A Constructible Bridge Bent Designed to Re-center after an Earthquake.

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Conventional Bridge Bent

- Cast-in-place concrete construction
Conventional Bridge Bent

- Slow to construct
Conventional Bridge Bent

- Susceptible to seismic damage
Conventional Bridge Bent

- Post-earthquake residual displacements
Proposed Improvements

- **Accelerate Construction**
  - Use precast components
  - (Connections are critical)

- **Reduce column damage**
  - Use rocking column approach
  - Columns rock as rigid bodies
  - Damage significantly reduced

- **Minimize residual displacements**
  - Use unbonded prestressing
Proposed Strategy

Precast Columns, Cap Beams and Girders

Confined Rocking Interface

Unbonded Pretensioned Columns

“Socket” Footing Connection
Accelerated Construction
Accelerated Construction
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Accelerated Construction
Accelerated Construction
Accelerated Construction
Field Deployment
(non-prestressed system)

Socket Connection

Cap-Beam Connection

I5, Grand Mound Bridge Replacement Project, 2012
Earthquake Damage
Sub-Assembly Tests
Sub-Assembly Tests
RC column after 10% drift
Rocking column after 10% drift
Post-Earthquake Residual Displacements
Precast, Pretensioned Column

- Bonded strand
- Unbonded strand
- Bonded strand
- Locally unbonded rebar
- Bonded rebar
- Discontinuous rebar
Moment-Rotation Behavior

Moment-Rotation

Strand + Rebar = Total
Moment-Rotation Behavior

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Moment-Rotation Behavior

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Moment-Rotation
Moment-Rotation Behavior

Strand + Rebar = Total

Moment-Rotation
Moment-Rotation Behavior

Moment-Rotation

Strand

+ 

Rebar

= 

Total
Moment-Rotation Behavior

Moment-Rotation

Strand + Rebar = Total
Moment-Rotation Behavior

Moment-Rotation

Strand  Rebar  Total

+   =
Moment-Rotation Behavior

Moment-Rotation

Strand + Rebar = Total
Quasi-static Test Results

Moment vs Drift Ratio

Drift Ratio [%]
-15 -10 -5 0 5 10 15

Moment [kip-in]
-4000 -3000 -2000 -1000 0 1000 2000 3000 4000
Shaking table tests
(without steel confining tube at interface)
Shaking Table Test Results

- Peak drifts: about the same
- Residual drifts: smaller in Pre-T column.
Upcoming Tests

- Quasi-static test on top connection (UW, Sept 2013)
- Shaking table tests on 3-bent bridge (UNR NEES, Spring 2014)
Conclusions
Pre-tensioned bent system

- **Accelerated Construction**
  - Pre-tensioned bent system uses essentially the same connections as the precast (non-ps) system, which has been successfully implemented in the field.

- **Seismic damage:**
  - Negligible concrete damage even at 10% drift.
  - Rebar fracture at approx. 5% to 6% drift.

- **Residual displacements:**
  - Much smaller than with RC columns
  - Approx. $0.1\delta_{peak}$. 
Thank You