Simulation and Information Technologies

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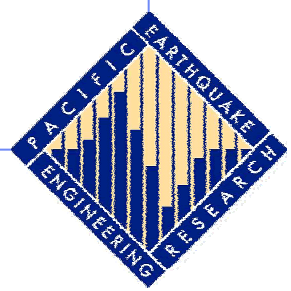
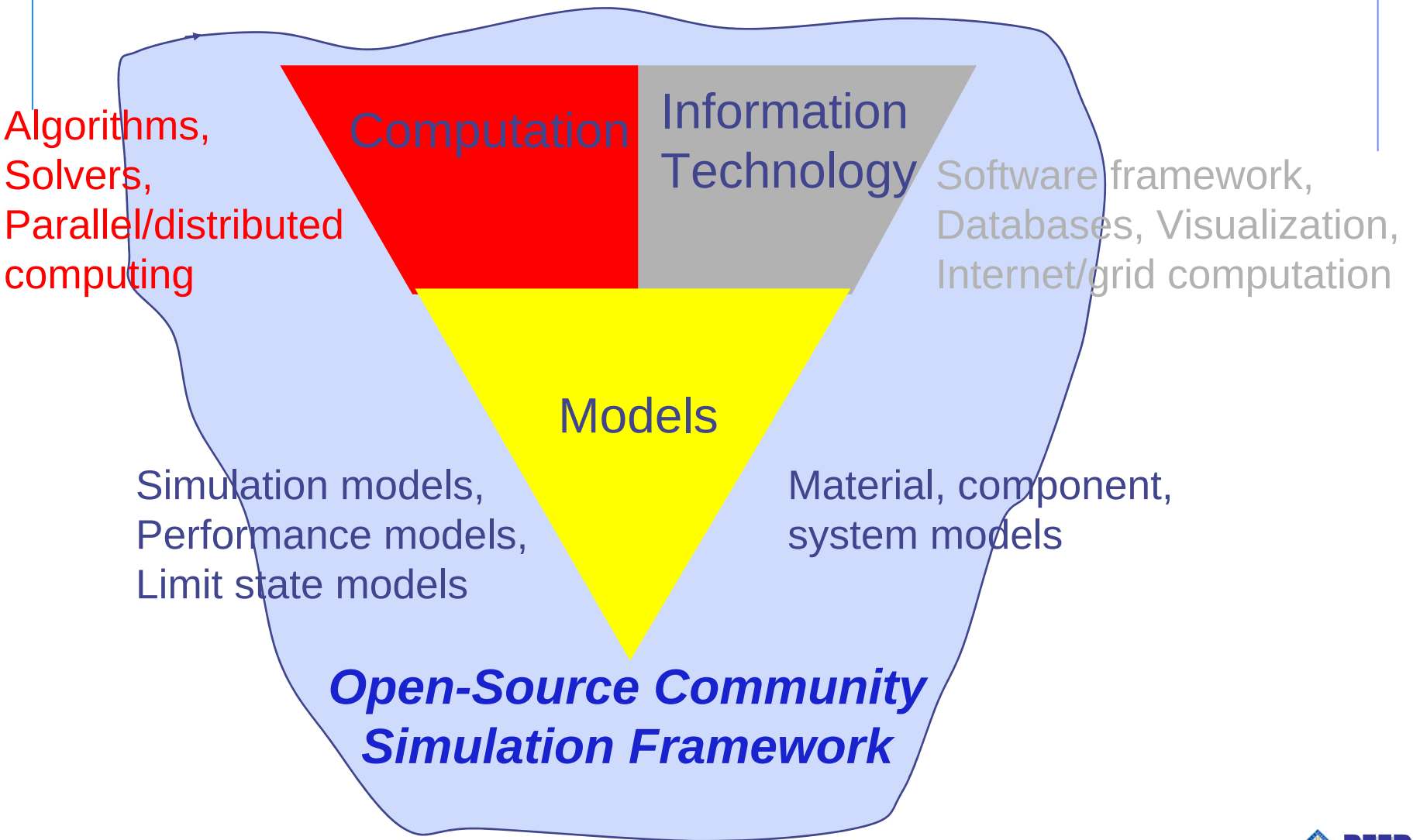


PEER Summative Meeting – June 13, 2007

Simulation Practice and Research Prior to PEER

- Simulation in practice:
  - Little use of pushover analysis, almost no use of nonlinear dynamic analysis
  - Models based on simple hinge representation
  - Very little consideration of soil-structure interaction
- Simulation in research:
  - Embedding of computational procedures in codes makes it difficult to use new models and Information Technology
  - “Closed-source” was the norm creating islands of software
  - Poor integration between structural and geotechnical simulation
  - Very little incorporation of probabilistic methods in simulation
- Combination of two impeded progress and both were inadequate for PBEE

Approach for Simulation in PEER



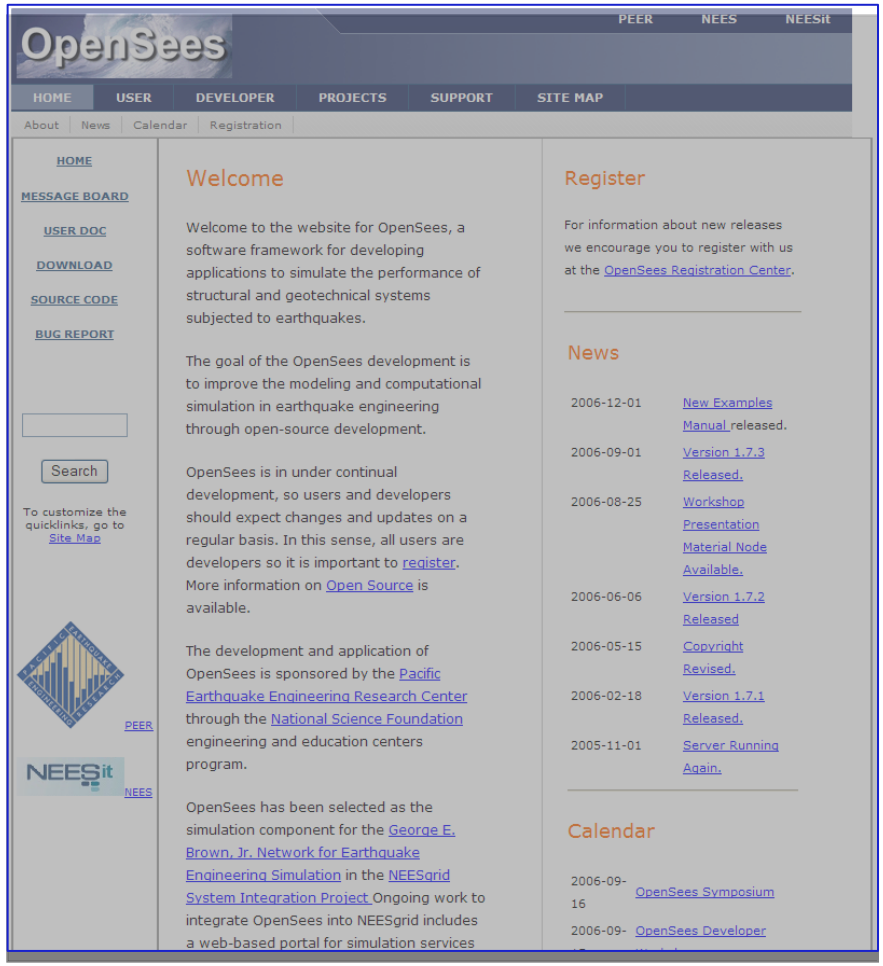
OpenSees

Open System for Earthquake Engineering Simulation

Pacific Earthquake Engineering Research Center

- OpenSees has been under development by PEER since before 1997
- Large group of developers and users
- Open-source and license for non-commercial use
- The only widely us community-based simulation software in CEE
- NEES has adopted OpenSees for the NEESit simulation component

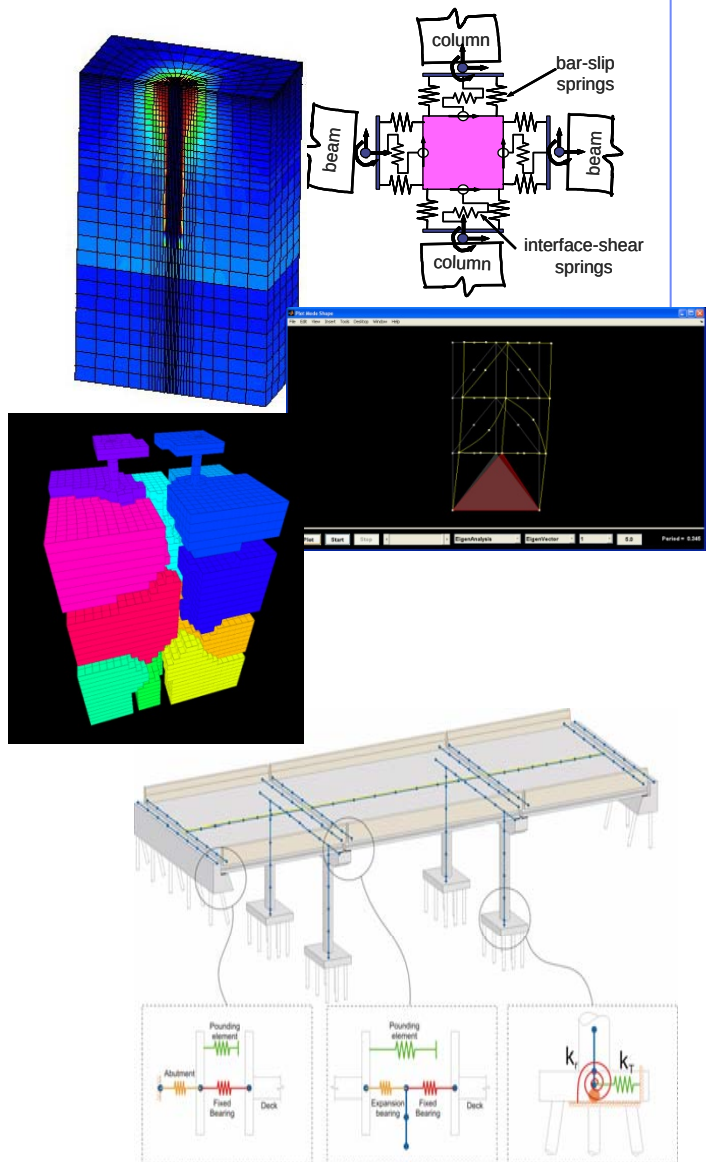
http://opensees.berkeley.edu



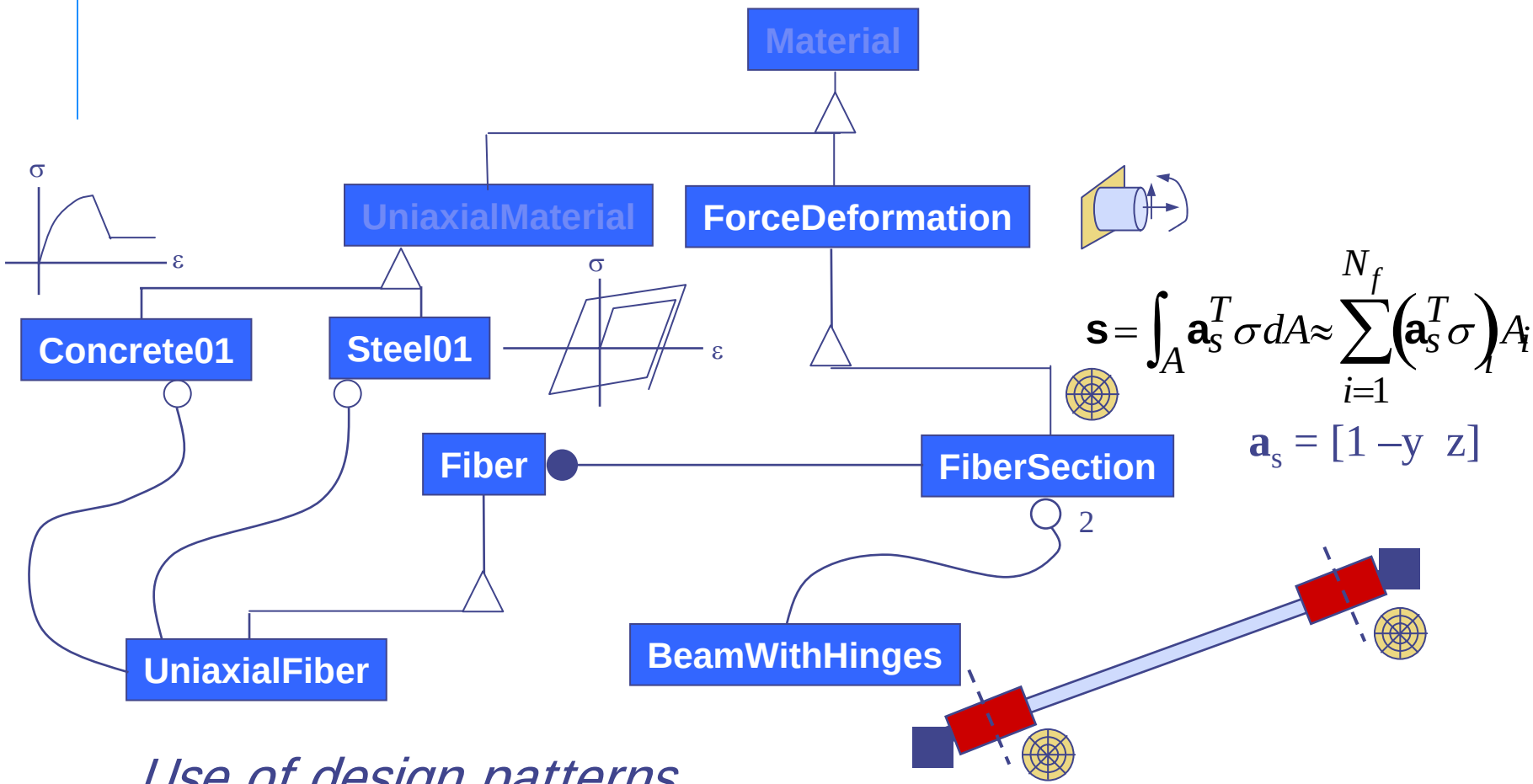
PEER

OpenSees Approach to Simulation

- Basic approach:
  - Modular software design for implementing and integrating modeling, numerical methods, and IT for scalable, robust simulation
  - Open-source software for building a community of users and developers
  - Focus on capabilities needed for PBEE
- Most users: a “code” for nonlinear analysis
- Generally: a software framework for developing simulation applications



Form Follows Mechanics

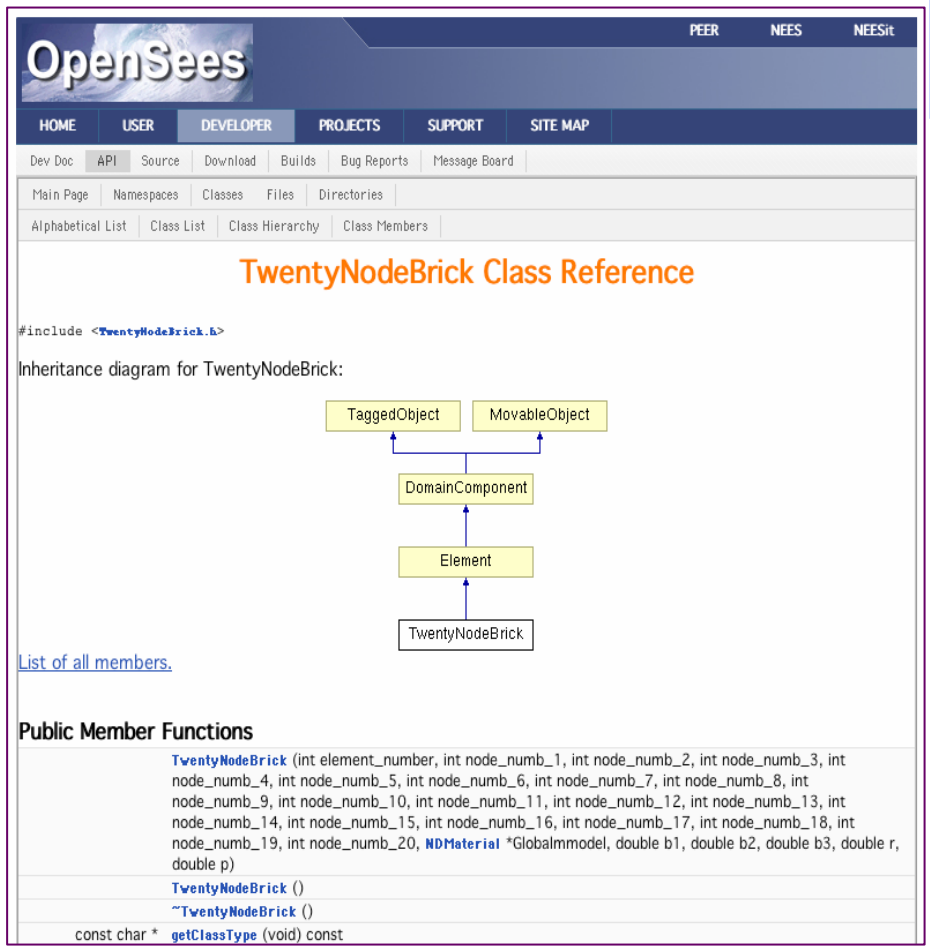


Use of design patterns.

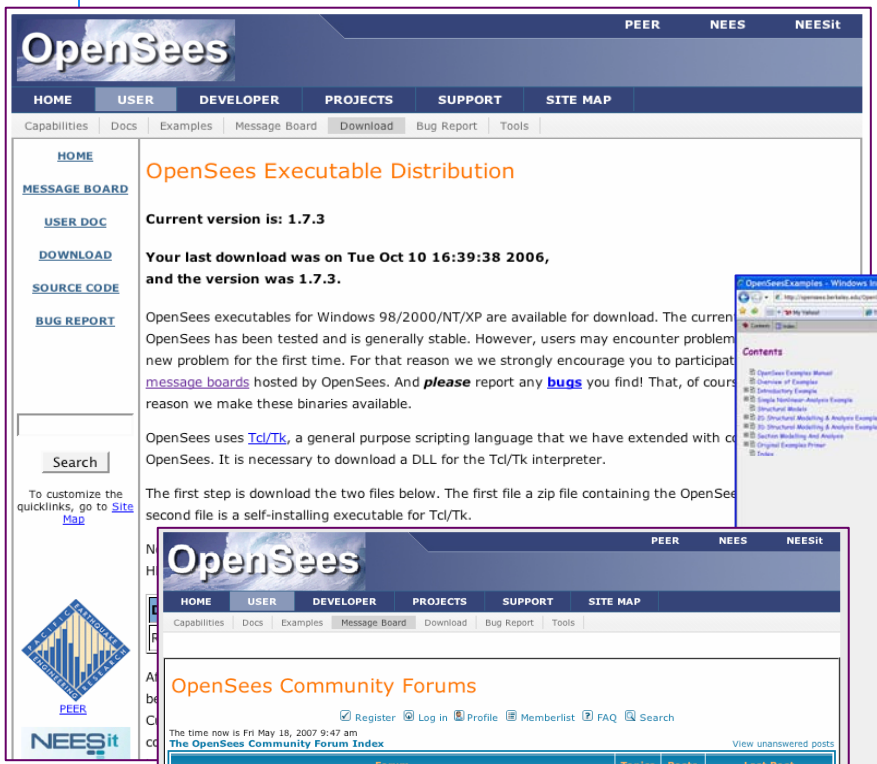
Framework Design/Source for Developers

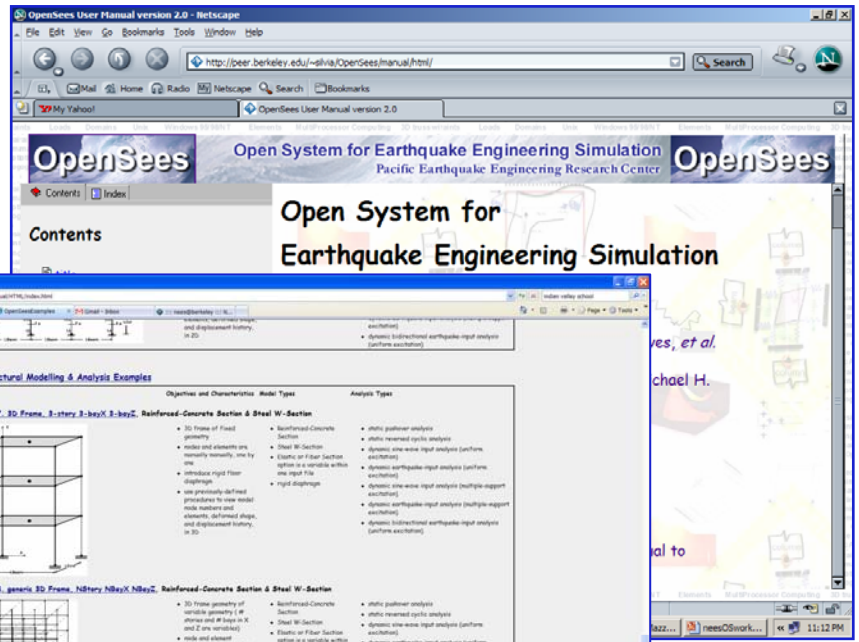
Source Code Viewing/Updating

Class Specification
Application Program Interface



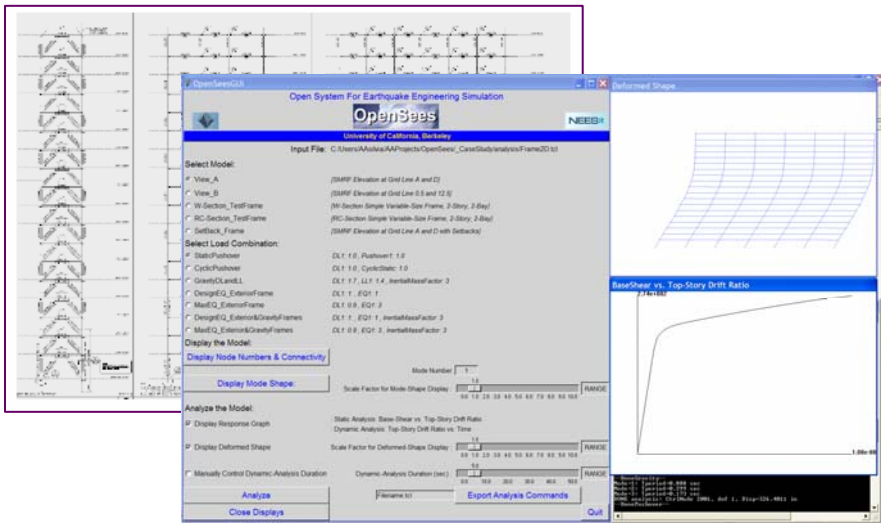
OpenSees User Support Services





OpenSees Days

OpenSees Framework Applications



Tall Building Analysis

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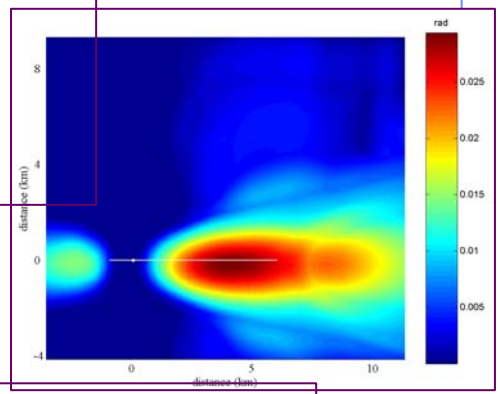
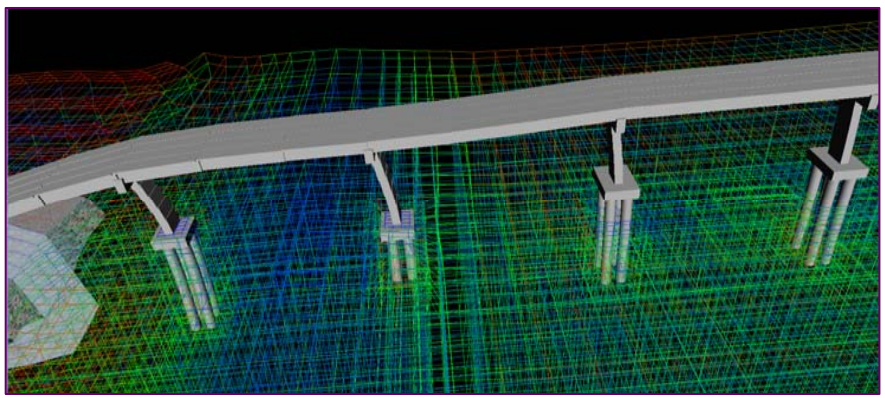




Advanced Visualization

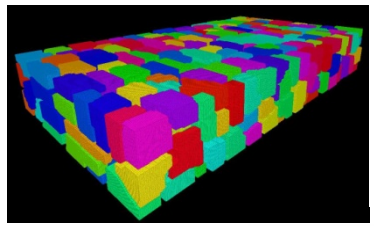
QuickTime™ and a
Animation decompressor
are needed to see this picture.

Seismic Performance of Urban Regions

PEER

NEESit: High-Performance Computing

- OpenSees implementations
  - Domain decomposition
  - High-fidelity site response by DRM
  - Large-scale parameter studies
- Teragrid allocation and usage
  - NEES wide 50,000 SU's (OpenSees, ABAQUS, Adina, LS-Dyna)
  - 22 projects have access to allocation
- NEESsphere interfaces for HPC jobs



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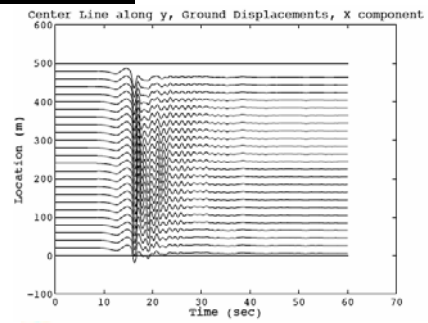
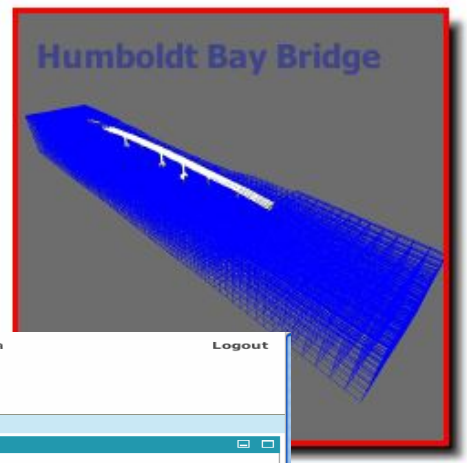
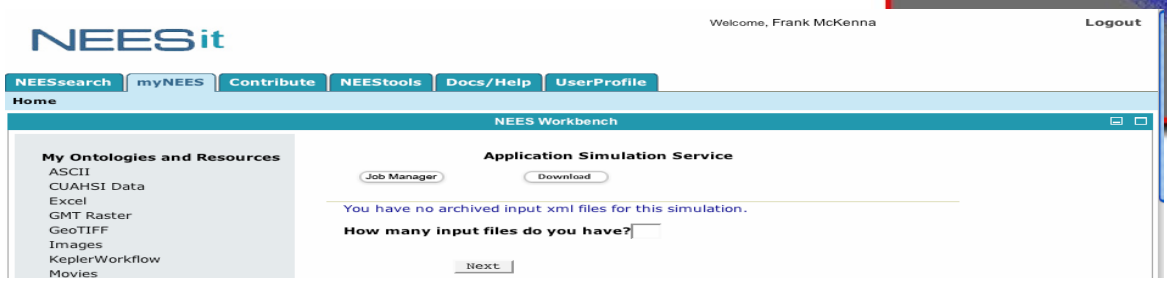
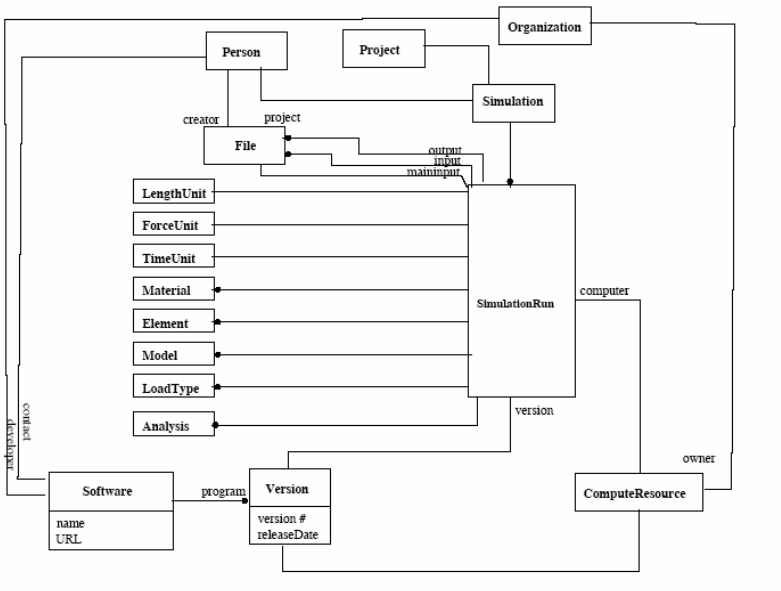
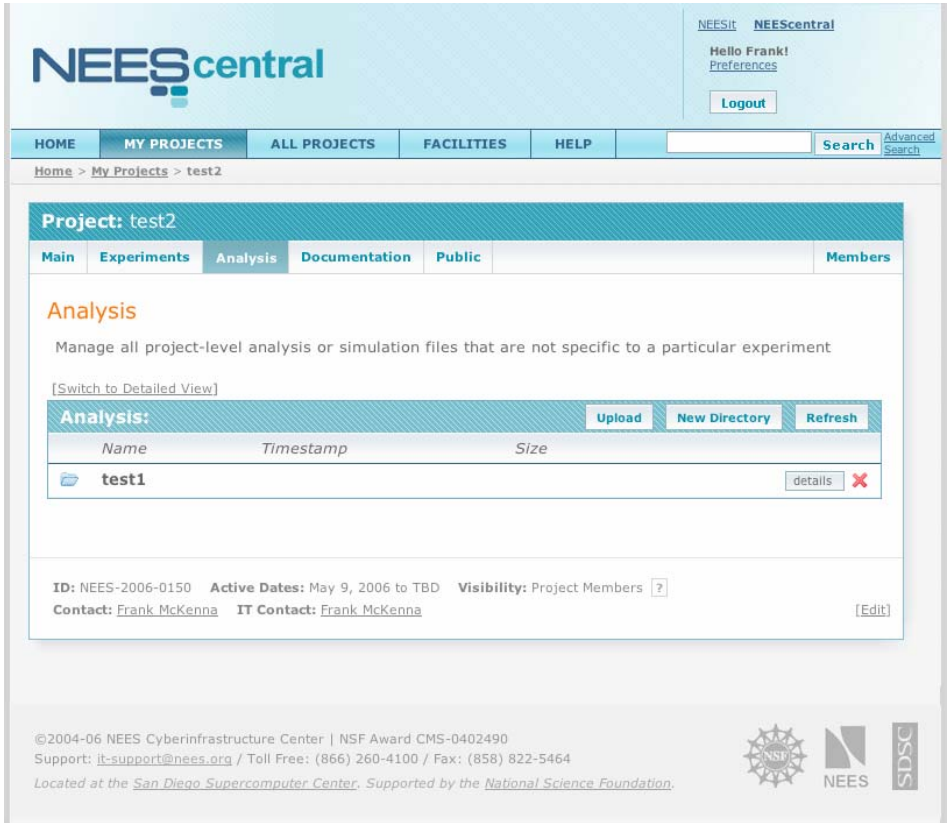


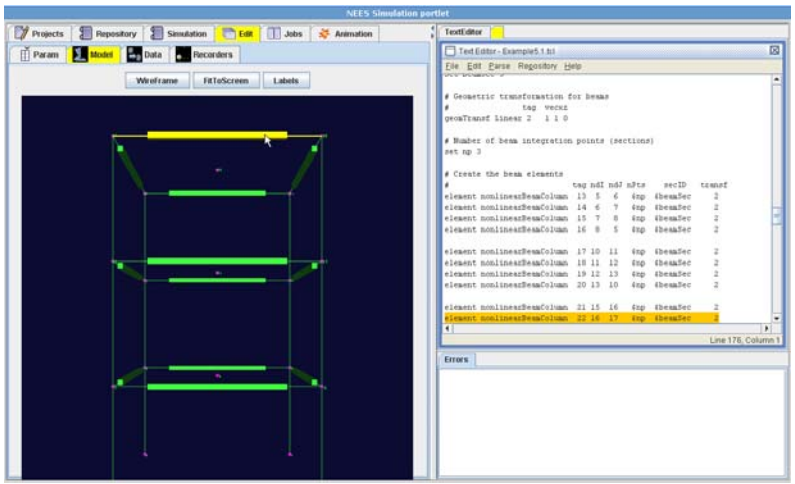




OpenSees Integration with NEESit







What Has Been Accomplished by PEER in Simulation/IT for Practice and Research?

- Simulation in practice:
  - Much more robust and validated models for R/C
  - Dynamic analysis for suite of ground motions used more widely, provide improved understanding of EDP distributions for PBEE
  - Recognition of importance of SSFI on many structures
- Simulation in research:
  - The first open-source software for earthquake engineering; developed an enabling technology for the community
  - Introduced a new generation of students to modern IT
  - Tackled more complex problems using teams of researchers to develop models, computational procedures, and model validations
  - Improved coordination between structural and geotechnical simulation
  - Created new opportunities for IT and cyberinfranstructure advances in earthquake engineering through NEES and other NSF initiatives
- Combination of two accelerated advances for simulation in PBEE, incorporated modern IT, and created a community of users.