Electrical and Gas System Component Characterization

Andre Filiatrault
University of California, San Diego
Armen Der Kiureghian
University of California, Berkeley

Thursday January 25
2:30 pm

2001 PEER Annual Meeting

PEER Lifeline Research Program

- Objective:
  - Provide data, models, and methods needed to improve the earthquake reliability and safety of lifeline systems
- Program Sponsors:

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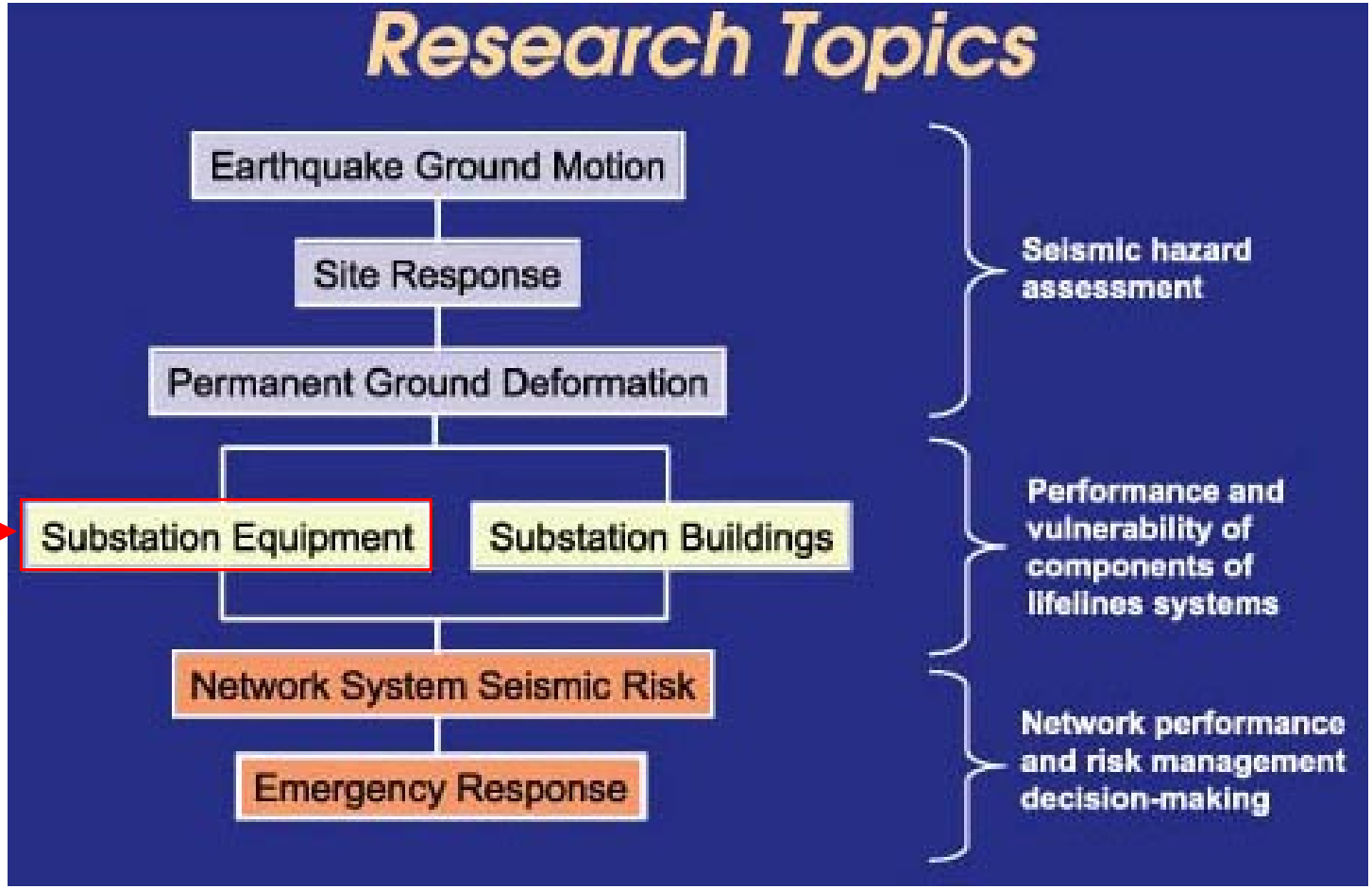
Contribution to PEER Mission

- Ensure consistent performance levels between lifeline systems and the built environment
- Required for full Performance-Based Earthquake Engineering (PBEE)

PEER Lifeline Research Program



Topic 4 →

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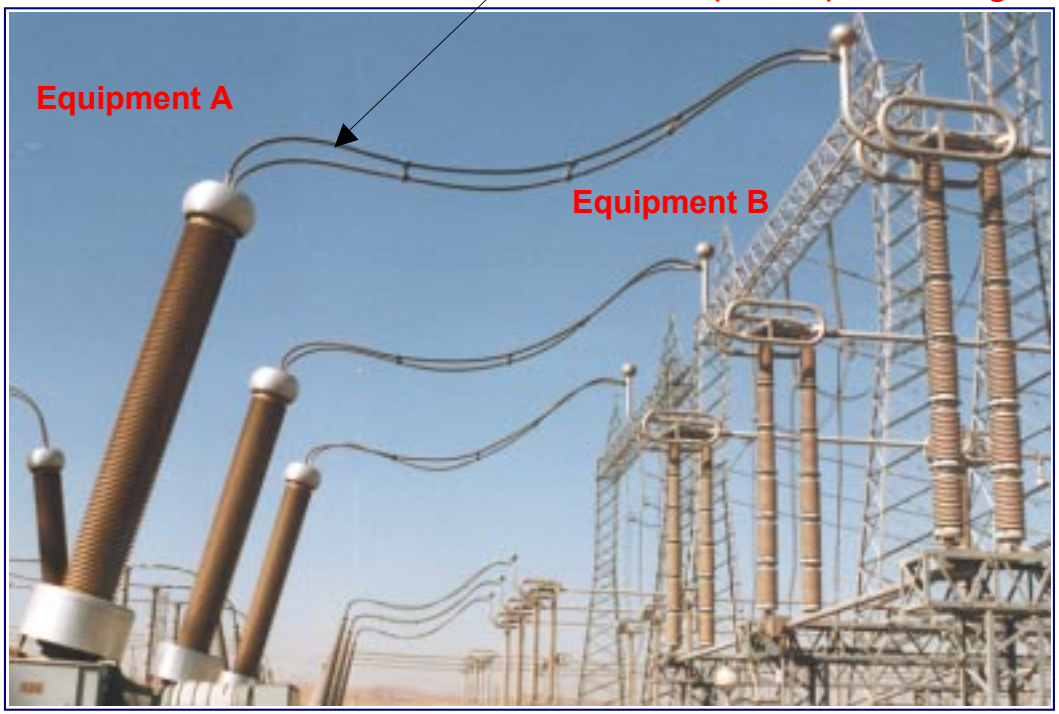
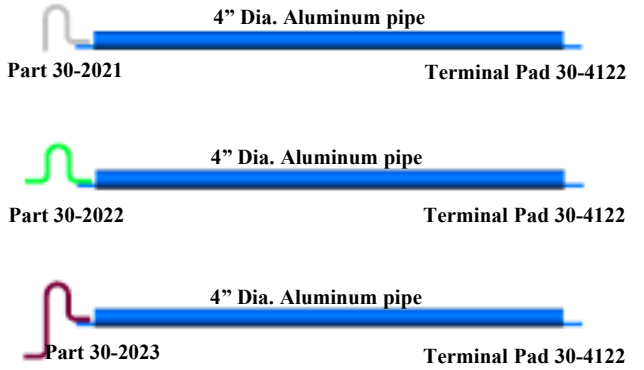
Topic 4 – Seismic Performance of Substation Equipment

- Current Projects:
  - Input Motions for Earthquake Simulator Testing of Electrical Substation Equipment
  - Equipment Overturning
  - Feasibility Evaluation of Large-Scale Testing
  - Analytical Studies Substation Equipment Interaction (Analytical Team at UCB)
  - Experimental Studies of Substation Equipment Interaction (Experimental Team at UCSD)

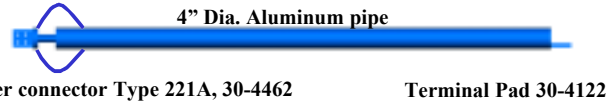
Substation Equipment Interaction



Rigid Bus with Flexible Strap Conductors (RB-FSC)



Rigid Bus-Slider



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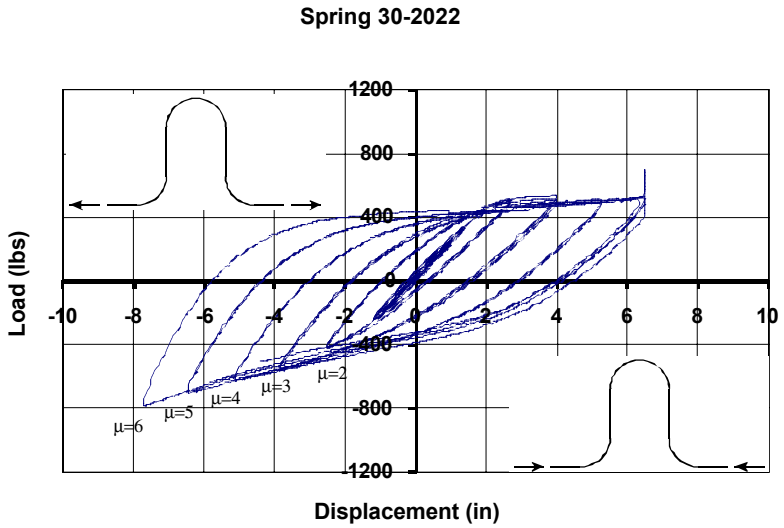
Analytical Studies on Interaction between Connected Electrical Substation Equipment (UCB)

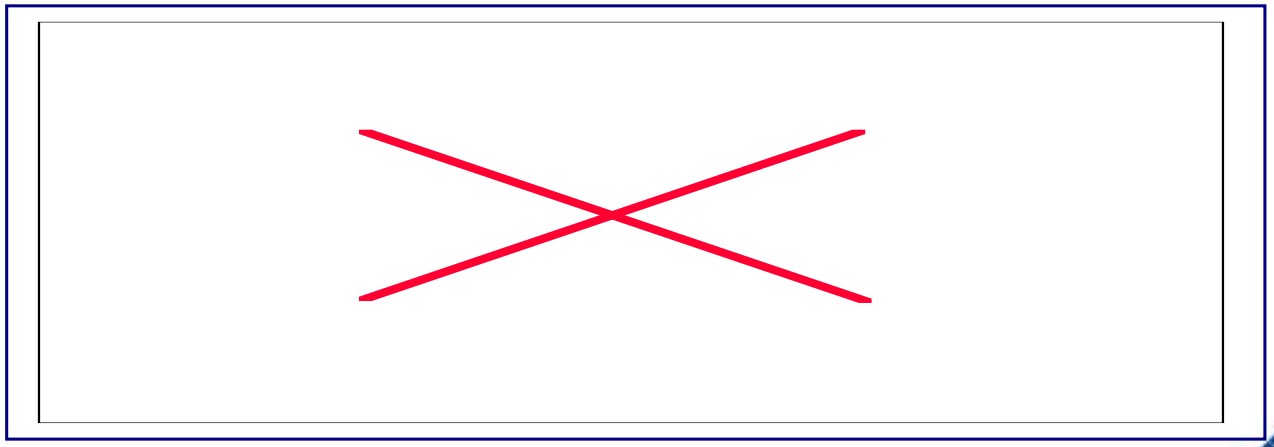
- **Team:** A. Der Kiureghian, J.L. Sackman, K.J. Hong, J. Song, UCB
- **Objective**
  - Gain insight into the effect of dynamic interaction between connected equipment.
  - Predict and quantify the effect of interaction.
  - Develop design rules to avoid the adverse interaction effect, or to account for it.
- **Scope**
  - Rigid bus with flexible connectors.
  - Flexible (cable) bus.

Experimental Studies on Interaction between Connected Electrical Substation Equipment (UCSD)

- **Team:** A. Filiatrault, S. Kremmidas, D. Evanger, C. Stearns UCSD
- **Objective**
  - Generate experimental data into the effect of dynamic interaction between connected equipment.
  - Support/validate analytical studies.
  - Quantify experimentally the effect of interaction.
- **Scope**
  - Rigid bus with flexible connectors.
  - Flexible (cable) bus.

Quasi-static Cyclic Tests of Rigid Bus Assemblies (UCSD)





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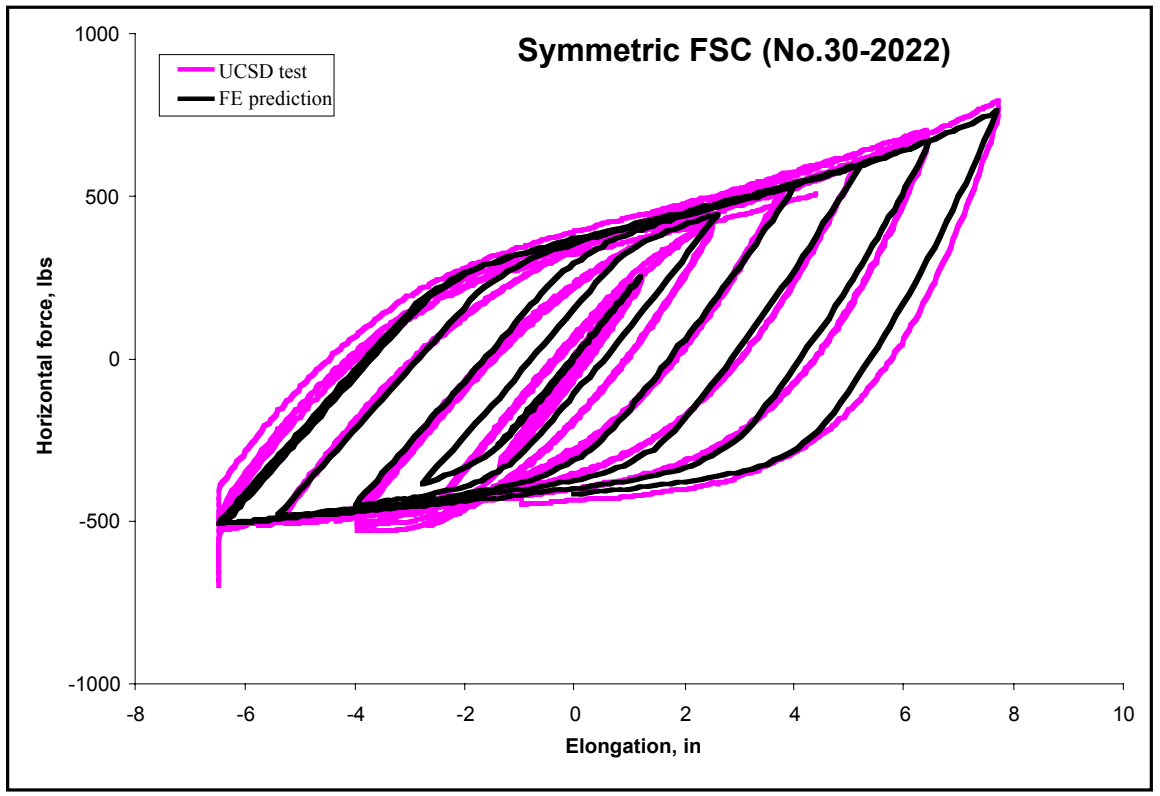
Finite Element Analysis of Rigid Bus Assemblies (UCB)



- Elasto-plastic, large deformation finite element analysis is performed to predict the hysteretic behavior of RB-FSC.

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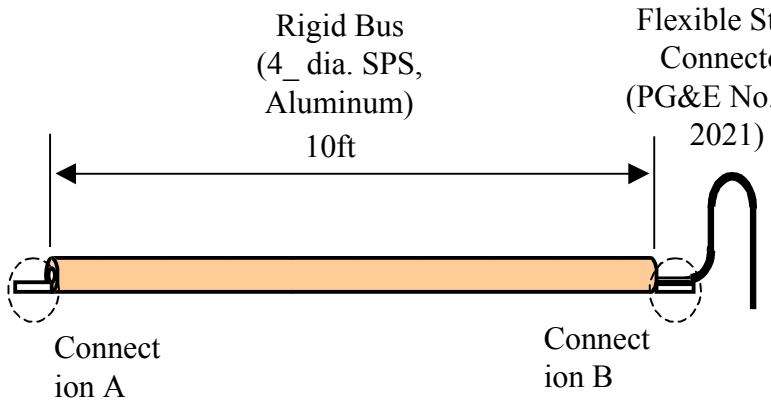
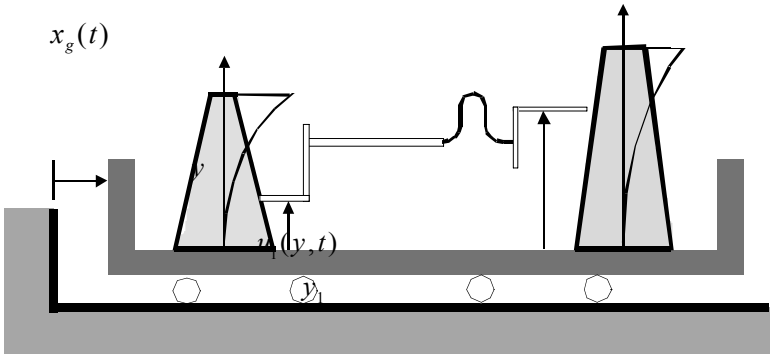
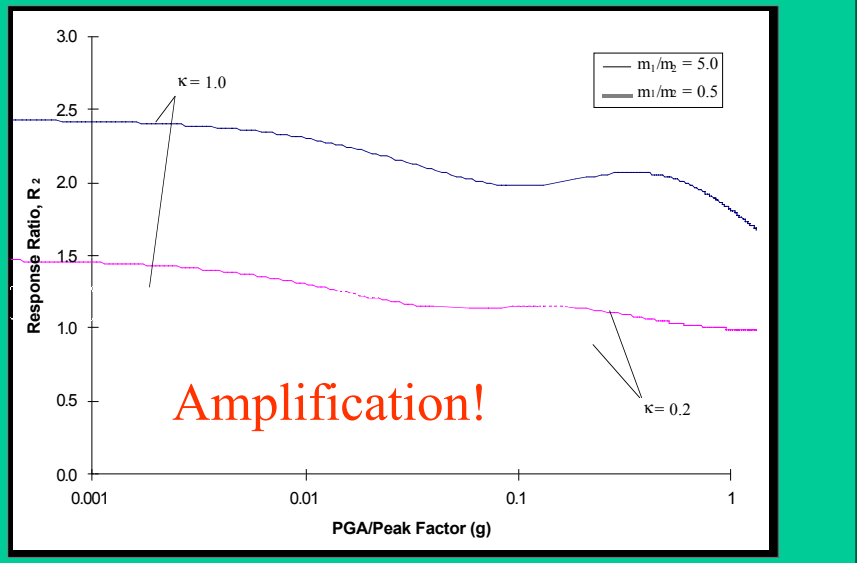
Analysis of Interaction Between RB-FSC-Connected Equipment Items (UCB)

$$\text{Response Ratio} = \frac{[\text{Peak equipment repsonse}]_{\text{connected}}}{[\text{Peak equipment response}]_{\text{stand alone}}}$$

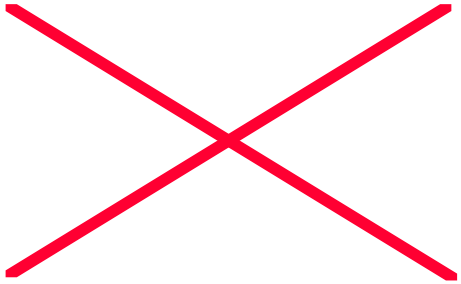






Higher-frequency equipment

Shake Table Tests of Pairs of Generic Substation Equipment Connected with Rigid Bus Assemblies (UCSD)



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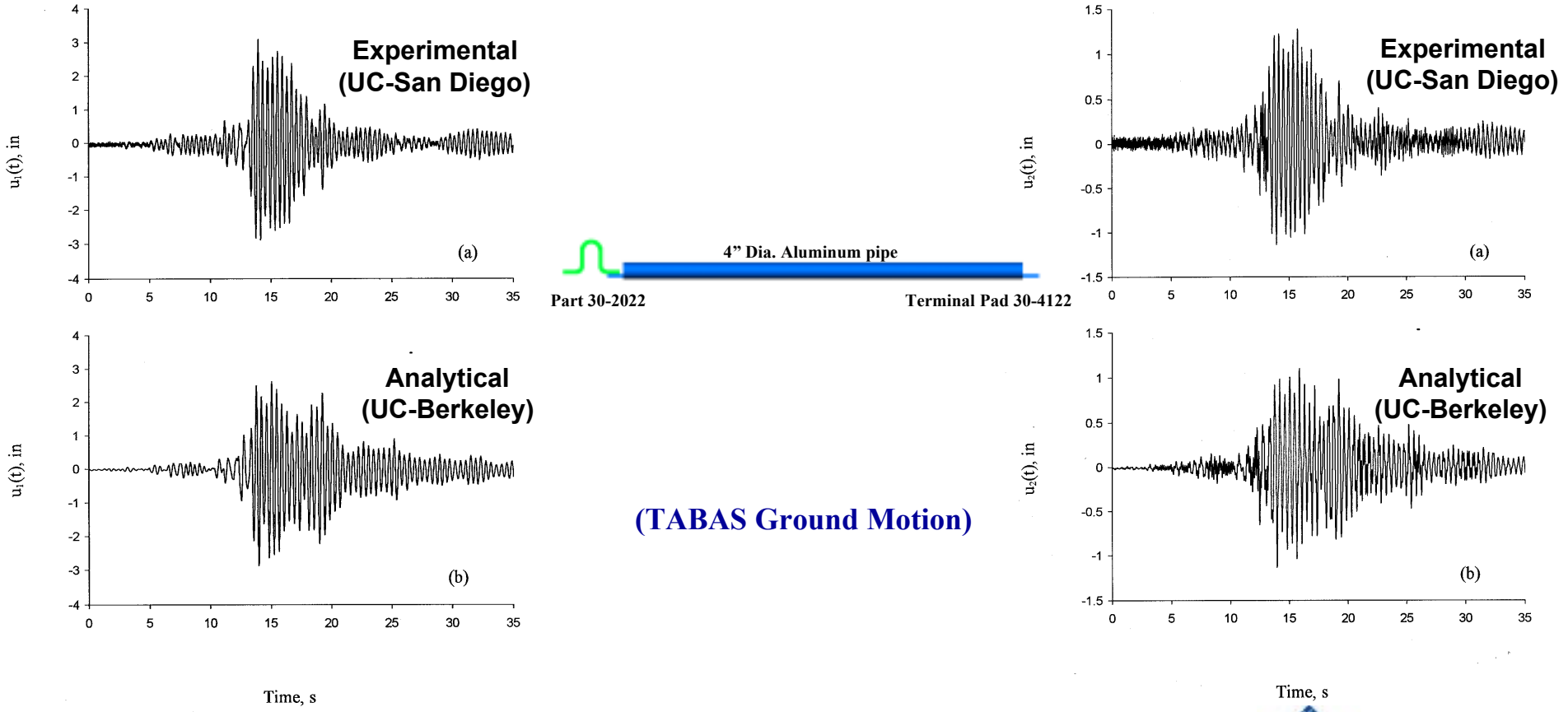
Comparison of Analytical Predictions and Shake Table Test Results

- **Equipment A: 2 Hz-800 lbs/Equipment B: 12 Hz-150 lbs**



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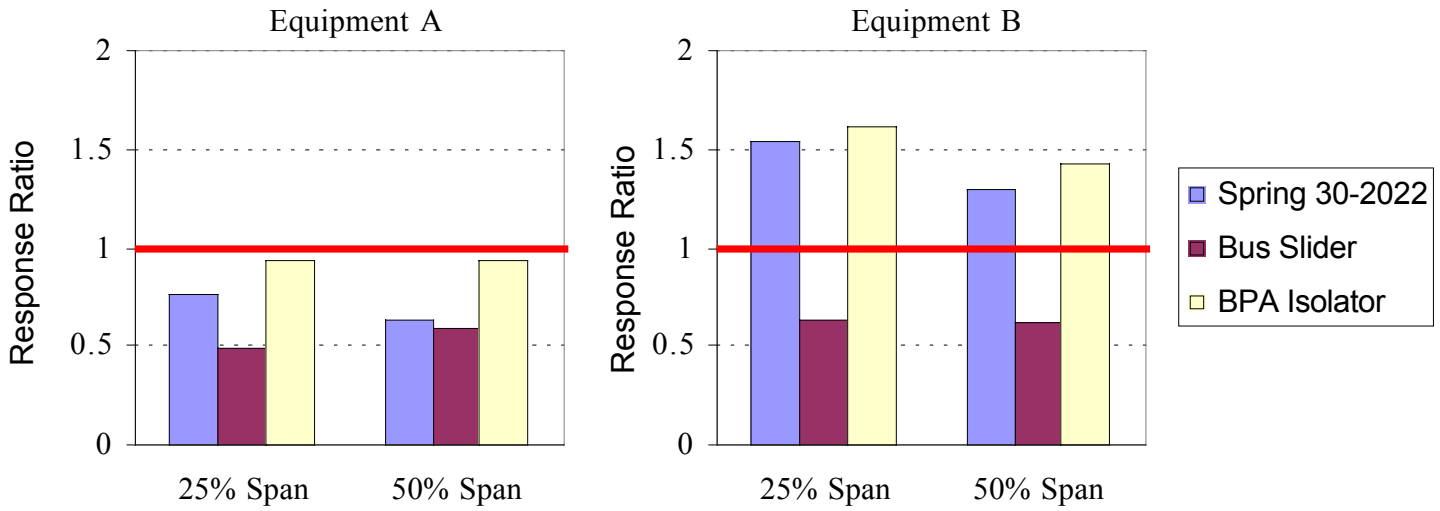
Shake Table Tests of Pairs of Generic Substation Equipment Connected with Rigid Bus Assemblies (UCSD)

- **Equipment A: 2 Hz-800 lbs / Equipment B: 6 Hz-150 lbs**

(TABAS Ground Motion)



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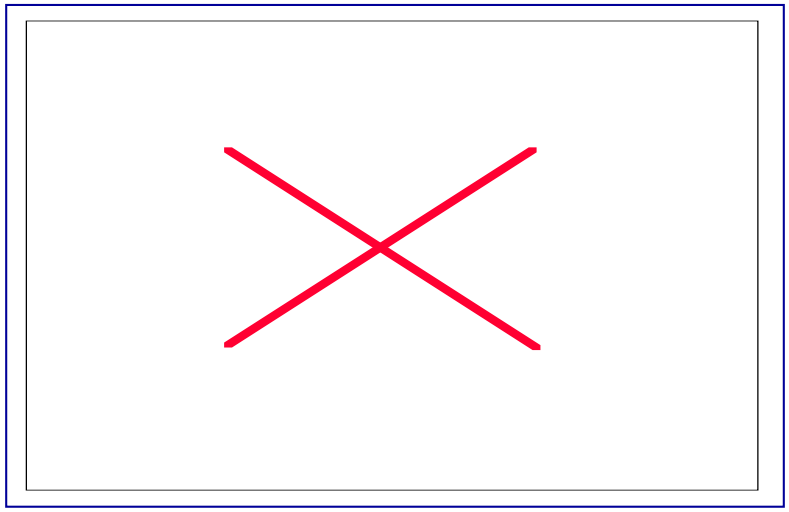
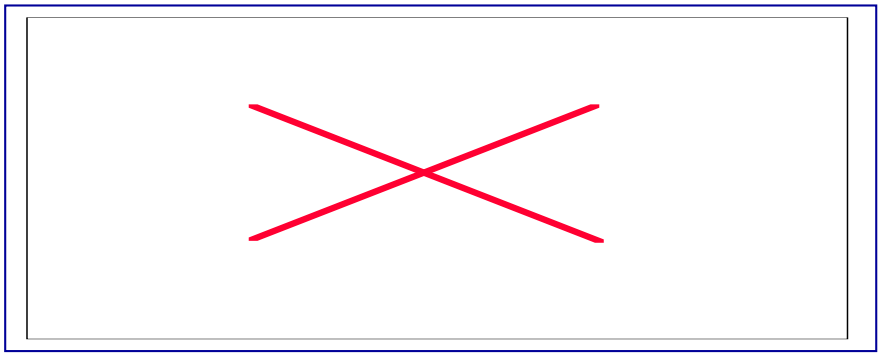
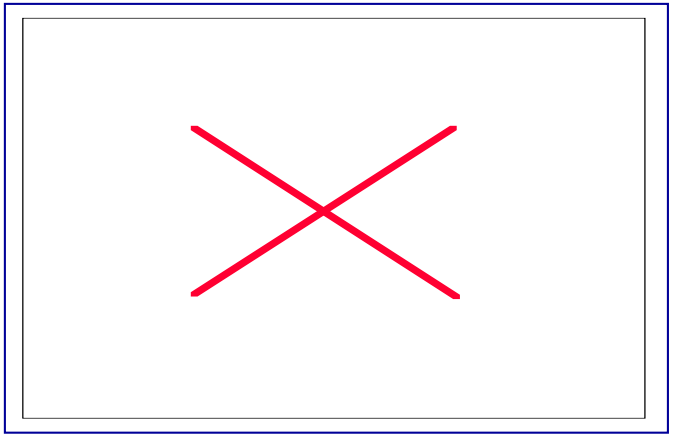
Quasi-static Cyclic Tests of Flexible Bus Assemblies (UCSD)

2300 MCM Single Conductor



1113 MCM Bundled Conductors





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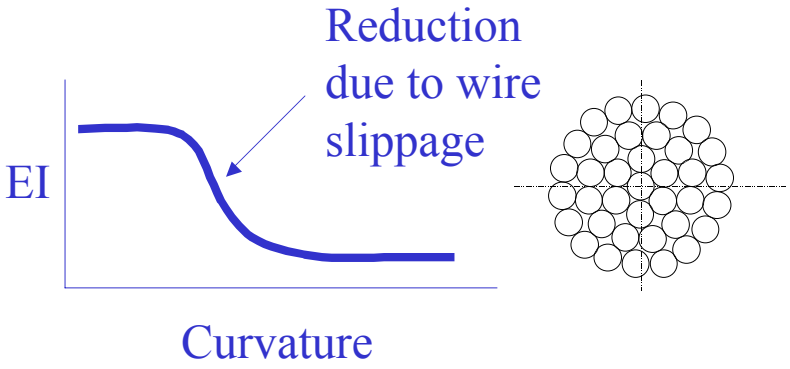
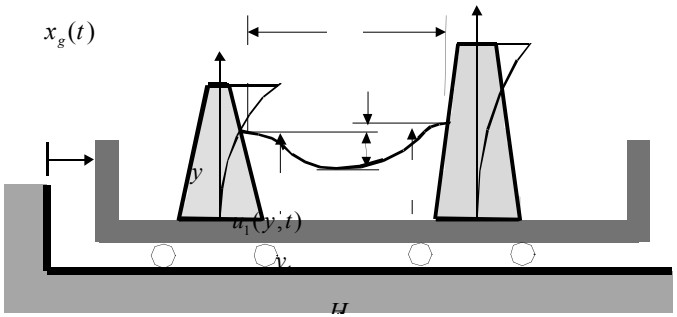
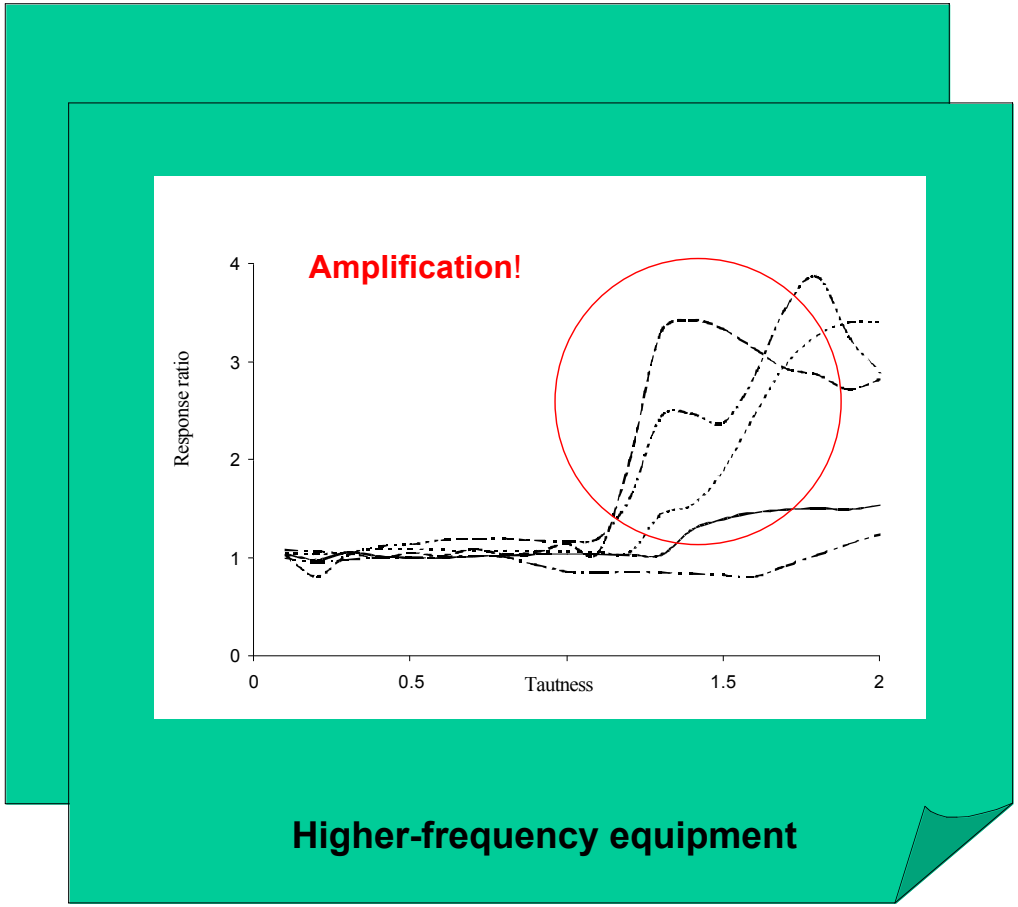
Analysis of Interaction Between Cable-Connected Equipment Items (UCB)







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Summary of Major Results

- Interaction effect can greatly amplify the equipment response.
- The higher-frequency equipment is usually adversely affected.
- Sufficient flexibility must be provided in the connector to avoid the adverse effect of interaction.
- Energy dissipation in the connector (plasticity or friction-slip) reduces the interaction effect.