Project:
PRECAST BRIDGE COLUMNS WITH ENERGY DISSIPATING JOINTS

Test Model:
SF-2 (1/3-Scale Precast Segmental Column with FRP)
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Abstract:

Conventional bridge construction involves a time consuming process associated with traffic delays and risk to public safety. In contrast, prefabricated bridge systems can expedite construction, thus minimizing traffic delays and construction site safety risk. Under moderate and strong earthquakes, it is essential for bridge columns to dissipate energy through nonlinear deformations in plastic hinges. Existing details for precast segmental columns offer minimal energy dissipation as a result of the discontinuity of longitudinal reinforcement; therefore, precast members are not used in high seismic zones.

A series of innovative precast concrete segmental columns are being developed and studied at the University of Nevada, Reno through a research project funded by the California Department of Transportation. The purpose of the study is to develop precast columns that are able to dissipate energy under cyclic loading. The first phase of this project involved analytical and experimental study of a segmental concrete column incorporating an elastomeric bearing pad in the plastic hinge. The second phase of the project includes designing and testing three different segmental concrete columns with different low-damage plastic hinges. In one column a conventional reinforced concrete detail is used and it is called SC-2 (Segmental with Concrete). The other two columns incorporate ECC (Engineered Cementitious Composite) referred to as SE-2 (Segmental with ECC) and FRP wrap referred to as SF-2 (Segmental with FRP) at the lower two segments, respectively.

SF-2 is a one-third scale precast segmental concrete column in which the first two segments are wrapped with two layers of FRP. The longitudinal steel dowels connect the base segment to the footing. A central high strength unbonded post tensioning rod is used to connect the segments and minimize the residual displacements. Energy dissipation is expected to take place mostly through the yielding of the longitudinal bars at base segment. The column will be subjected to the Sylmar earthquake (Northridge 1994) ground motion. The amplitude will be increased until failure. FRP wrapping provides confinement for the concrete and increases its ductility. It is expected to observe less concrete crushing, due to the gap opening, at the interface of base and second segments.
## Model Details Summary

<table>
<thead>
<tr>
<th>Column Height [inch]</th>
<th>Column Diameter [inch]</th>
<th>Longitudinal Steel ratio in first segment [%]</th>
<th>Transverse Steel ratio in all segment [%]</th>
<th>Aspect Ratio [%]</th>
<th>Axial Load [kips]</th>
<th>Axial Load Index</th>
<th>Scale</th>
<th>Subjected ground Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>72</td>
<td>16</td>
<td>1.00</td>
<td>1.41</td>
<td>4.5</td>
<td>80</td>
<td>111</td>
<td>21</td>
<td>17.33</td>
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</tbody>
</table>

## Rebar Properties

<table>
<thead>
<tr>
<th>Reinforcement</th>
<th>f_y [ksi]</th>
<th>f_u [ksi]</th>
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</thead>
<tbody>
<tr>
<td>Longitudinal bars</td>
<td>64</td>
<td>94</td>
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</table>

## Concrete Properties

<table>
<thead>
<tr>
<th></th>
<th>7 Day Strength [ksi]</th>
<th>28 Day Strength [ksi]</th>
<th>Test Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Footing and Third Segment</td>
<td>5.22</td>
<td>7.31</td>
<td>Pending</td>
</tr>
<tr>
<td>Base Segment</td>
<td>3.13</td>
<td>5.45</td>
<td>Pending</td>
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<tr>
<td>Second, Forth Segments</td>
<td>3.81</td>
<td>5.21</td>
<td>Pending</td>
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</table>
Note: For testing, a time compression factor of 0.577 is used.

Sylmar EQ Time Histories
<table>
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<tr>
<th>Run No.</th>
<th>X Sylmar</th>
<th>PGA [g]</th>
<th>Predicted</th>
<th>Achieved</th>
<th>Comment</th>
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<td>1</td>
<td>0.1</td>
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<td>9.77</td>
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<td>WN2</td>
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<tr>
<td>2</td>
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<td>0.15</td>
<td>0.41</td>
<td>18.36</td>
<td>0.57</td>
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<td>WN3</td>
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<td>3</td>
<td>0.5</td>
<td>0.305</td>
<td>1.61</td>
<td>25.3</td>
<td>2.23</td>
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<td>1</td>
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<td>6.08</td>
<td>33.94</td>
<td>8.44</td>
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<td>WN8</td>
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</table>
Force-Displacement under Sylmar Groundmotion SF-2
X0.1, 0.25, 0.5, 0.75, 1, 1.25, 1.5
Lift Bars
2 # 5
Opening 11" x 11"
Height 7"

Thread bar 1 5/8" diameter
Prestressing Unbonded Tendon Force=111kips

8 # 4
Longitudinal Bars

1/2 inch Cover Thickness

PVC Pipe dia.2.5 inch
thickness 0.25 inch

#3 @ 2.0 in
Spiral

#3 @ 4.0 in
Spiral
FRP Wrap

3/4 inch Cover Thickness

8 # 4
Longitudinal Bars

PVC Pipe dia.2.5 inch
thickness 0.25 inch

#3 @ 4.0 in
Spiral

16 in

2 Layers of FRP Wrap
0.04 inch each layer Thickness
Unidirectional in hoop dir.

16 in

116 in

36 in

72 in

25 in

#3 @ 4.0 in
Spiral

PVC Pipe dia.2.5 inch
thickness 0.25 inch

Base Segment

10 # 4
Longitudinal Bars

2 Layers of FRP Wrap
0.04 inch each layer Thickness
Unidirectional in hoop dir.

16 in

25 in

116 in

Column View
sg59 @ 50" Hight
sg60 @ 50" Hight
sg61 @ 100" Hight
sg62 @ 100" Hight

Strain gauges on
Post-tensioning Rod