Precast Bridge Bents for Seismic Regions

John Stanton, Marc Eberhard
Philip Davis, Olafur Haraldsson, Todd Janes, Hung Viet Tran.

University of Washington, Seattle.

PEER TSRP Meeting
Berkeley 2011.05.02
Background

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

- Have developed a family of connections
- Mix and match to suit conditions
  - Large bars in grouted ducts (column to cap beam)
  - Socket connections (column to footing)
Background

Self-centering structural systems

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

Self-centering performance.

- Laboratory tests to investigate ways of incorporating self-centering into ABC systems.

Work is ongoing (Janes, Davis).
Proposed Construction Procedure

1) Excavate footing.
Proposed Construction Procedure

2) Position and brace precast column.
Proposed Construction Procedure

3) Place footing reinforcement and cast.
4) Set cap-beam, grout bars into ducts.
Proposed Construction Procedure

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>
</tr>
</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>
</tr>
<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>
</tr>
<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>
</tr>
</tbody>
</table>
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 - 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

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.
Site Implementation - Footing
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
- Bonded strand
- Cracking plane
- c.i.p. footing
- C.i.p. footing
Spread Footing
Pre-tensioned system

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

Test specimens.

- One footing connection
- One cap-beam connection
Test Specimens

Cap beam specimen

Footing specimen
Preliminary Results

1. Re-centering good up to 4% drift.
Load vs. Displacement
Preliminary Results

1. Re-centering good up to 4% drift.

2. Failure initiated by bar buckling, followed by fracture.

3. No strands broke.

4. Damage to concrete at interface, possibly promoted by stub bars from footing.
2% drift
6% drift
Next Steps

1. Assemble and test cap beam specimen.
2. Data analysis
3. Strand bond tests
The End