Seismic Performance of Next Generation Bridge Components for Accelerated Bridge Construction (ABC)

TEST MODEL: Headed Coupler Partial Pedestal (HCPP)

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Brief Project Description:

The use of prefabricated structural elements is an integral part of many accelerated bridge construction (ABC) efforts. The connection of these prefabricated elements to the rest of the structural system is critical to the performance of the structure under service loads and extreme events. This project investigates the seismic response of rigid connections between precast columns and footing. Five half-scale column models will be tested by reversed cyclic loading. The baseline model used in this study is a conventional cast-in-place reinforced concrete column; this model is denoted in this study as “CIP”. Caltrans Seismic Design Criteria (SDC) was used to determine internal reinforcing steel to achieve a displacement ductility of 5. Furthermore, all detailing used in the CIP model adhered to Caltrans specifications. The four other column models to be tested in this study are composed of hollow precast concrete shells that are rigidly connected to the footing using mechanical rebar couplers located within the plastic hinge zone. After the rigid connection is made, the hollow shells are filled with self consolidating concrete (SCC). Two different mechanical couplers were selected for testing based on an extensive review of available literature. Coupler selection criteria included: mechanical performance under static and dynamic loading, Caltrans pre-qualification, and applicability to rapid construction. The two coupler types selected were the HRC 500 series upset headed coupler and the NMB grout sleeve coupler. Two models incorporate partial pedestals in order to reduced demand on the coupler region. The data compiled will be compared with the performance of the columns with that of similar cast-in-place construction and any necessary refinements will be identified based on the data and analyses. The ultimate objective is to make recommendations to Caltrans regarding precast column connection details, design methodology, and construction techniques.

<table>
<thead>
<tr>
<th>Model ID</th>
<th>Coupler Type</th>
<th>Partial Pedestal</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIP</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>HCNP</td>
<td>HRC 500</td>
<td>No</td>
</tr>
<tr>
<td>HCPP</td>
<td>HRC 500</td>
<td>Yes</td>
</tr>
<tr>
<td>GCNP</td>
<td>NMB Sleeve</td>
<td>No</td>
</tr>
<tr>
<td>GCPP</td>
<td>NMB Sleeve</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Column Model Details:

<table>
<thead>
<tr>
<th>Height in (mm)</th>
<th>Diameter in (mm)</th>
<th>Longitudinal Steel Ratio [%]</th>
<th>Transverse Steel Ratio [%]</th>
<th>Aspect Ratio</th>
<th>Axial Load kip (kN)</th>
<th>Axial Load Index [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>108 (2743)</td>
<td>24 (610)</td>
<td>1.92</td>
<td>1.05</td>
<td>4.5</td>
<td>203 (903)</td>
<td>10</td>
</tr>
</tbody>
</table>

Concrete & Grout Properties

<table>
<thead>
<tr>
<th>Component</th>
<th>7 – Day Strength psi (MPa)</th>
<th>28 – Day Strength psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footing (Conventional Concrete)</td>
<td>3751 (25.8)</td>
<td>5006 (34.5)</td>
</tr>
<tr>
<td>Column Shell/Pedestal (Conventional Concrete)</td>
<td>2974 (20.5)</td>
<td>3826 (26.4)</td>
</tr>
<tr>
<td>Column Core (SCC)</td>
<td>3505 (24.1)</td>
<td>-</td>
</tr>
<tr>
<td>Pedestal Duct Grout (W. R. Meadows 588-10K)</td>
<td>5724 (39.4)</td>
<td>7713 (53.1)</td>
</tr>
<tr>
<td>Coupler Region Grout (Sika 212)</td>
<td>5942 (40.9)</td>
<td>-</td>
</tr>
</tbody>
</table>

Steel Properties

<table>
<thead>
<tr>
<th>Expected Properties</th>
<th>f_y psi (MPa)</th>
<th>f_u psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse Bars: #3</td>
<td>68,000 (468)</td>
<td>95,000 (655)</td>
</tr>
<tr>
<td>Longitudinal Bars: #8</td>
<td>68,000 (468)</td>
<td>95,000 (655)</td>
</tr>
</tbody>
</table>
Loading Protocol: Drift vs. Cycle
Pushover Curve
Model Reinforcement Details

Loading Direction

W → E

Precast Shell Details in Coupler Region

Section B-B

1'-2"

#3 Spiral
2" Pitch

1'-4"

4"

11 - #8 bars

Section A-A

1'-2"

#3 Spiral
4" Pitch

11 - #3 bars

Section
B-B

Section
A-A

3' - 9"

2'

1' - 3"

6"

9'

8'

2' - 8\(\frac{1}{8}\)"

5' - 10"
Instrumentation: Strain Gages
Instrumentation: Displacement and Rotation
Test Set-up

- Strong Floor
- MTS - 220 kip Actuator
- Hollow-core Jacks
- Axial Load Spreader Beam
- Steel Bearing Plate
- High Strength Threaded Rods
- Grout Pad

WEST ↔ EAST