A Precast Bridge Bent System for Seismic Regions

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Background

- Traffic congestion.
- Need to accelerate on-site bridge construction.
- Use precast concrete components.
- Connection details need to be:
  - seismic-resistant
  - readily constructible.
Background

Self-centering structural systems

- Unbonded prestressing tendons for elastic restoring force.
- Yielding steel for energy dissipation.
Project Tasks

1. Analysis of Residual Displacements.
   - Improve previous OpenSEES models.
   - Simulate responses for a range of bridge properties and ground motions.
   - Correlate degree of re-centering with structural details.

Work is ongoing (Haraldsson).
Project Tasks

2. **Self-centering performance.**
   - Laboratory tests to investigate ways of incorporating self-centering into ABC systems.

*Work is ongoing (Janes, Hung).*
Proposed Construction Procedure

1) Excavate footing.
Proposed Construction Procedure

2) Position and brace precast column.
Proposed Construction Procedure

3) Place footing reinforcement and cast.
Proposed Construction Procedure

4) Set cap-beam, grout bars into ducts.
5) Place girders, diaphragms and deck.
<table>
<thead>
<tr>
<th>Connection Details</th>
<th>c.i.p. RC (ref)</th>
<th>Precast RC</th>
<th>Precast prestressed</th>
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</thead>
<tbody>
<tr>
<td>Cap-beam to column</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
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<tr>
<td>Column to spread footing</td>
<td><img src="image4" alt="Diagram" /></td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
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<tr>
<td>Column to drilled shaft</td>
<td><img src="image7" alt="Diagram" /></td>
<td><img src="image8" alt="Diagram" /></td>
<td><img src="image9" alt="Diagram" /></td>
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</table>
Cap Beam Connection - Many small ducts

Conventional c.i.p. detail → precast.
Many ducts, tight tolerances.
Cap Beam Connection – Large bars

- 4ft diameter column
- 5ft x 3.5ft cap beam
- 6 # 18 rebar
- 8.5” corrugated steel ducts
- High strength grout
Cap Beam Connection – Seismic test

Failure occurs in the column.

Large-bar precast connection behaves the same as a cast-in-place connection.
Footing Connection - Construction

Note:
Headed bars
Footing Connection - Headed Bars

Headed bars provide good anchorage.

Internal forces:
Strut and Tie Model.
Footing Connection

Hooked bars facing out
(Conventional cip configuration)

Load transfer is tangential to hook.
Ineffective!
Spread Footing Connection - Test
Spread Footing Connection - Test

After seismic testing. Foundation undamaged.
Spread Footing Connection – Seismic Test

Failure in column.

Footing undamaged.

Behavior identical to conventional c.i.p. system.

Seismic performance exactly as wanted.
Spread Footing Connection
Conclusions

1. Shorter on-site construction time.
2. Simple to fabricate, transport and erect.
3. Footing undamaged in lateral load and vertical load tests.
4. Seismic performance as good as, or better than, conventional c.i.p. construction.
Spread Footing
Pre-tensioned system

1. Pre-tensioning solves corrosion problems perceived to exist in post-tensioning.

2. Pre-tension in a plant.
   - Good QC.
   - Special equipment and extra site time for post-tensioning are not needed.
   - Can add rebars for energy dissipation.

3. Configuration of connection to cap beam?
Pre-tensioned System Connections

PC cap-beam
Sleeved strand
Bonded rebar
Cracking plane
c.i.p. footing
Bonded strand
Spread Footing
Pre-tensioned system

1. Strand needs to be:
   • Debonded over much of column height.
   • Anchored at top and bottom.
   • Use epoxy strand for good bond?
Spread Footing
Pre-tensioned system

Specimens now being designed.

- One footing connection
- One cap-beam connection

Testing planned to start October 2010.
Field load testing