Contributions to OpenSees Framework for Sensitivity, Reliability and Optimization Analyses

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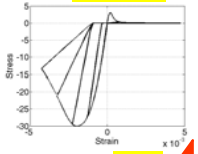
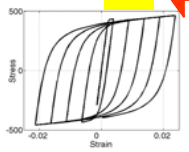
Future Large-Scale Applications of Presented Methodology

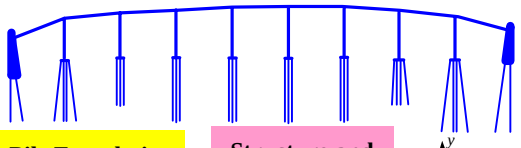
NONLINEAR FINITE ELEMENT RESPONSE AND RESPONSE SENSITIVITY ANALYSIS

Concrete



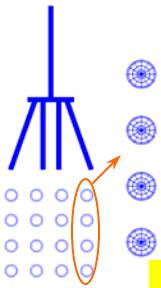
Steel





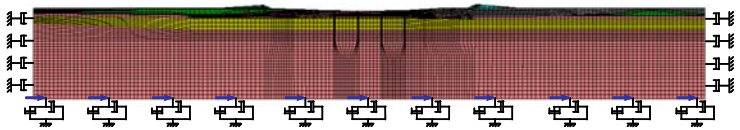
Pile Foundation

Structure and Foundation

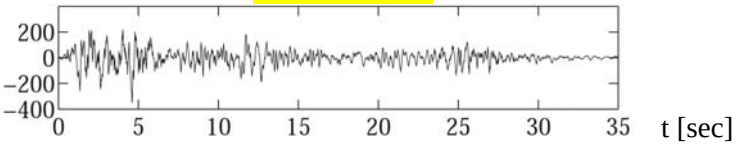


Fiber Section

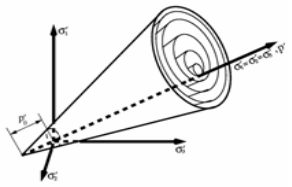
Soil Mesh and Absorbing Boundaries



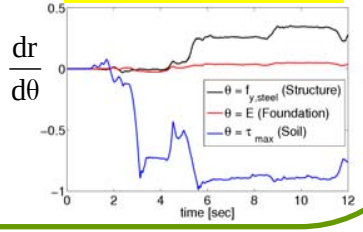
Seismic Input



Soil Constitutive Models



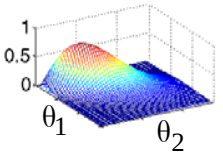
Response & Response Sensitivities

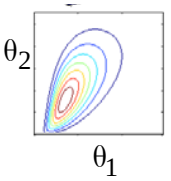


PROBABILISTIC CHARACTERIZATION OF MATERIALS, GEOMETRY AND INPUT LOADING

Joint PDF of Random Variables

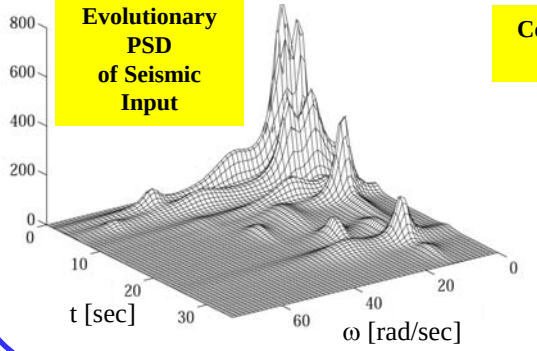
Nataf Model



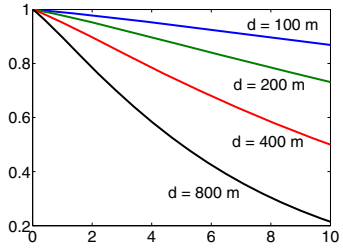


Stochastic Earthquake Ground Motion Model

Evolutionary PSD of Seismic Input

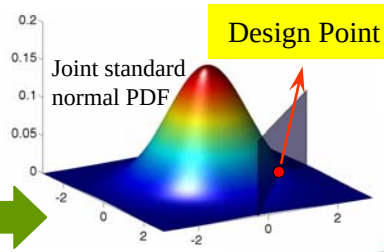


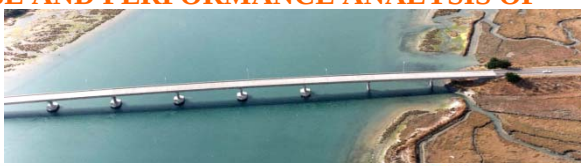
Coherency Functions for Asynchronous Ground Motion

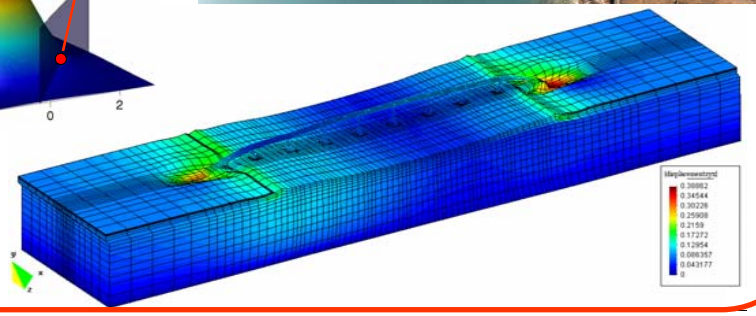


PROBABILISTIC RESPONSE AND PERFORMANCE ANALYSIS OF SFSI SYSTEMS

Design Point







Long Term Objectives

- Extend state-of-the-art in deterministic modeling and analysis of large and complex structural and/or geotechnical systems subjected to earthquake loading to allow:
  - Response sensitivity analysis using the Direct-Differentiation-Method (DDM)
  - Optimization of structural and/or geotechnical systems
  - Finite element model calibration/updating based on experimental/field data
  - Probabilistic response analysis
  - Reliability analysis
  - Reliability-based optimization
  - Life-cycle performance-based assessment and design of existing and new structural and/or geotechnical systems

Objectives of Current Project

- Extension of computational framework in OpenSees to perform sensitivity, reliability and optimization analyses of structural and/or geotechnical systems.
- Development and implementation of a new visualization method to investigate the topology of limit-state surfaces in high-dimensional spaces in the context of nonlinear FE time-invariant and time-variant reliability analyses.
- Implementation in OpenSees of the recently developed Design Point – Response Surface – Simulation (DP-RS-Sim) method for computational reliability analysis.
- Development of demonstration applications for sensitivity, probabilistic response, reliability and optimization analyses and FE model updating of building and bridge structures.
- Preparation of Users' Guide documentation for the new software modules for sensitivity, probabilistic response, reliability and optimization analyses in OpenSees.

Overview of Past Work by PEER Researchers

(T. Haukaas & A. Der Kiureghian, M. Scott, G. Fenves & F. Filippou, Q. Gu, M. Barbato & J.P. Conte, …)

- Development of algorithms for DDM-based FE response sensitivity analysis for:
  - Various uni-axial and multi-axial nonlinear hysteretic material models
  - Different types/formulations of finite elements:
    - 2-D and 3-D continuum-type elements (e.g., quadrilateral, brick, …)
    - Frame-type (beam-column) elements (monolithic and composite)
    - Zero-length elements
    - Displacement-based, force-based, and mixed finite element formulations
    - Finite elements with internal DOF's (with static condensation)

Overview of Past Work by PEER Researchers

- Cross-section models for frame-type models:
  - Stress and strain resultant model
  - 2-D layer-discretized and 3-D fiber-discretized section models for steel I-beams, R/C members and steel-concrete composite members
- Multi-point constraint handler:
  - Transformation method
  - Penalty method
  - Lagrange multipliers method

- New FE parameterization framework in OpenSees (M. Scott,Oregon State University)
  - Integration of existing capabilities in OpenSees for sensitivity and reliability analysis with this new FE parameterization framework