LATEST SEISMIC ABC
APPLICATIONS

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&

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California Department of Transportation
CALTRANS SEISMIC CONNECTIONS
RESEARCH & APPLICATION

- PC Column Connections
- PC Girder Connections
- Applications
- ABC System Bridge Tests
- NGB2 Research
- MTD 20-20 & Design Examples
- SDC 2.0
### Caltrans PC & ABC Seismic Research Contracts

#### PC Seismic Research at Caltrans

<table>
<thead>
<tr>
<th>Topic</th>
<th>Researcher</th>
<th>S&amp;S</th>
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<tbody>
<tr>
<td>NEB - Column Connections 65A0372-2176</td>
<td>UNR</td>
<td>$307,815</td>
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<td>CFT 1 - Footing Connections 59A061-1072</td>
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<td>CFT 2 - Bunt Cap Connections 65A0466-2417</td>
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<td>Column Pins &amp; Connections 65A0466-2423</td>
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<td>Column-Pile shaft 59A0710-1305</td>
<td>UCSd</td>
<td>$1,087,197</td>
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<td>PC Bridge Columns w/ Energy Jts 59A091-1999</td>
<td>UNR</td>
<td>$300,000</td>
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<td>Border Continuity 1 59A0615-2001</td>
<td>ISU</td>
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<td>Border Continuity 2 65A0411-2565</td>
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<td>Column Footing 65A0423-2281</td>
<td>UNR</td>
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<td>Structure Isolation for ABC-058 TO 1-59A0791</td>
<td>SCScnl</td>
<td>$357,000</td>
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<tr>
<td>Continuity Analysis TO 3 58A0791</td>
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<td>PC Full Depth Deck Panels 65A0353-2544</td>
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<td>$254,575</td>
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<td>ABC System Bridge(s) 65A0588-7757</td>
<td>UNR</td>
<td>$770,295</td>
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<td>Seismic Anchorage Performance 65A007-3022</td>
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<td>Recovery Column 65A0832-2877</td>
<td>UCSd</td>
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- **2008**
- **2019**

Total S&S: $6,454,385

- Completed Contracts
- Ongoing Contracts
LAUREL STREET OC
ROUTE 780, VALLEJO, CA 2018

Column to Cap Connection
UNR CA14-2176

Girder Continuity Connection
ISU CA16-2265

Precast Wide Flange Girder
Precast Drop Cap
Precast Column
Next Generation of Bridge Columns for ABC in High Seismic Zones

M. Tazarv, M. Saiid Saiidi

UNR CA14-2176

UHPC Filled Duct Connections
Plunged-No-Coupler (PCN)
SEISMIC PERFORMANCE OF PRECAST GIRDER-TO-CAP FOR ABC OF INTEGRAL BENTS

J. Vander Werff, R. Peggar, Z. Cheng, S. Sritharan
ISU CA16-2265

Extended Unstressed Strand Girder Continuity Connection

Table 1: Estimated Construction and Cost Risk for Girder Continuity Systems

<table>
<thead>
<tr>
<th>System</th>
<th>Construction Assembly Risk*</th>
<th>Cost *</th>
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<tbody>
<tr>
<td>Jrw-T</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Drop</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Drop-6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Mod Drop/CIP</td>
<td>3</td>
<td>2</td>
</tr>
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</table>

* 1-low, 5-high
Independent analysis of ISU results helped to verify the findings and can be used to develop other connections in the future.
CONNECTION DETAILS ON PLANS

Column to Cap

20 #14 bars thread through 4” ID UHPC filled ducts

Girder Continuity

Girder Continuity established by 8 overlapping prestressing strands extending out of the precast girder.
FABRICATION & ERECTION TOLERANCES BUILT INTO THE PLANS

Vertical tolerance in CIP locations

1’ 8” formed hole for 12” shear key

#14 bars (1.88” deformed diameter) in 4” ID ducts

Location, spacing and orientation of columns critical
UHPC IMPLEMENTATION

• Proprietary Procurement – Ductal JS1000
  • 14 ksi @ 4 days
  • 21 ksi @ 28 days
• Close coordination with FHWA and Lafarge during design and specification development
• Prequalification
• Work Plan
• Full Scale Mock Ups
  • #14 reinforcing bar pull out test
  • UHPC placement
ABC GUIDANCE & TOOLS

- Checklists
- Design Guidance
- Standard Details
- Special Provisions
- Checklists
- Design Examples

UHPC IMPLEMENTATION CHECKLIST

ABC PRECAST BRIDGE ELEMENTS CHECKLIST
PULL OUT TEST

#14 REINFORCING BAR IN UHPC FILLED DUCT

- Yield at 145 kips
- Peak load at 215 kips
- Rebar achieved ultimate strength
- Rebar remained bonded throughout testing
- No pullout of bar, UHPC, or corrugated duct
- Elongation of bar along debonded length
UHPC was placed as directed on the plans
All spaces filled, uniform distribution of fibers and accurate rebar location
Preassembly required of full size columns proved problematic

CT allowed contractor to use short columns and template compatibility

“Bullet” used to guide rebar into ducts
Construction - Precast Column Placement

Columns pinned at the bottom

Column placement template
Construction - Grouting of Column Pins & Placement of UHPC in Drop Cap

Non-shrink grout used at base of column

24 cubic feet of UHPC placed in column to cap connection voids
Construction - Girder Erection

Extended Strands for Continuity Connections
Laurel Street OC – Structure Complete January, 2018
MULTI-SPAN PRECAST ABC PILOT PROJECT
ROUTE 46/99 SEPARATION (REPLACE) 2019

Shafter, CA
Unstressed Strand
Loop Girder
Continuity
Connection
ISU CA16-2265
Experimental and Analytical Seismic Studies of Bridge Piers with Innovative Pipe Pin Column-Footing Connections and Precast Cap Beams

Mehrsoroush, M. Saiid Saiidi, CA14-2281

Pipe pin at base of column
Route 46/99 Separation ABC Pilot Project
Experimental and Analytical Seismic Studies of a Two-Span Bridge System with Precast Concrete Elements and ABC Connections

J. Benjumea, M. Saiid Saiidi, A. Itani
Report No. CCEER 19-02
(4) Grouted Duct Connection

- Previous research: UW-WDOT
- Guarantee strength and stability during erection of the girders and deck panels
- High early strength, non-shrink grout \( f'_{\text{gout}_{28d}} = 10.5 \text{kst} \)
(5) Girder-to-Cap Beam Connection for Positive Seismic Moment

- Previous research: Iowa State U.-Caltrans
- Moment resistance provided by the extended strands and dowel bars
- 2-stage CIP diaphragm:
  - Stage 1 (concrete $f_c = 4,000$ psi)
  - Stage 2 (UHPC $f_c = 21.5$ ksi)
- Four strands extended (36% of total strands per girder)
(5) Girder-to-Cap Beam Connection for Positive Seismic Moment

- No visible cracks in the girder-to-cap beam either in the interior or the exterior girders.
BRIDGE 2: Tested October, 2018
Cyclic Large-Scale Column Testing

Objectives:

- Emulate the structural and seismic behavior of the previously tested cast-in-place model using precast connections with non-proprietary cementitious composite material filled ducts.
- Compare the structural and seismic behavior of previously tested PNC details that used Ultra-High Performance Concrete filled duct connections
Deployed Research Becomes Standardized Design Guidance
THREE EXAMPLES BEING COMBINED AS ATTACHMENTS TO MTD 20-20
CT Seismic Policy: No-Splice Zones in Plastic Hinge Regions

8.2.2 Reinforcement Splices in Seismic Critical Members

8.2.2.1 No-Splice Zones

The “No-Splice Zones” for SCMs shall correspond to the plastic hinge regions specified in Section 5.3.2. No-Splice Zones shall be clearly identified on the plans.

Except as specified herein, splicing of main flexural reinforcement shall not be permitted in No-Splice Zones.

The No-Splice Zone in seismic critical members may be shown on the plans either as a fixed dimension or as a fraction of the height or length of the member.
### Splice Requirements for Main Longitudinal Reinforcement

<table>
<thead>
<tr>
<th>Member</th>
<th>Location</th>
<th>Splice Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>All SCMs</td>
<td>Inside plastic hinge region</td>
<td>Not allowed, except as specified in Section 8.2.2.1</td>
</tr>
<tr>
<td></td>
<td>Outside plastic hinge region</td>
<td>Ultimate butt</td>
</tr>
<tr>
<td>Type II Shaft</td>
<td>Top 20 ft</td>
<td>Not allowed</td>
</tr>
<tr>
<td></td>
<td>Elsewhere</td>
<td>Service</td>
</tr>
<tr>
<td>Piles within pile groups in class S1 soil</td>
<td>Everywhere</td>
<td>Lap</td>
</tr>
<tr>
<td>Bent Caps, Footings, and Pile Caps</td>
<td>Inside Critical Zone*1</td>
<td>Not allowed</td>
</tr>
<tr>
<td></td>
<td>Outside Critical Zone*2</td>
<td>Service</td>
</tr>
<tr>
<td>Superstructures</td>
<td>Inside Critical Zone*1</td>
<td>Not allowed</td>
</tr>
<tr>
<td></td>
<td>Outside Critical Zone*1</td>
<td>Service or Lap*2</td>
</tr>
</tbody>
</table>

*1 Critical zones for capacity protected members shall be taken as locations where the moment demand is greater than 75% of the maximum moment demand in the member.

*2 Service splice shall be used for reinforcement provided for longitudinal pushover analysis. Lap splice shall not be used to splice this reinforcement.
Precast Girder Connection Design Guidance