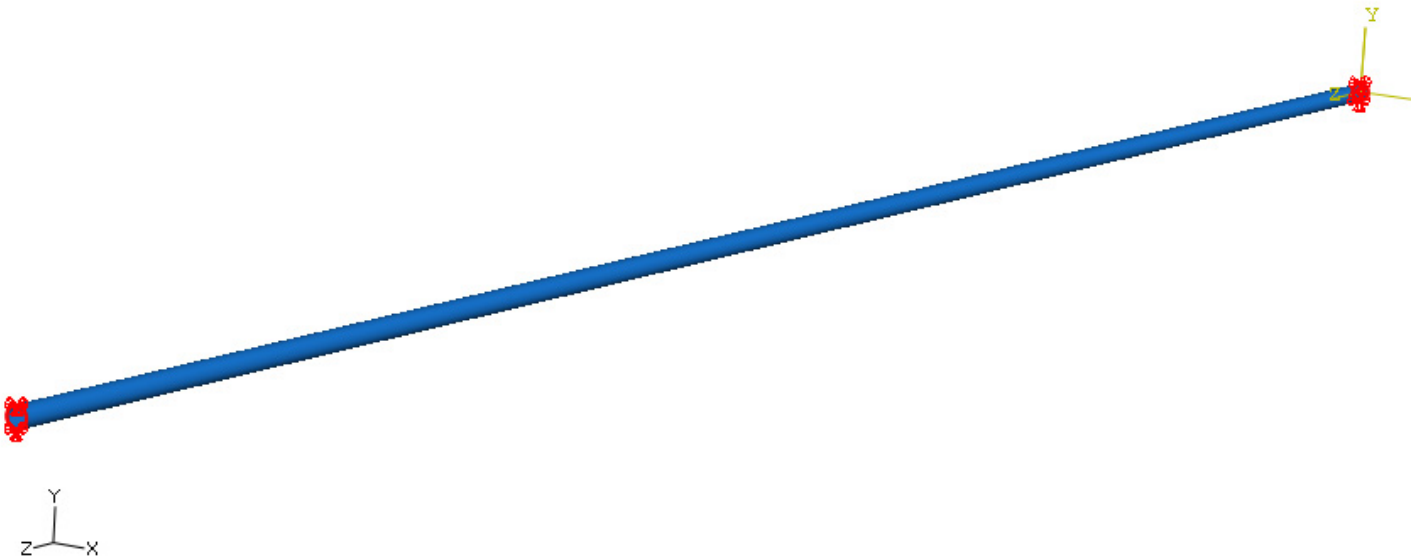
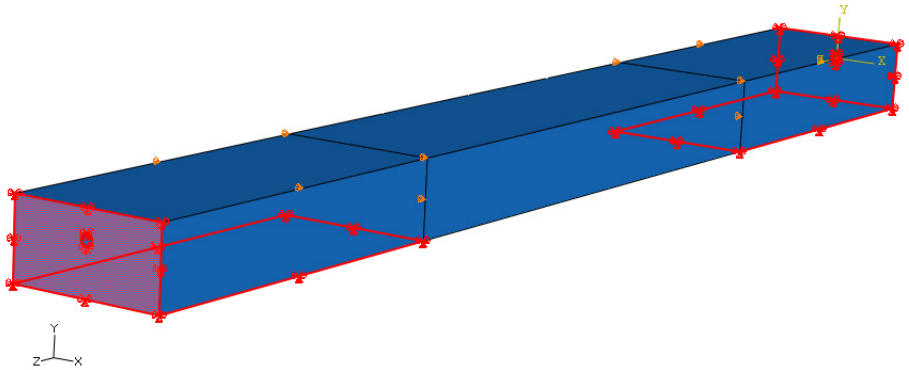
Pipe Boundary Conditions

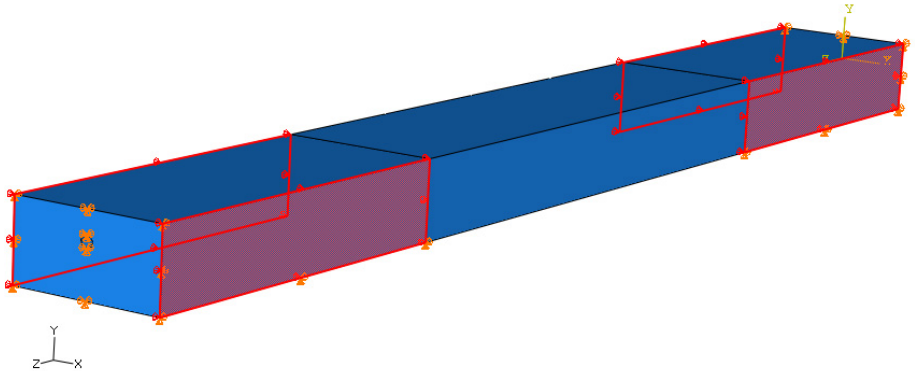


Pipe boundaries constrained in x,y and z axes directions.

Soil Boundary Conditions



Soil boundaries constrained in "x","y" and "z" axes directions



Soil boundaries constrained in "x" axis direction

Input:Soil Displacement field

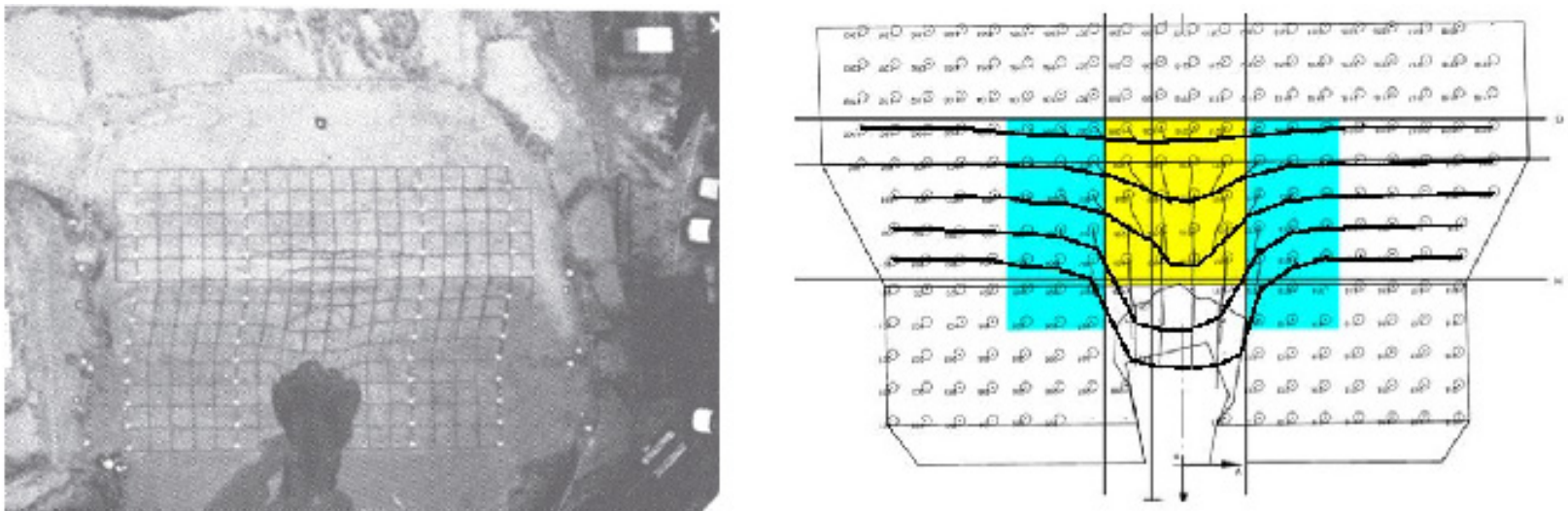
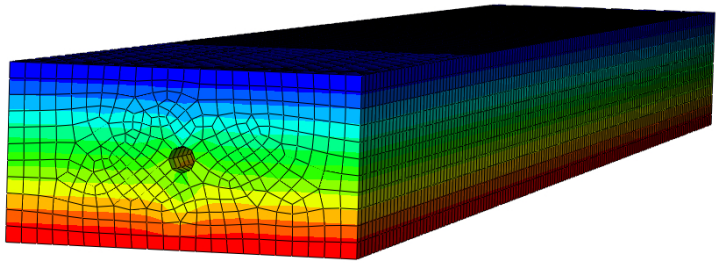
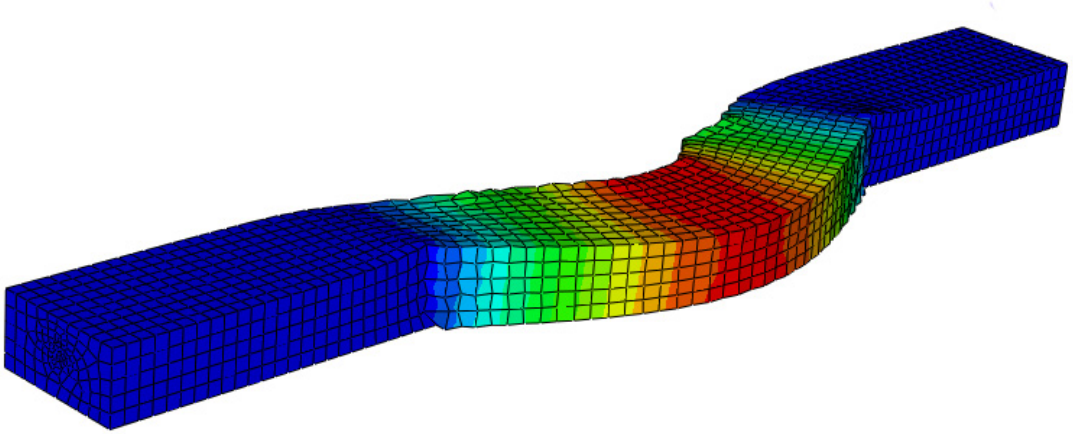


Figure: Goldscheider and Lizcano (2004)

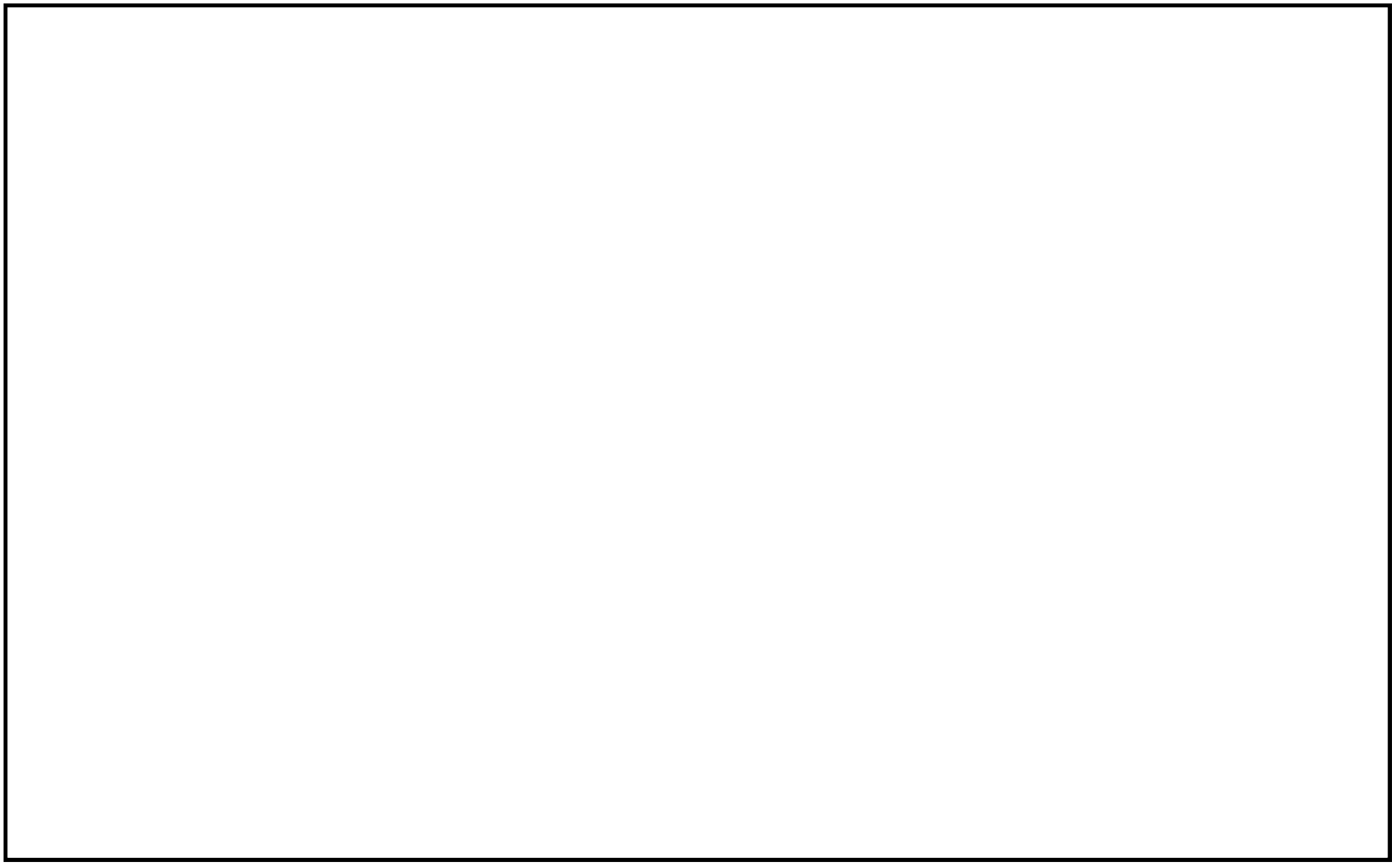
Steps



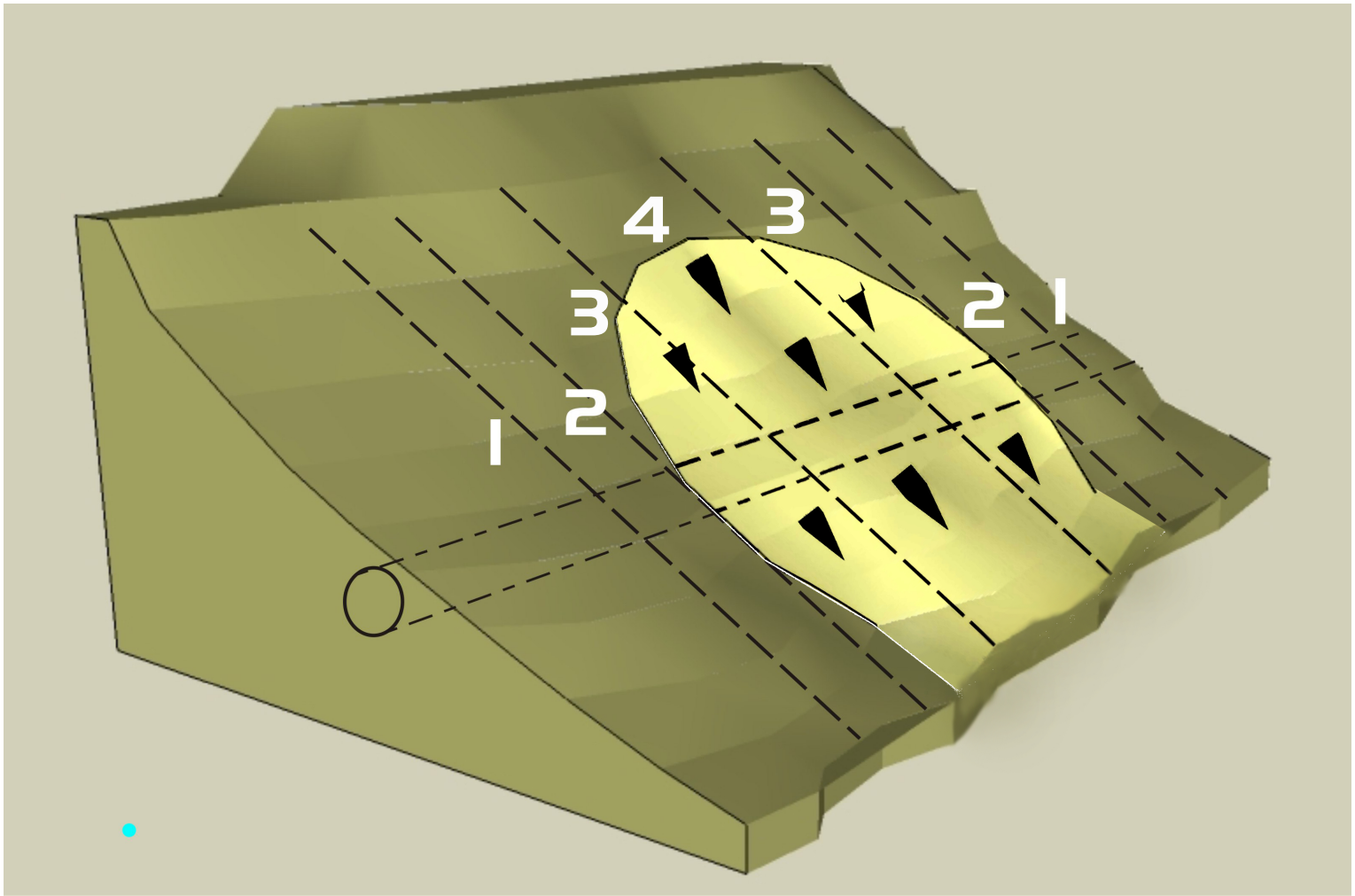
Step 1: Geostatic stress distribution



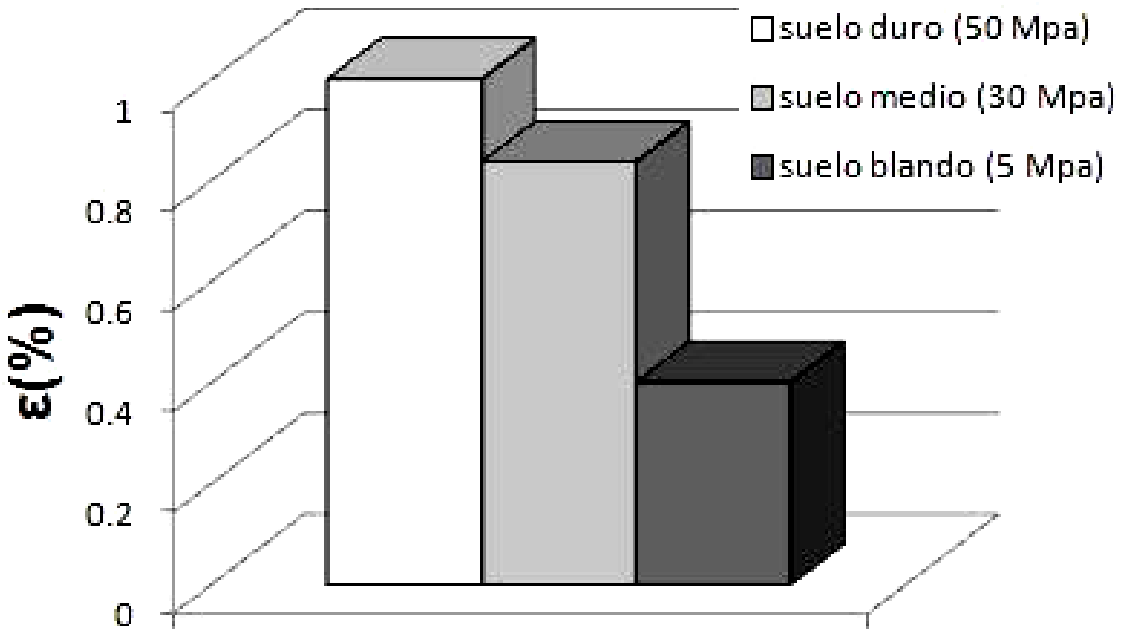
Step 2: Soil deformed shape after the landslide event



4 Regions found in the model



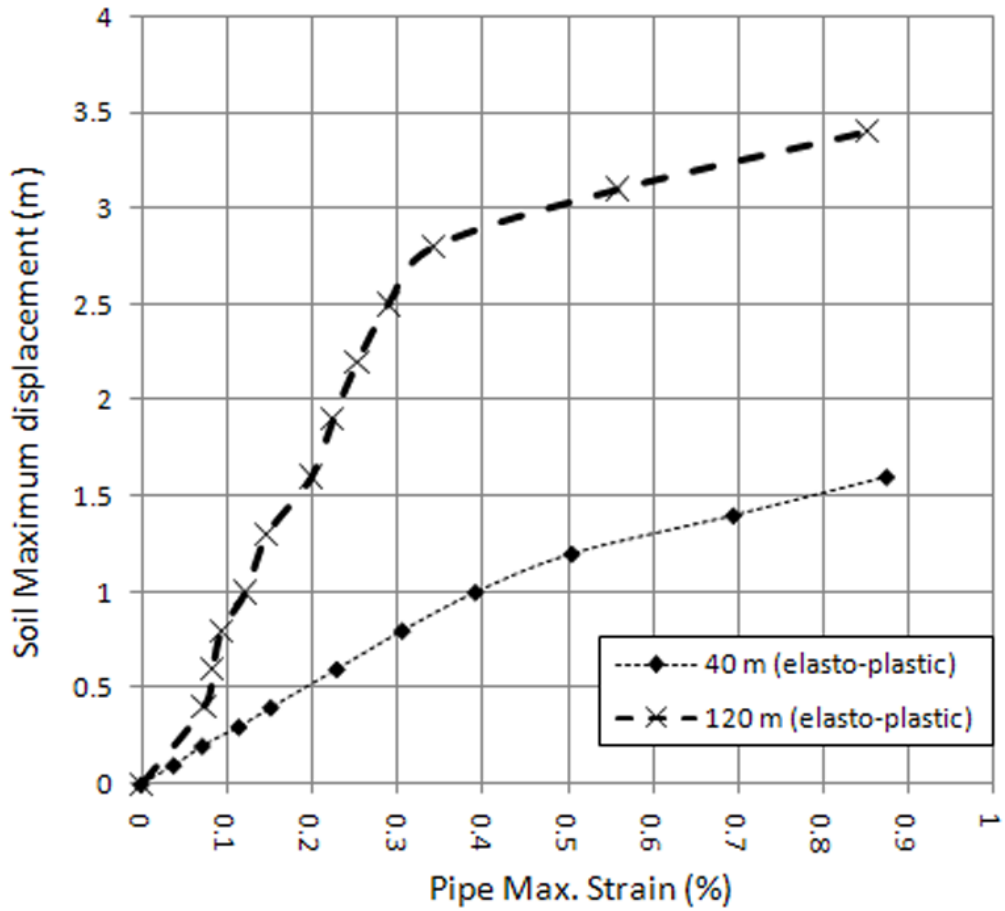
Influence of the Soil Stiffness



Landslide Length = 120m

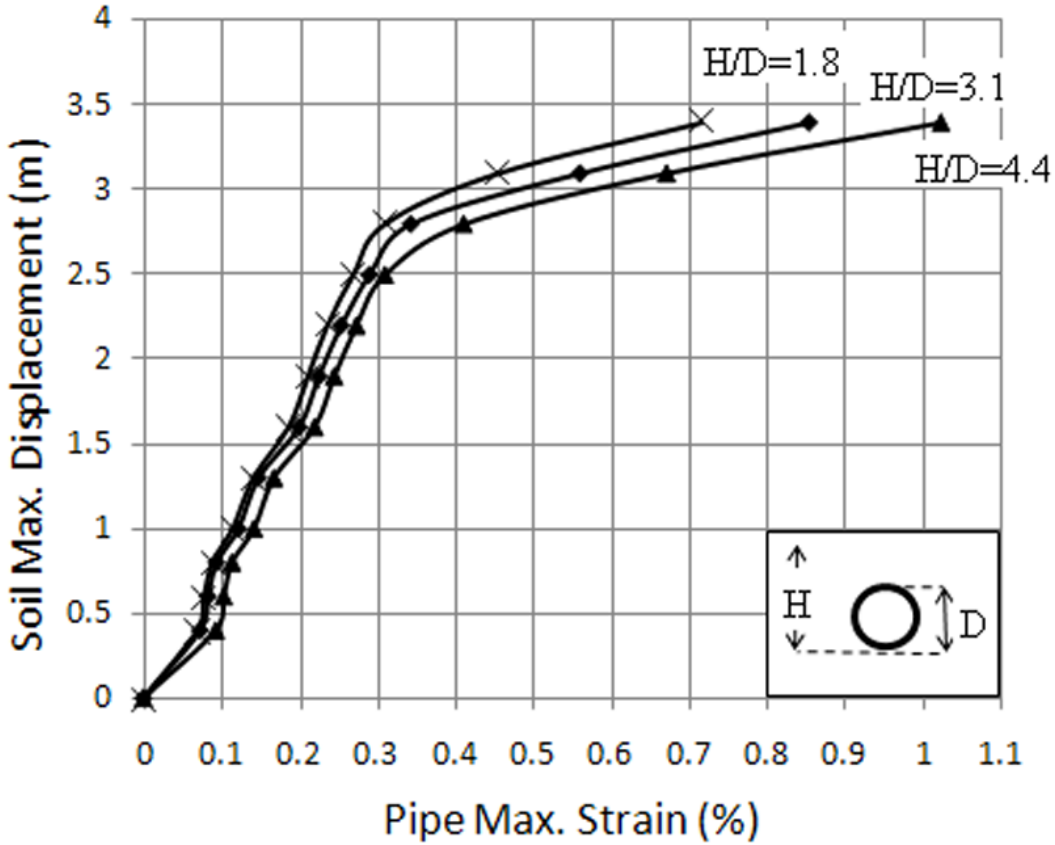
Max. Displacement = 1.7m

Influence of the Landslide Length



Hard Soil

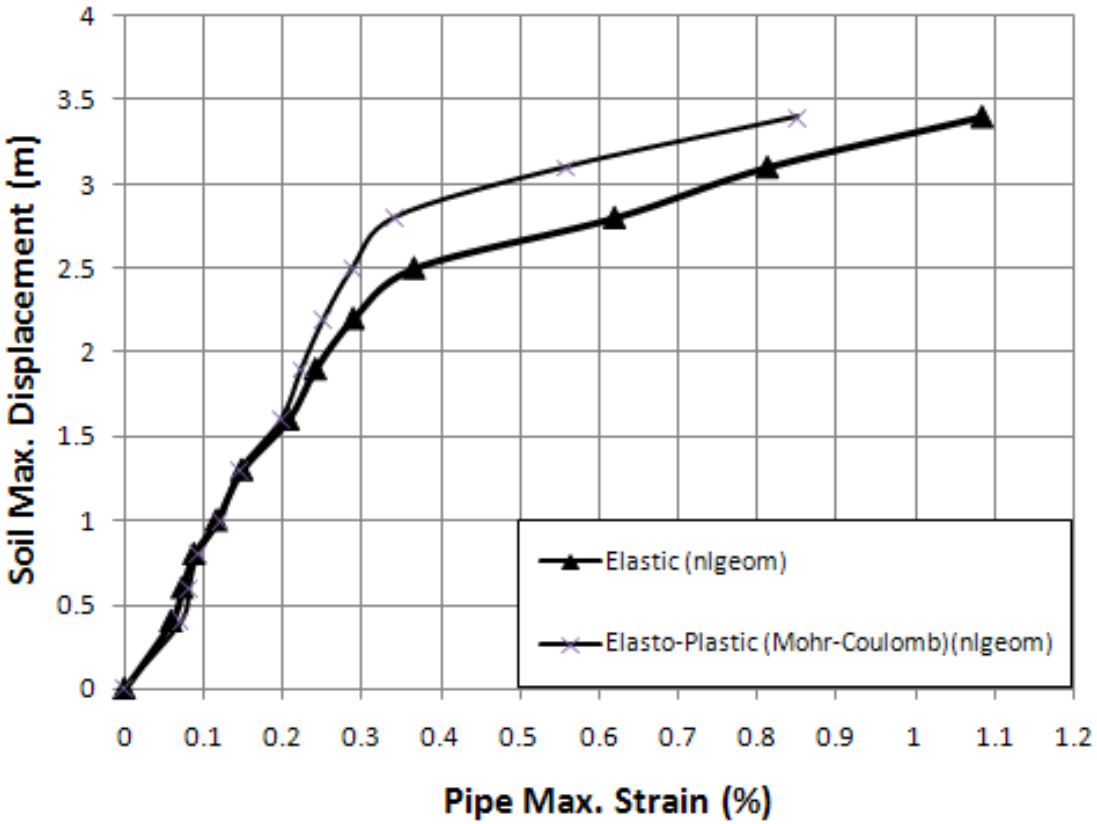
Influence of the pipe embedment ratio



Landslide Length=120m

Hard Soil-Elasto plastic

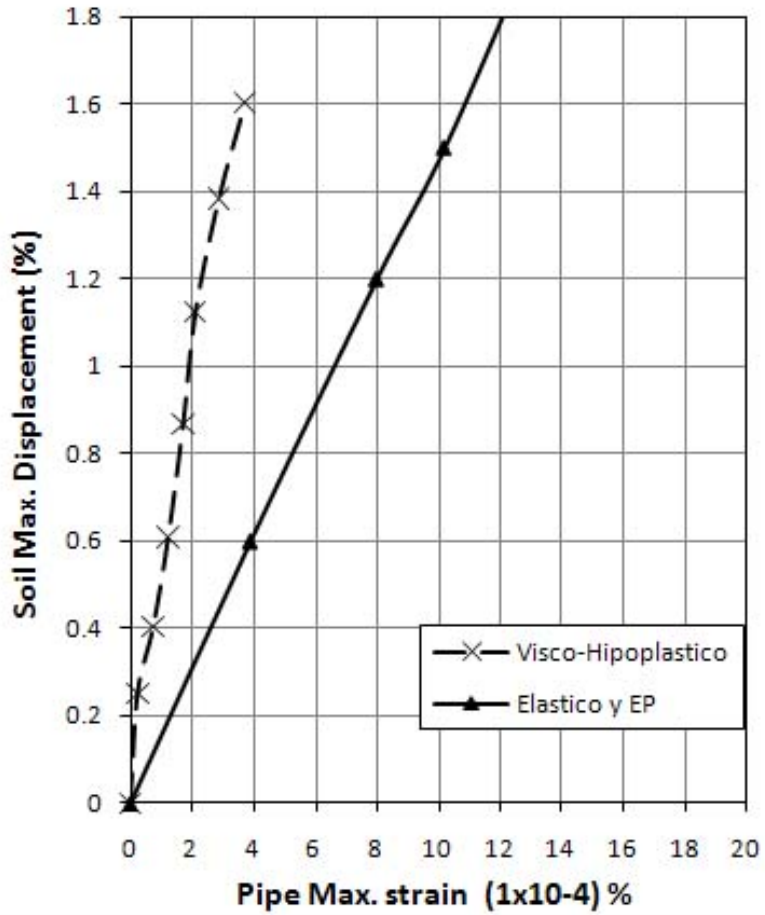
Influence of the Soil Constitutive Model



Landslide Length=120m

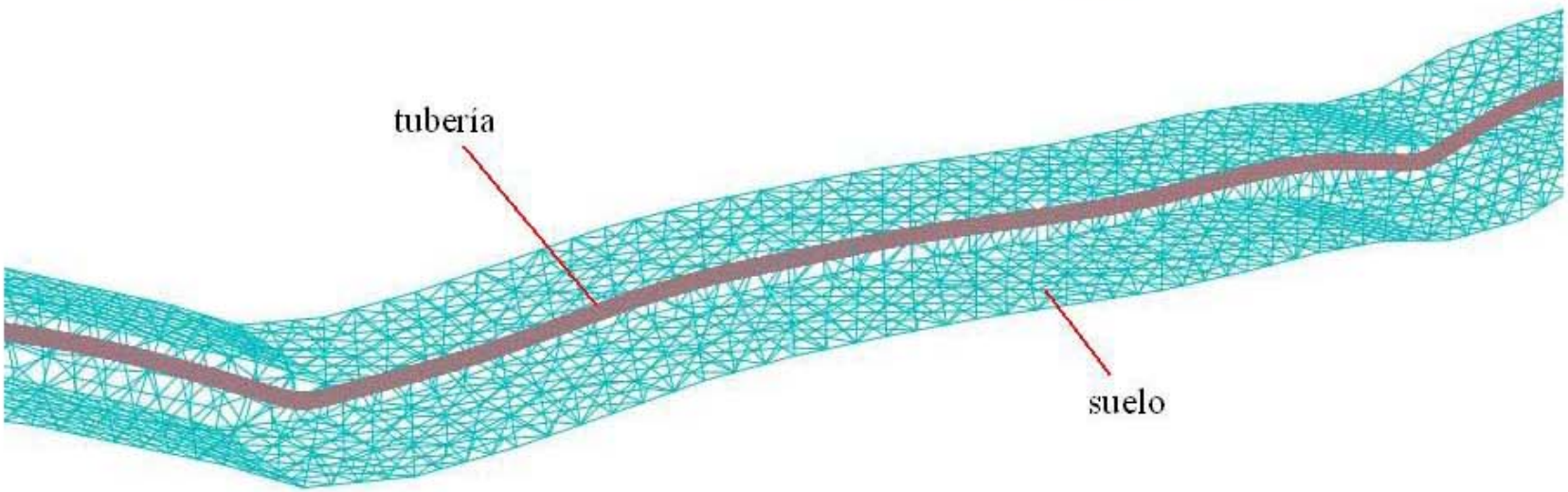
Hard Soil

Visco-hipoplastic soil constitutive model

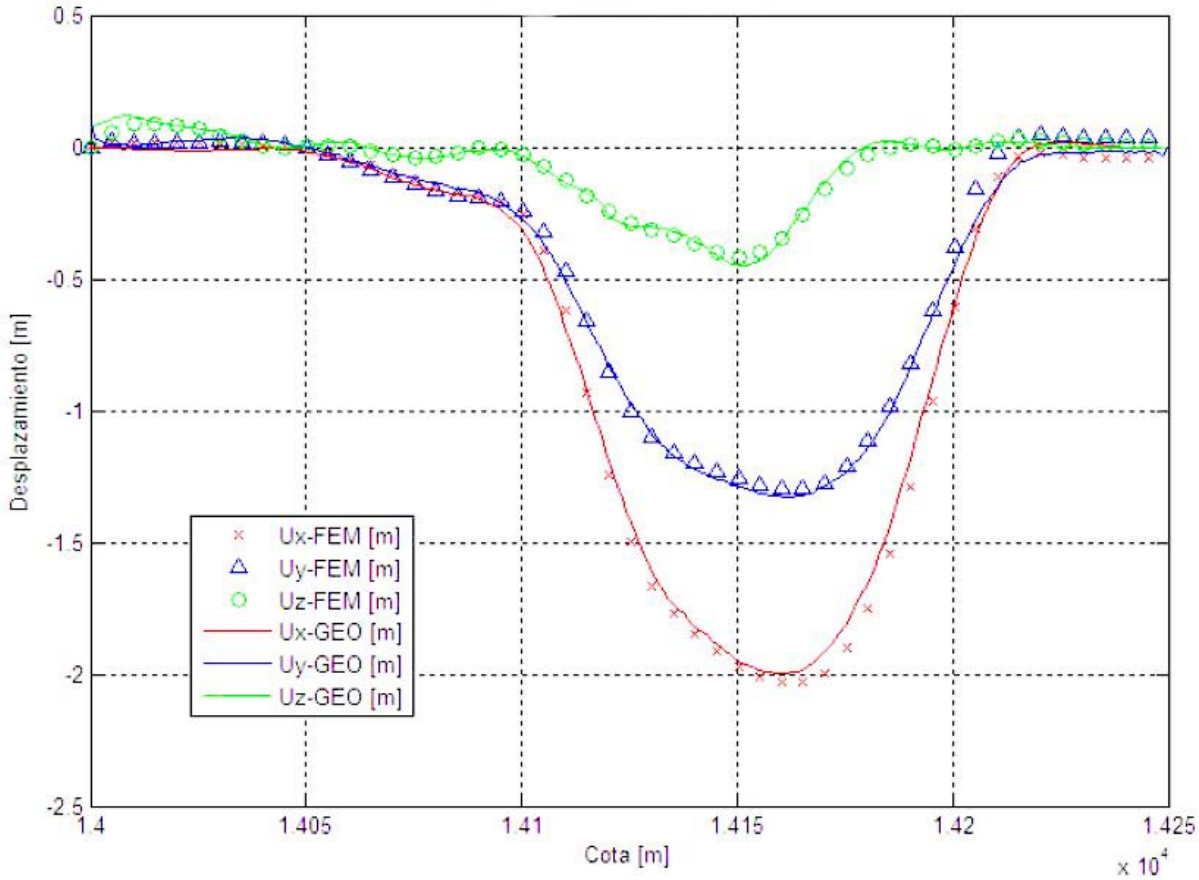


Landslide Length=70m Hard Soil.

Real Geometry of Soil and Pipe in the Model

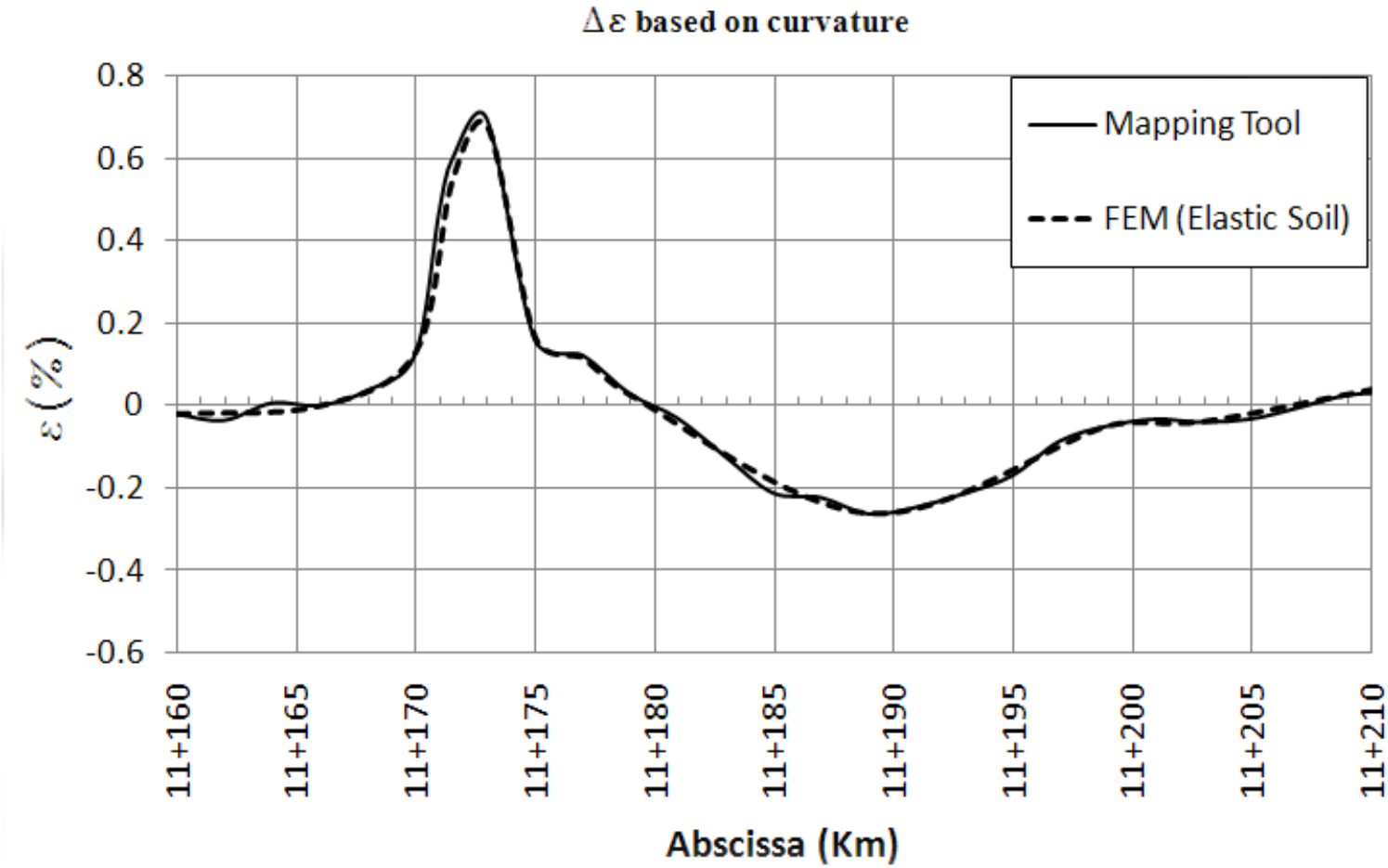


Deformed shape FEM (elastic soil) vs.Mapping Tool

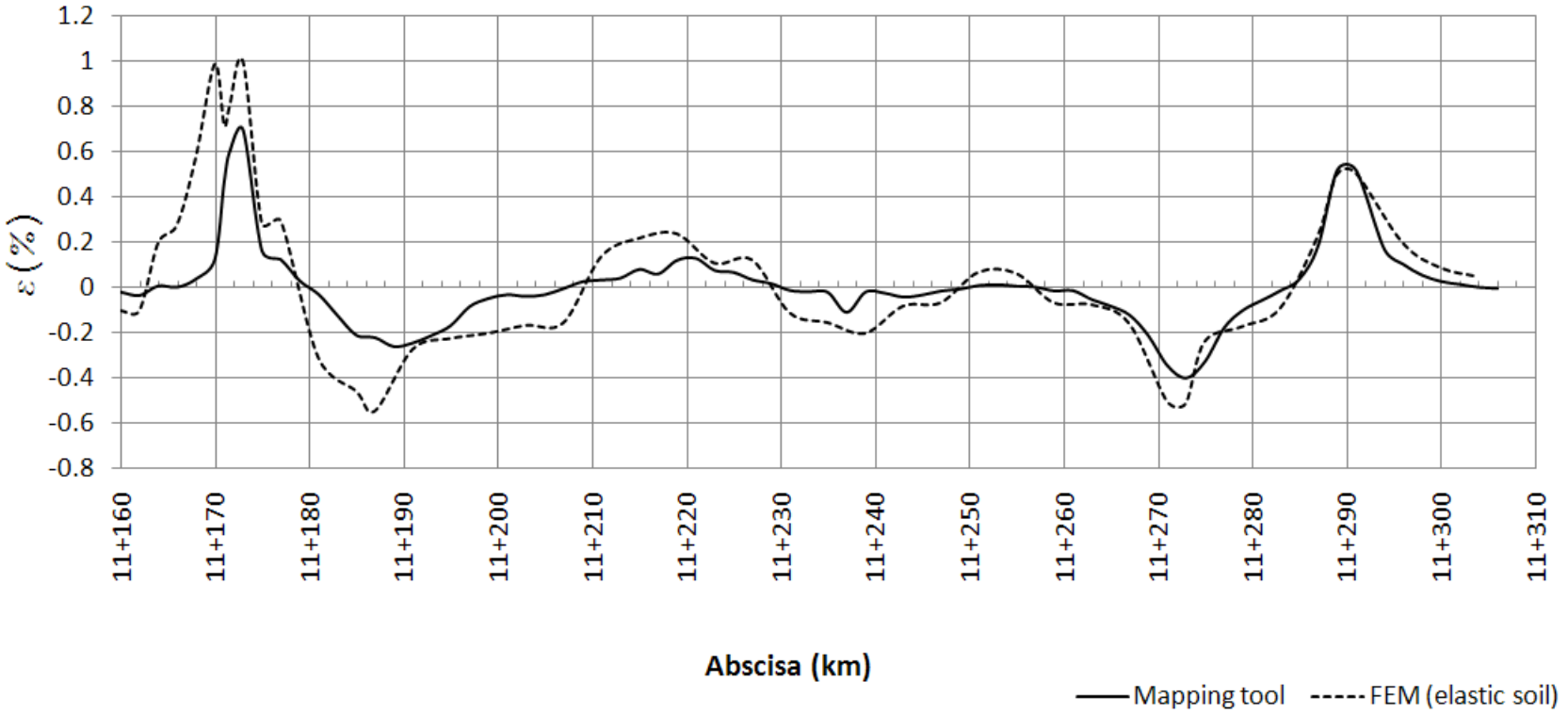


Landslide Length =120m Max. Displacement = 1.7m

Comparison of Horizontal Strains Based on Curvature



Total Strains in FEM vs. Strains Reported by the Mapping Tool



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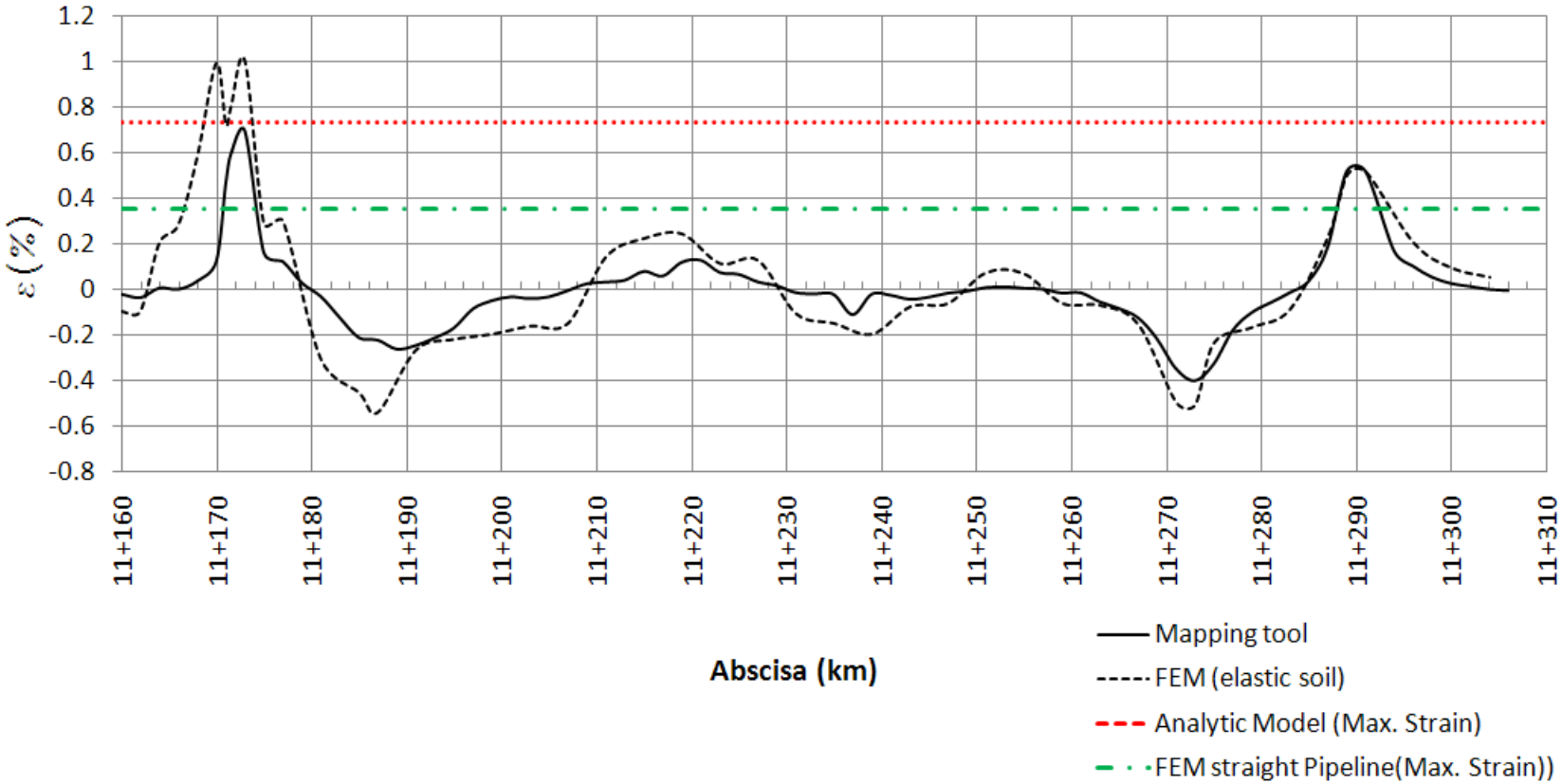
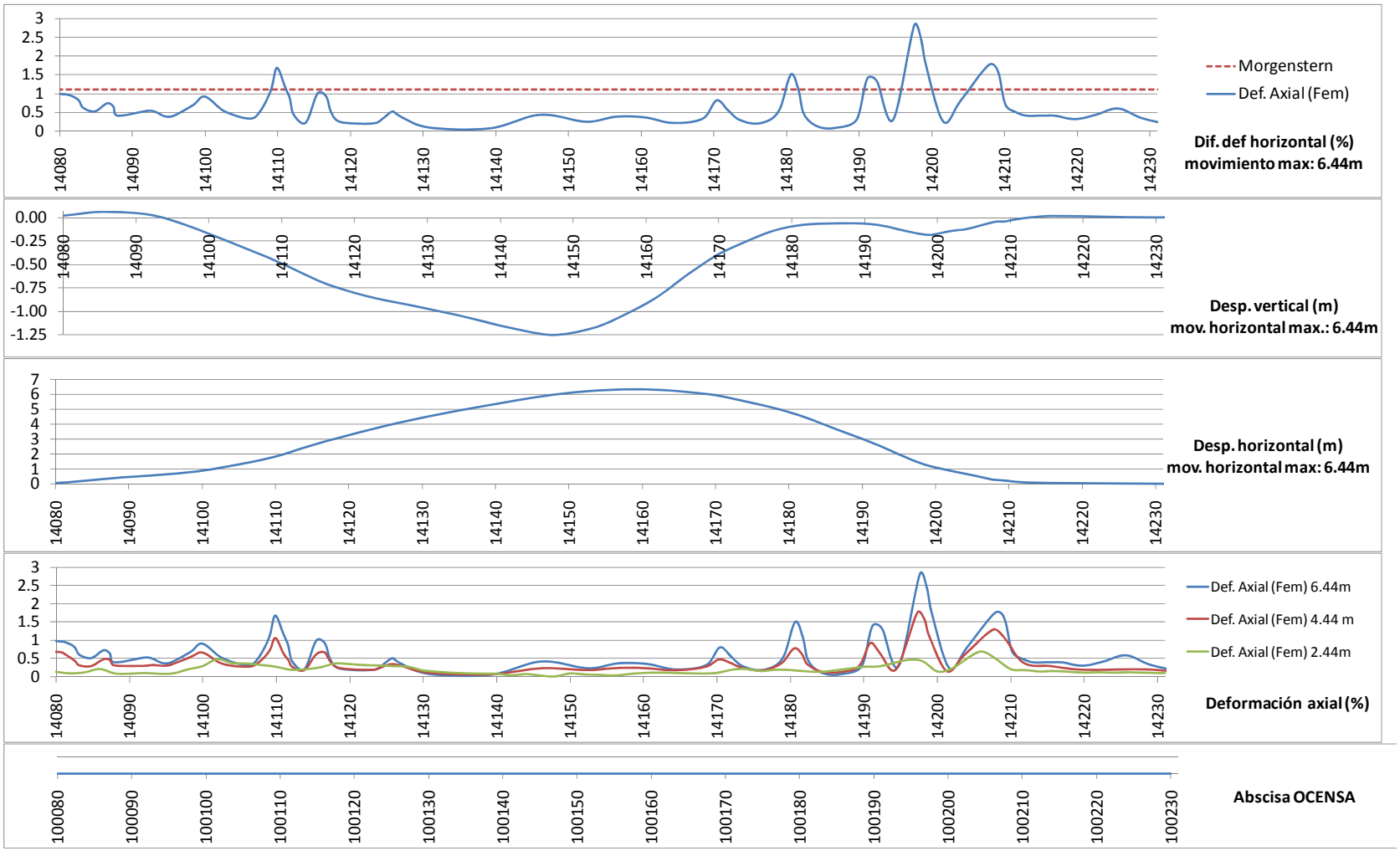


Chart obtained



Concluding Remarks

- The proposed model allows the study of soil-pipe interaction problems in landslides, and it can be calibrated easily with field data.
- The phenomenon is sensitive to the soil stiffness. This means that placing weaker materials in the trench in Regions 1 and 2 will reduce the response of the pipe under soil movements.
- The mapping tools used in the practice are so good in determining the bending strains in the pipe, but care must be taken with the axial strains resulting from tensile stresses than can‘t be measured with this tool.

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- In transverse soil movements,curved pipelines suffer bigger strains than straight pipelines.
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