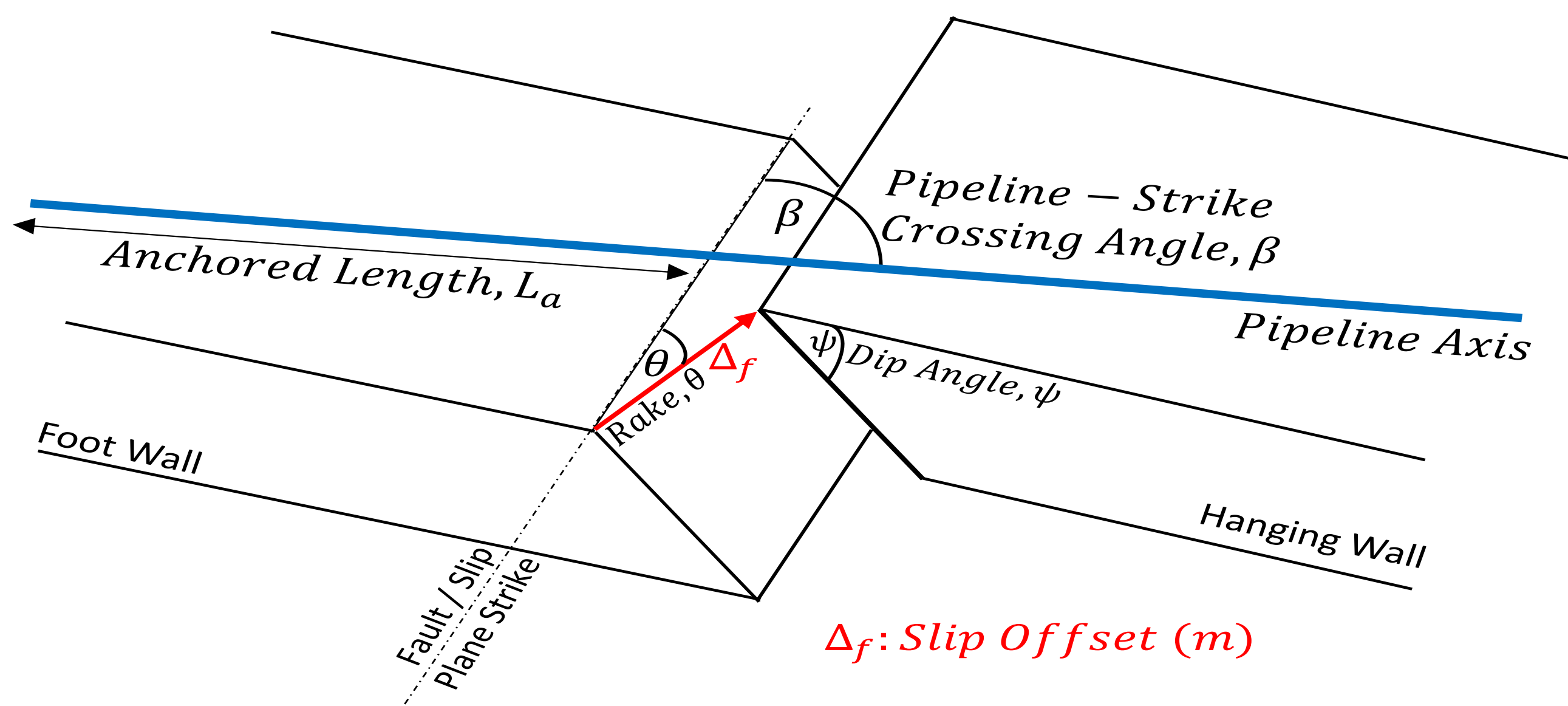


Task Description/Goals/Outcomes

- Finite element (ABAQUS) simulation of comprehensive scenarios of soil-pipeline interaction (pipe dimension, steel material, soil strength, pipe-fault geometry, slip direction).
- Produced over a million validated numerical simulation data to build an estimation model.
- Developed longitudinal pipe strain-ground offset estimation model for 3-D movement.

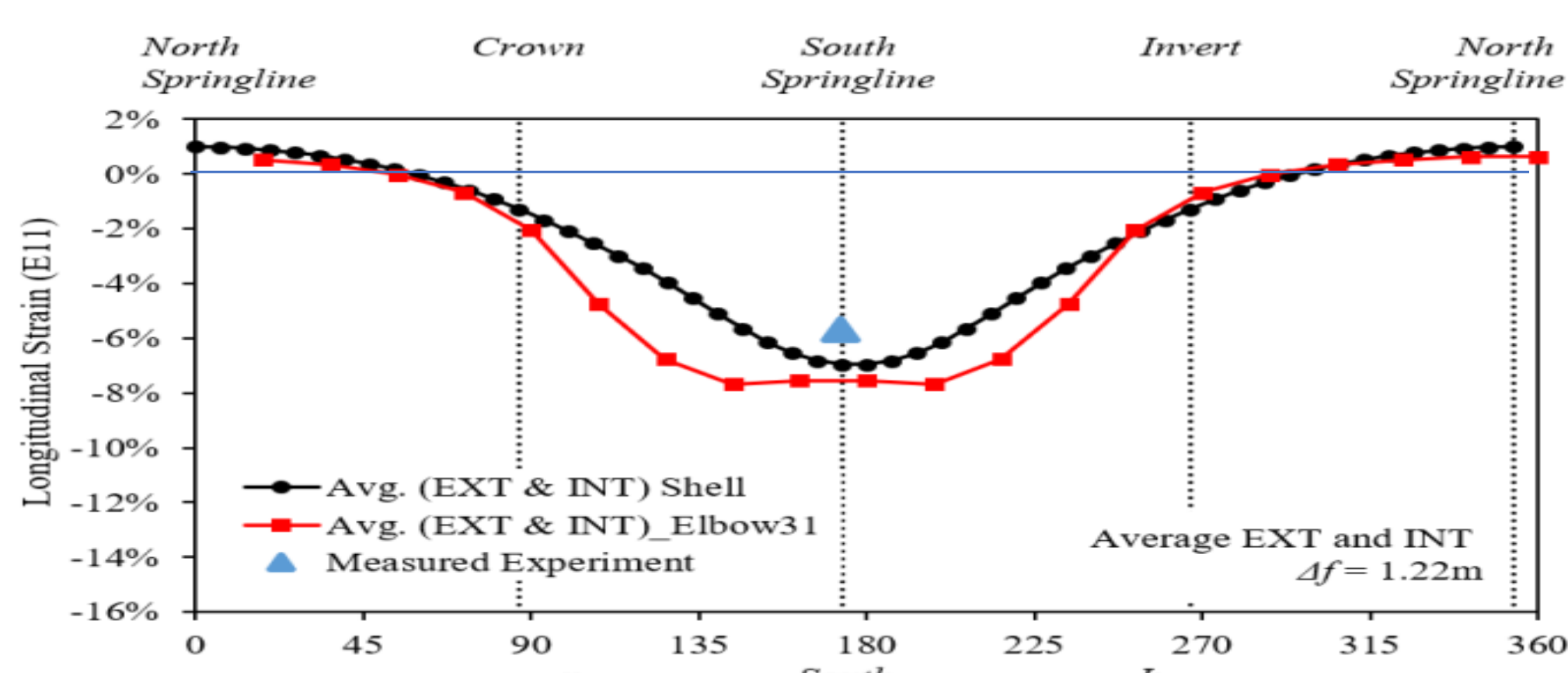
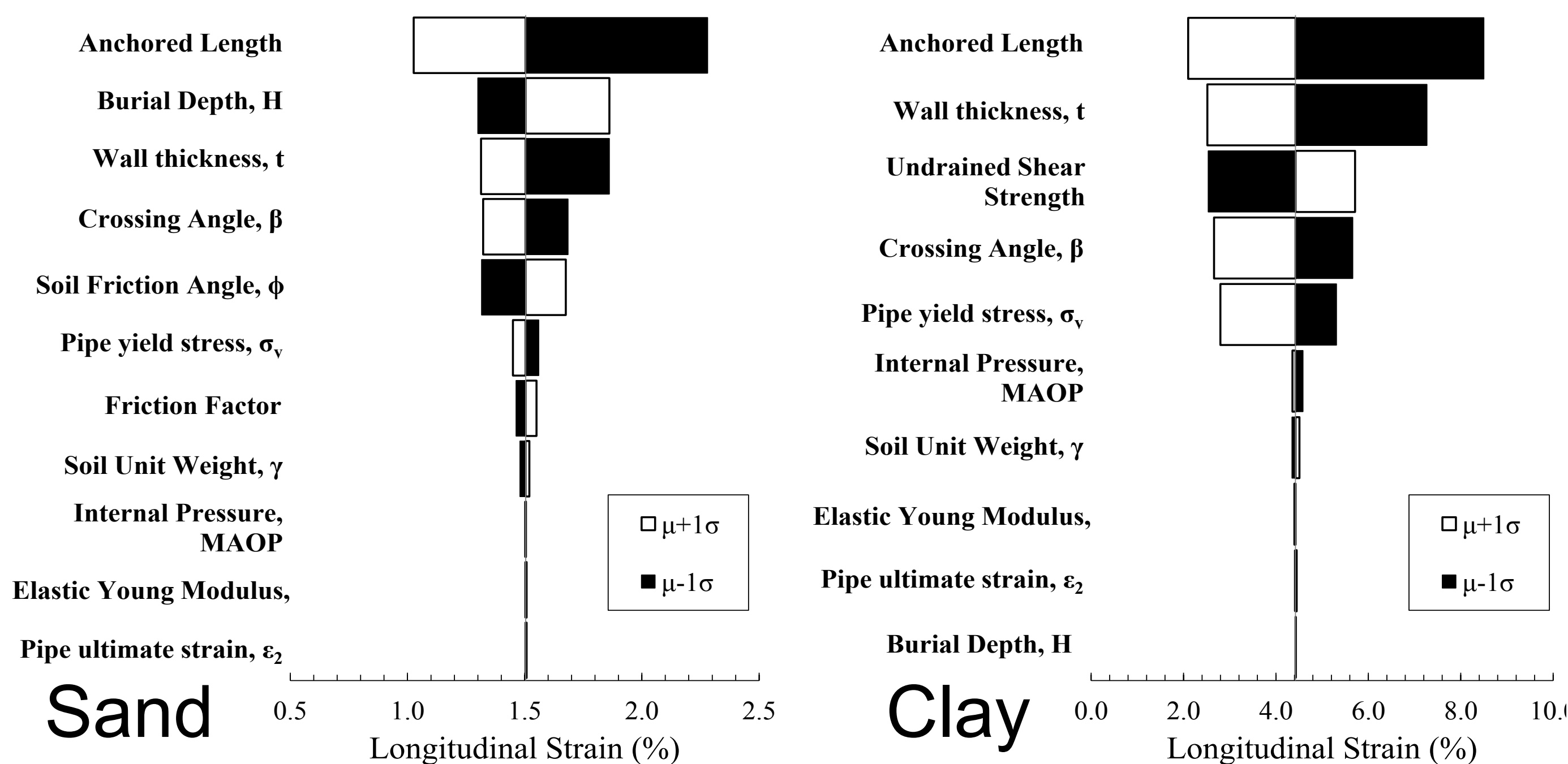
Problem



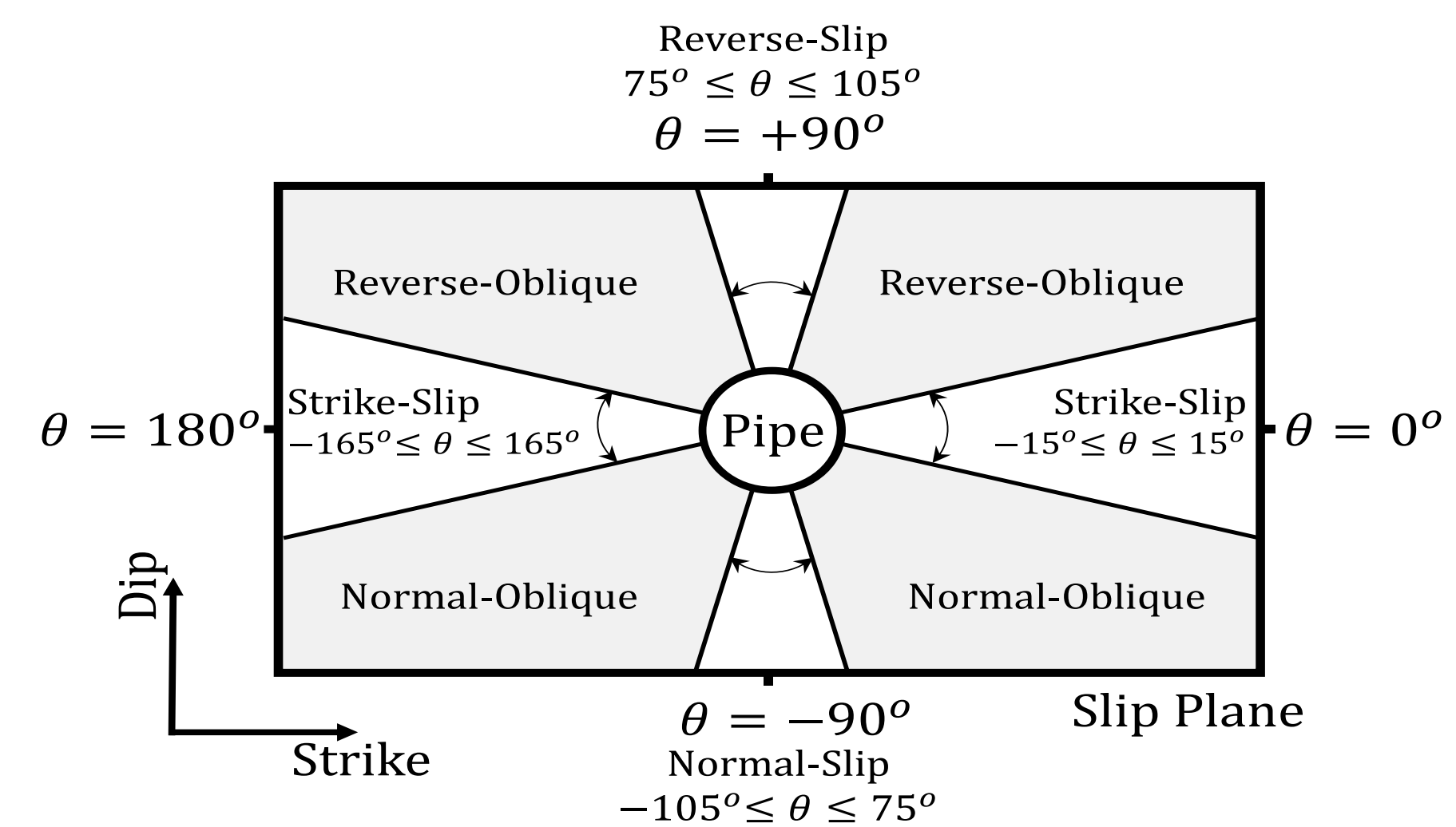
Buried continuous pipeline subjected to 3D permanent ground deformation

Finite-Element Simulation

- Sensitivity Analysis & Production Run
- Pipeline: ELBOW31 (ABAQUS)
- Soil: Bilinear Spring + Gap Element



Comparison of ABAQUS (Shell & Elbow31 element) with measured experiment longitudinal compressive strain

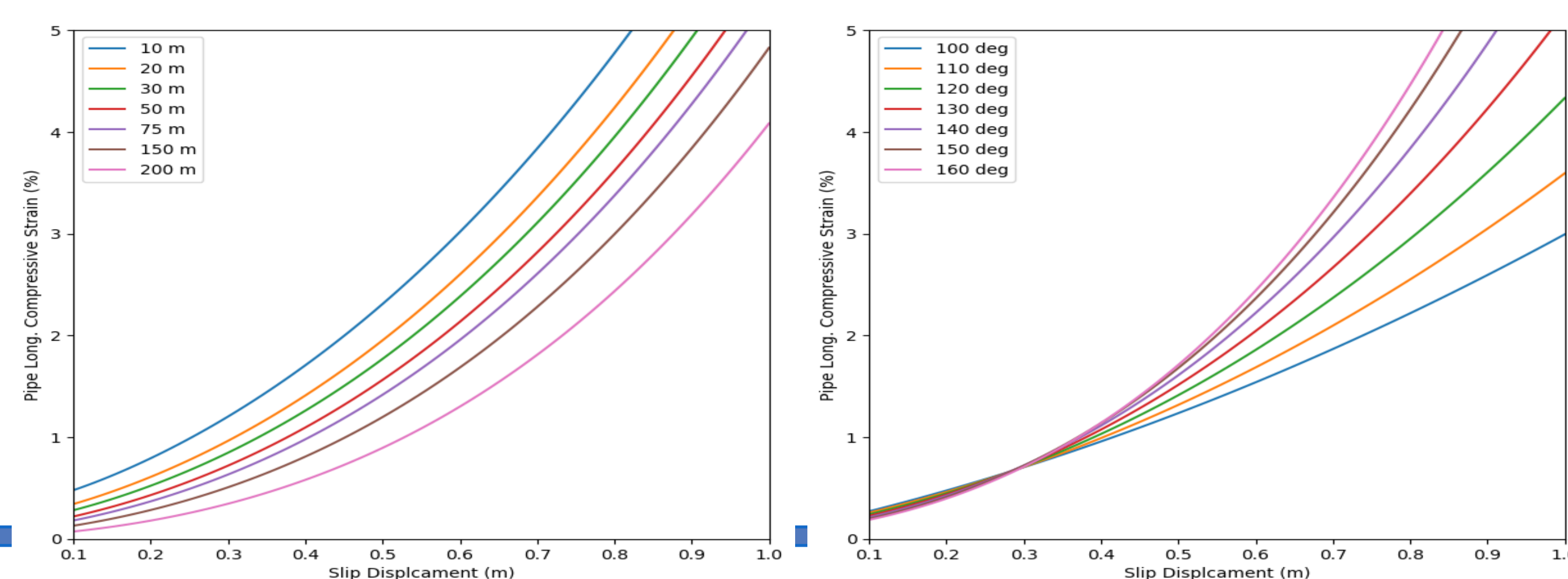
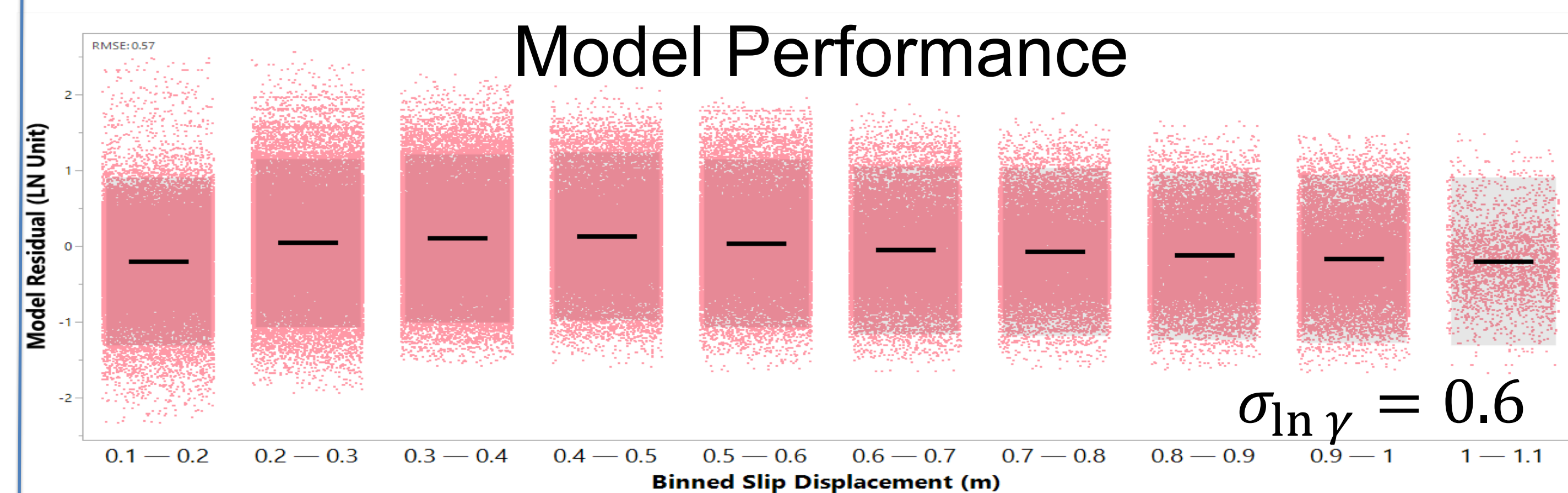


- 3 modes of soil-pipeline ground deformation put pipe into compression or tension failure mode.
- SSI response modeled in ABAQUS using beam-spring model

Long. Pipe Strain Estimation Model

- Fixed-effects regression model for Tension & Compression Mode

$$\ln(\gamma_{long}(\%)) = f_0 + f_{BM}(\Delta f, \beta, \theta, \psi) + f_{La}(L_a, \Delta f, \beta, \theta, \psi) + f_{pipe}(D, t, \Delta f) + f_{steel}(SMYS) + F(\theta)f_{soil}(t_{ult}, q_{ult}, q_{vu}, q_{vd}) \pm \sigma_{\ln \gamma}$$



Example of model estimation for different anchored length and β (Compression)