

Нумеричко моделирање интеракције конструкције и тла у земљотресном инжињерству: ТЛО

Борис Јеремић

Professor, University of California, Davis, CA, USA
Faculty Scientist, Lawrence Berkeley National Laboratory, Berkeley, CA, USA

Српско удружење за земљотресно инжењерство
СУЗИ

17 Септембар 2020

Outline

Introduction

Site Effects, Rock and Soil Modeling

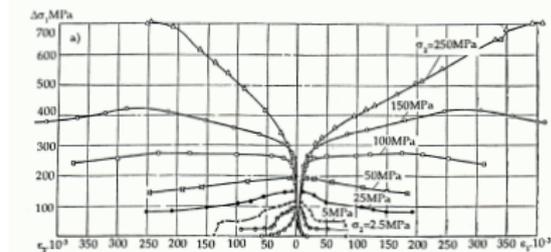
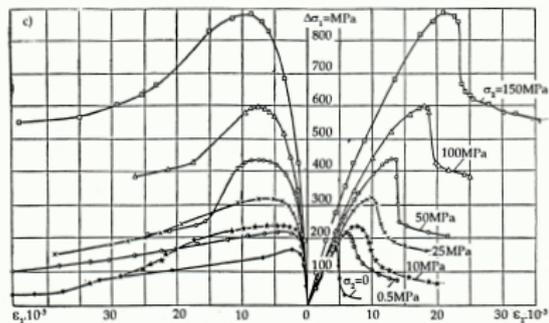
Summary

Rock and Soil Material Data

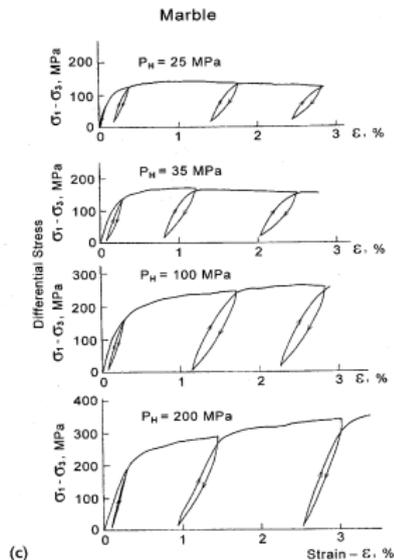
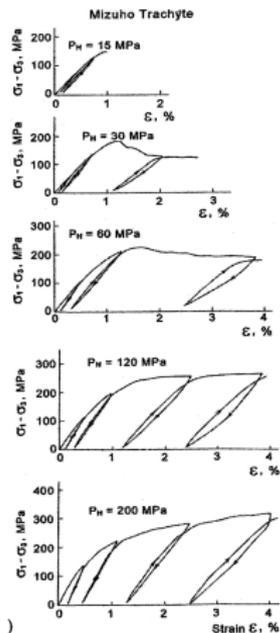
- ▶ Rock assumed to be linear elastic (?)
- ▶ Soil inelastic

Depth	Geotechnical parameters	Nominal unit capacities
0 to 5 ft	Loose sand/fill $\gamma = 110$ pcf effective friction angle = 28 deg soil modulus parameter, $k = 25$ pci $v_{s0} = 580$ ft/s	neglect skin friction neglect end bearing
5 to 30 ft	Soft clay $\gamma = 110$ pcf undrained shear strength, $s_u = 700$ psf soil modulus parameter, $k = 25$ pci strain at 50 percent of maximum stress, $\epsilon_{50} = 0.01$ $v_{s0} = 700$ ft/s	skin friction = 0.40 ksf neglect end bearing
30 to 100 ft	Medium dense sand $\gamma = 120$ pcf effective friction angle = 36 deg soil modulus parameter, $k = 50$ pci $v_{s0} = 1,040$ ft/s	skin friction = 3.0 ksf end bearing = 100 ksf
Pile cap resistance	300 pcf, ultimate passive pressure	

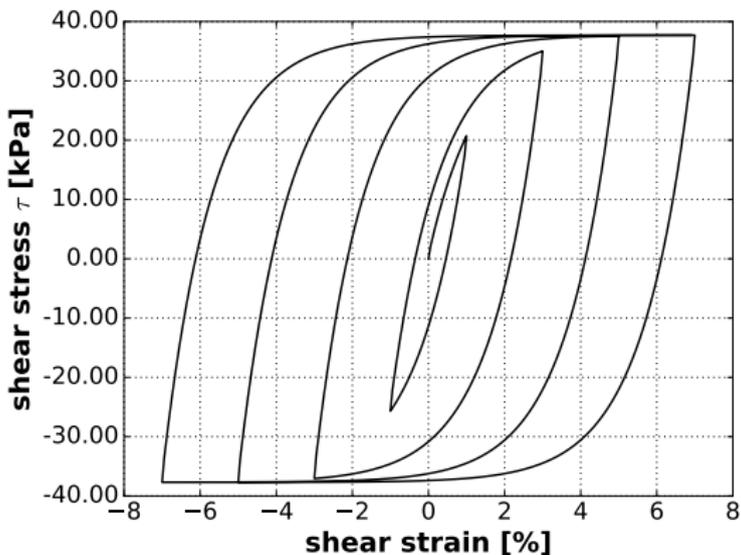
Inelastic Response of Rock, Granite, Marble



Inelastic Response of Rock, Trachyte, Marble



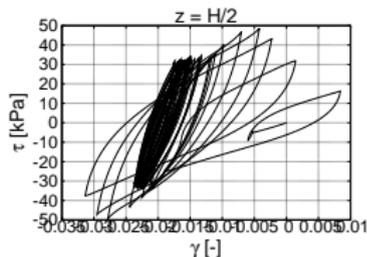
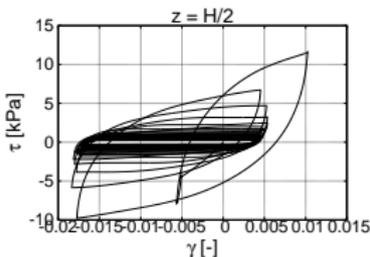
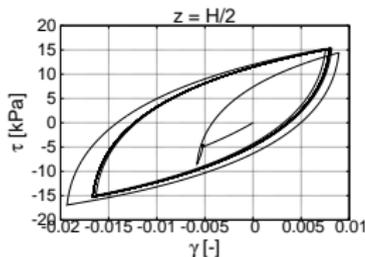
Inelastic Response of Soil



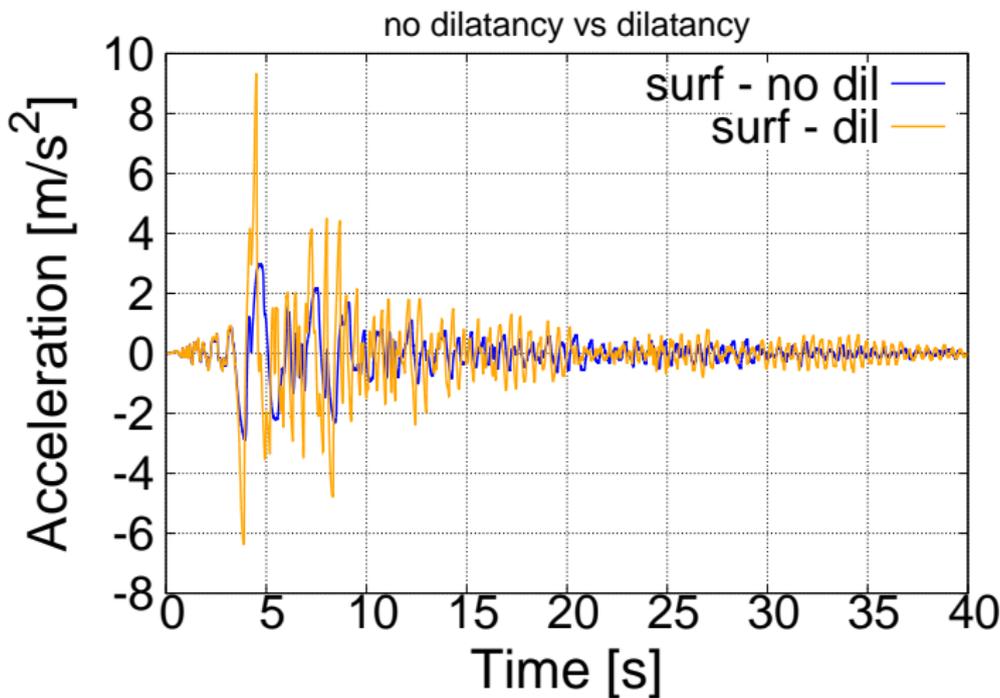
Soil Volume Response

- ▶ Soil behavior is very much a function of volumetric response
- ▶ Dilative soils: increase volume due to shearing
- ▶ Compressive soils: decrease volume due to shearing
- ▶ Modulus reduction and damping curves do not provide volumetric data
- ▶ Soil volume change will affect response due to volume constraints

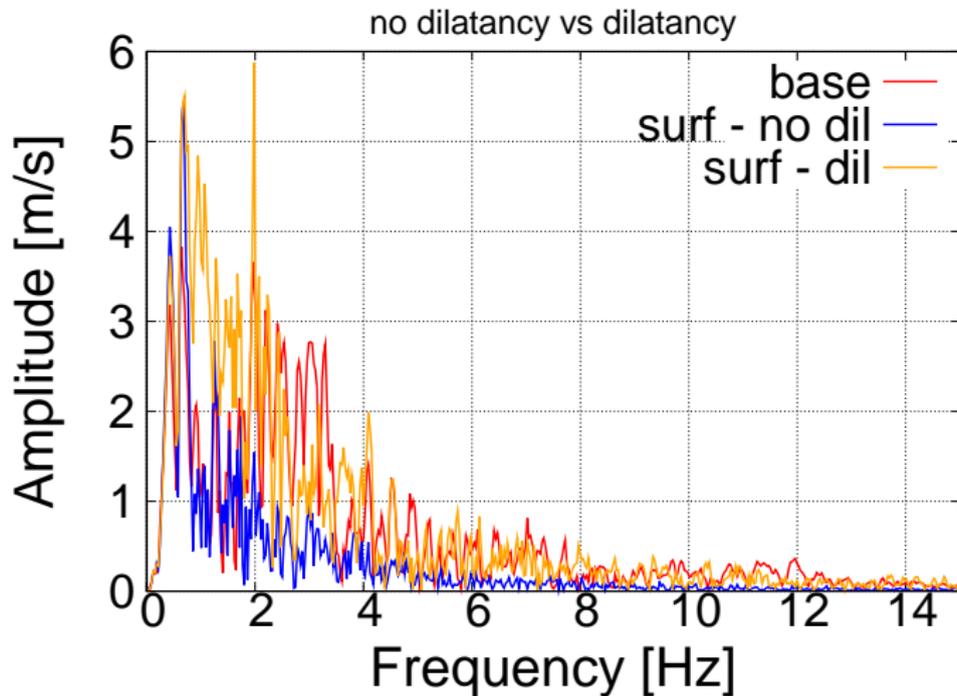
No Volume Change, Compressive and Dilative Soil



Northridge, No Volume Change and Dilative Soils



Northridge, No Volume Change and Dilative Soils

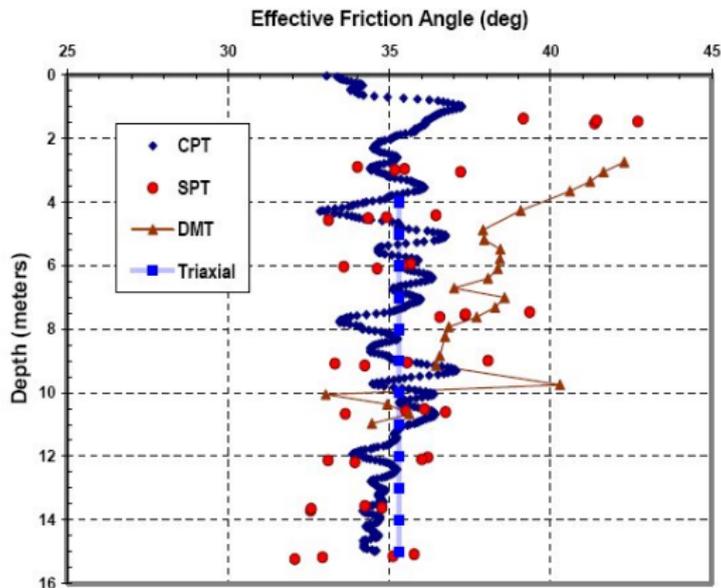


Soil Uncertainties and Quantification

- ▶ Natural variability of soil deposit (Fenton 1999)
 - ▶ Function of soil formation process
- ▶ Testing error (Stokoe et al. 2004)
 - ▶ Imperfection of instruments
 - ▶ Error in methods to register quantities
- ▶ Transformation error (Phoon and Kulhawy 1999)
 - ▶ Correlation by empirical data fitting (e.g. CPT data → friction angle etc.)

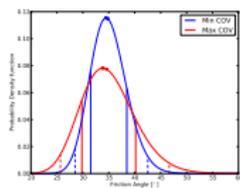
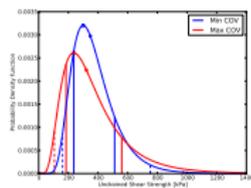
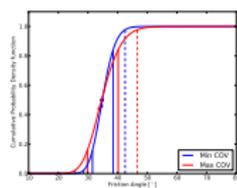
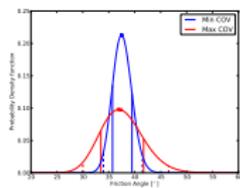
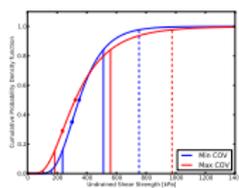
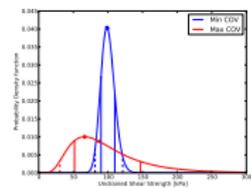
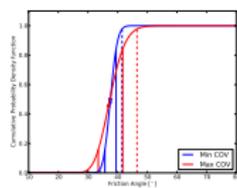
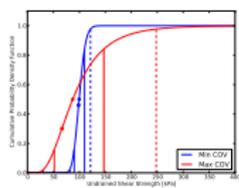
Material Behavior Inherently Uncertain

- ▶ Spatial variability
- ▶ Point-wise uncertainty, testing error, transformation error

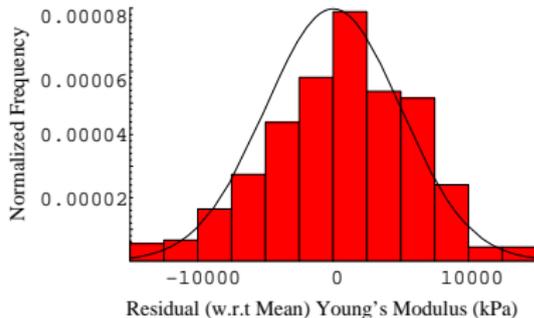
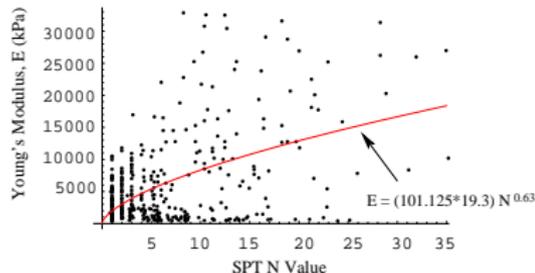


(Mayne et al. (2000))

Parametric Uncertainty: Material Properties

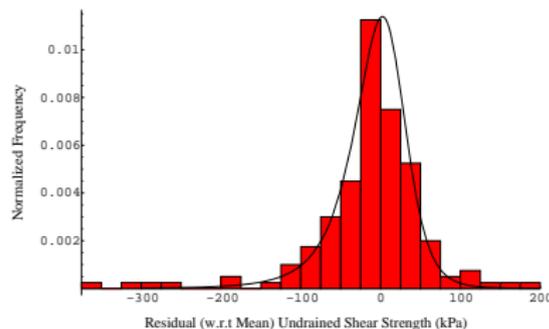
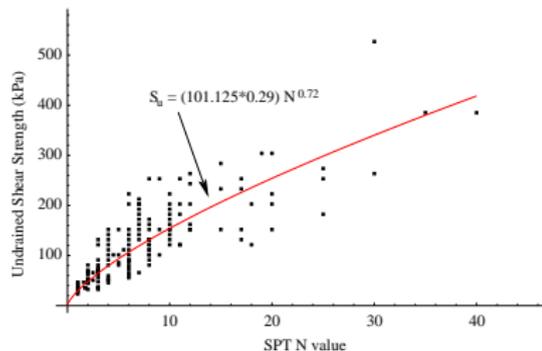
Field ϕ Field c_u Lab ϕ Lab c_u 

SPT Based Determination of Young's Modulus



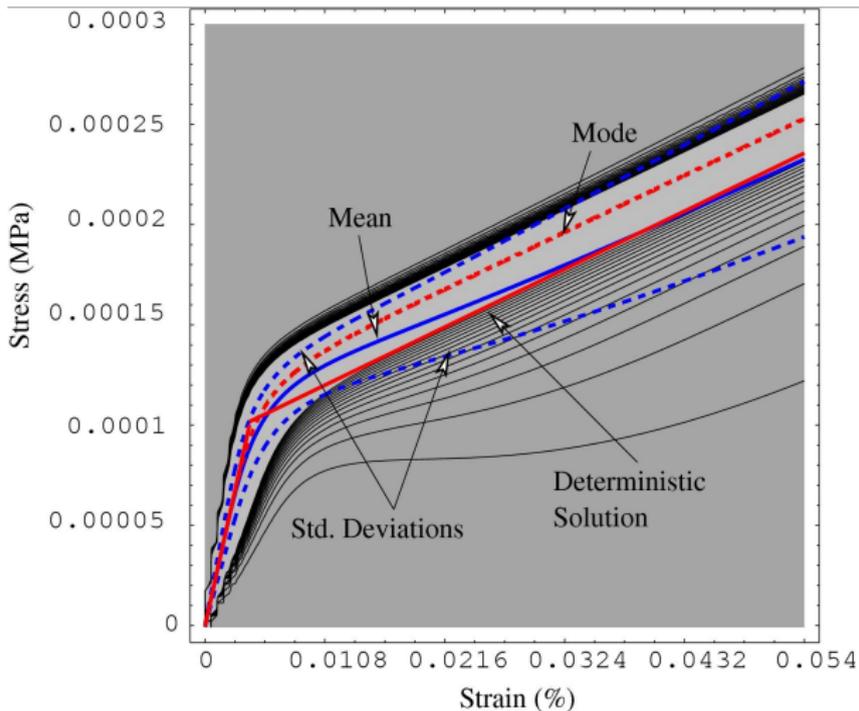
Transformation of SPT N -value \rightarrow 1-D Young's modulus, E (cf. Phoon and Kulhawy (1999B))
Histogram of the residual (w.r.t the deterministic transformation equation) Young's modulus, along with fitted probability density function

SPT Based Determination of Shear Strength

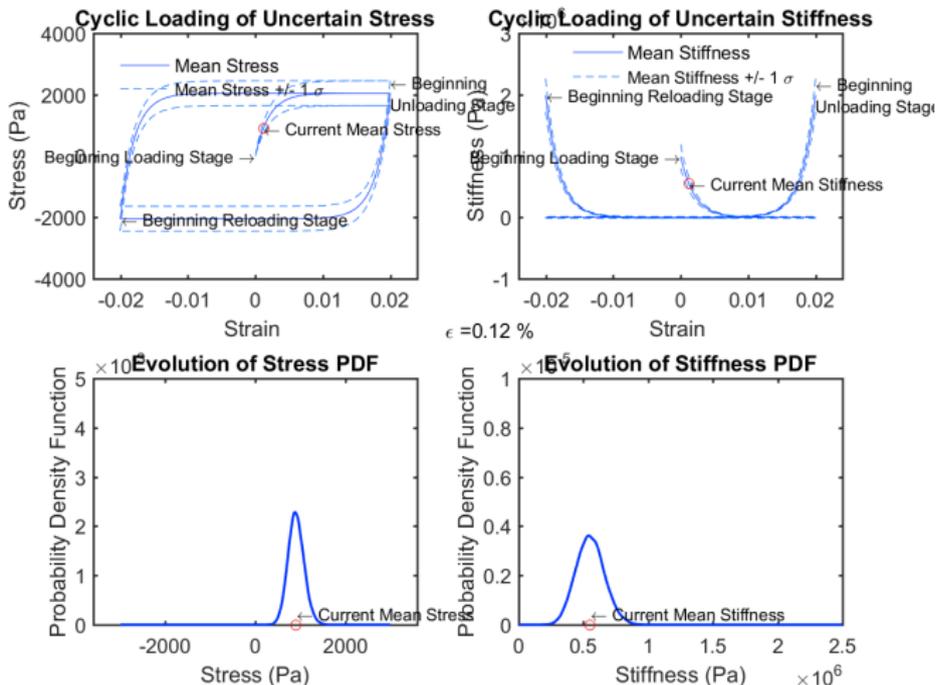


Transformation of SPT N -value \rightarrow undrained shear strength, s_u
(cf. Phoon and Kulhawy (1999B))
Histogram of the residual (w.r.t the deterministic transformation equation) undrained strength, along with fitted probability density function (Pearson IV)

Probabilistic Elastic-Plastic Response

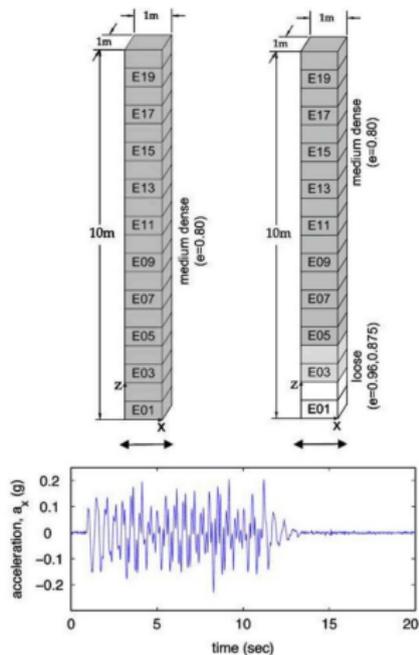


Probabilistic Elastic-Plastic Response

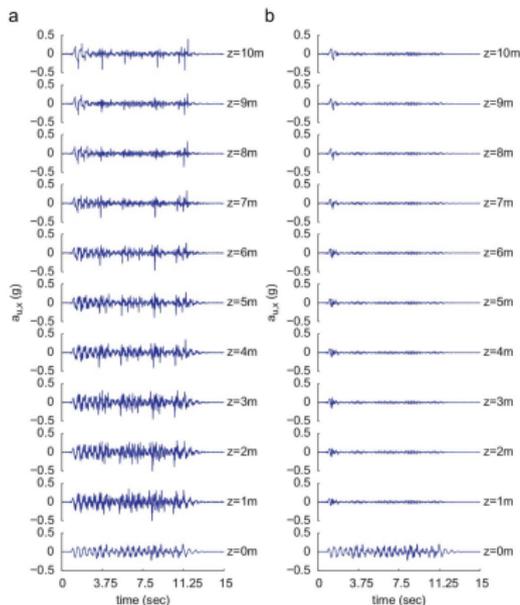


(MP4)

Liquefaction as Base Isolation, Model



Liquefaction, Wave Propagation



Liquefaction, Stress-Strain Response

