

# Geomechanics Elements and Models in OpenSees

Boris Jeremić

Department of Civil and Environmental Engineering  
University of California, Davis

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## Outline

### Material Models

- Elastic

- Small Deformation Elastic–Plastic Continuum

- Small Deformation Elastic–Plastic Uniaxial

- Small Deformation Elastic–Plastic Multiaxial

- Large Deformation Hyperelastic–Plastic Continuum

### Elements

- Single Phase

- Multi Phase

### Various Procedures

## Elastic Material Models

- ▶ Small deformation elasticity (linear isotropic, nonlinear isotropic, cross anisotropic...)
- ▶ Large deformation hyperelasticity (Neo–Hookean, Ogden, Logarithmic, Mooney–Rivlin, Simo–Pister...)

## Elastic–Plastic Continuum Models

- ▶ Small deformation *template* elasto–plasticity
  - ▶ Yield surfaces: von Mises, Drucker–Prager, Cam–Clay, Rounded Mohr–Coulomb, Parabolic Leon...
  - ▶ Plastic flow directions: Drucker–Prager, von Mises, Cam–Clay, Rounded Mohr–Coulomb, Manzari Dafalias
  - ▶ Evolution Laws: Linear scalar, nonlinear scalar (CamClay), Linear (translational and rotational) tensorial, nonlinear (translational and rotational) tensorial (Armstrong Frederick and bounding surface),
- ▶ Large deformation *template* hyperelasto–plasticity
  - ▶ Yield surfaces: von Mises, Drucker–Prager...
  - ▶ Plastic flow directions: Drucker–Prager, von Mises, Cam–Clay, Rounded Mohr–Coulomb, Manzari Dafalias
  - ▶ Evolution Laws: Linear/nonlinear scalar, Linear (translational and rotational) tensorial
- ▶ Stochastic elasto–plasticity

## Elastic–Plastic Uniaxial

- ▶ P–Y springs response material model

## Elastic–Plastic Multiaxial Models

- ▶ Generalized foundation rocking material (M, N, T) model
- ▶ 2D frictional contact material model

## Large Deformation Hyperelastic–Plastic Models

- ▶ Large deformation hyperelasticity (Neo–Hookean, Ogden, Logarithmic, Mooney–Rivlin, Simo–Pister...)
- ▶ Large deformation *template* hyperelasto–plasticity
  - ▶ Yield surfaces: von Mises, Drucker–Prager...
  - ▶ Plastic flow directions: Drucker–Prager, von Mises, Cam–Clay, Rounded Mohr–Coulomb, Manzari Dafalias
  - ▶ Evolution Laws: Linear/nonlinear scalar, Linear (translational and rotational) tensorial

## Single Phase Formulations

- ▶ Small deformation solid elements (8, 20, 21, 27, 8-20 variable node bricks)
- ▶ Large deformation (total Lagrangian) solid elements (20 node brick)

## Multi Phase Formulations

- ▶ Fully coupled, u–p–U and u–p elements for small deformations
- ▶ Fully coupled u–p elements for large deformations

## Various Procedures

- ▶ Hyperspherical Arc–length constraint equations
- ▶ Plastic Domain Decomposition (dynamic CPU load balancing distributed parallel implementation)
- ▶ Domain reduction method for seismic input/characterization