Bridge Component Characterization

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Key Elements

- Approach slab
- Abutments
- Foundations
- Movement Joints
- Columns/Piers
- Superstructure
- Nonstructural Features

PEER Bridge Program

Focus on:

- Monolithic reinforced concrete bridge construction
- New rather than older construction detailing
- Representative of:
  - Viaducts
  - Overcrossings
  - Major interchanges

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Bridge Research Program

Seismic Hazard

- Intensity Measures

Demand Model

- Damage Measures

Capacity Model

- Performance Measures

Decision Model

- Decision Measures

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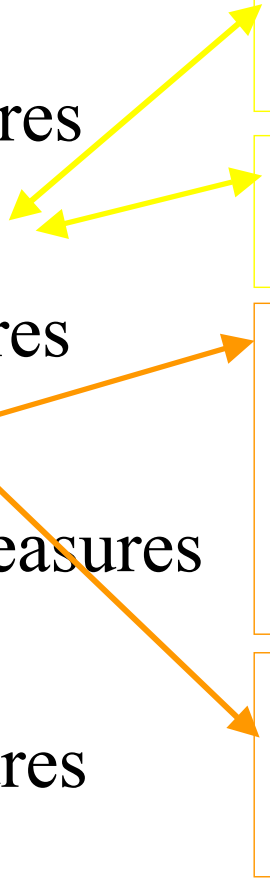

Improved soil-pile-interaction models

Improved models for RC columns and connections

Testing of columns and connections to improve understanding of behavior and validation of numerical models

Database development on performance measures given a demand

Bridge Research Program

Seismic Hazard

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Capacity Model

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Decision Model

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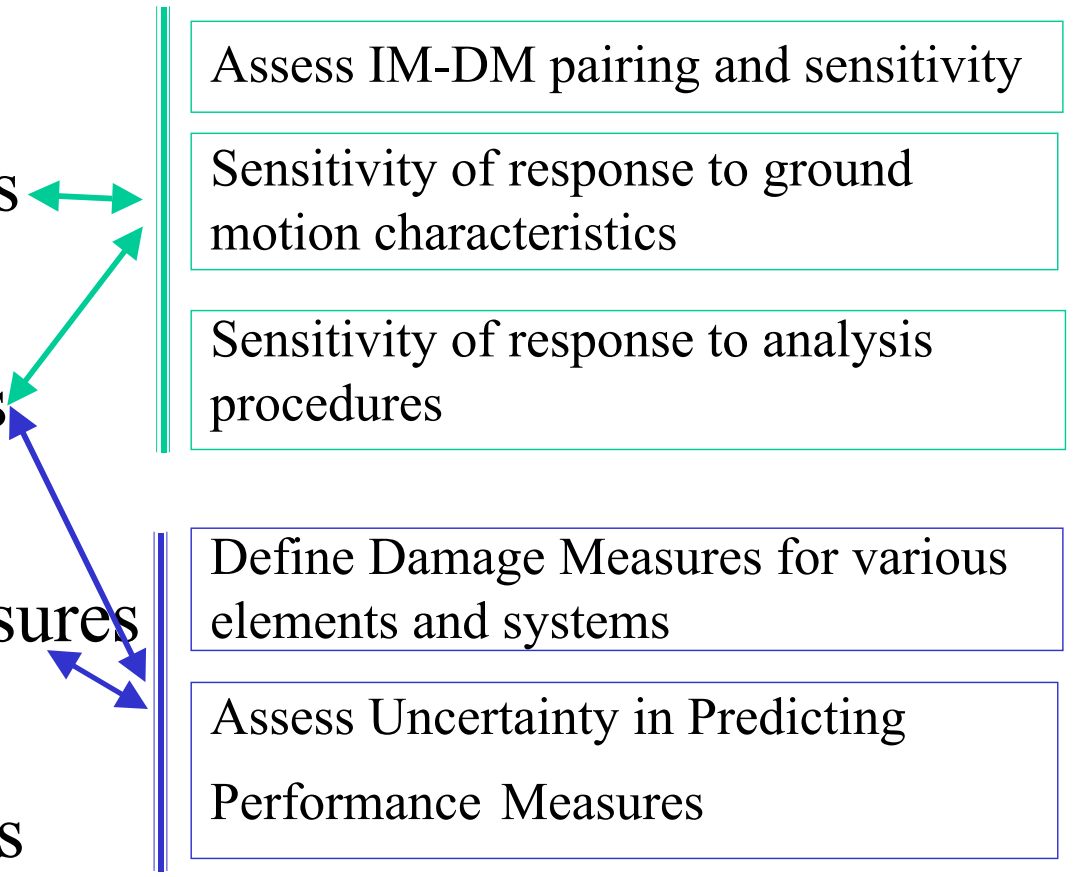

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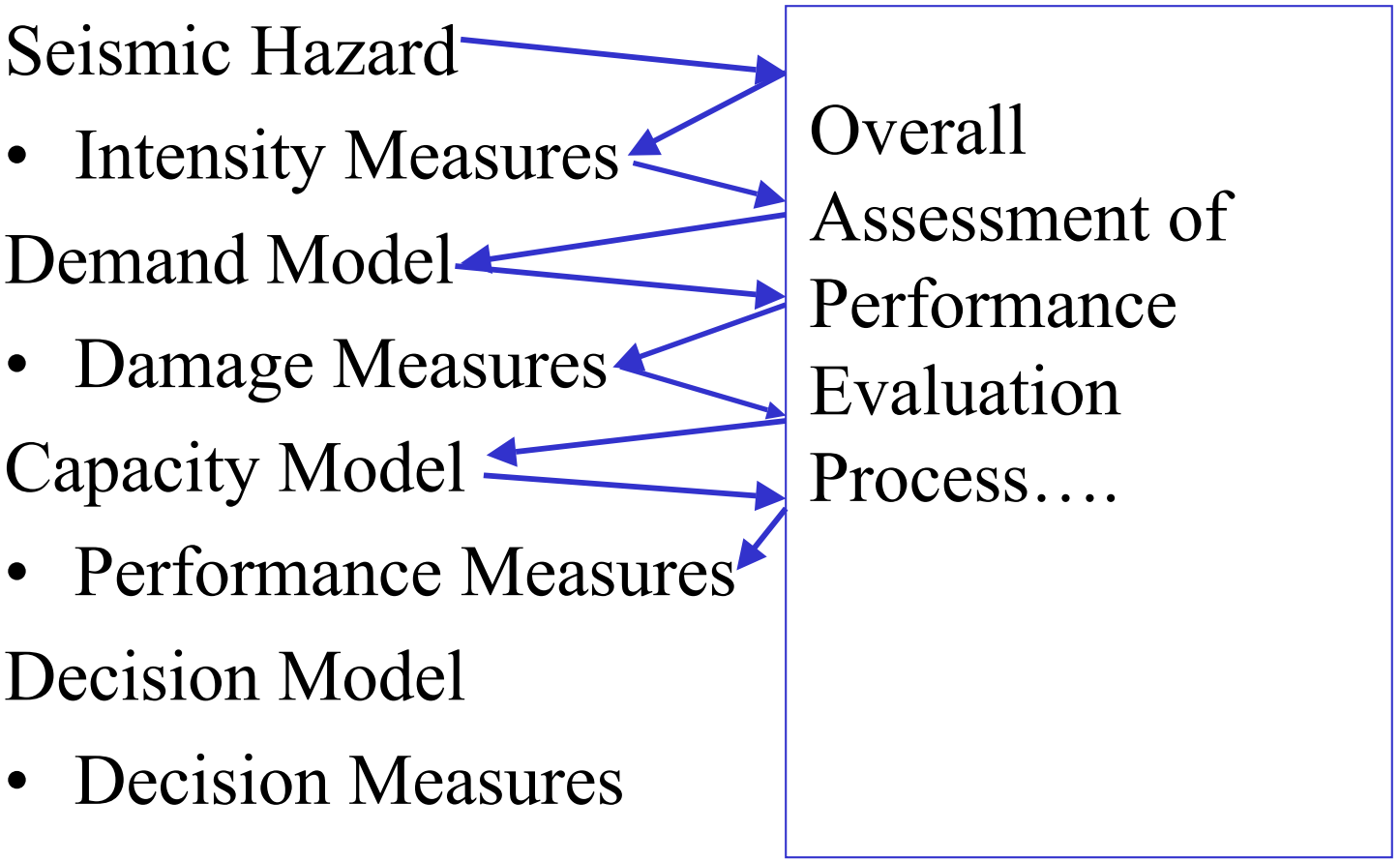
Bridge Research Program



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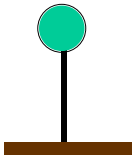
Seismic Demands



Effect of long duration ground motions (PI: Eberhard)

Large magnitude events (M=8 & 9)

- Near and distant sites
- Stiff and soft soil conditions

Simple bridge idealization

- Well and poorly confined columns
- Analytical models calibrated to existing data and new test results

Sensitivity of various damage intensity parameters to ground motion and structural characteristics

⇨ Assess design recommendations

Effect of near-fault pulse motions (PI: Mahin)

Near-fault motions

- Effect of ground motion directivity
- 1,2 and 3 components of excitation

Simple bridge idealizations

- Ductile columns with circular and interlocking spiral confinement
- Calibrated to shaking table tests

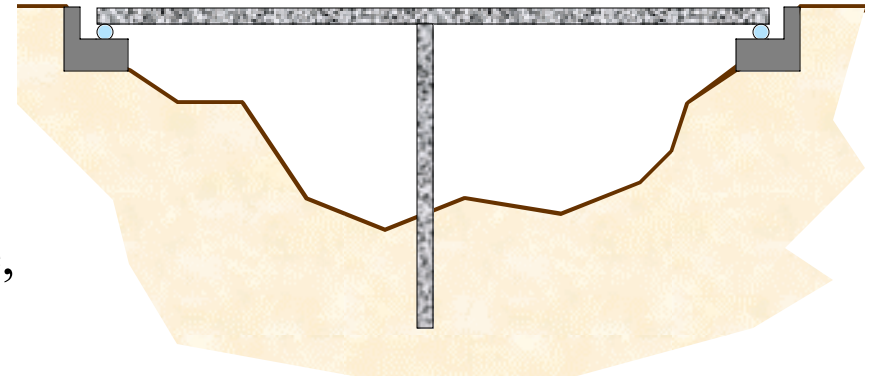
Analysis procedures (elastic response spectrum and time history analysis vs. various nonlinear techniques)

⇨ Assess design recommendations

Seismic Demands

Probabilistic Seismic Demand Analysis (PI: Stojadinovic)

Focuses on assessing statistical relation between Damage Measures and Intensity Measures



- Idealized three dimensional models of bridges with various geometries
- Damage Measures (peak local curvature, peak and residual displacement, etc.)
- Intensity Measures (Spectral displacement at various periods, etc.)
- Assess sensitivity of performance to ground motion characteristics (magnitude, distance de-aggregatization)
- Assess Damage Measure-Intensity Measure pairing for different bridge configurations and characteristics

Spirally Reinforced Column Tests

Test Matrix

- Loading history
  - Traditional cyclic
  - Pulse initiated cyclic
  - Variable axial load
  - Shaking table testing
- Loading rates:

  Fast and quasi-static
- Aspect ratios:

  Moderate and low
- Cross-section

  Circular and interlocking spirals

Effect of Axial Load Variation

Baseline Column

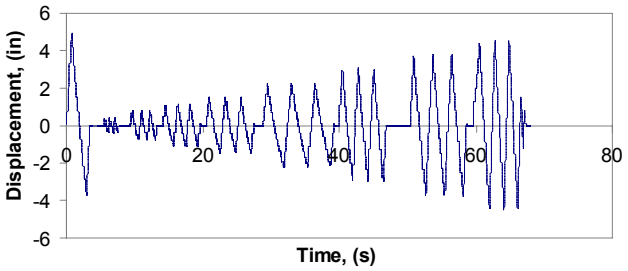
- Circular, spirally reinforced cross section
- -1/4 scale (16-in. dia.)
- Aspect ratio of 6
- 1% longitudinal steel
- $0.07f'_cA_g$

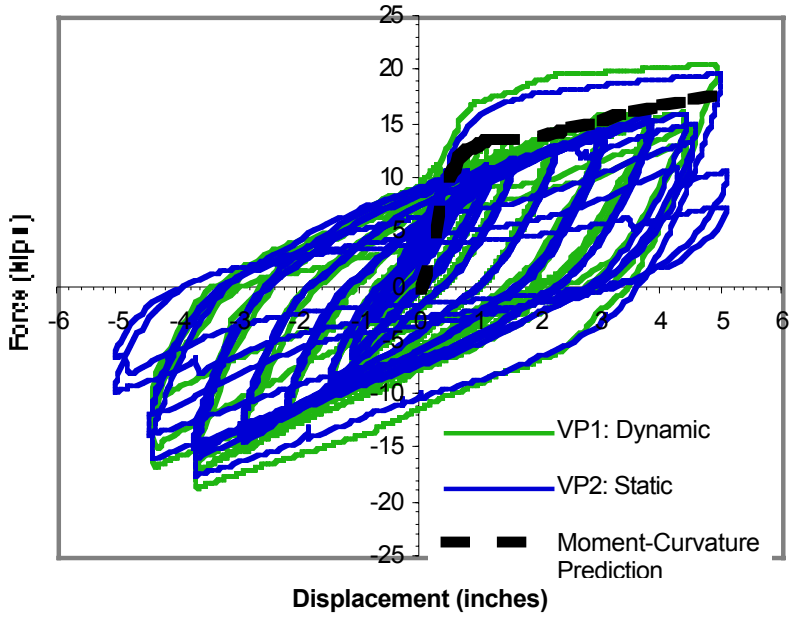
PI: Xiao

- Axial Load
  - Constant (0, 0.3f'cAg)
  - Proportional to lateral loading
  - Two cases of nonsyncronized axial loading (vertical or orthogonal effects)
- Monotonic or cyclic lateral loading
- Has effect on hysteretic behavior, p.h. length, and failure mode

Rate of Loading Effects

- Baseline column used
- Dynamic analyses conducted to assess local strain rates for a variety of near-fault records
- Ideal loading history established
- A small, but measurable rate effect was identified
- Plastic hinge length smaller than for cyclic loading, resulting in initial underestimate of flexural capacity





PIs: Ashford and Filiatrault

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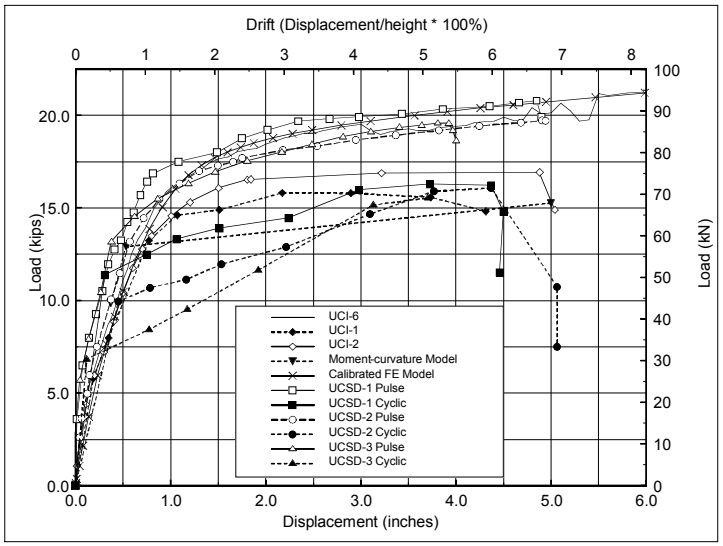
Effect of Loading History

Characterize sensitivity of response of spirally reinforced concrete columns having different aspect ratios to loading history (PI: Pardoen)

- Baseline column cross-section used
- Aspect ratios selected produce columns with little, limited or high ductility
- Traditional cyclic loading histories compared to ones initiated by pulses
- Strong analytical component



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Shaking Table Tests

PI: Mahin

Objectives:

- Data to validate analytical models
- Compare performance for near-fault and long-duration excitations
- Assess effects of multiple components of ground motion
- Assess cumulative damage models

	Unidirectional	Bidirectional
Earthquake 1 Olive View (Northridge, 1994)	Specimen A1	Specimen A2
Earthquake 2 Llolleo (Chile, 1986)	Specimen B1	Specimen B2

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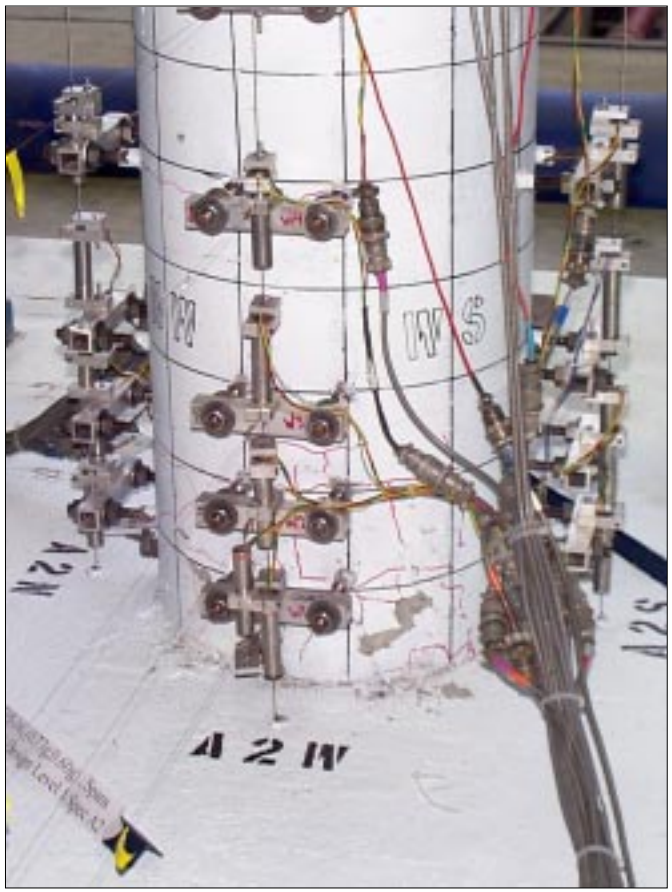
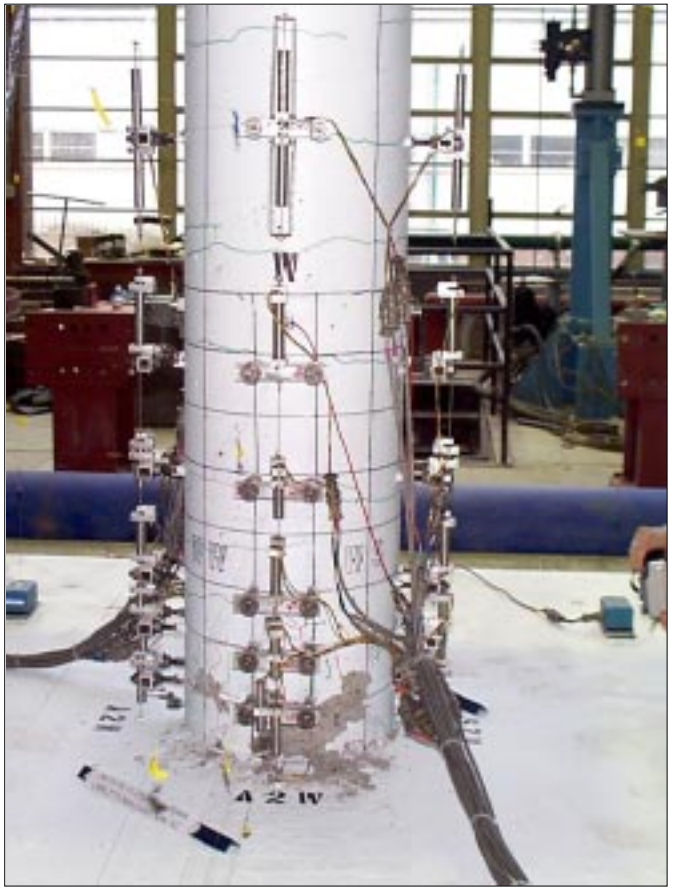
Column Performance



After Design Level Event (R=4)



After First Maximum Level Event (μ=6)

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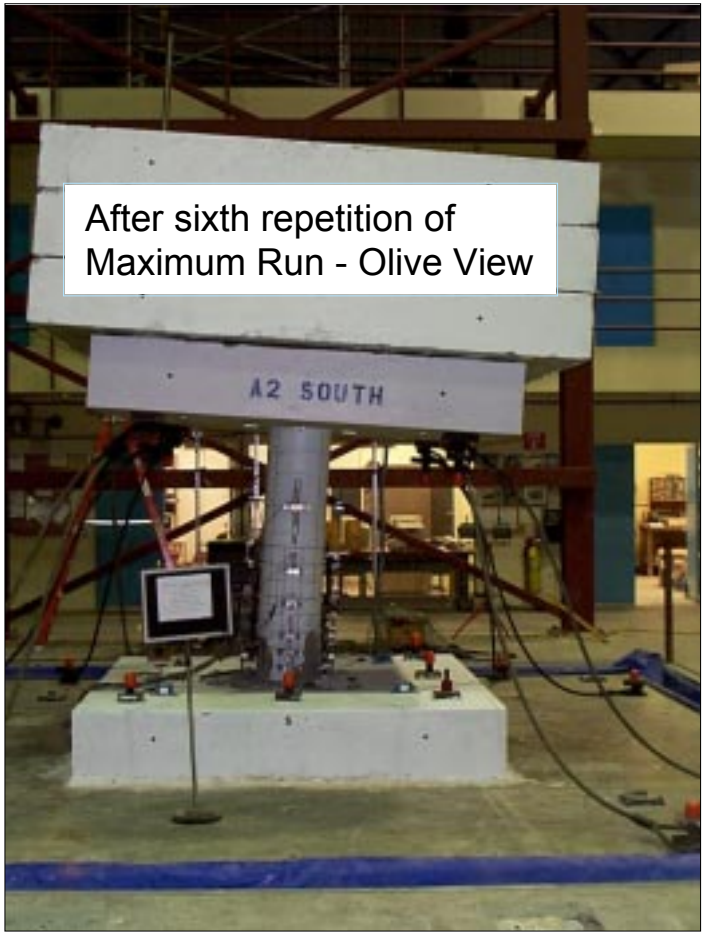
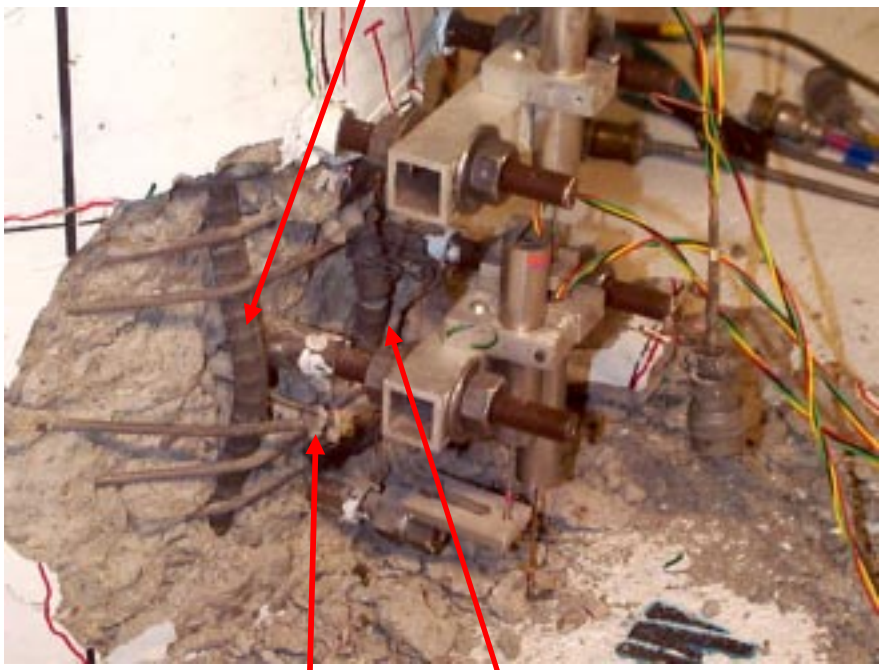
Condition at end of tests





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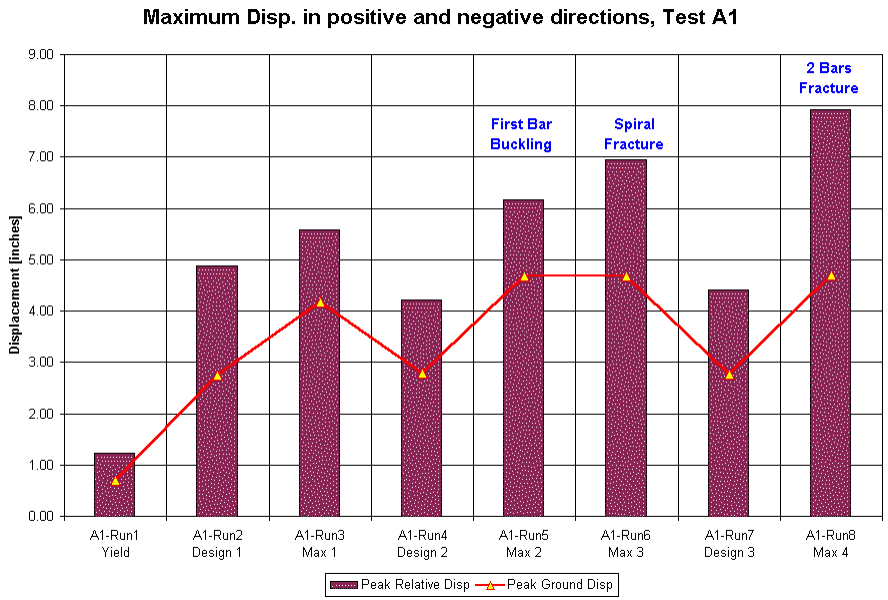
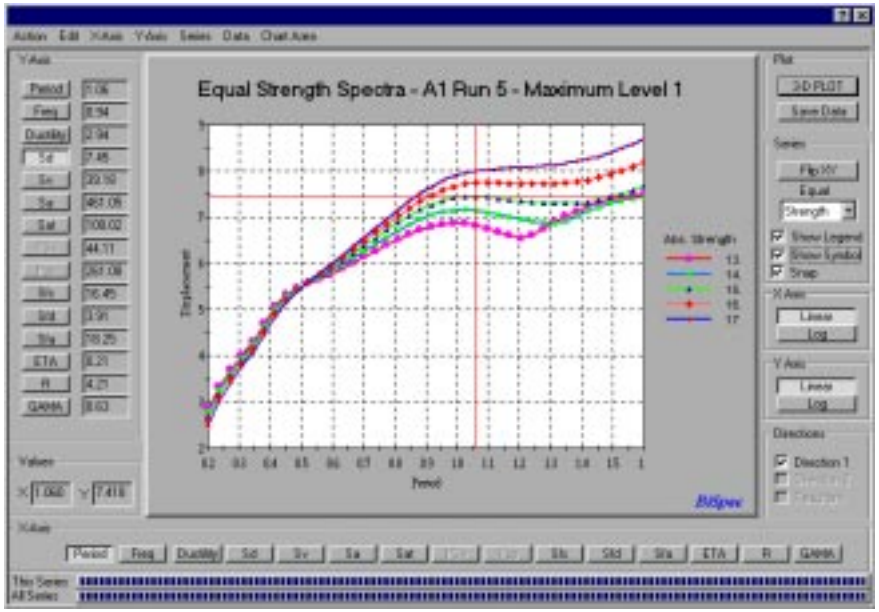
Peak Displacement Response





Bi-directional input has limited effect and in the cases considered extends life of column

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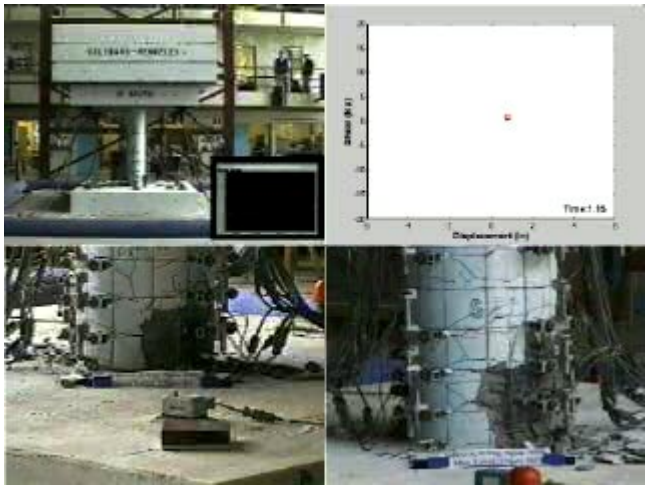
Long Duration Excitations



1985 Llolleo, Chile Record

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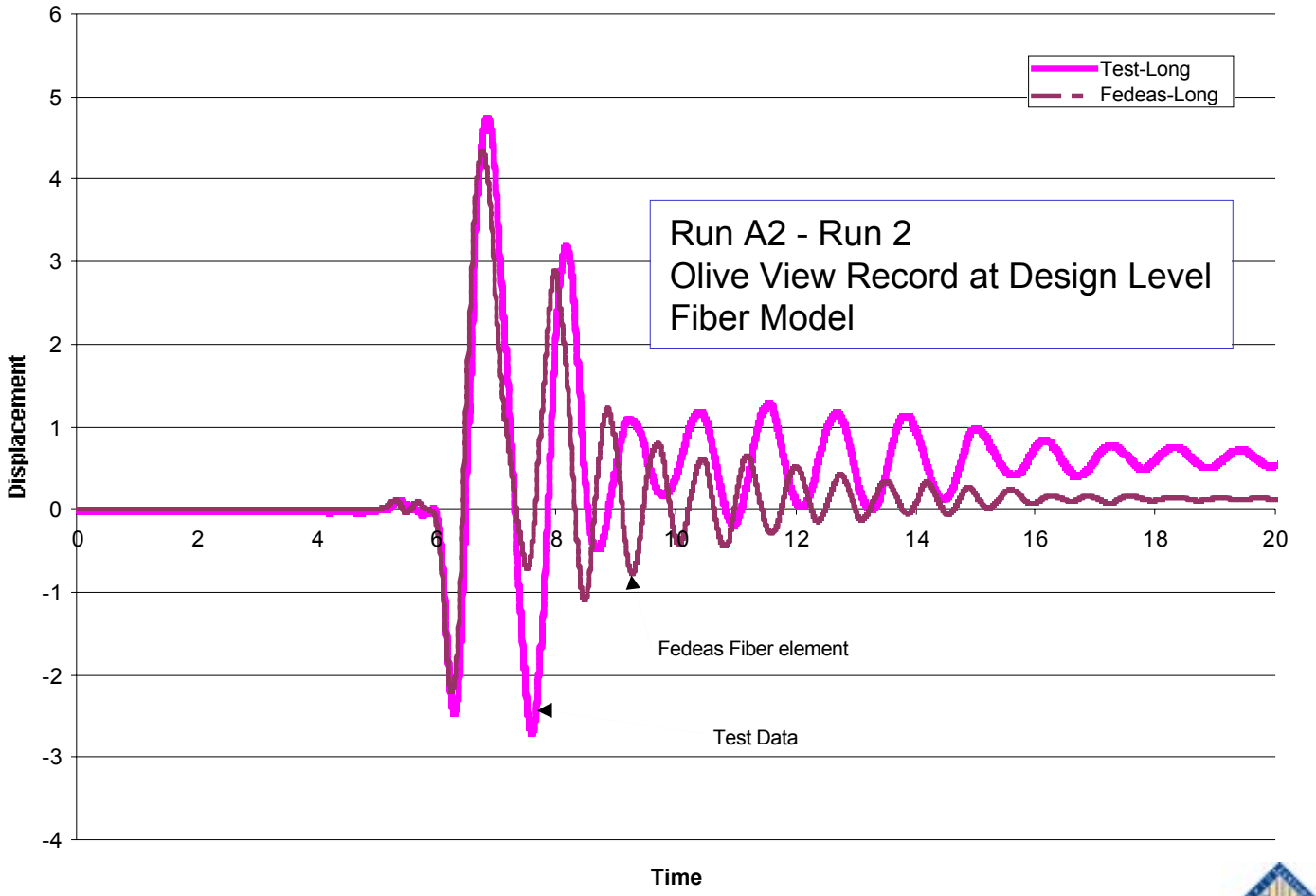
Correlation With Analysis



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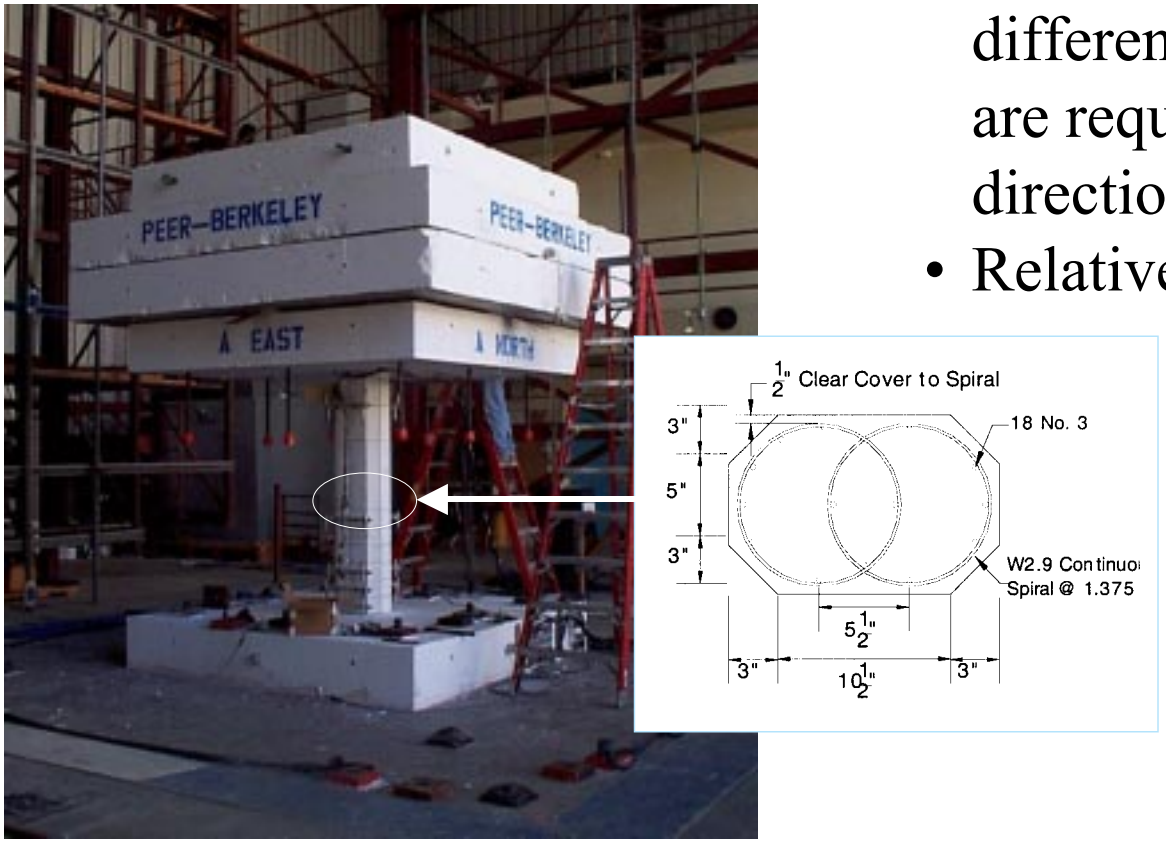
Interlocking Spiral Columns



- Column widely used where different strengths or stiffnesses are required along each direction
- Relatively little research

  Three specimens
  - 1/6 scale
  - 1% Long. steel
  - 1989 Los Gatos Record
    - •Strong axis only
    - •Bi-directional
  - Tabas Record
    - •Bidirectional

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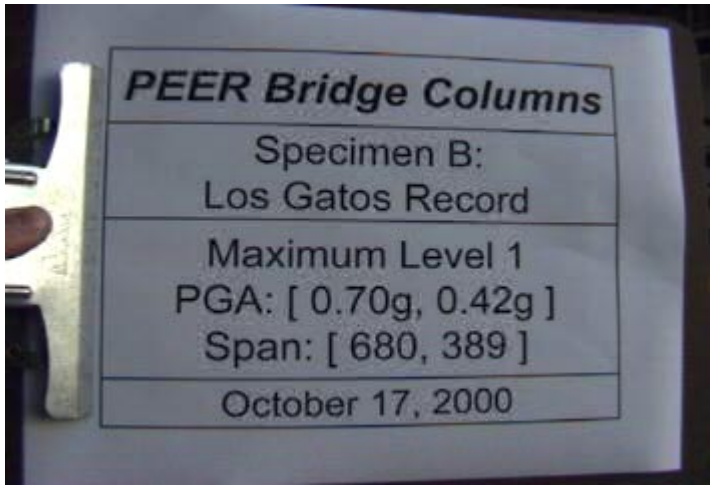
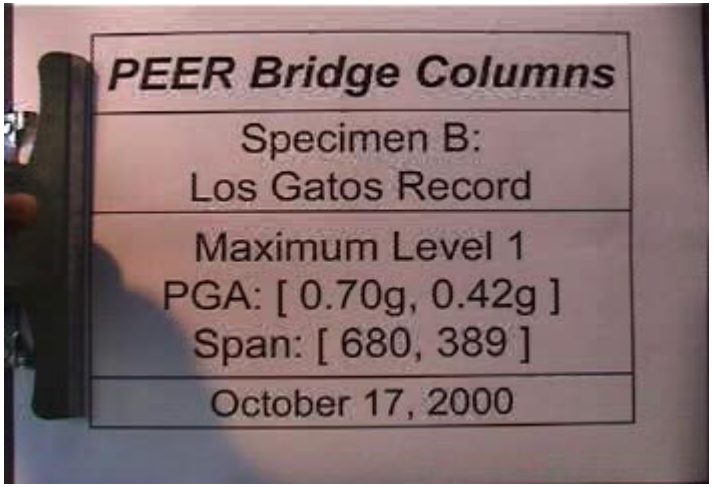
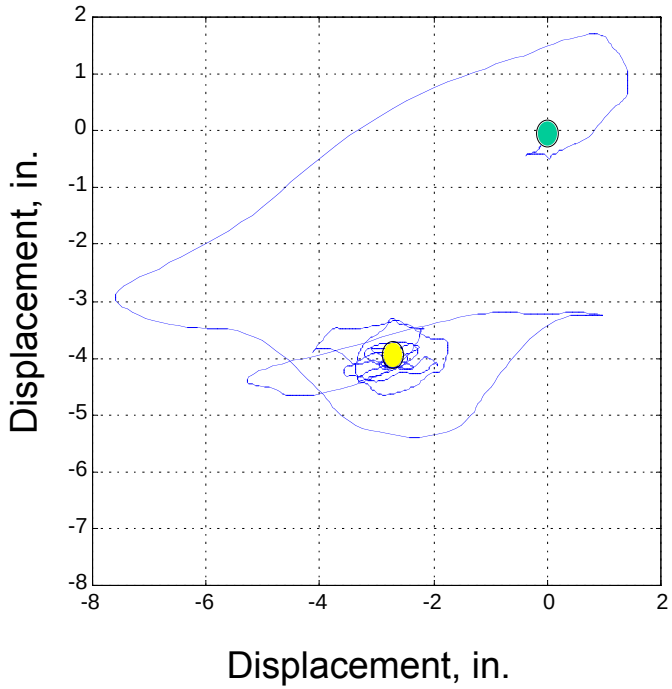
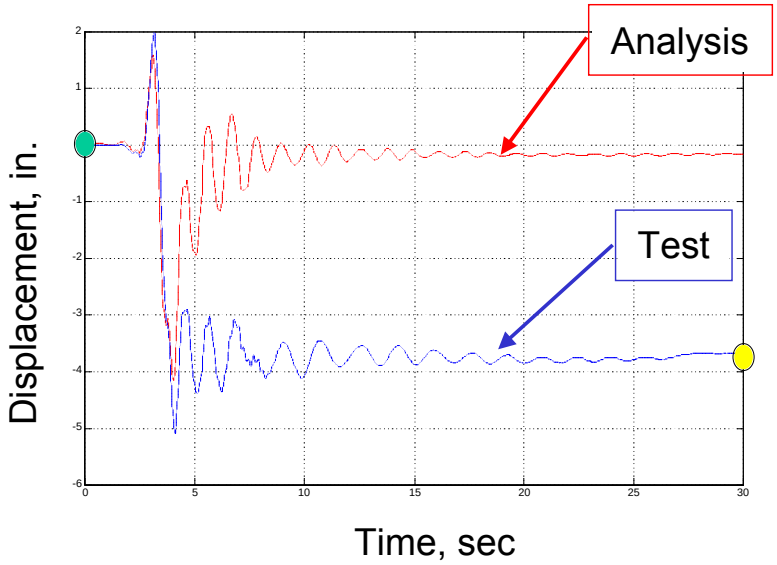
Interlocking Spiral Columns





Bi-directional Response





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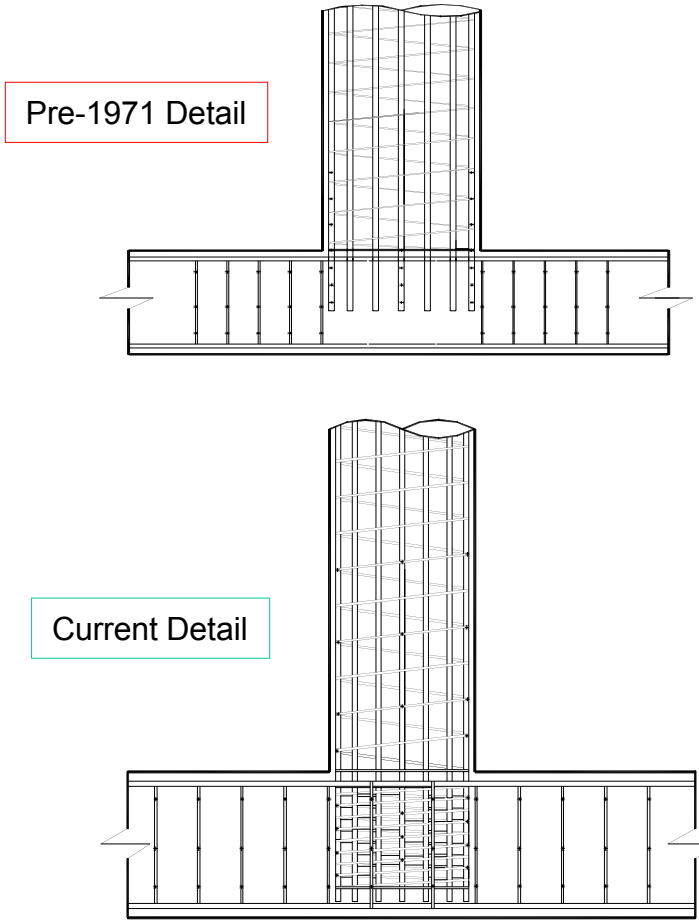
Connection behavior

- Assess effect of rate of loading on current and pre-1971 column to bent cap connection design details
- Four 1/2 scale models
- Cyclic and pulse-initiated cyclic load histories considered



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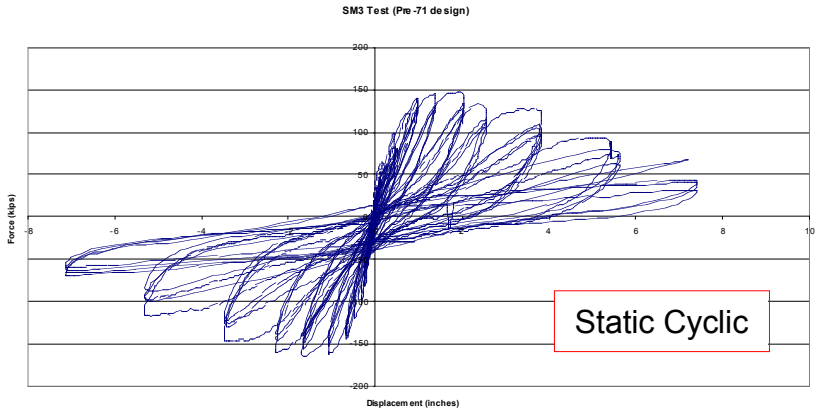
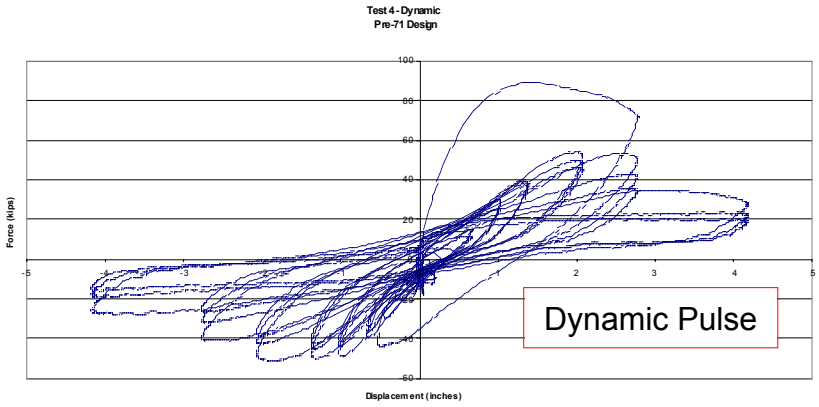
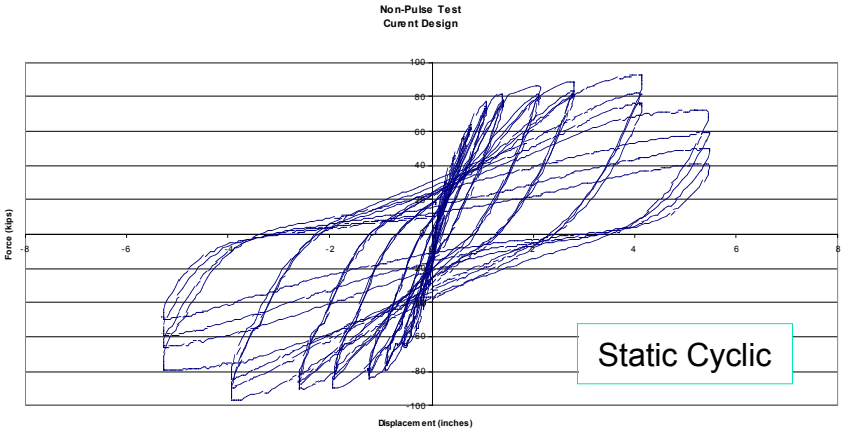
Connection Behavior

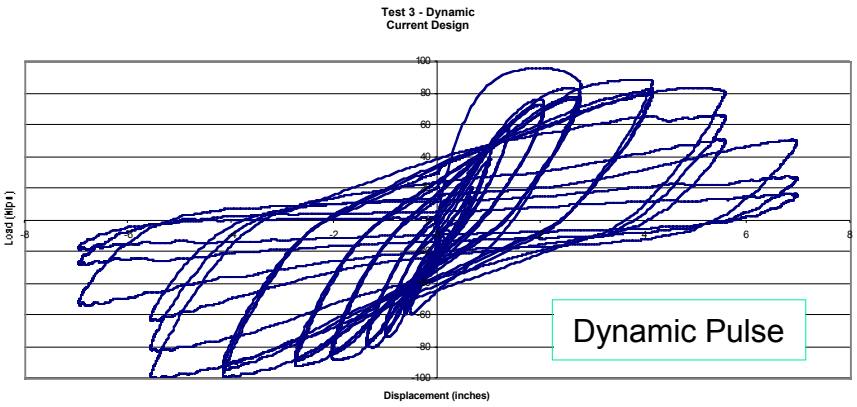
Pre-1971 Detail





Current Connection Detail





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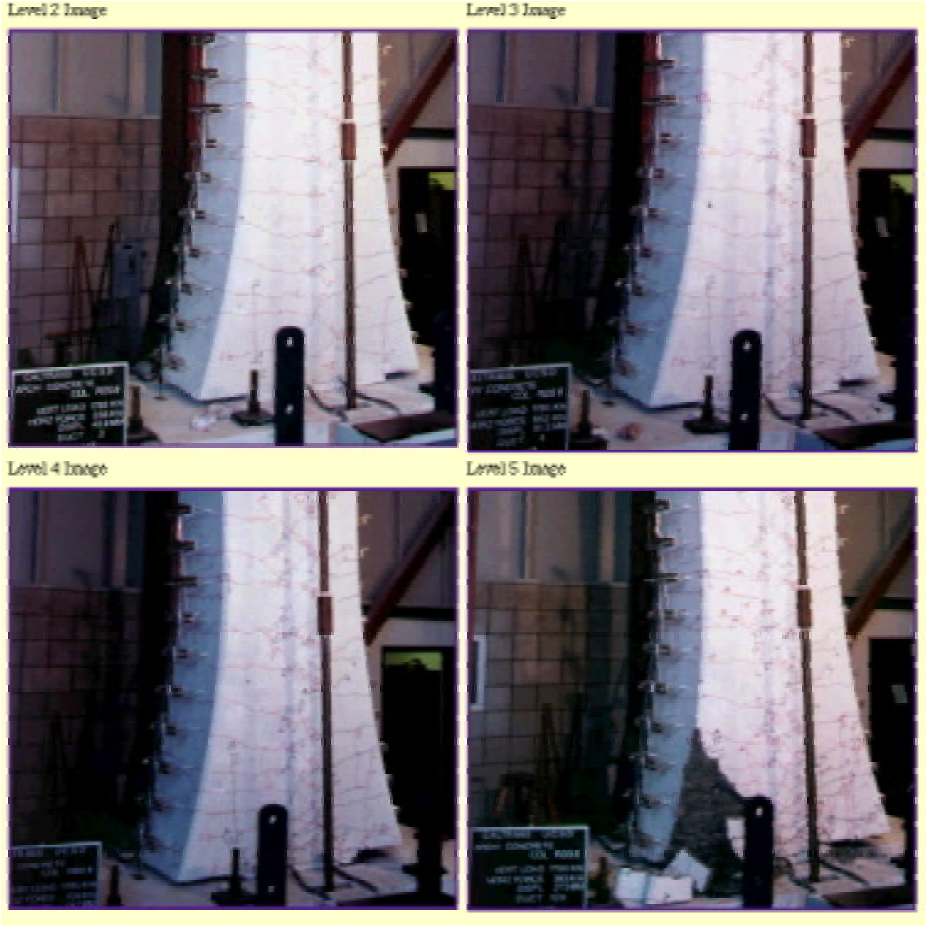
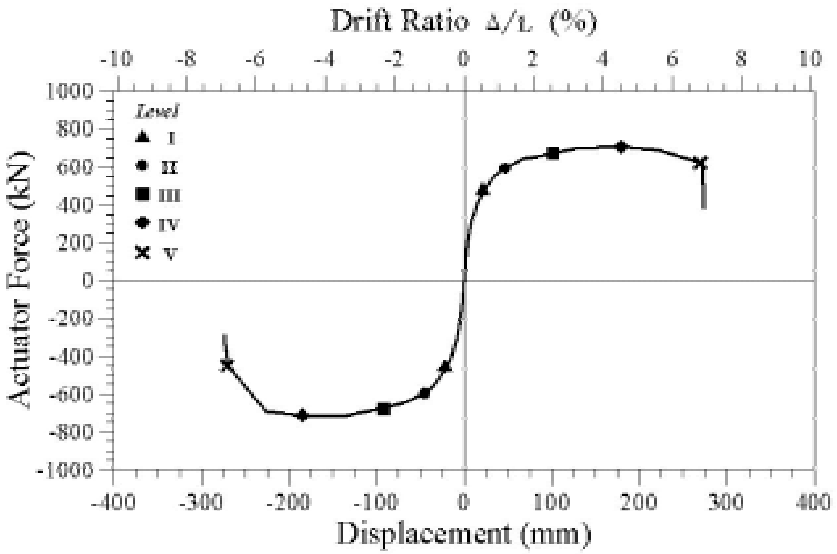
PEER Bridge Performance Database

http://www.structures.ucsd.edu/PEER/peer.html



Quantitative Definitions of Performance Levels Provided



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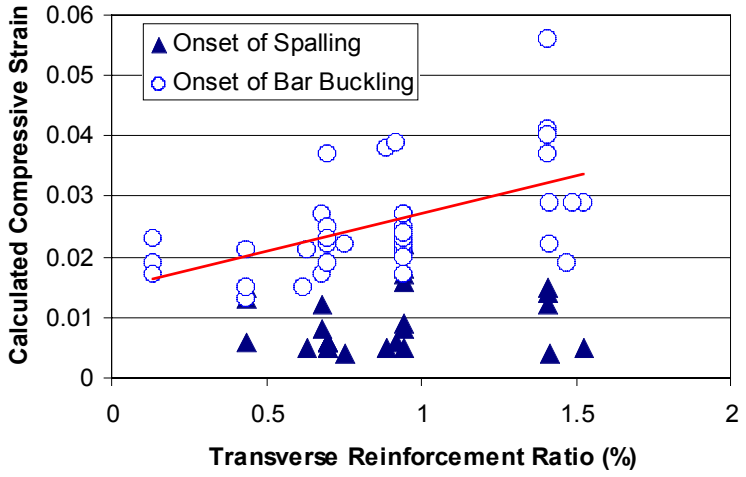
Performance Parameter Prediction

Uncertainties in Structural Performance Parameter Estimates (PI: Eberhard)

Assesses predictions of key performance (spalling, bar buckling) and modeling (strength, stiffness) parameters given demand estimates

- Database of 400+ column tests compiled (circular & rectangular)
- *http://ce.washington.edu/~peera1*
- Analysis models for various performance parameters established and evaluated using synthesized data



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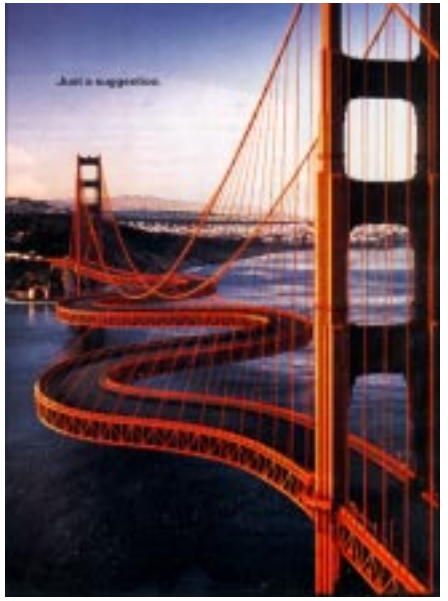
Pulling it all together

Fragility Assessment of Bridge Systems (PI: Seible, Elgamal, Conte)

- Test bed structures with real world complexity
- Seismic Hazard assessment
- Study of Damage Measures based on simplifying analytical assumptions
- Selection of Performance Measures
- Assessment of Capacity
- Evaluation of probability of achieving performance for a given hazard
- Integrate information/results developed by others
- Assess/improve methods
- Identify needed research

Future

- Pull information together and evaluate
- Assess and improve numerical models
- Theoretical issues related to element and system capacity definitions
- System level tests
- Modeling and assessment tools for: abutments, foundations, etc.
- Information on Decision Variables (direct and indirect costs, interruption of service)
- Assess performance objectives in view of results
- Work with transportation system group



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