

Discovering OpenSees: Introduction to OpenFresco *Express*

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University of California, Berkeley*



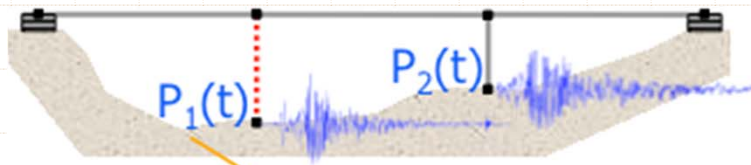
OpenFresco

Introduction

- ★ Populations of seismically active regions grow denser
 - ★ Greater odds for large-scale catastrophes (Haiti 01/2010, Chile 02/2010, New Zealand 02/2011, Japan 03/2011)
 - ★ Improve knowledge and understanding of the complex nonlinear response and behavior of new and existing civil structures during seismic events
- ➔ Experimental testing of structures is the cornerstone of earthquake engineering

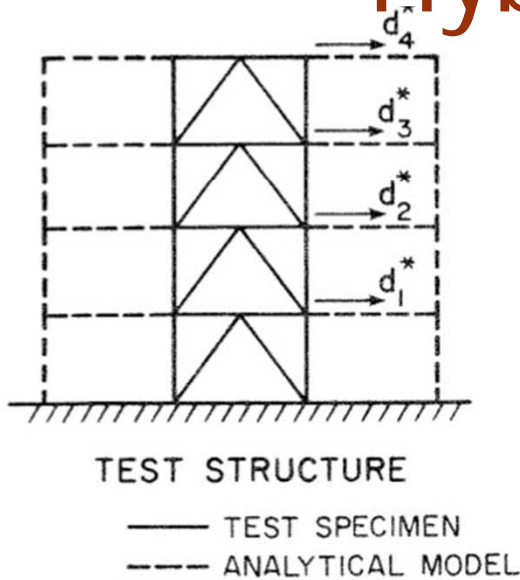
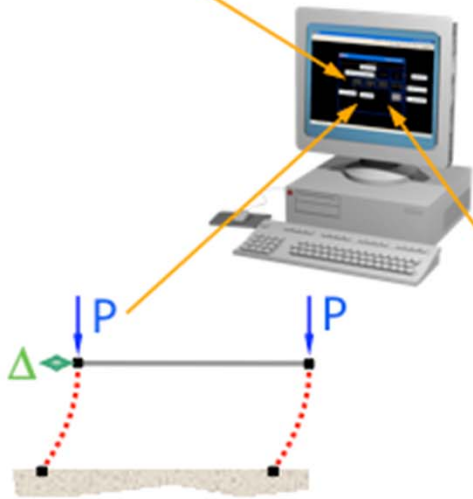
Outline of Presentation

1. Introduction to Hybrid Simulation
2. Downloading and Installing
3. Example 1: Building first Hybrid Model
4. Simulated vs. Real Controllers
5. Error Monitors
6. Example 2: Two Story Building
7. Other Resources
8. Summary & Conclusions

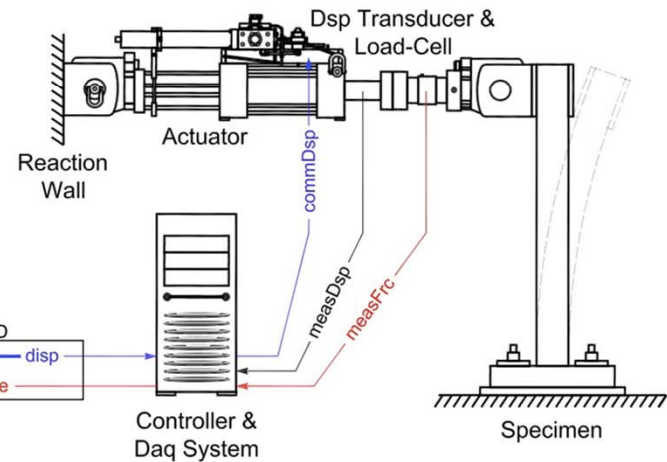
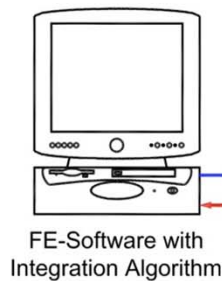


$$\cdot \ddot{\mathbf{u}} + \mathbf{C} \cdot \dot{\mathbf{u}} + \mathbf{P}_r(\mathbf{u}) = \mathbf{P}(t)$$

Introduction to Hybrid Simulation



Discrete FE-Model with static & dynamic loading



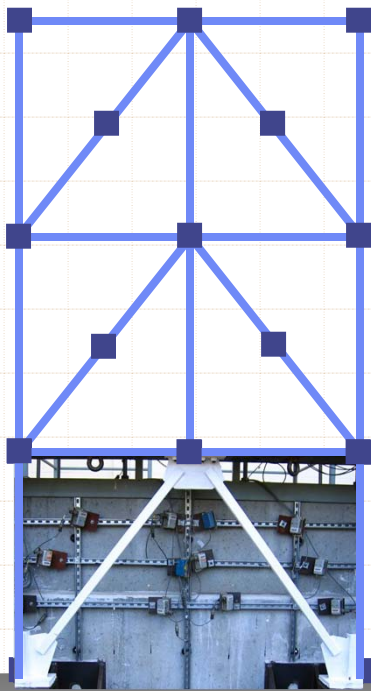
Comparison of Exp. Test Methods

	Quasi-Static	Shaking Table	Hybrid Simulation
Dynamics	NO	YES	YES
Strain Rate Effects	NO	YES	YES (if real-time test)
Large- or Full-Scale	YES	NO (limited by table)	YES

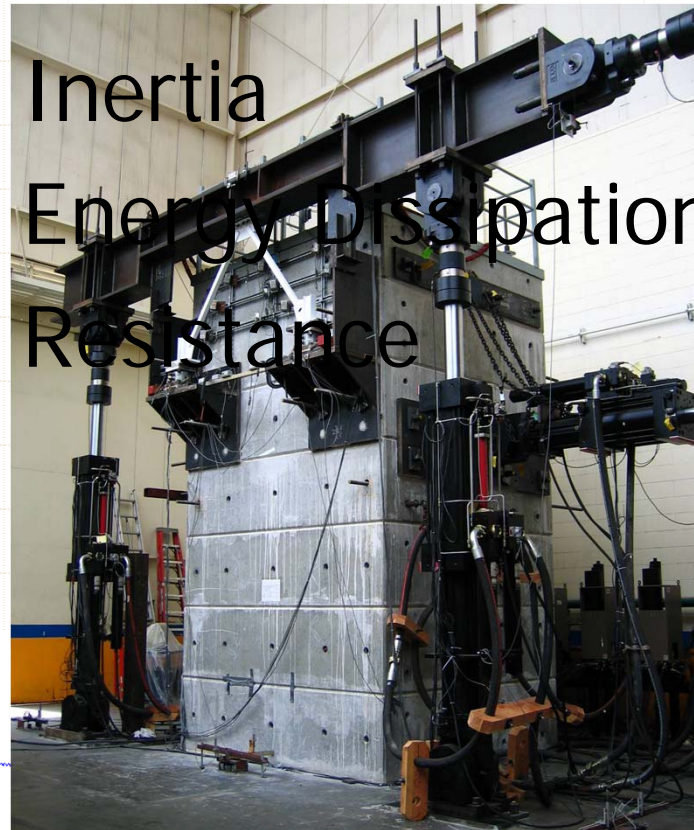
- ★ First Hybrid Simulation (Online Test) in 1975 by Takanashi et al.

Hybrid Simulation

$$\mathbf{M} \cdot \ddot{\mathbf{u}} + \mathbf{C} \cdot \dot{\mathbf{u}} + \mathbf{P}_r(\mathbf{u}) = \mathbf{P}(t)$$



- ✦ Inertia
- ✦ Energy Dissipation
- ✦ Resistance



Hybrid Simulation

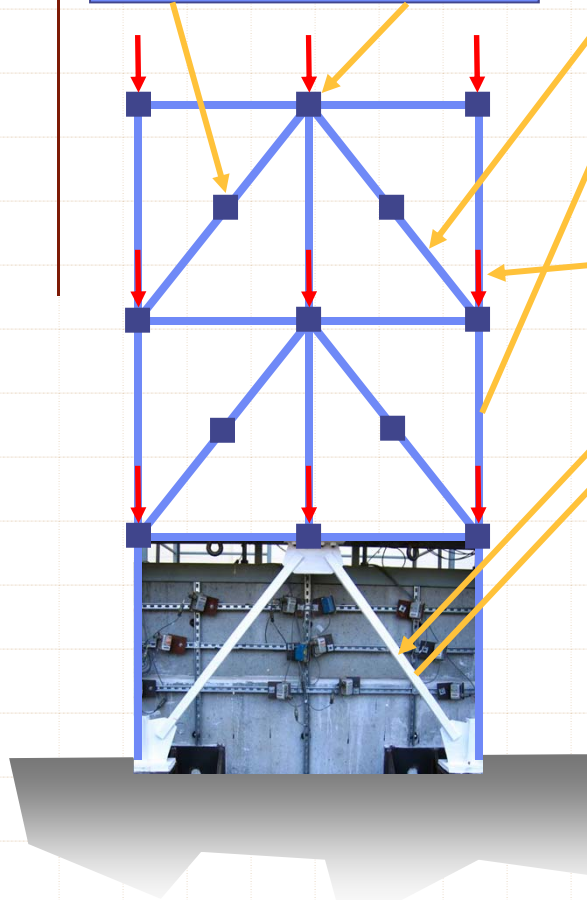
$$\mathbf{M} \cdot \ddot{\mathbf{u}} + \mathbf{C} \cdot \dot{\mathbf{u}} + \mathbf{P}_r(\mathbf{u}) = \mathbf{P}(t)$$

Dynamic Loading:

- Seismic
- Wind
- Blast/Impact
- Wave
- Traffic

Static Loading:

- Gravity
- Prestress



analytically add nonlinear geometric effects to measured resisting forces

 analytical model of structural energy dissipation and inertia

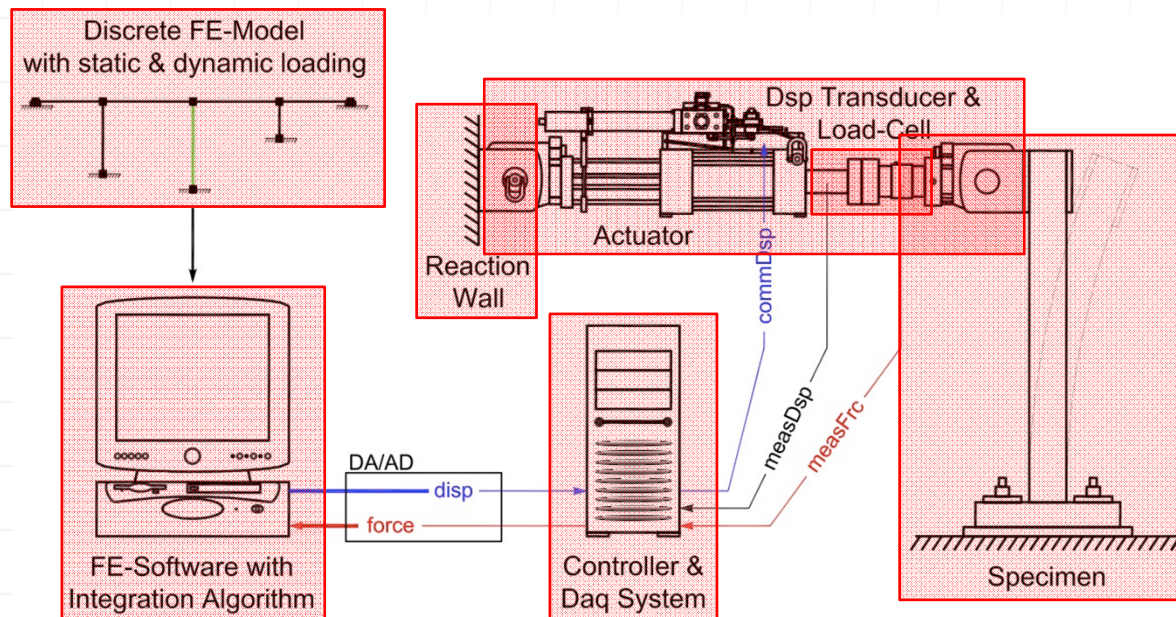
 physical model of structural resistance

Hybrid Simulation

- ★ Model the well understood parts of a structure in a finite element program on one or more computers
- ★ Leave the construction and testing of the highly nonlinear and/or numerically hard to model parts of the structure in one or more laboratories
- ★ Can be considered as a conventional finite element analysis where physical models of some portions of the structure are embedded in the numerical model

Required Components

1. Discrete model of the structure to be analyzed, including the static and dynamic loading
2. Servo-hydraulic control system with static or dynamic actuators
3. Physical test specimen, including a reaction-frame
4. Data acquisition system with instrumentation



What is OpenFresco?

- ★ Open source Framework for Experimental Setup and Control
- ★ Secure, object oriented, network enabled “**middleware**” -- Pairs computer analysis software with laboratory control systems and other software to enable hybrid and collaborative computing:
- ★ Computational Drivers
 - OpenSees
 - OpenFresco *Express*
 - Abaqus
 - LS-DYNA
 - Matlab
 - Simulink
 - Ansys
 - UI-SimCor
- ★ Control Systems
 - dSpace
 - MTS
 - ◆ STS family
 - ◆ Flextest/CSI
 - ◆ Flextest/Scramnet
 - National Instruments
 - Pacific Instruments
 - ADwin

What is OpenFresco *Express*

- ★ Graphical user interface that is designed to simplify the running of hybrid simulations
- ★ Guides the user through a step-by-step process to define the key parameters in a hybrid simulation
- ★ Plots test data and error monitors in real time for checking the validity of results
- ★ Allows the user to perform ground motion or free vibration tests



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HOME

OpenFresco (the Open-source Framework for Experimental Setup and Control) is an environment-independent software framework, that connects finite element models with control and data acquisition systems in laboratories to facilitate hybrid simulation of structural and geotechnical systems.

Hybrid simulation is an experimental testing technique where a test is executed based on a step-by-step numerical solution of the governing equations of motion for a hybrid model, formulated considering both the numerical and physical portions of a structural system. In order for the earthquake engineering community to take full advantage of this technique, OpenFresco standardizes the deployment of hybrid simulation and extends its capabilities to applications where advanced numerical techniques are utilized, boundary conditions are imposed in real-time, and dynamic loading conditions caused by wind, blast, impact, waves, fire, traffic, and, in particular, seismic events are considered. Accordingly, the architecture of the OpenFresco software package provides a great deal of flexibility, extensibility, and re-usability to the researcher or developer interested in hybrid simulation.

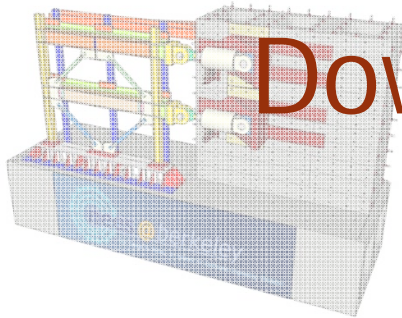
Search

Menu

- Log in
- Register

Downloads

- OpenFresco
- OpenFrescoExpress
- OpenSees Navigator



Downloading and Installing OpenFresco Express



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DOCUMENTATION

General Manuals

- OpenFresco Installation & Getting Started Manual 2.6
- OpenFresco Command Language Manual 2.6
- OpenSSL How To

Example Manuals

- OpenFresco Example Manual 2.6 - LabVIEW
- OpenFresco Example Manual 2.6 - LS-DYNA
- OpenFresco Example Manual 2.6 - Matlab
- OpenFresco Example Manual 2.6 - OpenSSL
- OpenFresco Example Manual 2.6 - PortalFrame
- OpenFresco Example Manual 2.6 - SignalFilter
- OpenFresco Example Manual 2.6 - SimDomain
- OpenFresco Example Manual 2.6 - SimFEAdapter
- OpenFresco Example Manual 2.6 - UI-SimCor
- OpenFresco Example Manual 2.6 - xPCTarget

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SUBVERSION REPOSITORIES OPENFRESKO OpenFresco calm English - English

(root)/trunk/SRC - Rev 332

Rev HEAD Go

Rev 329 | Last modification | Compare with Previous | View Log | RSS feed

LAST MODIFICATION

Rev 332 2012-06-15 10:50:44
 Author: aschell
 Log message:
 updated copyright information

Path	Rev	Date	Author	Log	RSS
branches/	288	5090 07h	hongkim	Log	RSS
logs/	206	1042d 09h	aschellenberg	Log	RSS
trunk/	332	12d 11h	aschell	Log	RSS
EXAMPLES/	321	312d 23h	aschellenberg	Log	RSS
GUI/	332	12d 11h	aschell	Log	RSS
MAKES/	314	402d 08h	aschellenberg	Log	RSS
SRC/	332	12d 11h	aschell	Log	RSS
WIN32/	329	119d 00h	aschell	Log	RSS
COPYRIGHT	332	12d 11h	aschell	Log	RSS
Makefile	314	402d 08h	aschellenberg	Log	RSS

Compare Paths

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http://openfresco.berkeley.edu



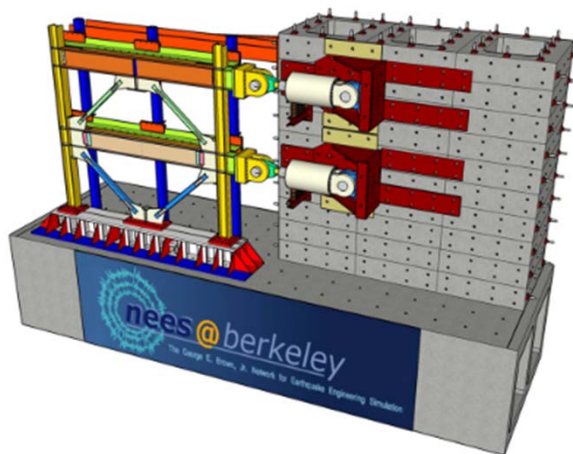
OpenFresco

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Search

Menu

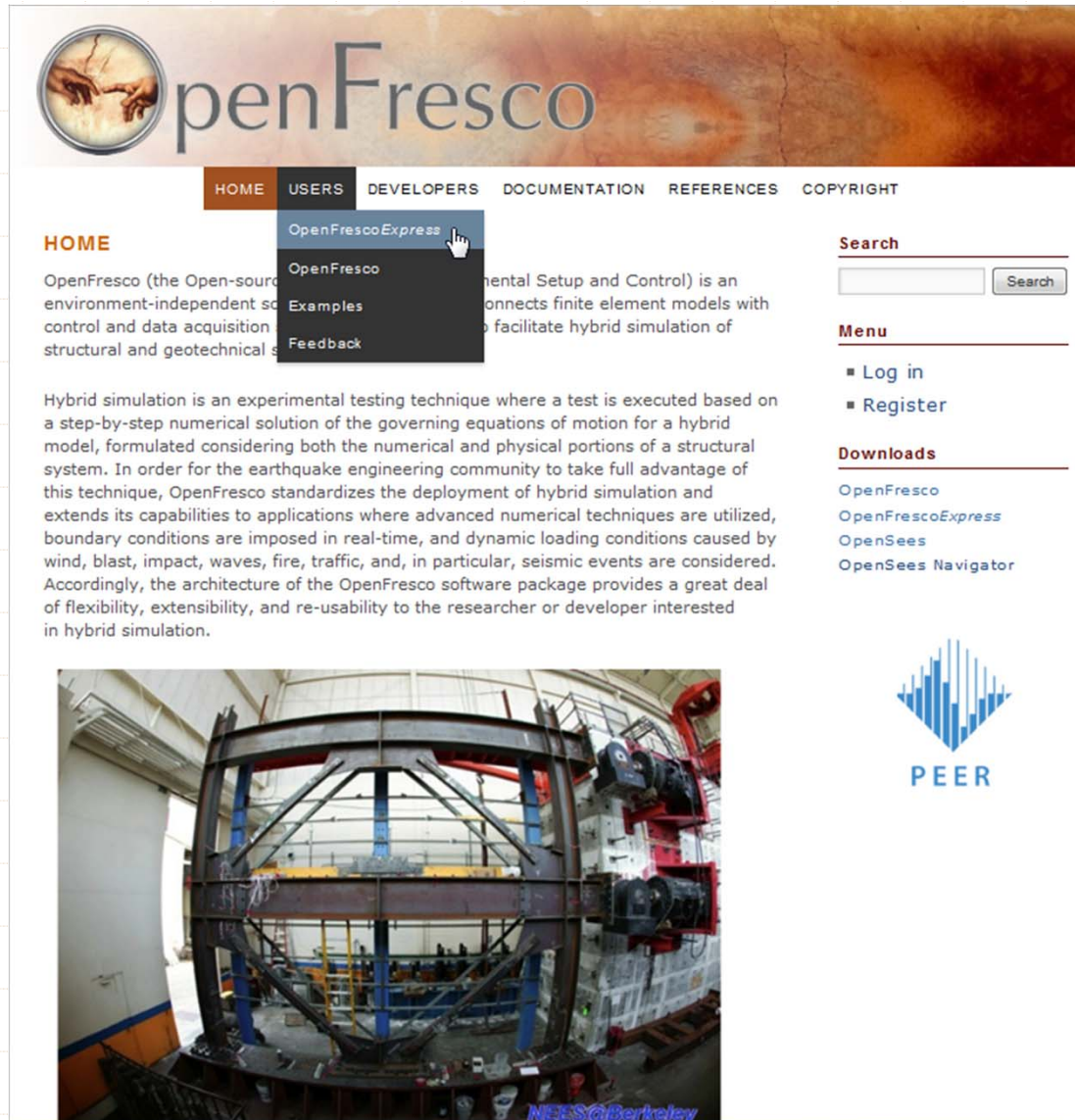
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Downloads

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[OpenSees Navigator](#)



<http://openfresco.berkeley.edu/users/express/>



OpenFresco

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HOME

OpenFresco (the Open-source Experimental Setup and Control) is an environment-independent software that connects finite element models with control and data acquisition systems to facilitate hybrid simulation of structural and geotechnical systems.

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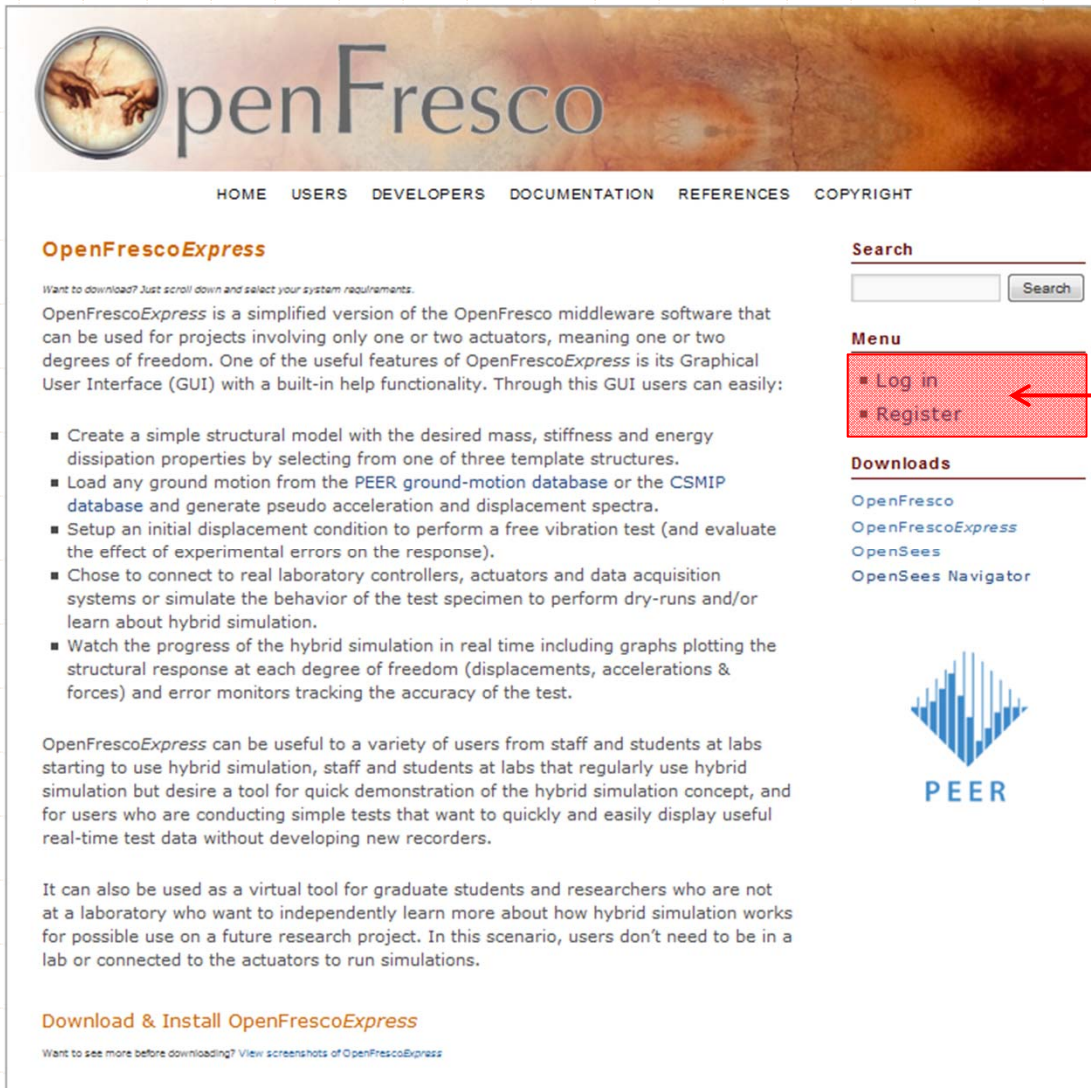
- OpenFresco
- OpenFrescoExpress
- OpenSees
- OpenSees Navigator



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Login or Register



The screenshot shows the OpenFresco website interface. At the top, there is a navigation menu with links for HOME, USERS, DEVELOPERS, DOCUMENTATION, REFERENCES, and COPYRIGHT. Below this, the main content area is titled "OpenFrescoExpress" and includes a search bar, a menu with "Log in" and "Register" options, and a "Downloads" section. The "Log in" and "Register" options are highlighted with a red box and a red arrow pointing to them from the right. The "Downloads" section lists "OpenFresco", "OpenFrescoExpress", "OpenSees", and "OpenSees Navigator". At the bottom of the page, there is a "Download & Install OpenFrescoExpress" section with a link to view screenshots.

OpenFrescoExpress

Want to download? Just scroll down and select your system requirements.

OpenFrescoExpress is a simplified version of the OpenFresco middleware software that can be used for projects involving only one or two actuators, meaning one or two degrees of freedom. One of the useful features of OpenFrescoExpress is its Graphical User Interface (GUI) with a built-in help functionality. Through this GUI users can easily:

- Create a simple structural model with the desired mass, stiffness and energy dissipation properties by selecting from one of three template structures.
- Load any ground motion from the PEER ground-motion database or the CSMIP database and generate pseudo acceleration and displacement spectra.
- Setup an initial displacement condition to perform a free vibration test (and evaluate the effect of experimental errors on the response).
- Chose to connect to real laboratory controllers, actuators and data acquisition systems or simulate the behavior of the test specimen to perform dry-runs and/or learn about hybrid simulation.
- Watch the progress of the hybrid simulation in real time including graphs plotting the structural response at each degree of freedom (displacements, accelerations & forces) and error monitors tracking the accuracy of the test.

OpenFrescoExpress can be useful to a variety of users from staff and students at labs starting to use hybrid simulation, staff and students at labs that regularly use hybrid simulation but desire a tool for quick demonstration of the hybrid simulation concept, and for users who are conducting simple tests that want to quickly and easily display useful real-time test data without developing new recorders.

It can also be used as a virtual tool for graduate students and researchers who are not at a laboratory who want to independently learn more about how hybrid simulation works for possible use on a future research project. In this scenario, users don't need to be in a lab or connected to the actuators to run simulations.

Download & Install OpenFrescoExpress

Want to see more before downloading? [View screenshots of OpenFrescoExpress](#)

First, log in if you already have an account or register for a new account

Download Files

Download & Install OpenFrescoExpress

Want to see more before downloading? [View screenshots of OpenFrescoExpress](#)

For download instructions, click on the system requirements that match the computer where you will install the software:

PC (32-bit):

PC (64-bit):

Select OS platform

1. Install Tcl/Tk

If you have not installed Tcl/Tk on your computer, please download the Tcl/Tk installation file below and double-click to install it (OpenFresco employs Tcl/Tk 8.5).

When installing Tcl/Tk it is essential that you change the installation directory to "C:\Program Files\Tcl" during the course of the installation. If you run OpenFrescoExpress and you see an error message to the effect, "Cannot find tcl85.dll", you have skipped this step and must reinstall Tcl/Tk. Note that you will probably have to uninstall the version you just installed first. [Download Tcl/Tk 8.5](#)

2. Install MATLAB Compiler Runtime libraries

 [Download MCR Installer for 64-bit Windows](#) (.exe file, 352 MB)

3. Install OpenFrescoExpress

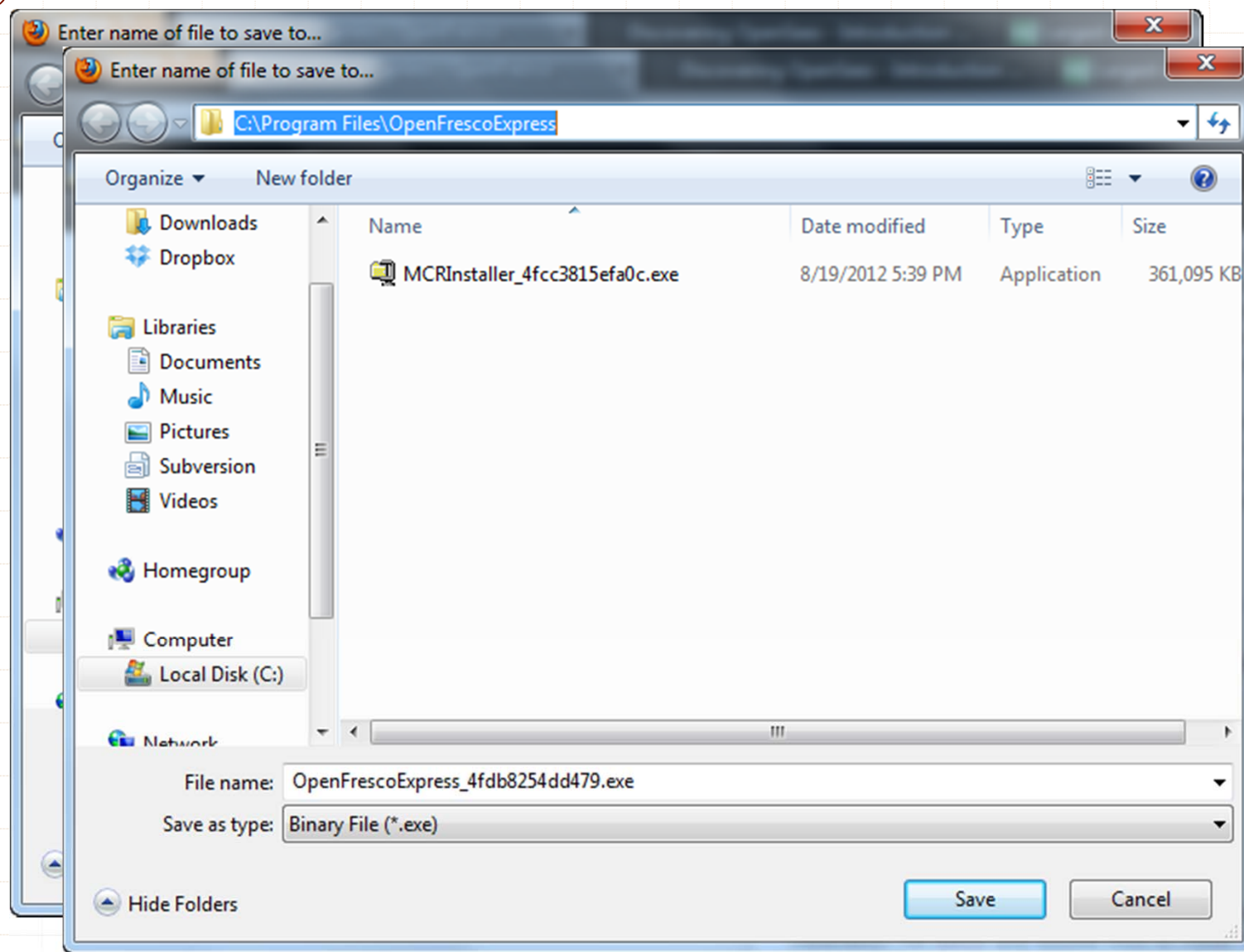
 [Download OpenFrescoExpress for 64-bit Windows](#) (.exe file, 8 MB)

MAC (32-bit):

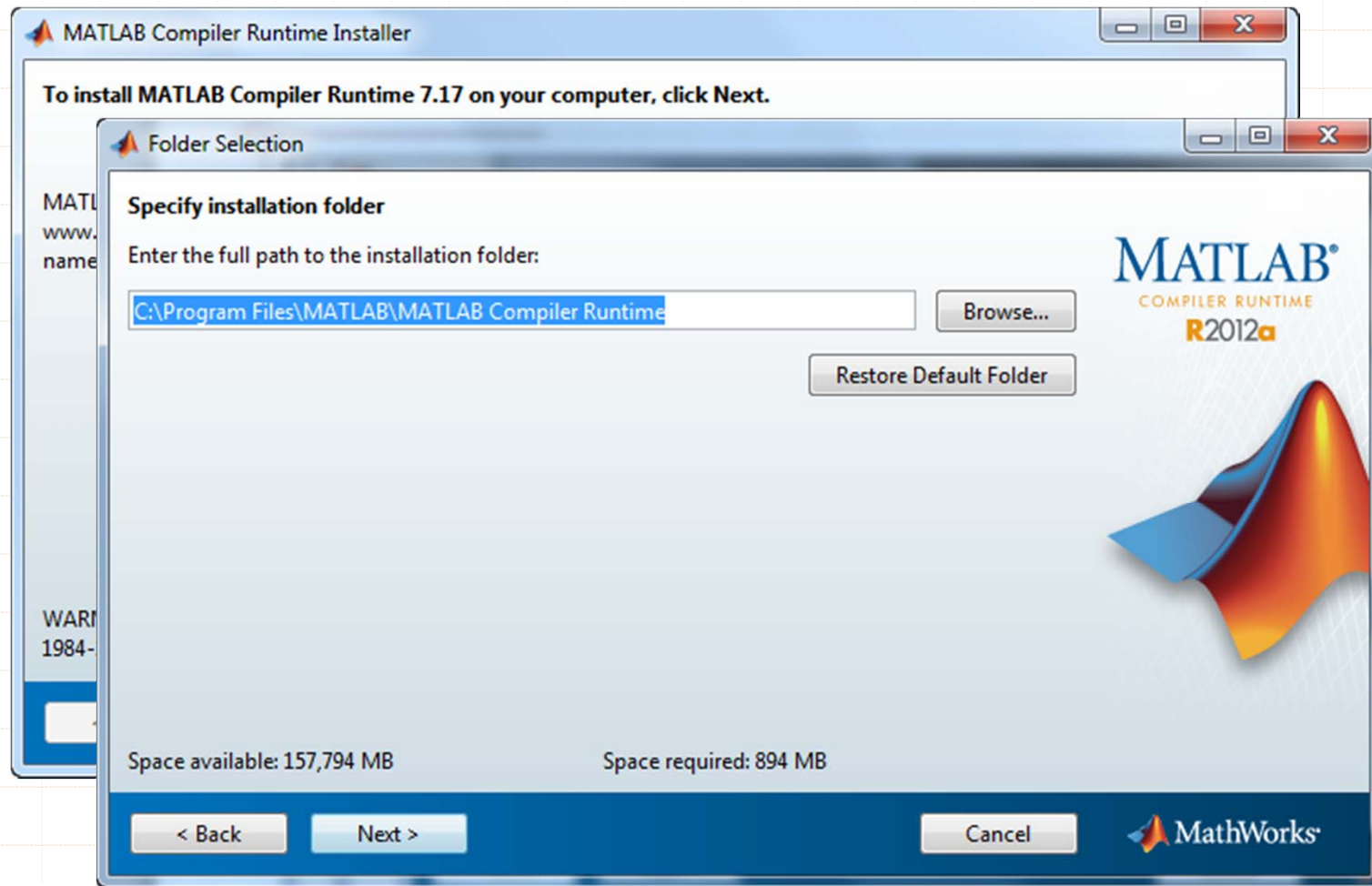
[Edit](#)

1. Download and install Tcl/Tk 8.5
Important: install in C:\Program Files\Tcl
2. Download and install MCR
3. Download OpenFresco *Express* and save in a convenient directory

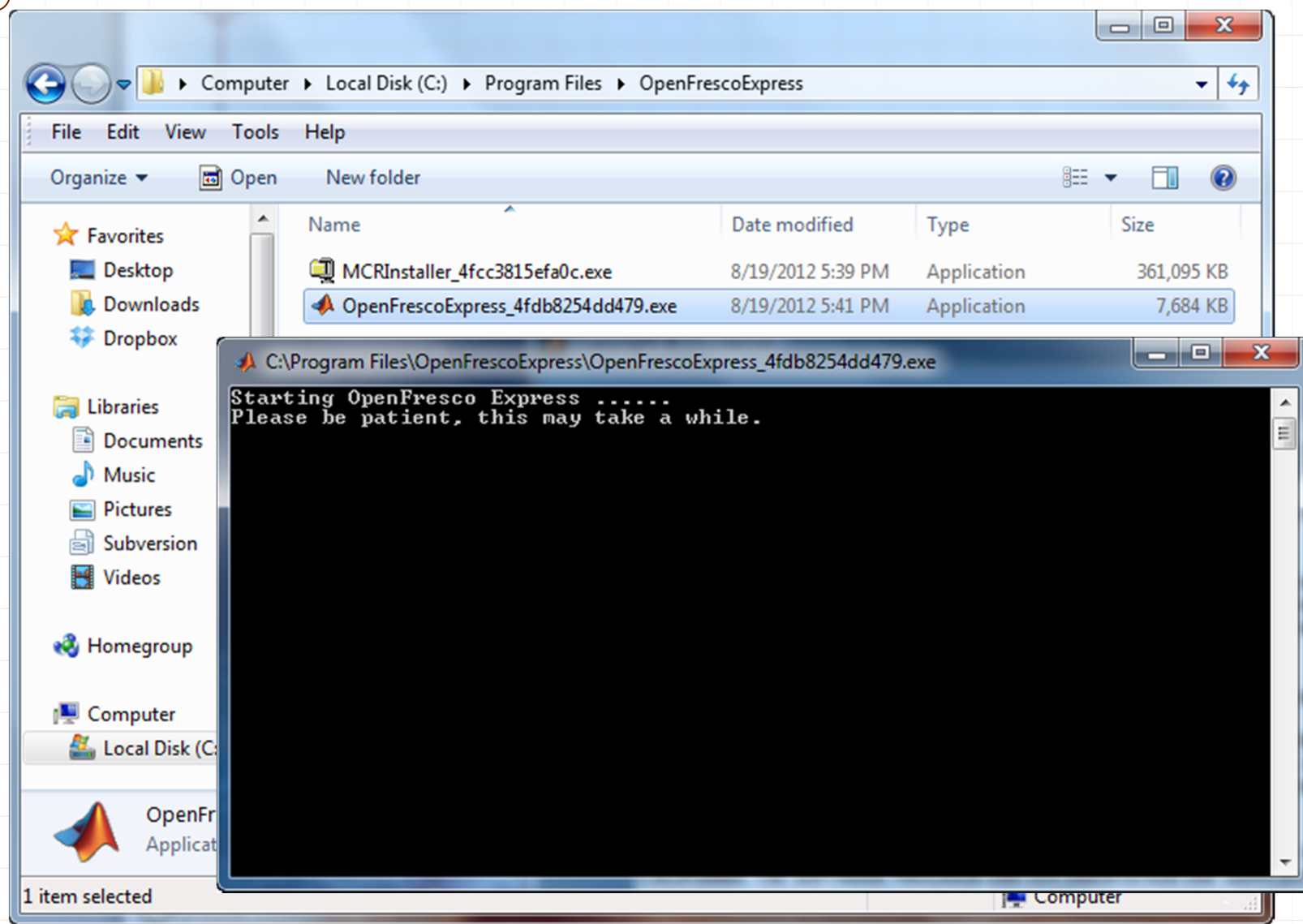
Save files in convenient directory



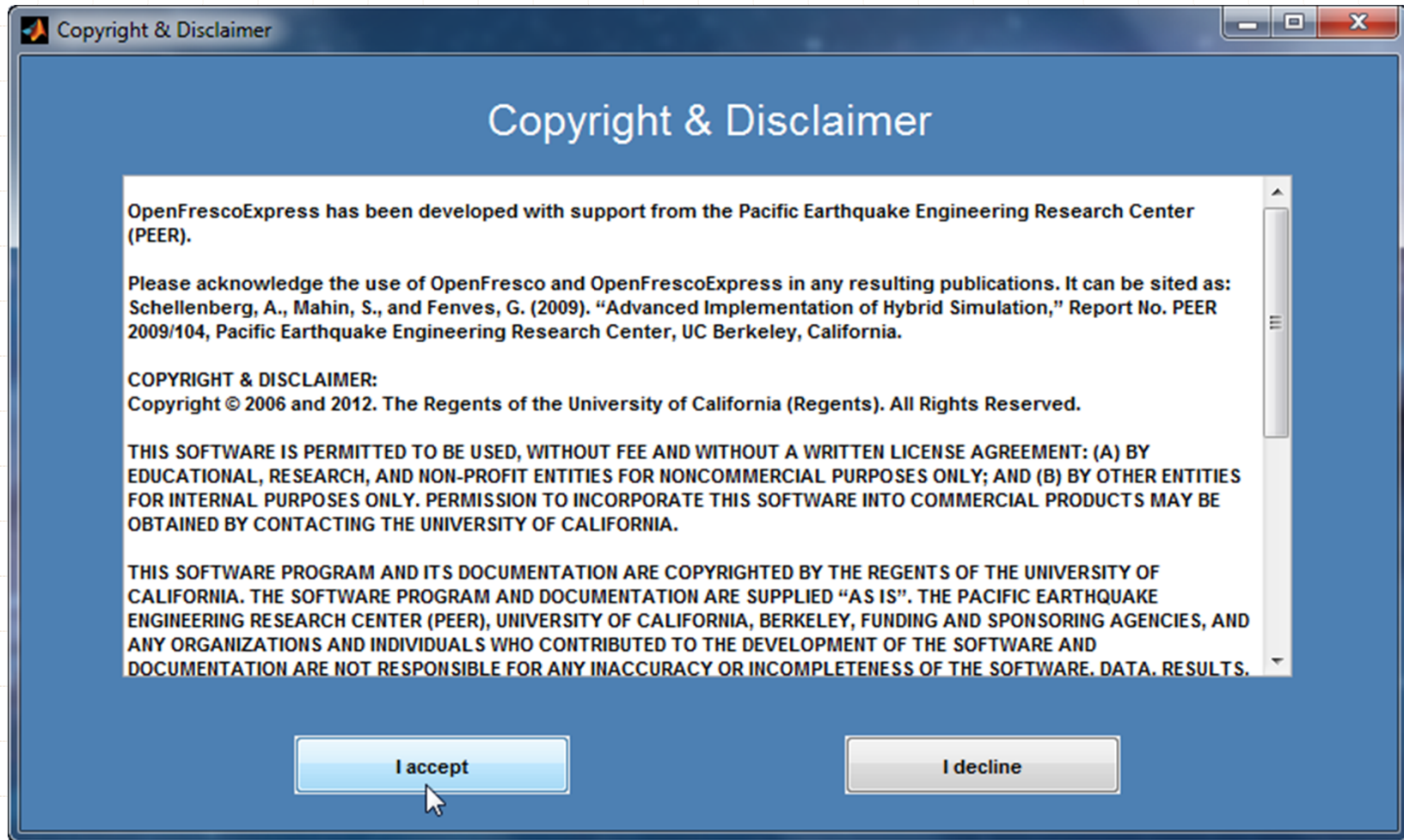
Install Matlab Compiler Runtime



Start OpenFresco *Express*



Read and Accept Copyright

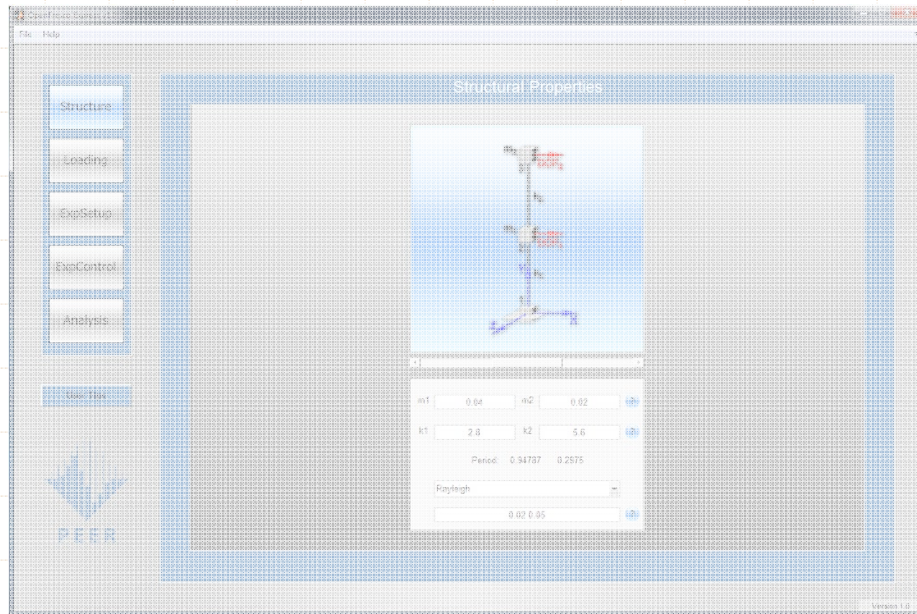
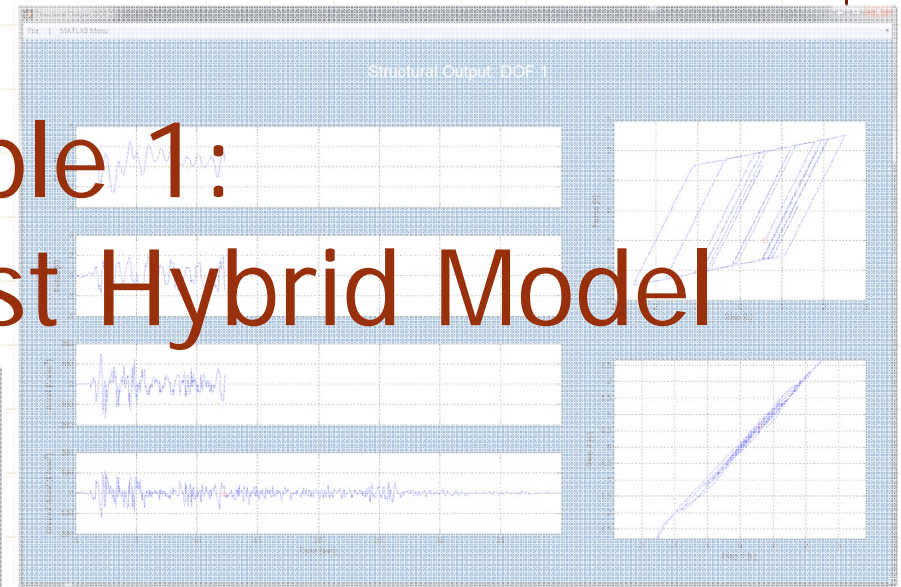


Splash Screen





Example 1: Building your first Hybrid Model



Define Structural Properties

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Structural Properties

Assign Mass

Assign Stiffness

Select & Assign Damping

Period is immediately calculated

Select Structure

m 0.02

k 2.8

Period: 0.53103

Mass Proportional

0.02

Version 1.0

Define Loading

Select Type of Loading

Load Ground Motion File

Select Loading

You can click on this button to find ground motions from PEER or CESMD, or you can upload your own file. Note that unrecognized formats require the time step to be input manually.

Click on any plot to see more details

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Version 1.0

Loading

Ground Motions

Free Vibration

DOF 1

File: C:\Program Files\OpenFrescoExpress

dt: 0.01

Scale Factors

Amplitude: 386.1

Time: 1.0

ag [L/sec²]

Time [sec]

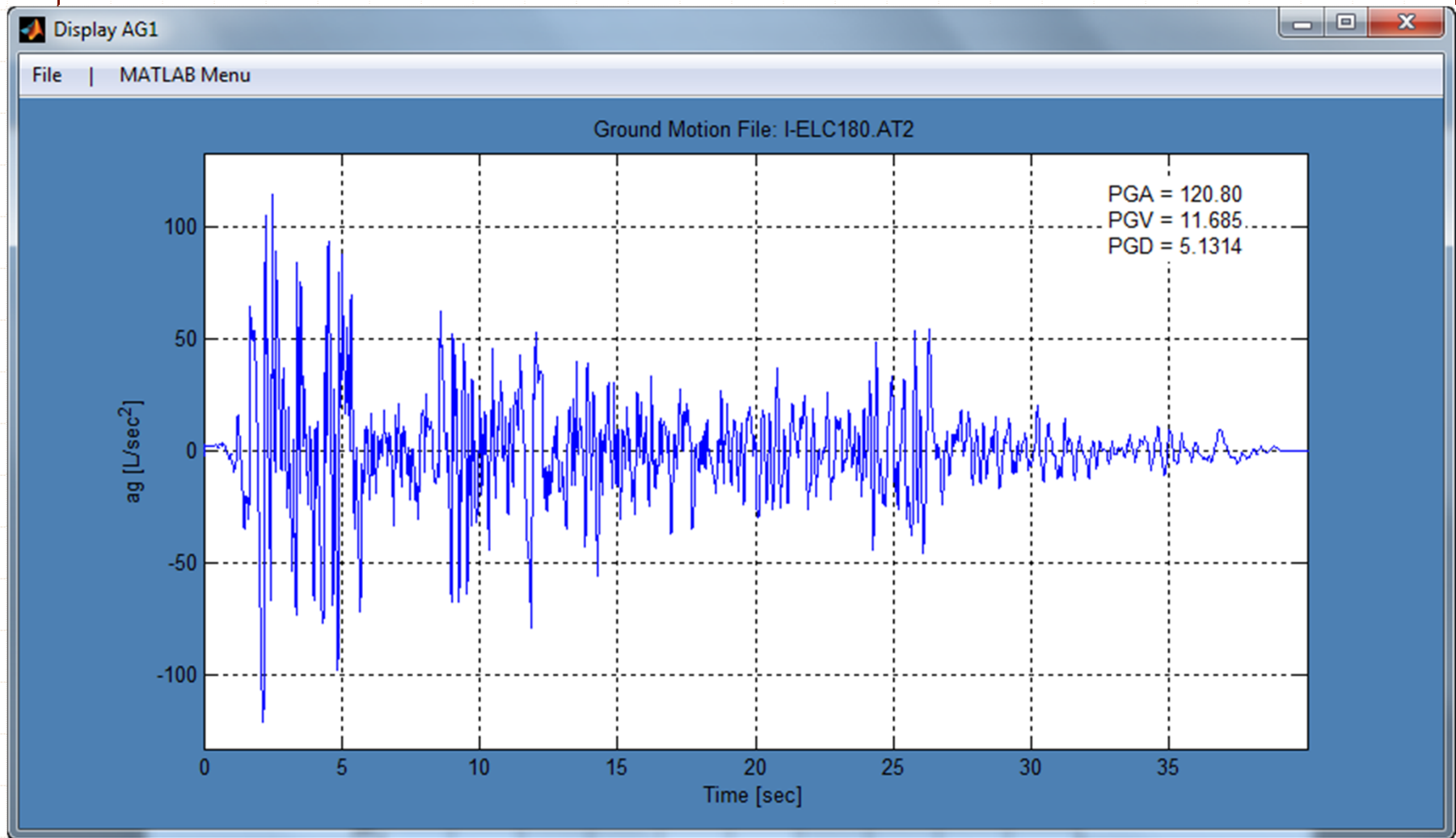
Sa [L/sec²]

Period [sec]

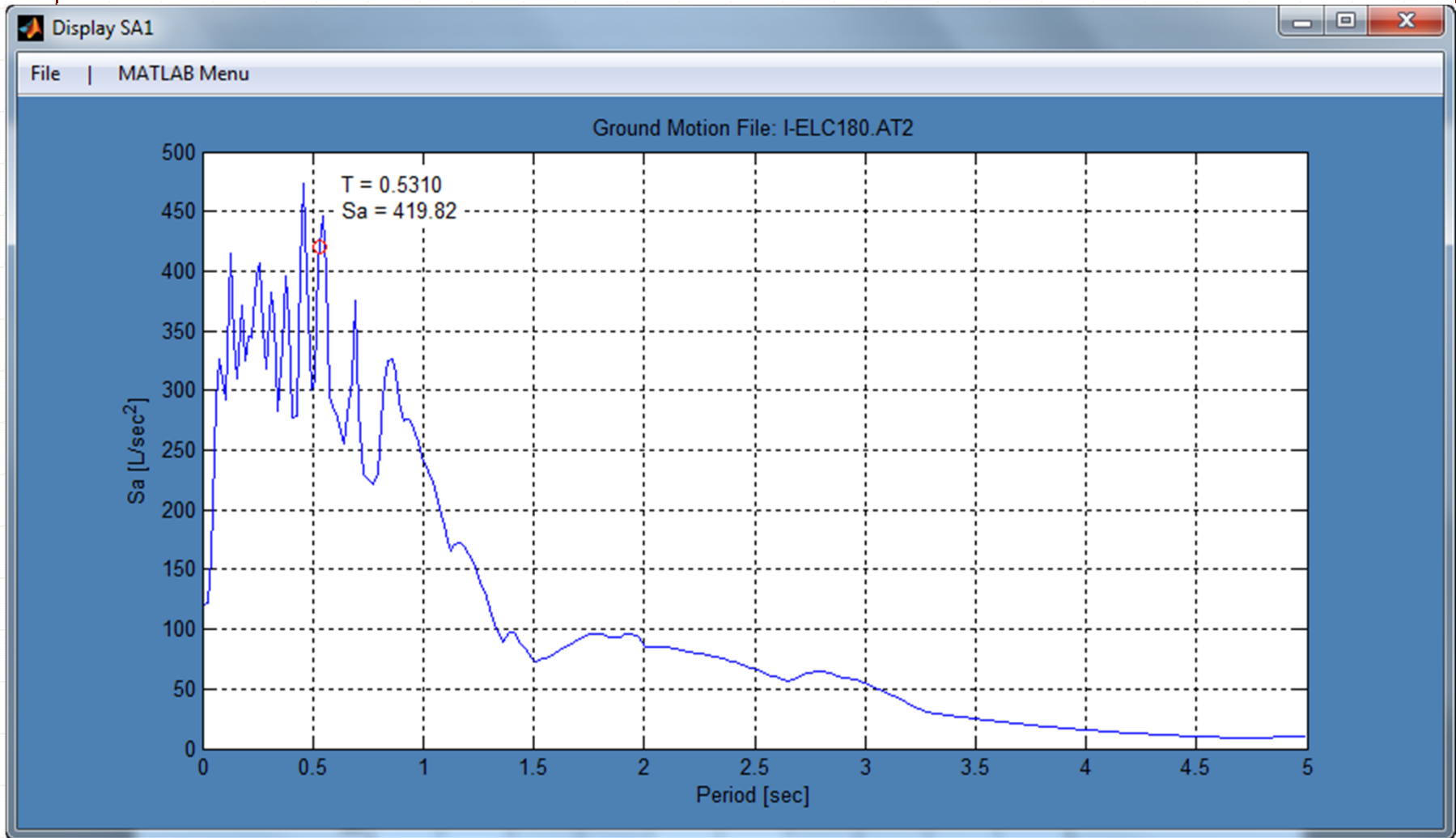
Sd [L]

Period [sec]

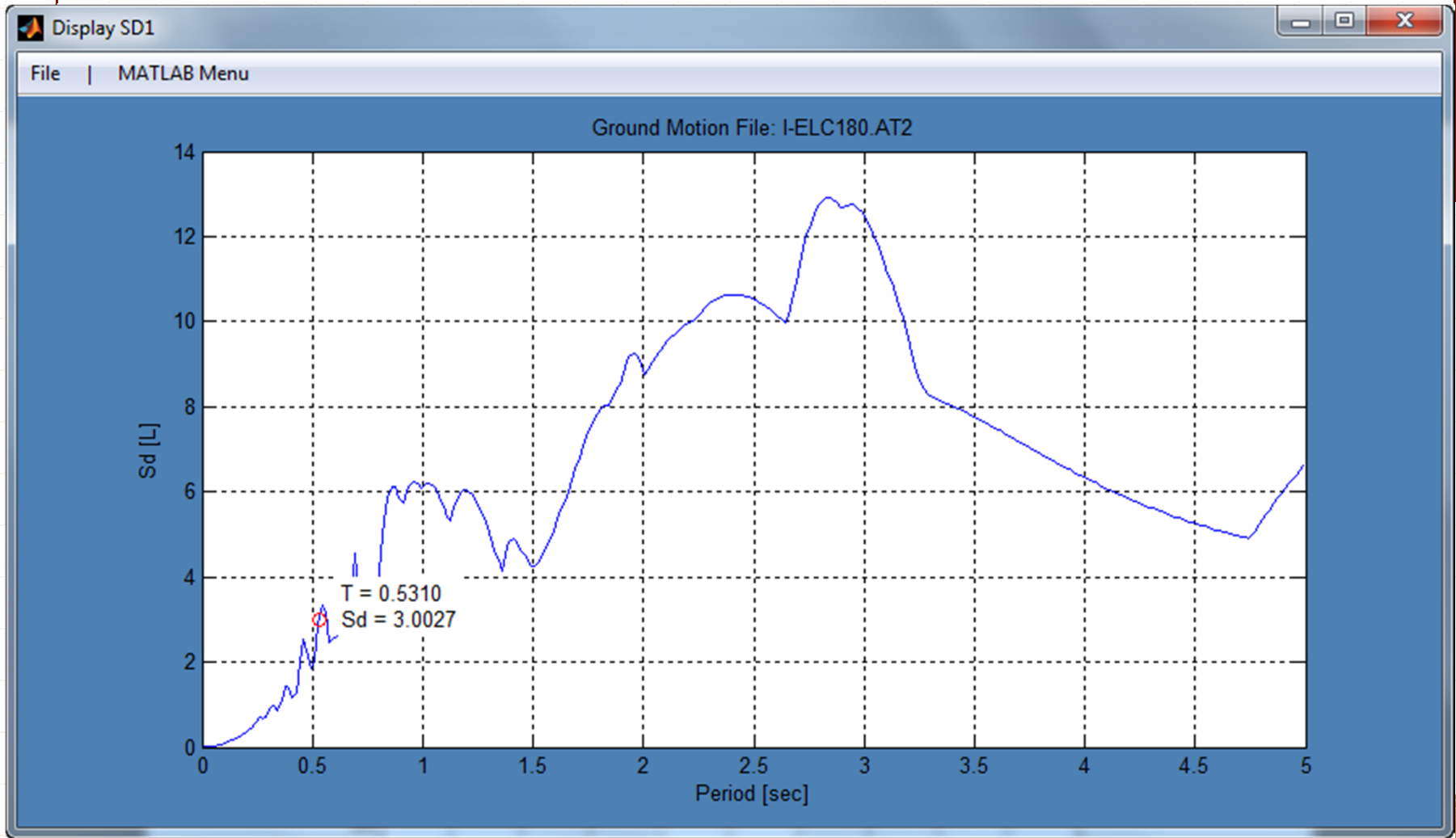
Ground Acceleration History



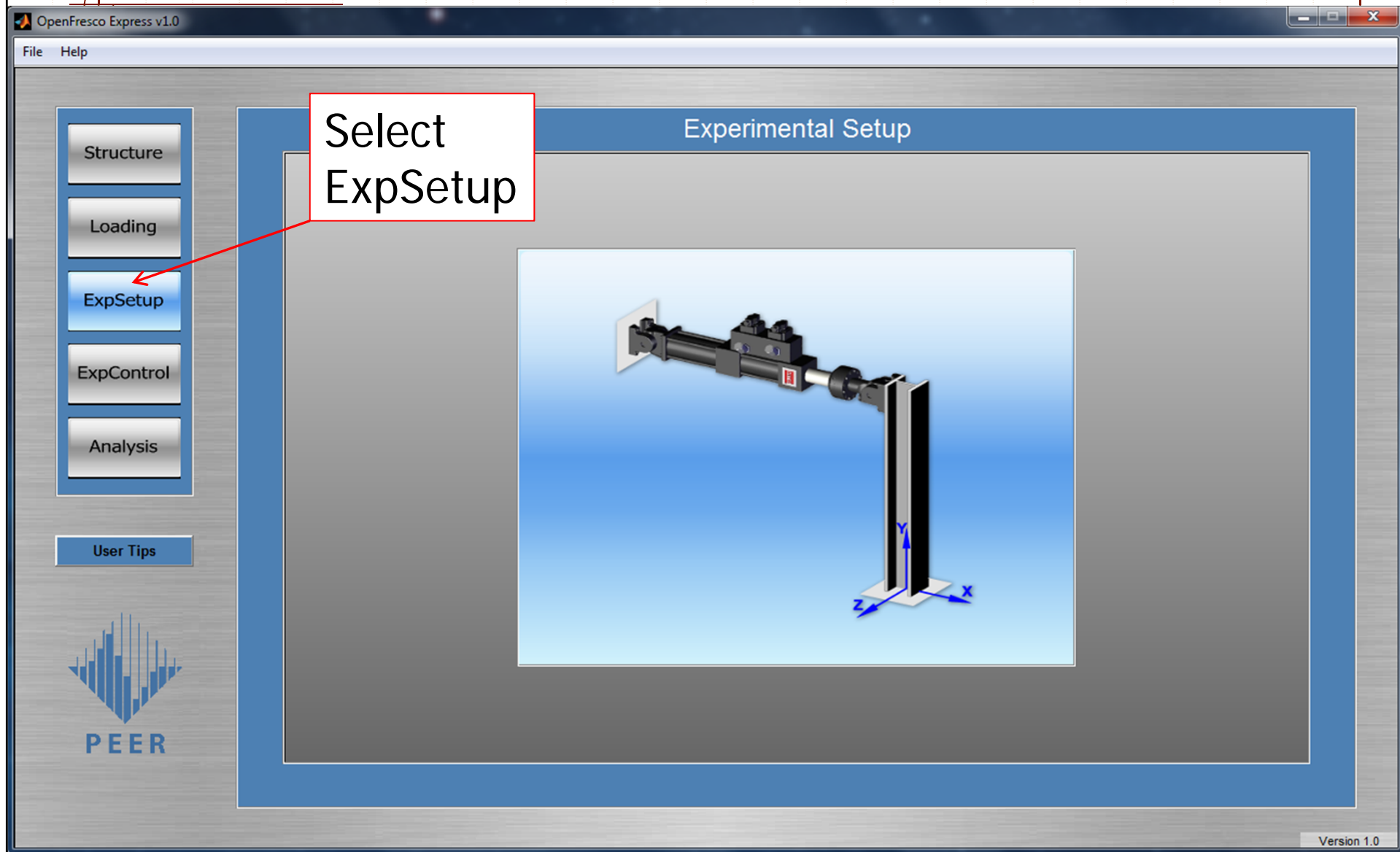
Pseudo Acceleration Spectra

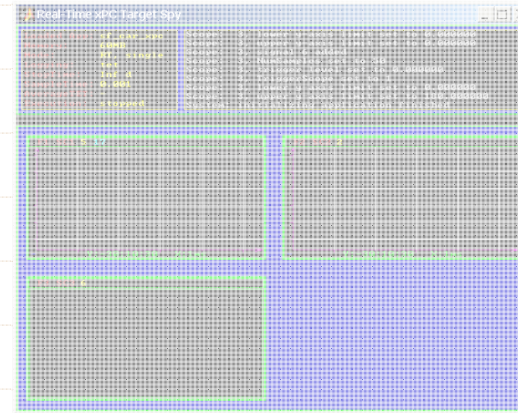
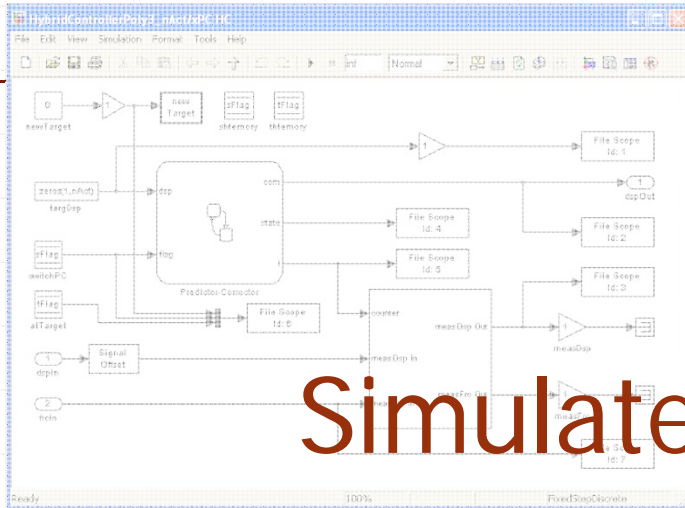


Displacement Spectra



Experimental Setup

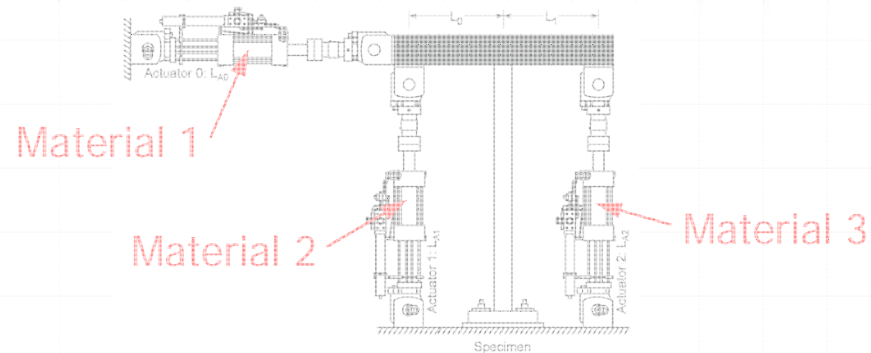
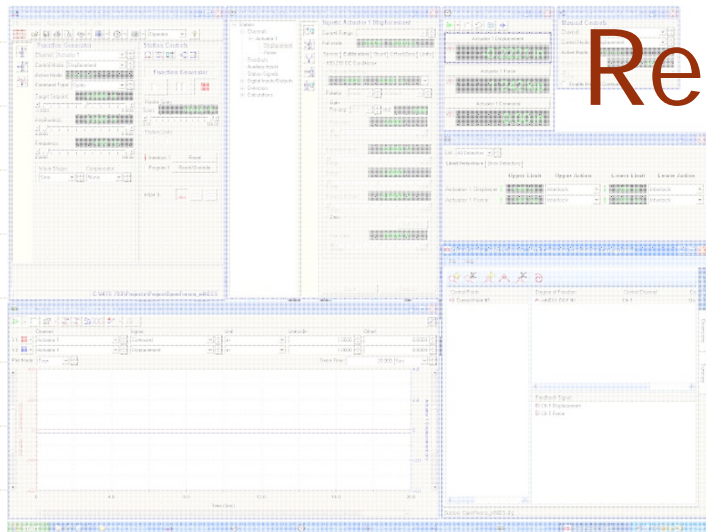




Simulated Controllers VS. Real Controllers



Sysstran[™]



Simulated Experimental Control

The screenshot displays the OpenFresco Express v1.0 software interface. The main window is titled "OpenFresco Express v1.0" and contains a menu bar with "File" and "Help". On the left side, there is a vertical toolbar with buttons for "Structure", "Loading", "ExpSetup", "ExpControl", "Analysis", and "User Tips". The "ExpControl" button is highlighted with a blue border. The main area of the window is titled "Experimental Control" and contains two buttons: "Simulation" and "Real Controller". The "Simulation" button is highlighted with a blue border. Below these buttons is a dropdown menu with the text "Choose DOF..." and a list of options: "Choose DOF...", "Choose DOF...", and "DOF 1". The "DOF 1" option is highlighted with a blue background. Three red arrows point from text boxes to the interface: one from "Select ExpControl" to the "ExpControl" button, one from "Select Simulation" to the "Simulation" button, and one from "Select DOF" to the "DOF 1" option in the dropdown menu. The PEER logo is visible in the bottom left corner, and the version number "Version 1.0" is in the bottom right corner.

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Experimental Control

Simulation Real Controller

Choose DOF...

Choose DOF...

DOF 1

Select ExpControl

Select Simulation

Select DOF

Version 1.0

Simulated Experimental Control

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Experimental Control

Simulation Real Controller

DOF 1

Define Control: SimUniaxialMaterial

Number of Actuators: 1

Choose Material: Material Type...
Material Type...
Elastic
Elastic-Perfectly Plastic
Steel - Bilinear
Steel - Giuffrè-Menegotto-Pinto

Version 1.0

Select UniaxialMaterial to Simulate Control

Select Type of Material

Simulated Experimental Control

OpenFresco Express v1.0

File Help

Structure
Loading
ExpSetup
ExpControl
Analysis
User Tips

PEER

Experimental Control

Simulation Real Controller

DOF 1

Define Control: SimUniaxialMaterial

Number of Actuators: 1

Choose Material: Steel - Bilinear

Yield Strength (Fy): 1.5

Initial Elastic Modulus (E): 2.8

Strain Hardening Ratio (b): 0.01

Input Material Properties

The graph plots stress or force on the vertical axis against strain or deformation on the horizontal axis. The curve starts at the origin, rises linearly to a yield point at F_y with a slope of E . It then continues with a shallower slope of $b \cdot E$ until it reaches a peak stress of $F_y + b \cdot E$. The yield strength is also indicated as $-F_y$ on the negative axis, and the initial elastic modulus is $-E$ on the negative axis. The strain hardening ratio is $b \cdot E$ on the negative axis.

Real Experimental Control

The screenshot displays the OpenFresco Express v1.0 software interface. On the left side, there is a vertical navigation pane with buttons for Structure, Loading, ExpSetup, ExpControl, and Analysis. The ExpControl button is highlighted with a red arrow pointing to a callout box that says "Select ExpControl".

The main workspace is titled "Experimental Control" and contains two tabs: "Simulation" and "Real Controller". The "Real Controller" tab is selected and highlighted with a red arrow pointing to a callout box that says "Select Real Controller".

Below the tabs, there is a "Define Control" section. A dropdown menu is open, showing a list of control types: LabVIEW, MTSCsi, SCRAMNet, dSpace, and xPCtarget. The "MTSCsi" option is highlighted with a blue background and a mouse cursor, with a red arrow pointing to a callout box that says "Select Type of Controller".

At the bottom left of the interface is the PEER logo, and at the bottom right is the text "Version 1.0".

Real Experimental Control

The screenshot displays the OpenFresco Express v1.0 software interface. The main window is titled "Experimental Control" and contains two tabs: "Simulation" and "Real Controller". The "Real Controller" tab is active, showing a configuration panel with the following fields:

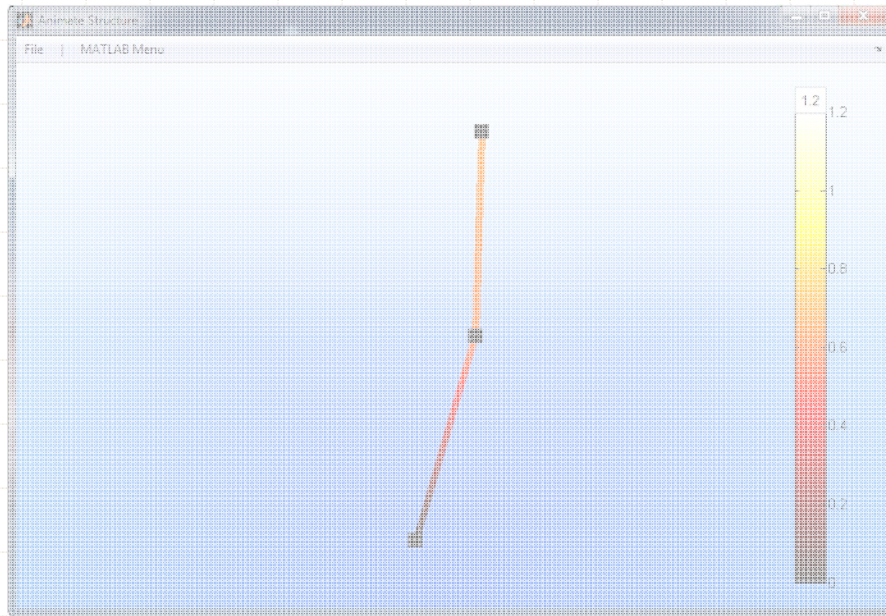
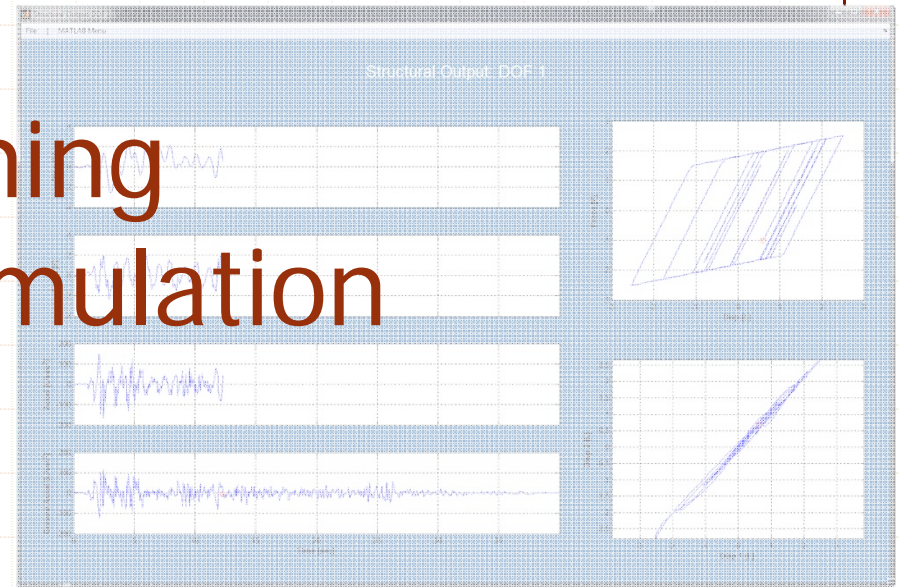
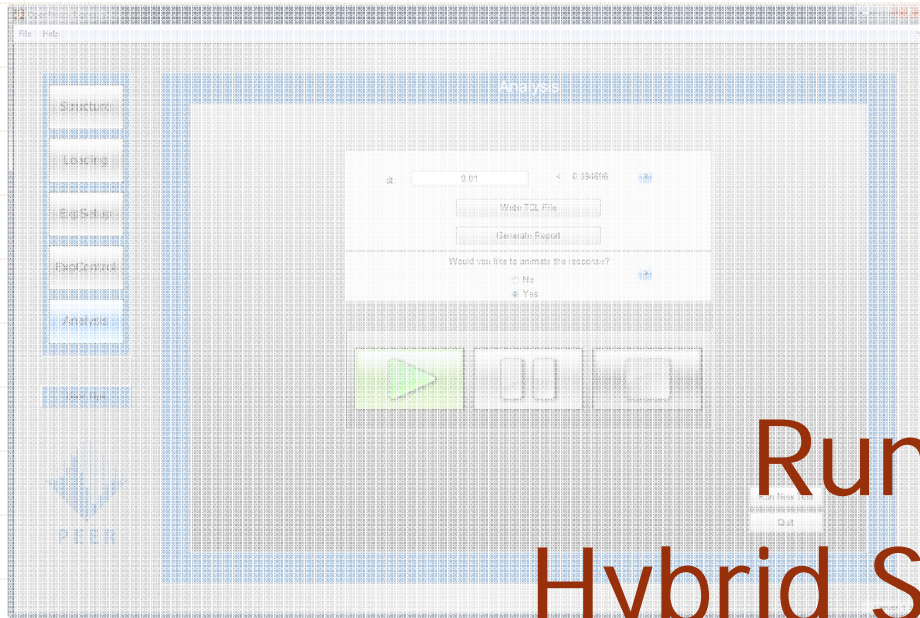
- Define Control: MTSCsi (dropdown menu)
- Configuration File Name: OpenFresco_mNEES (text input)
- Configuration File Path: C:\Users\Andreas\Documents\MTS_CSI\Op (text input)
- Ramp Time: 0.1 (text input)

Two red callout boxes provide instructions:

- A box labeled "Input Ramp Time" points to the "Ramp Time" input field.
- A box labeled "Browse for MTS CSI config file" points to the browse button next to the "Configuration File Name" field.

The interface also features a left sidebar with buttons for "Structure", "Loading", "ExpSetup", "ExpControl", "Analysis", and "User Tips". The PEER logo is visible at the bottom left, and the version number "Version 1.0" is at the bottom right.

Running Hybrid Simulation



Analysis

The screenshot displays the OpenFresco Express v1.0 software interface. The main window is titled "Analysis" and contains the following elements:

- Left Sidebar:** A vertical menu with buttons for "Structure", "Loading", "ExpSetup", "ExpControl", "Analysis" (highlighted in blue), and "User Tips".
- DT Input:** A text field labeled "dt:" containing the value "0.01", with a comparison "< 0.16903" to its right.
- Buttons:** "Write TCL File" and "Generate Report" buttons are positioned below the DT input.
- Animation Prompt:** A section titled "Would you like to animate the response?" with radio buttons for "No" (selected) and "Yes".
- Help Text:** A red-bordered box contains the text: "In order to ensure stability when using the explicit Newmark method, dt must be less than the indicated maximum value." A red arrow points from this box to the "dt:" input field.
- Callouts:** Two white callout boxes with red borders and arrows. One points to the "Analysis" button in the sidebar, and the other points to the "Generate Report" button.
- Bottom Panel:** A row of three large buttons: a play button, a pause button, and a stop button.
- Bottom Right:** "Run New Test" and "Quit" buttons.
- Version:** "Version 1.0" is displayed in the bottom right corner of the window.

Select Analysis

Click here to write TCL input files

Optionally Generate Report

In order to ensure stability when using the explicit Newmark method, dt must be less than the indicated maximum value.

Report/Input Summary

The screenshot displays the OpenFresco Express v1.0 software interface. The main window is titled 'Analysis' and contains a 'Report' dialog box. The 'Report' dialog box is titled 'Input Summary' and displays the following text:

```
=====
OpenFresco Express v1.0                               19-Aug-2012 21:19:52
=====
o File   : OPFE_Report.txt
o Purpose: Summary of inputs for use with OpenFresco Express

Model Properties:
=====
o Type: 1 DOF Column
o Mass [m]: 0.0200
o Stiffness [F/L]: 2.8000
o Period [sec]: 0.5310
o Frequency [Hz]: 1.8831
o Damping Type: Mass Proportional
o Damping Value: 0.0200
o Mass Proportional Damping Factor: 0.4733
o Stiffness Proportional Damping Factor: 0.0000

Loading:
=====
```

The 'Report' dialog box has an 'OK' button at the bottom. The main 'Analysis' window has a sidebar on the left with buttons for 'Structure', 'Loading', 'ExpSetup', 'ExpControl', 'Analysis', and 'User Tips'. The 'Analysis' button is highlighted. The PEER logo is visible in the bottom left corner of the main window. The version number 'Version 1.0' is displayed in the bottom right corner of the main window.

Analysis: Start Hybrid Simulation

The screenshot shows the OpenFresco Express v1.0 software interface. The main window is titled "Analysis" and contains several controls. On the left, a vertical sidebar has buttons for "Structure", "Loading", "ExpSetup", "ExpControl", "Analysis" (highlighted in blue), and "User Tips". Below the sidebar is the PEER logo. The main area features a "dt" input field with the value "0.01" and a comparison "< 0.16903". Below this are "Write TCL File" and "Generate Report" buttons. A dialog box asks "Would you like to animate the response?" with radio buttons for "No" (selected) and "Yes". At the bottom, there are three large buttons: a play button, a stop button, and a refresh button. In the bottom right corner, there are "Run New Test" and "Quit" buttons. The version "Version 1.0" is displayed in the bottom right corner of the window.

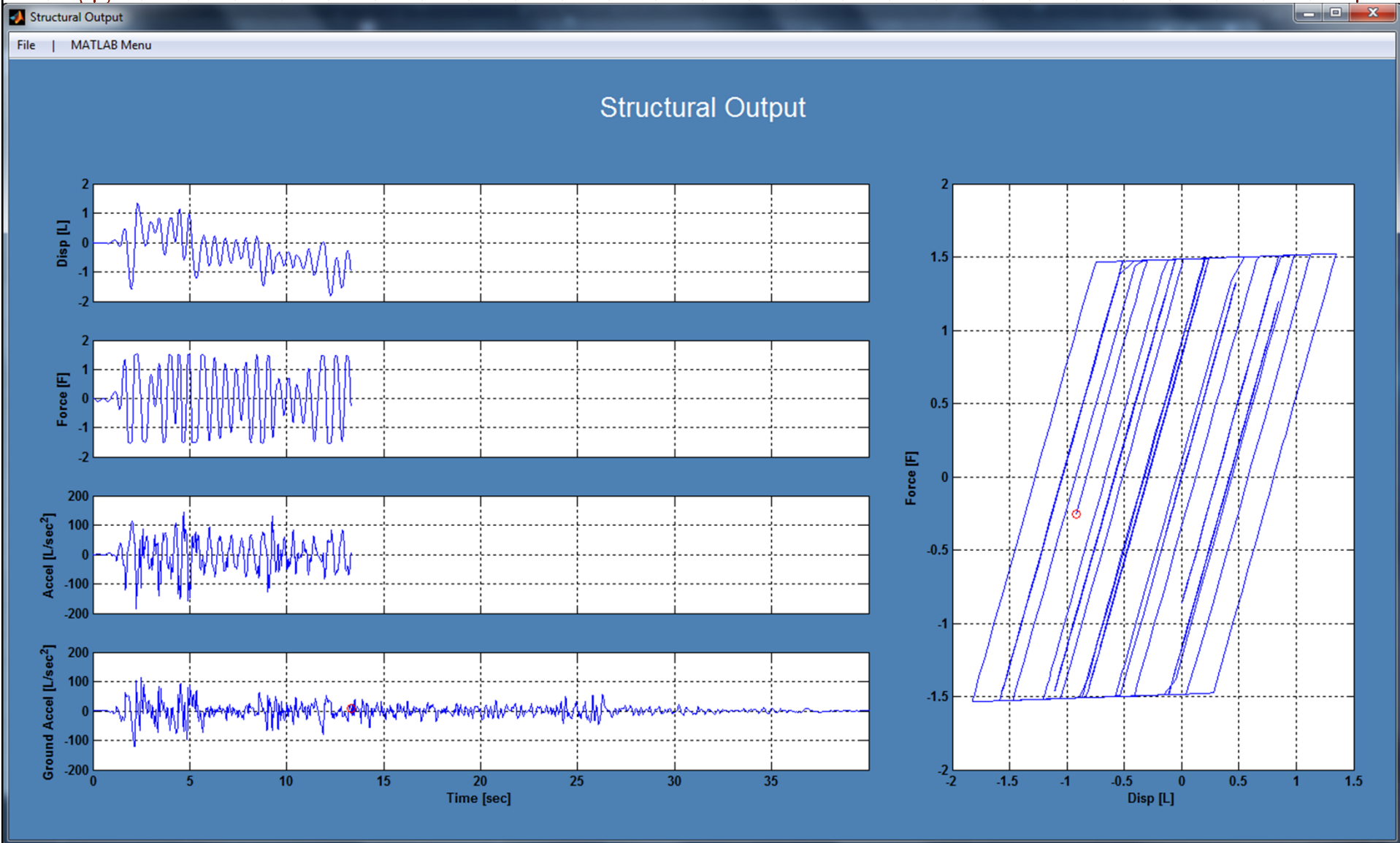
Select Analysis

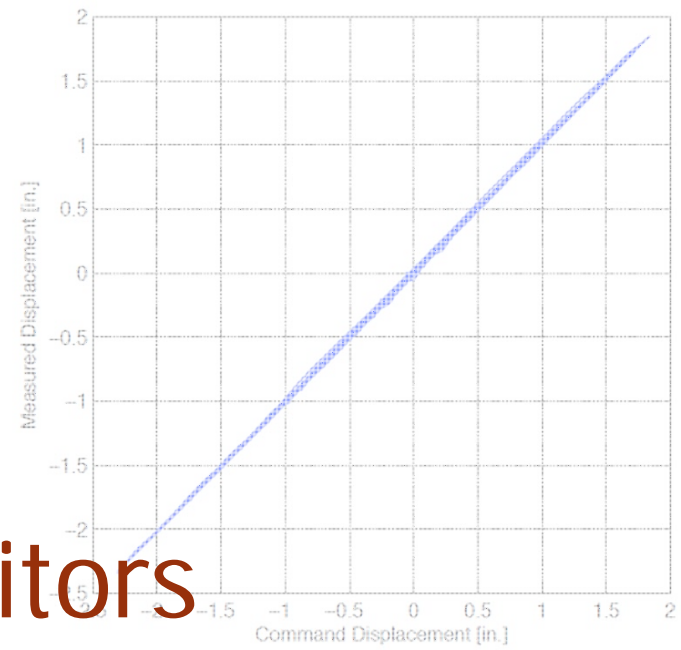
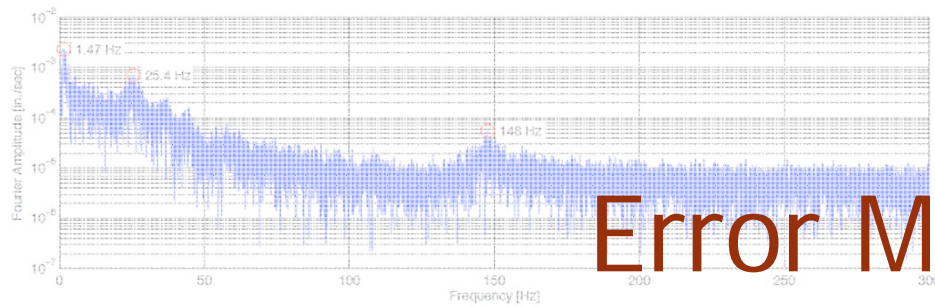
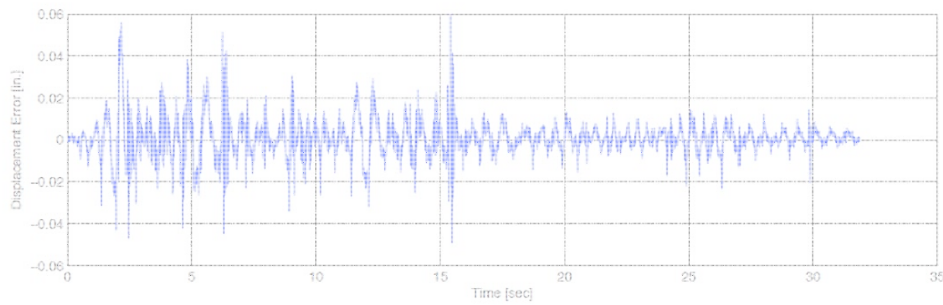
Click here to write TCL input files

Click Play

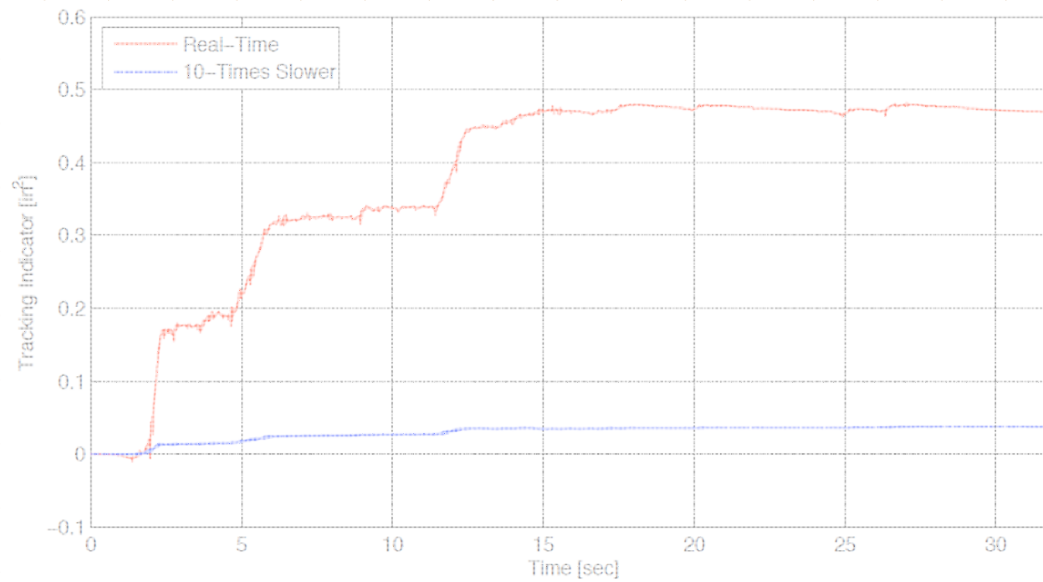
In order to ensure stability when using the explicit Newmark method, dt must be less than the indicated maximum value.

Structural Output

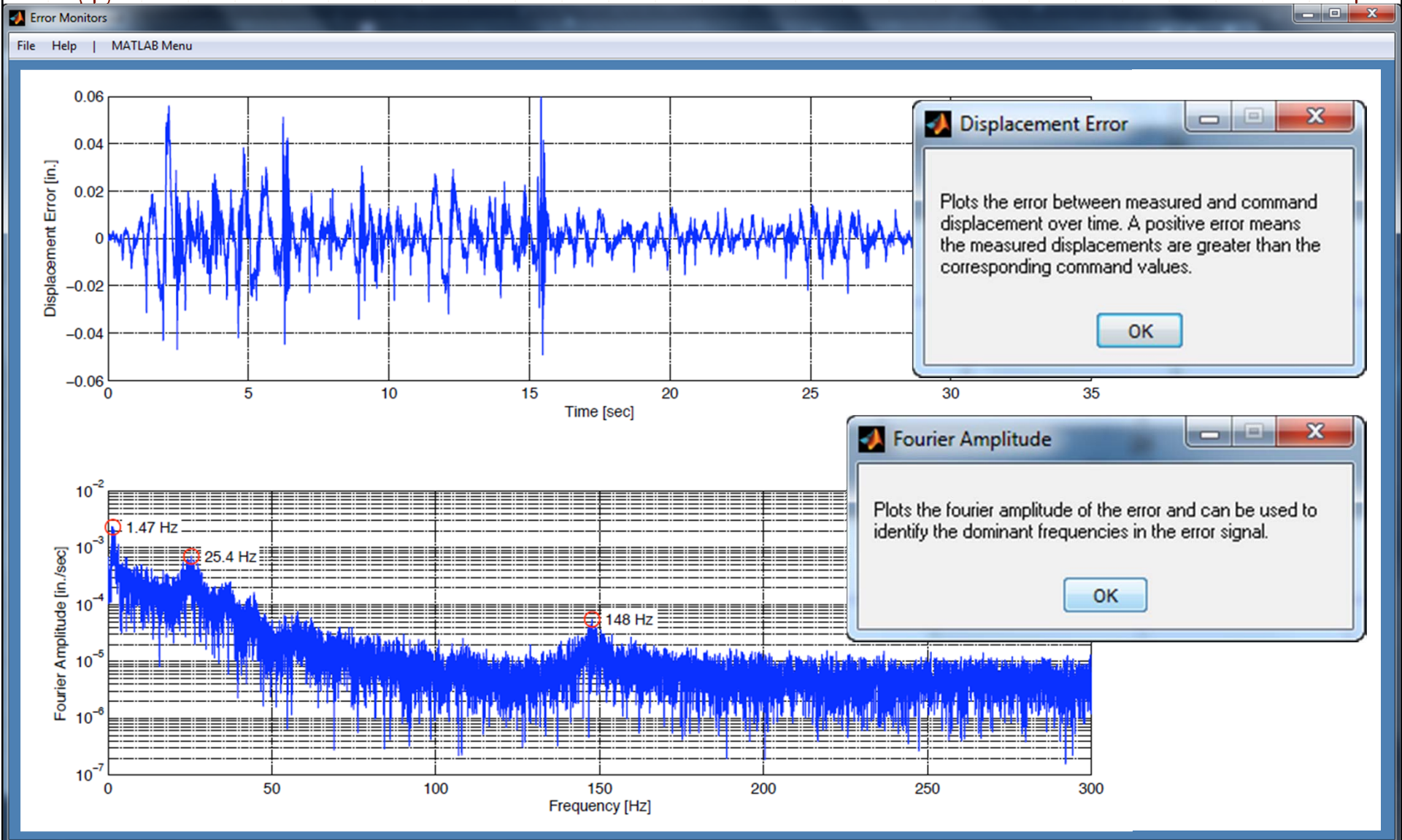




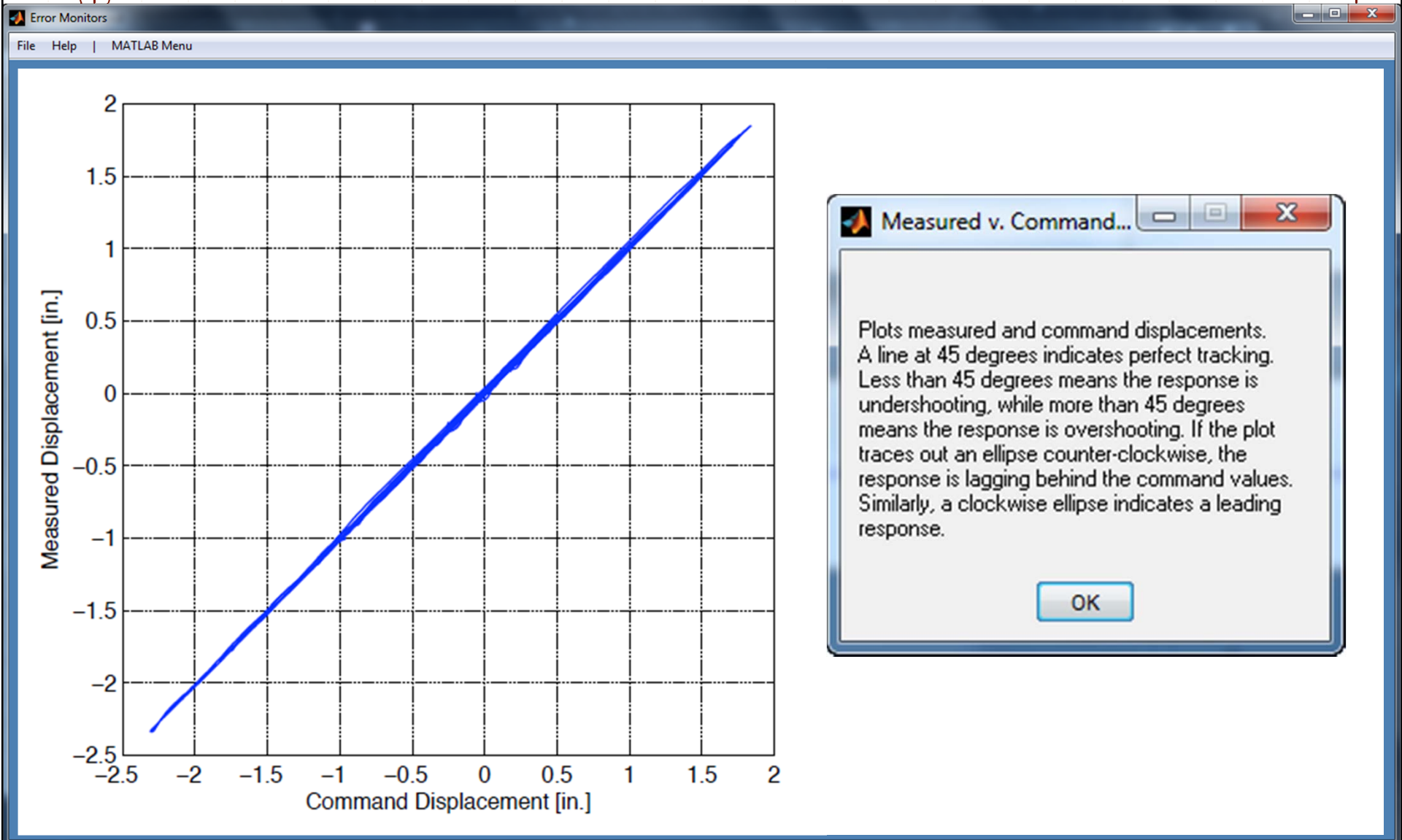
Error Monitors



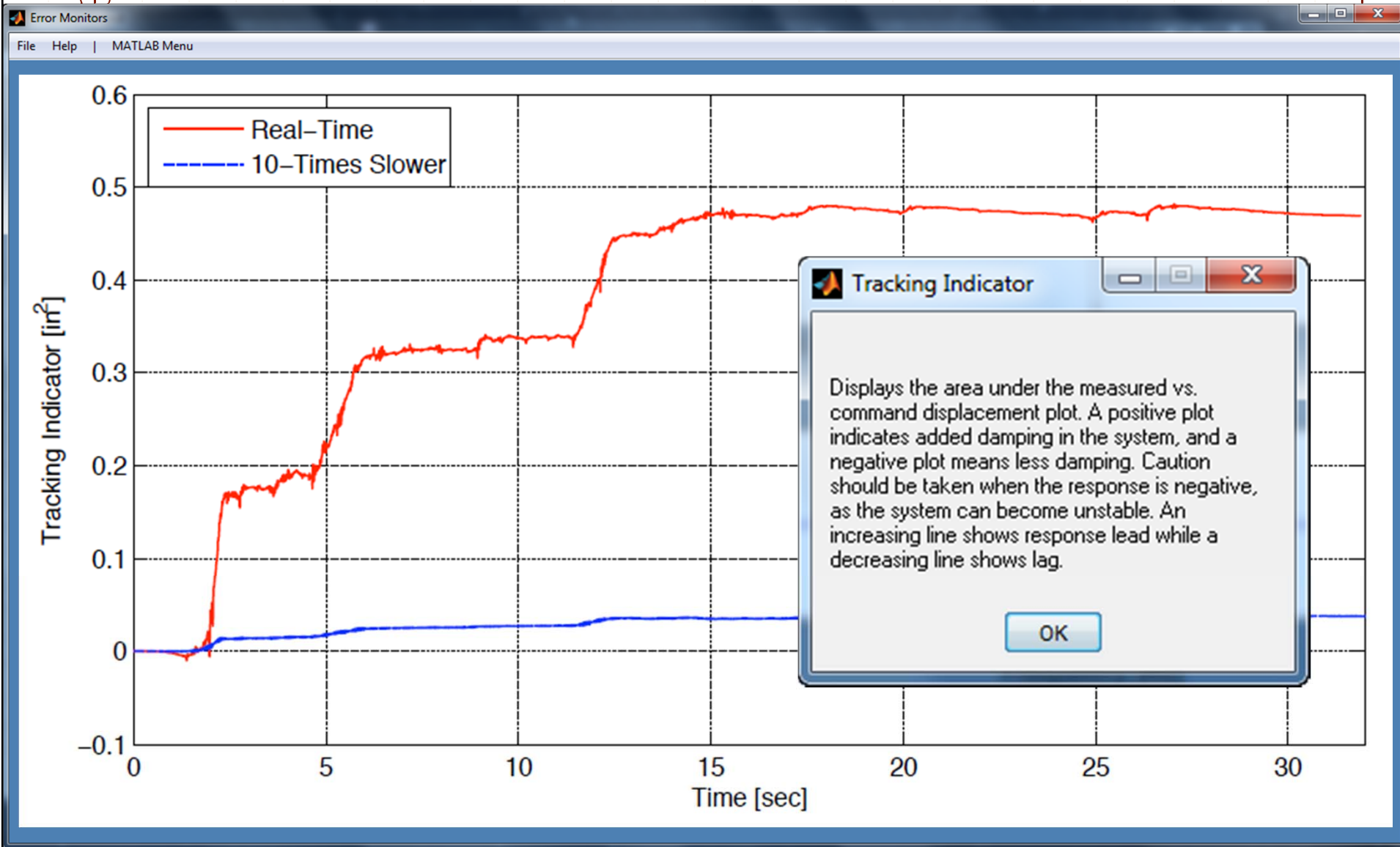
Error Monitors: dispError and FFT



Error Monitors: Subspace Plot

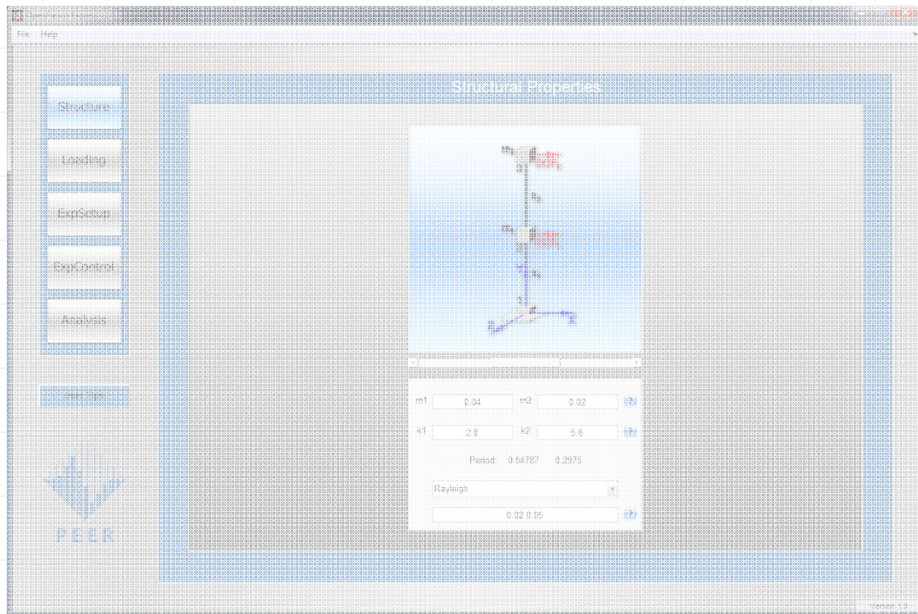
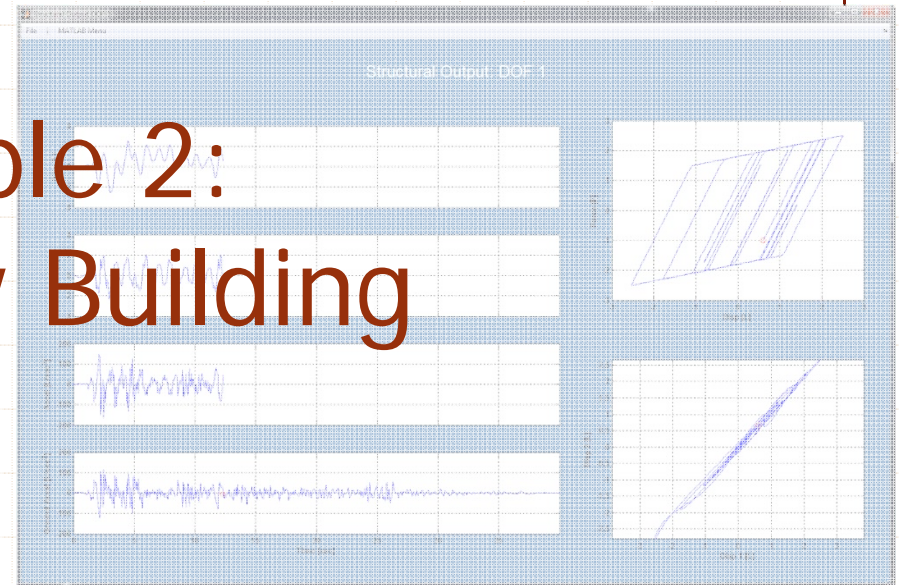


Error Monitors: Tracking Indicator





Example 2: Two Story Building



Structural Properties

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Structural Properties

Select Structure

Assign Masses

Assign Story Stiffnesses

Select & Assign Damping

Periods are immediately calculated

m1: 8.39/4 m2: 8.39/4

k1: 1324 k2: 1236

Period: 0.40864 0.1584

Rayleigh

0.015 0.03

Version 1.0

Define Loading: 1994 Northridge

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Version 1.0

Select Type of Loading

Ground Motions Free Vibration

Select Loading

File: C:\Program Files\OpenFrescoExpress
dt: 0.005

Scale Factors
Amplitude: 386.1
Time: 1.0

ag [L/sec²]

Time [sec]

Sa [L/sec²]

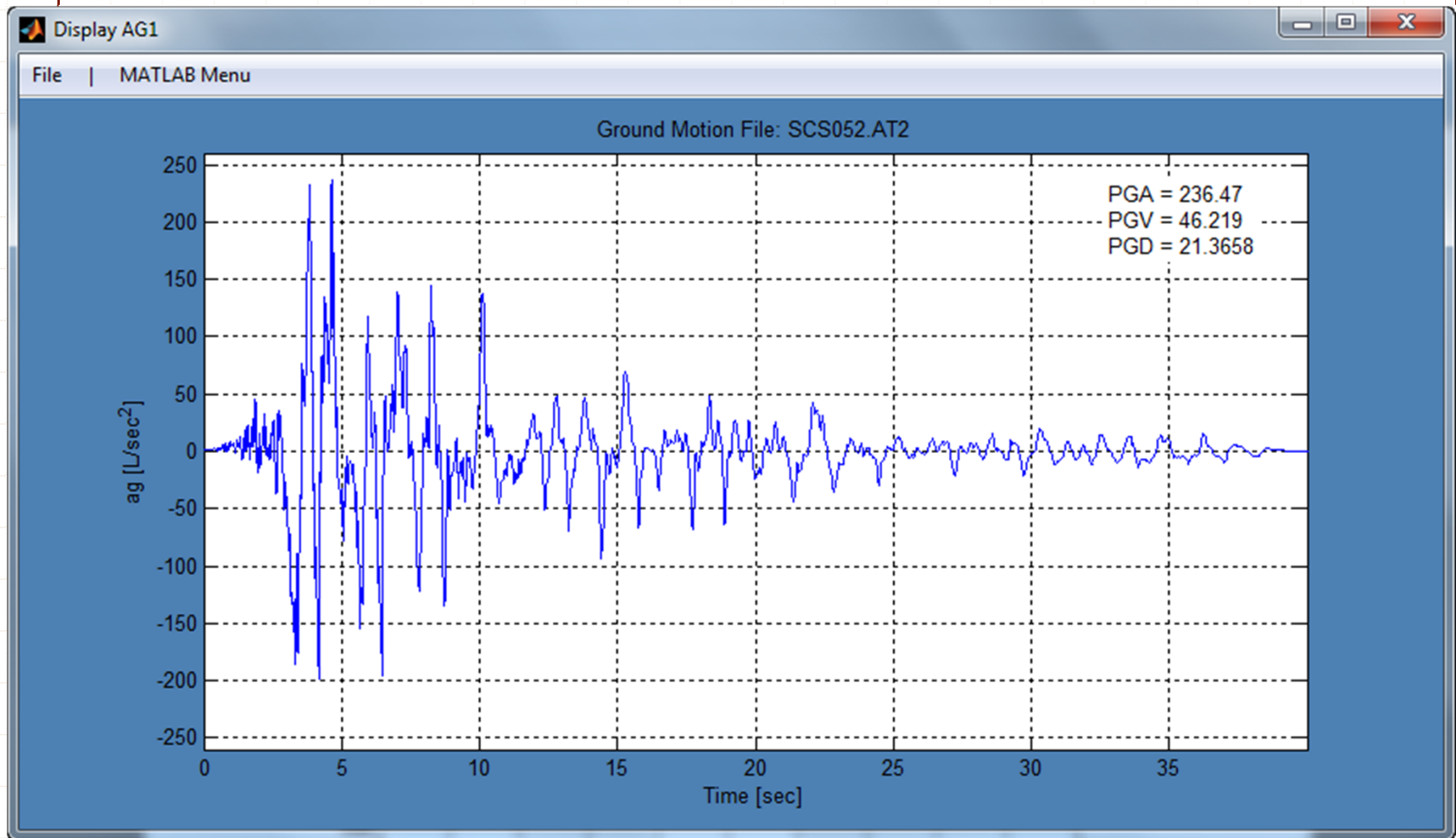
Period [sec]

Sd [L]

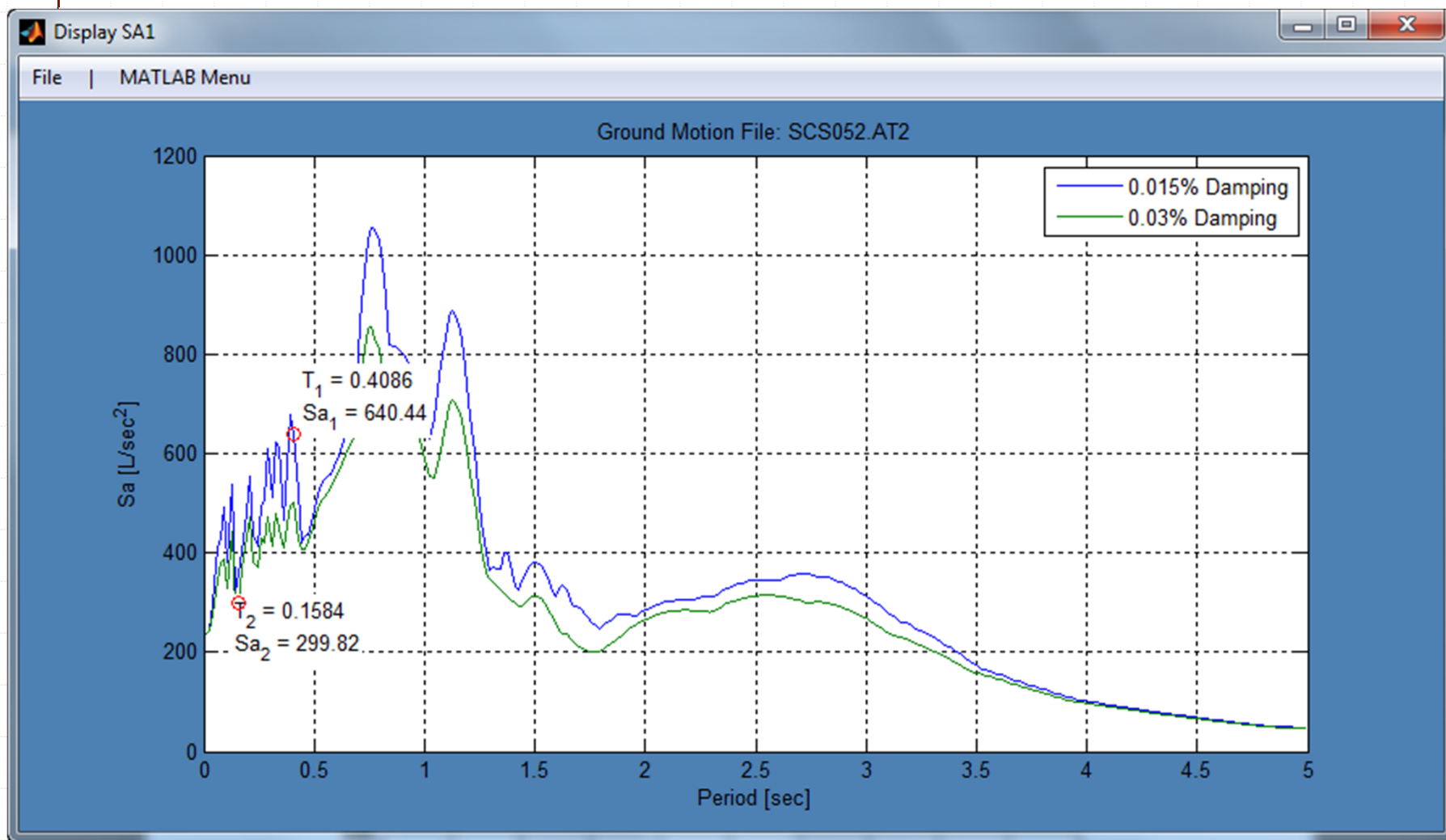
Load Ground Motion File

Click on any plot to see more details

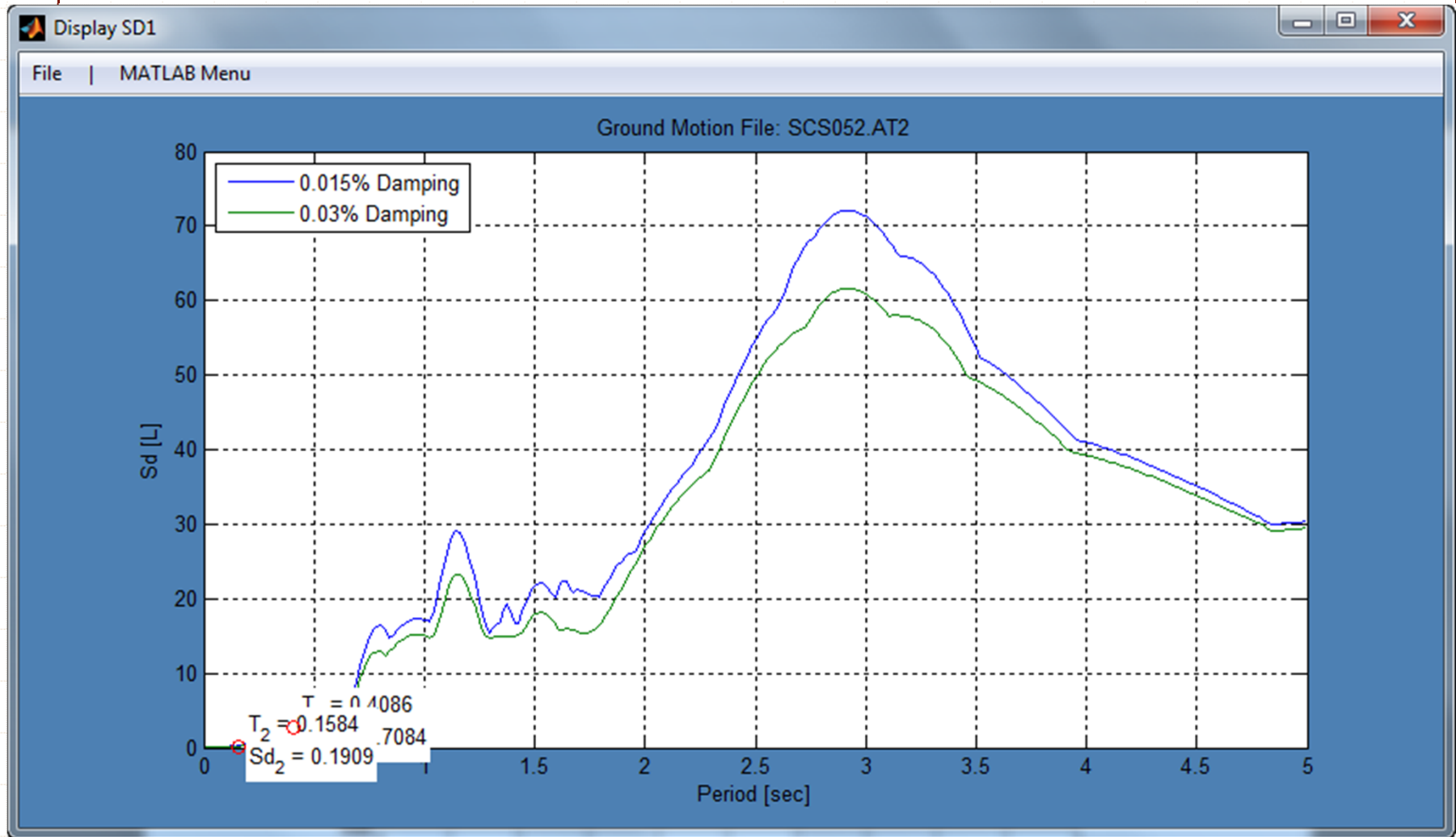
Ground Acceleration History



Pseudo Acceleration Spectra



Displacement Spectra



Define Loading: Free Vibration

The screenshot shows the 'OpenFresco Express v1.0' software interface. On the left is a vertical navigation menu with buttons for 'Structure', 'Loading', 'ExpSetup', 'ExpControl', 'Analysis', and 'User Tips'. The 'Loading' button is highlighted with a red box and an arrow pointing to it from a text box labeled 'Select Loading'. The main workspace has two tabs: 'Ground Motions' and 'Free Vibration', with the latter selected. A red box labeled 'Select Type of Loading' has an arrow pointing to the 'Free Vibration' tab. Below the tabs are three input fields: 'Initial Displacement' (set to 'Mode 1' and '0.1 0.167'), 'Ramp Time' (set to '10'), and 'Free Vibration Time' (set to '20'). A red box labeled 'Input Free Vibration Parameters' has an arrow pointing to the 'Initial Displacement' field. At the bottom of the workspace is a graph titled 'Displacement [L]' vs 'Time [sec]'. The graph shows a blue line that ramps up linearly, then drops sharply to a peak, followed by a series of decaying oscillations. A red dashed vertical line marks the start of the vibration. Labels on the graph include 'Initial Displacement' (pointing to the peak), 'Ramp Time' (pointing to the initial linear slope), and 'Vibration Time' (pointing to the duration of the oscillations).

Experimental Setup

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

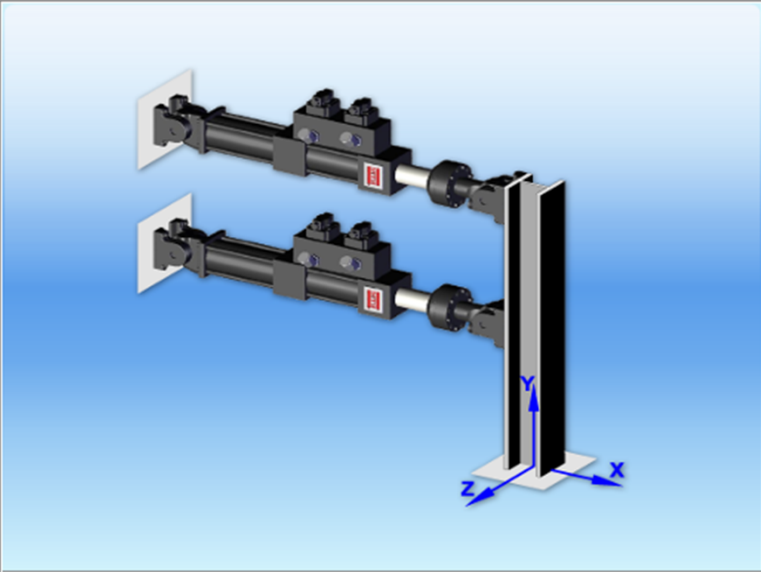
Analysis

User Tips

PEER

Experimental Setup

Select ExpSetup



Version 1.0

The image shows a screenshot of the OpenFresco Express v1.0 software interface. On the left side, there is a vertical menu with buttons for 'Structure', 'Loading', 'ExpSetup', 'ExpControl', 'Analysis', and 'User Tips'. The 'ExpSetup' button is highlighted in blue, and a red arrow points to it from a white box with the text 'Select ExpSetup'. The main area of the software is titled 'Experimental Setup' and contains a 3D CAD model of a mechanical assembly. The assembly consists of two actuators connected to a vertical plate. A coordinate system with X, Y, and Z axes is shown at the base of the plate. The PEER logo is visible in the bottom left corner of the software window, and the version number 'Version 1.0' is in the bottom right corner.

Experimental Control: Story 1

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Experimental Control

Simulation Real Controller

Story 1

Define Control	SimUniaxialMaterial
Number of Actuators	2
Choose Material	Steel - Giuffré-Menegotto-Pinto
Yield Strength (Fy)	600
Initial Elastic Modulus (E)	1324
Strain Hardening Ratio (b)	0.1
Elastic-Plastic Transition (R0)	15

Version 1.0

Input Material Properties for 1st Story

Experimental Control: Story 2

OpenFresco Express v1.0

File Help

Structure

Loading

ExpSetup

ExpControl

Analysis

User Tips

PEER

Experimental Control

Simulation Real Controller

Story 2

Define Control	SimUniaxialMaterial
Number of Actuators	2
Choose Material	Steel - Giuffré-Menegotto-Pinto
Yield Strength (Fy)	600
Initial Elastic Modulus (E)	1236
Strain Hardening Ratio (b)	0.01
Elastic-Plastic Transition (R0)	15

Version 1.0

Input
Material
Properties
for 2nd Story

Analysis

The screenshot displays the OpenFresco Express v1.0 software interface. The main window is titled "Analysis" and contains several interactive elements. On the left side, there is a vertical menu with buttons for "Structure", "Loading", "ExpSetup", "ExpControl", "Analysis", and "User Tips". The "Analysis" button is highlighted in blue. Below the menu is the PEER logo. The central area of the window is titled "Analysis" and contains a form with the following elements:

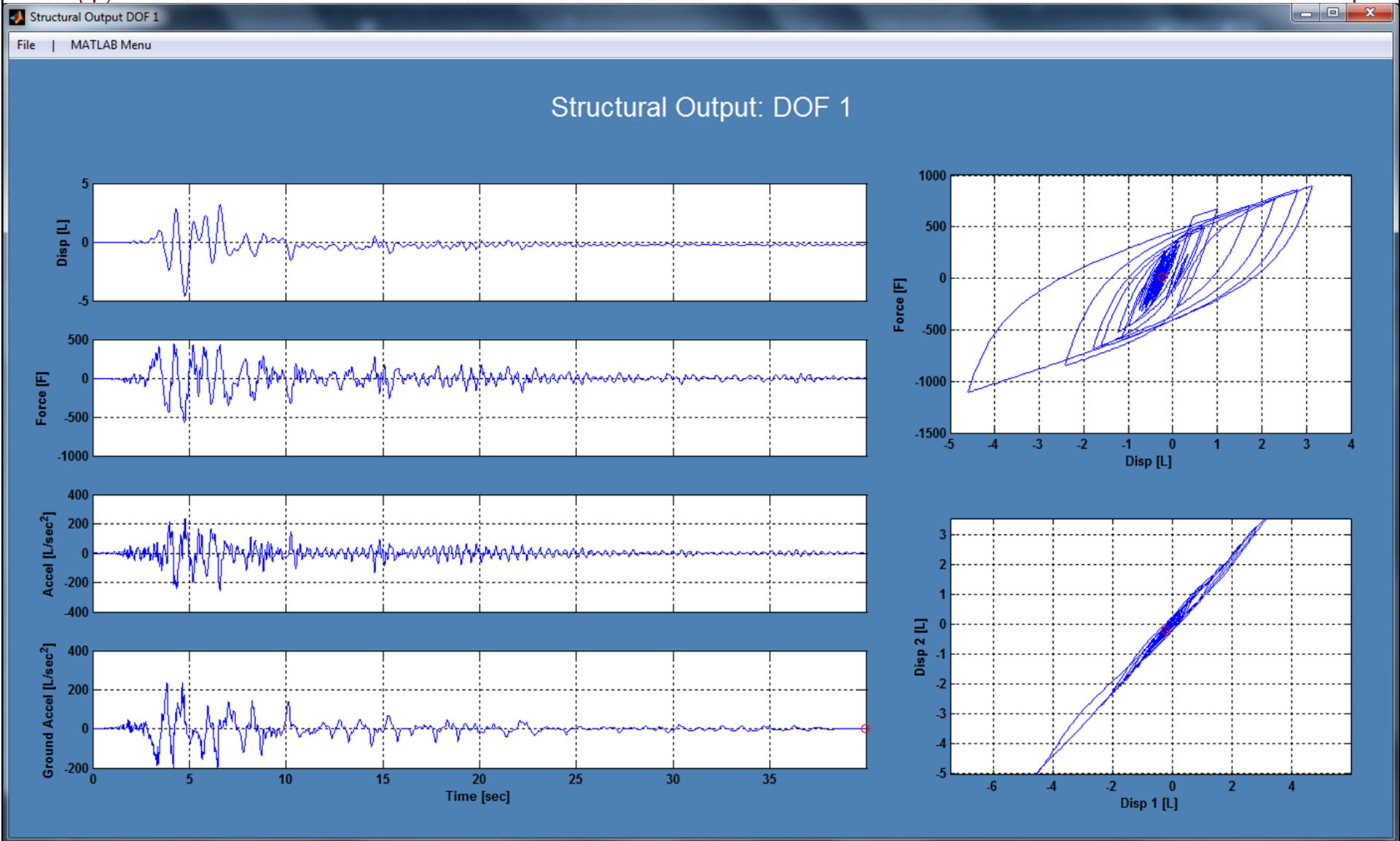
- A text input field for "dt" with the value "0.005" and a comparison "< 0.050422". A red arrow points from a callout box to this field.
- A "Write TCL File" button, with a red arrow pointing from a callout box to it.
- A "Generate Report" button, with a red arrow pointing from a callout box to it.
- A question: "Would you like to animate the response?" with radio buttons for "No" and "Yes" (selected).
- Three large buttons at the bottom: a play button, a pause button, and a stop button.
- Two buttons at the bottom right: "Run New Test" and "Quit".

Annotations and callouts:

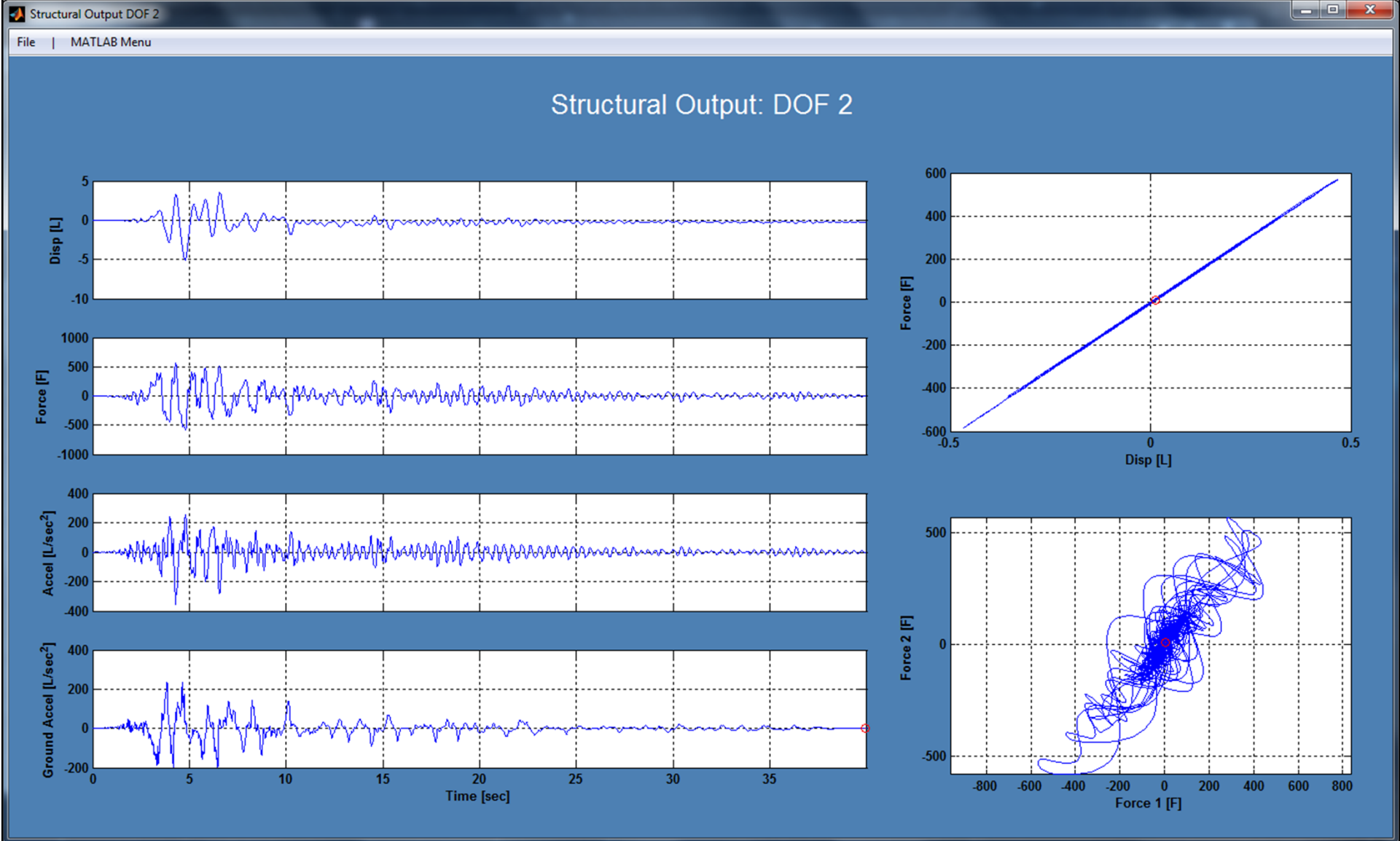
- A red box with the text "Select Analysis" has an arrow pointing to the "Analysis" button in the left menu.
- A red box with the text "Click here to write TCL input files" has an arrow pointing to the "Write TCL File" button.
- A red box with the text "Optionally Generate Report" has an arrow pointing to the "Generate Report" button.
- A red box with the text "In order to ensure stability when using the explicit Newmark method, dt must be less than the indicated maximum value." has an arrow pointing to the "dt" input field.

Version 1.0

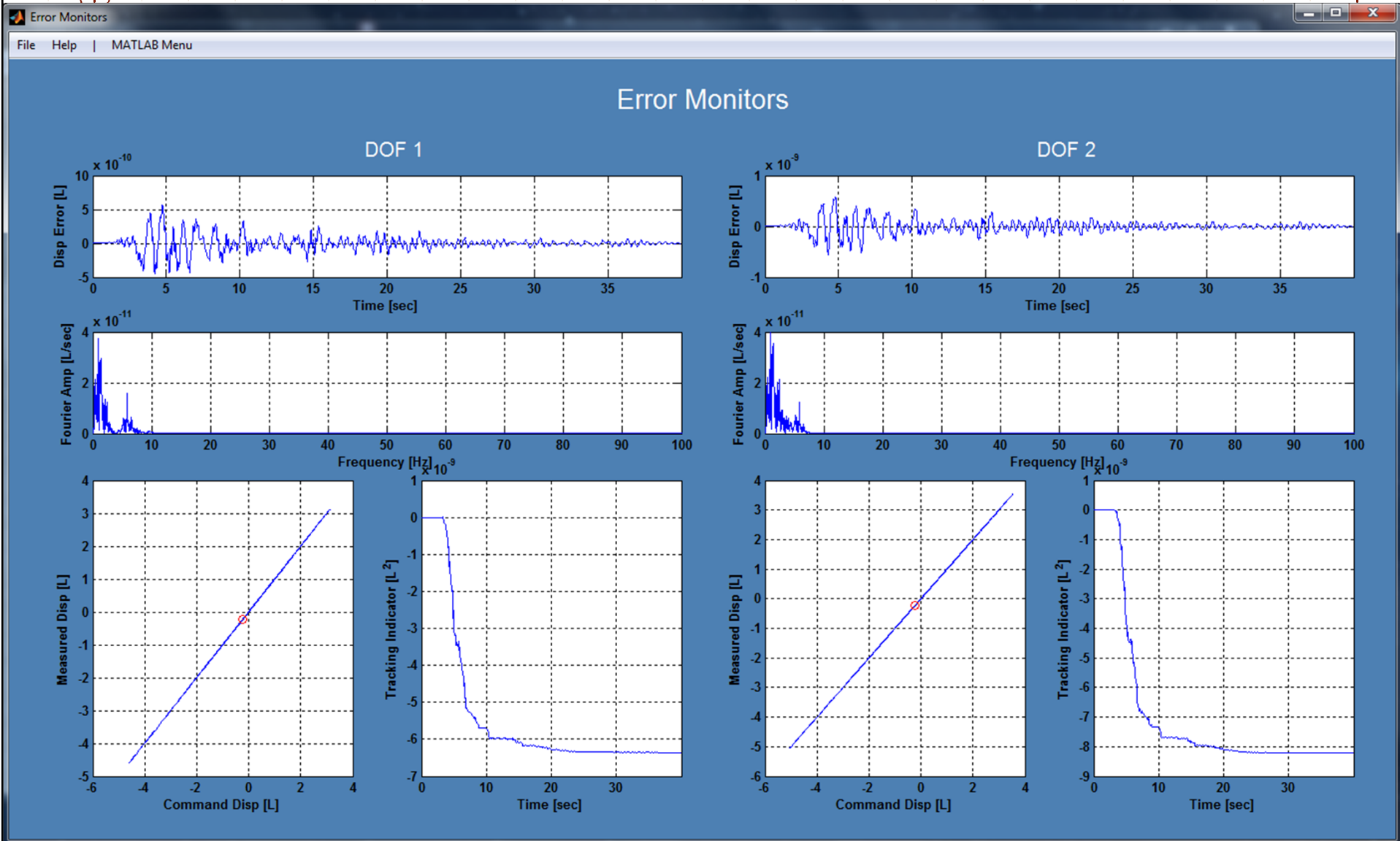
Structural Output: 1st Story



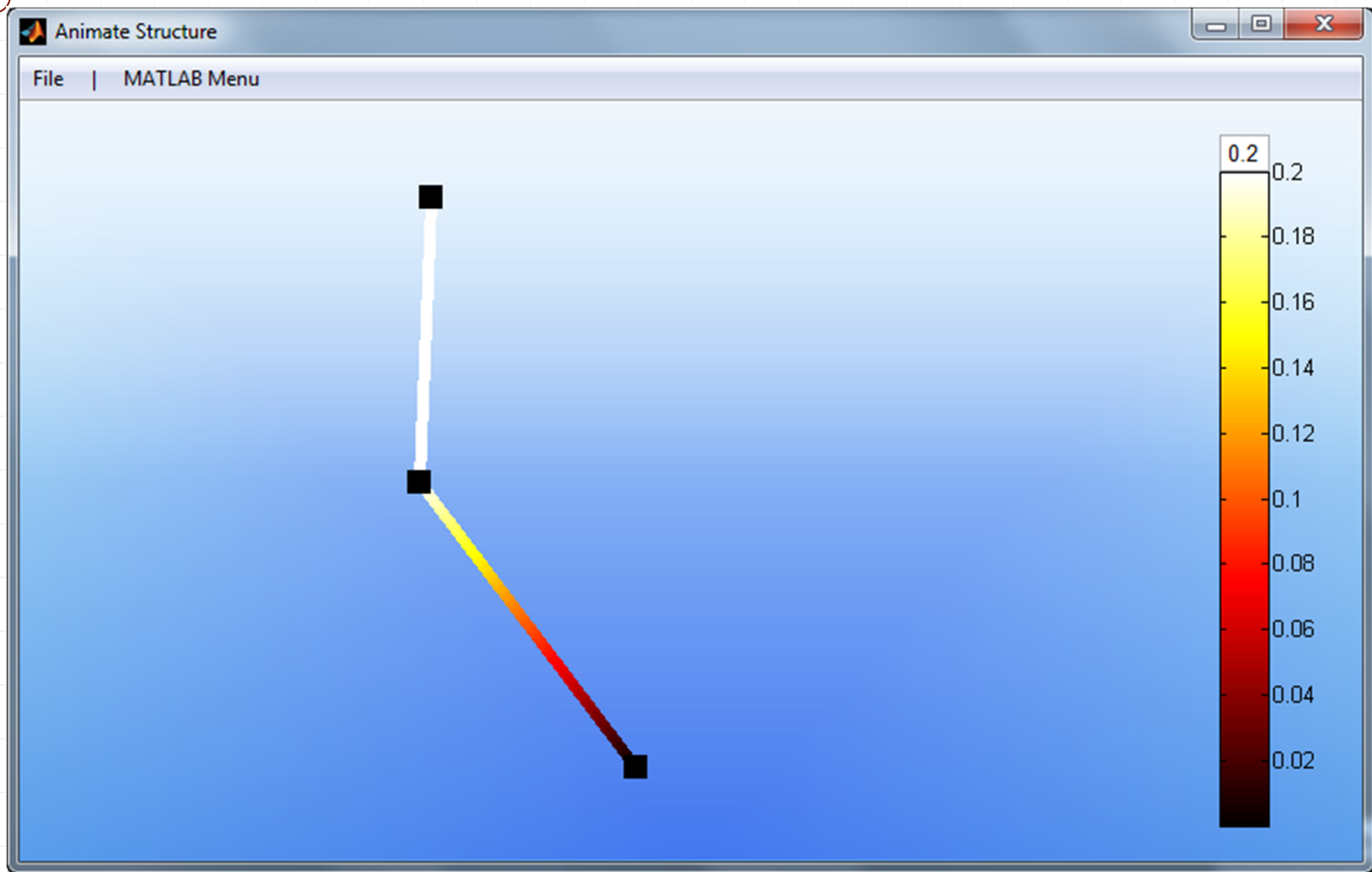
Structural Output: 2nd Story



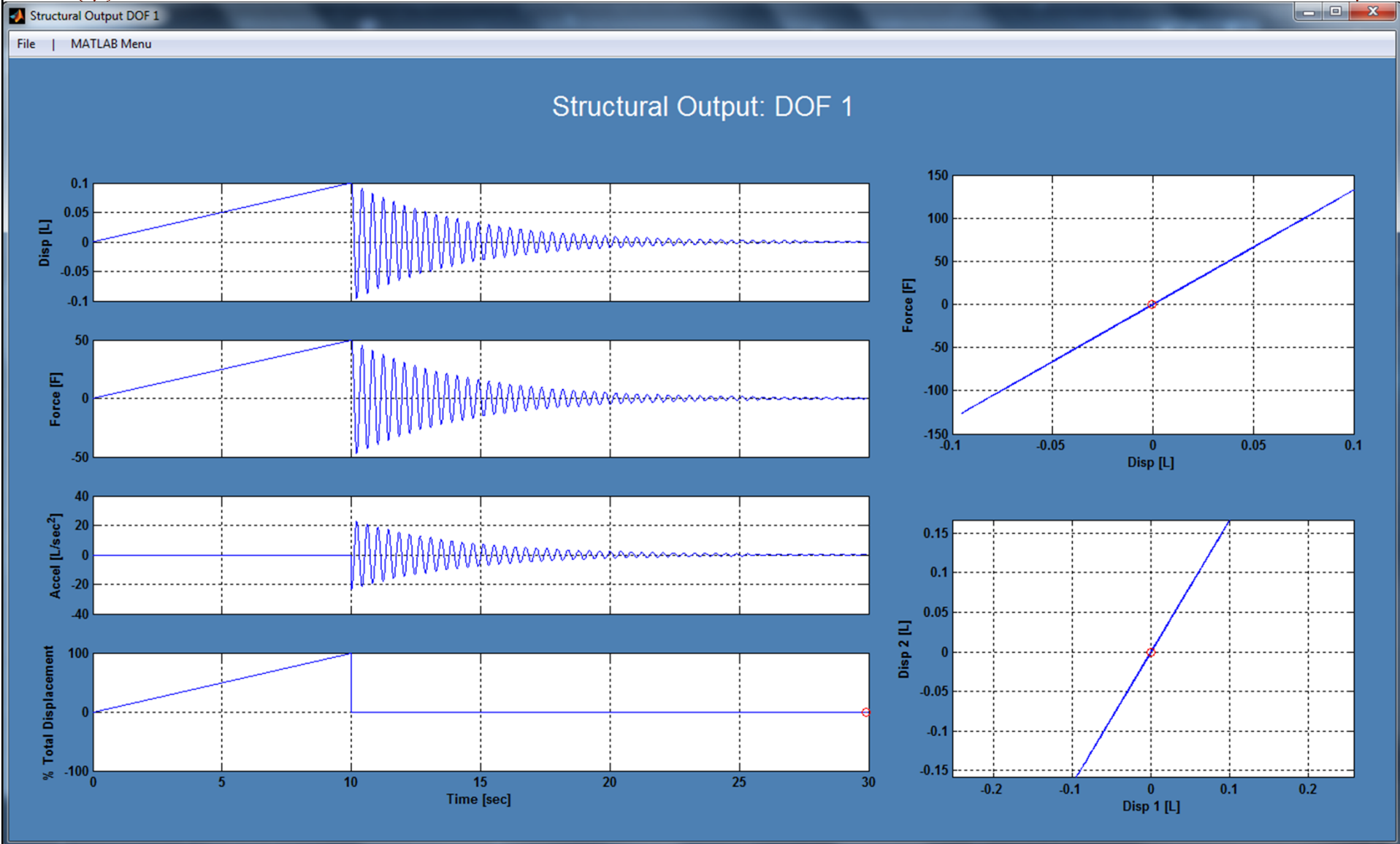
Error Monitors



Animation of Model



Free Vibration Response





OpenFresco

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HOME

OpenFresco (the Open-source Framework for Experimental Setup and Control) is an environment-independent software framework, that connects finite element models with control and data acquisition systems in laboratories to facilitate hybrid simulation of structural and geotechnical systems.

Hybrid simulation is an experimental testing technique where a test is executed based on a step-by-step numerical solution of the governing equations of motion for a hybrid model, formulated considering both the numerical and physical portions of a structural system. In order for the earthquake engineering community to take full advantage of this technique, OpenFresco standardizes the deployment of hybrid simulation and extends its capabilities to applications where advanced numerical techniques are utilized, boundary conditions are imposed in real-time, and dynamic loading conditions caused by wind, blast, impact, waves, fire, traffic, and, in particular, seismic events are considered. Accordingly, the architecture of the OpenFresco software package provides a great deal of flexibility, extensibility, and re-usability to the researcher or developer interested in hybrid simulation.

Search

Search

Menu

- Log in
- Register

Downloads

- OpenFresco
- OpenFrescoExpress
- OpenTest Navigator

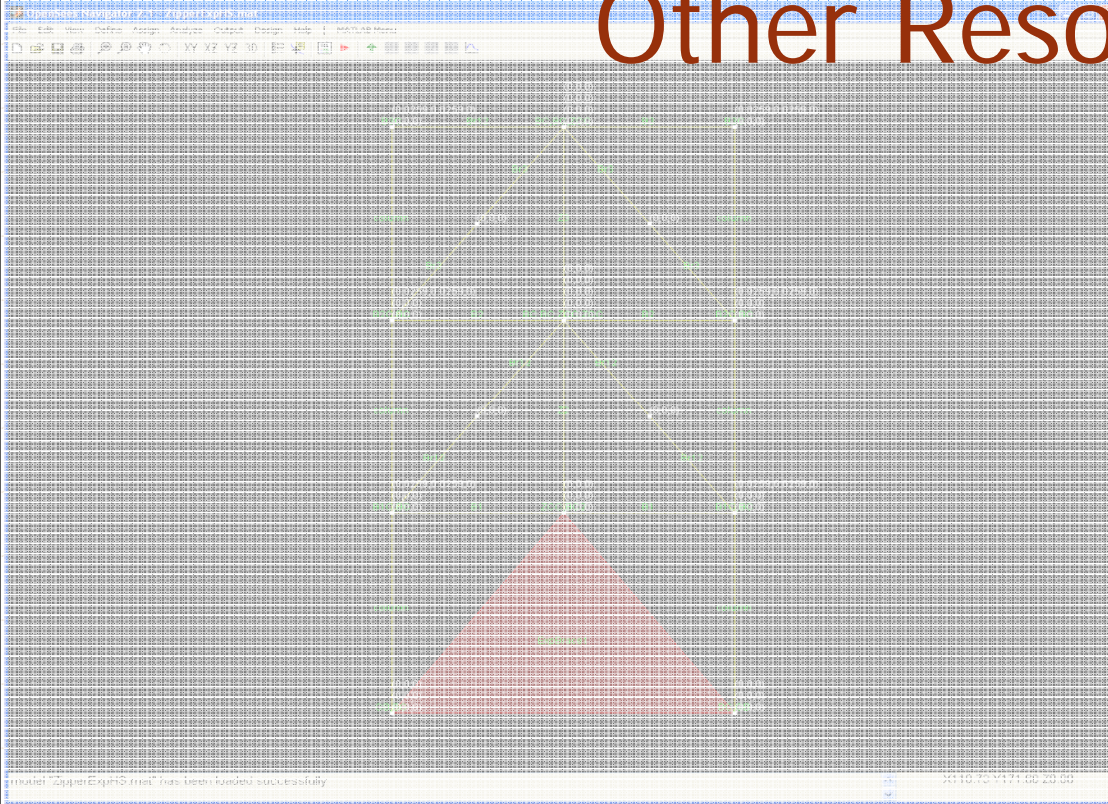


PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Advanced implementation of Hybrid Simulation

Other Resources

Andreas H. Schellenberg
 Stephen A. Mahin
 Gregory L. Fenves
 University of California, Berkeley



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More Information

OpenFresco

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HOME

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Hybrid Simulation

$$M \cdot \ddot{u} + C \cdot \dot{u} + P_r(u) = P(t)$$

Dynamic Loading:

- Seismic
- Wind
- Blast/Impact
- Wave
- Traffic

Static Loading:

- Gravity
- Prestress

Download documentation and software:
<http://openfresco.berkeley.edu>

energy dissipation and inertia
 physical model of structural resistance

OpenFrescoExpress is a self-contained software package, including a easy-to-use graphical user interface, that facilitates hybrid testing of systems having up to two degrees of freedom. OpenFrescoExpress addresses the needs of a wide range of users including:

- laboratory staff and research students learning about hybrid simulation and starting to use this experimental testing method.
- staff and students at laboratories that regularly use hybrid simulation but desire a tool for quick demonstration of the hybrid simulation testing method.
- researchers who are conducting simple tests and would like to take advantage of a graphical user interface that quickly and easily displays useful real-time test data.
- graduate students and researchers who are not at a laboratory but wish to run the software as a pure simulation tool to learn more about hybrid simulation and how it works.

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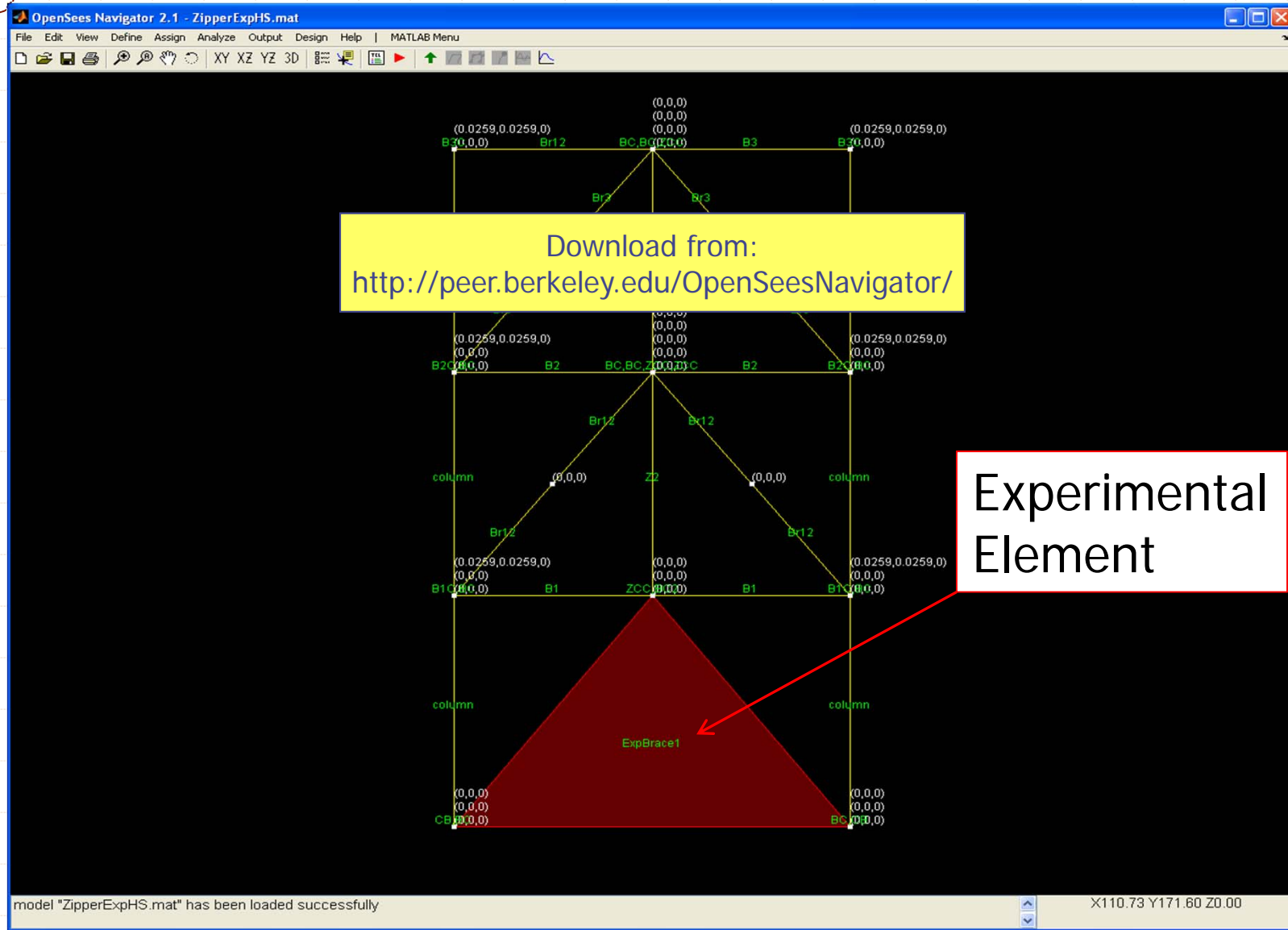
Advanced Implementation of Hybrid Simulation

Andreas H. Schellenberg
 Stephen A. Mahin
 Gregory L. Fenves
 University of California, Berkeley

Download report from:
<http://peer.berkeley.edu/publications/>

PEER 2009/104
 NOVEMBER 2009

OpenSees Navigator



Experimental Element

Summary & Conclusions

- ★ OpenFresco *Express* is a simplified version of the OpenFresco middleware software for 1DOF and 2DOF systems
- ★ Easy to graphically setup hybrid model
- ★ Ground motion and free vibration HS
- ★ Chose to connect to real laboratory controllers, actuators and data acquisition systems or simulate the behavior of the test specimen to perform dry-runs and/or learn about HS

Summary & Conclusions

- ★ Watch the progress of the HS in real time including graphs plotting the structural response and error monitors tracking the accuracy of the test
- ★ For more advanced problems you can use OpenFresco with the computational driver of your choice
- ★ If you like to use a graphical user interface for more advanced problems try OpenSees Navigator

Questions? Thank you!

The development of OpenFresco has been sponsored in parts by the National Science Foundation through grants from the NEES Consortium, Inc.

The development of OpenFresco *Express* has been sponsored by the Pacific Earthquake Engineering Research Center (PEER)



OpenFresco