Extending application of SDCL steel bridge system to ABC applications in seismic regions

By

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WHAT IS SIMPLE FOR DEAD LOAD AND CONTINUOUS FOR LIVE LOAD (SDCL) STEEL BRIDGE SYSTEM?

simple for dead load

continuous for live load
Resulting moments in SDCL system because of dead and live loads

Dead Loads

Live Loads

Conventional System

SDCL System
M+ Increases
M- Decreases
No Bolted Connection
Ease of Construction
More stable system
Enhanced Service life
NEGATIVE MOMENT MECHANISM

Tension Reinforcement over middle support to resist tension force
About 2%

Region over Middle support

Mechanism to transfer compression force
EXAMPLE OF DETAIL OVER PIER: NON-SEISMIC APPLICATION
Need about 2% Steel to resist tension
SDCL: ABC APPLICATION – NON-SEISMIC
SDCL: ABC APPLICATION – NON-SEISMIC

- Cope Top Flange
- Longitudinal Reinforcement
- Deck
- Girder
- Bearing Blocks
Each module can be constructed without temporary bracing and simply supported at the ends - worker safety
Deck can be partial or full thickness
Railing can be cast before or after
Placing modules over bridge supports
For span of about 135 ft, each module weigh less than 100 tons
No span limitation
Small shrinkage and creep deflection
Result in matching elevation of Adjacent units.
For more detail information see archived webinars

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HIGH SEISMIC DETAIL: SDCL
SEISMIC SYSTEM SELECTED

- ERS-1 feasible for SDCL test
- Deformation under the longitudinal component of earthquake loads
SEISMIC DETAIL

Push-down loading

Simulating gravity loads

Push-up loading

Simulating vertical component of seismic loads

Inverse loading

Simulating longitudinal component of seismic loads
SEISMIC DETAIL
ABC Application of SDCL Using Envisioned Connection
Steps in the investigation

1- Develop the connection detail – **Completed**

2- Carry out a component test to study the behavior of the proposed connection detail – **Completed**

3- Carry out Shake table test – Will be completed late this year or early next year

4- Propose a complete design criteria
PROTOTYPE BRIDGE
COMPONENT TEST

Design of Test Specimen
COMPONENT TEST

Test Setup
COMPONENT TEST
Design of Test Specimen

- Scale down test model
- Dimensions: Scaled down to 1/3
- Reinforcements: Redesigned
COMPONENT TEST

Design of Test Specimen

- Design requirements
  - Capacity protected member were designed to remain elastic
  - Predefined damage areas (plastic hinge locations) must be forced at locations away from diaphragm
## Component Test

### Design of Test Specimen

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Required</th>
<th>Provided</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{st}$</td>
<td>3.72</td>
<td>3.72</td>
<td>Column Longitudinal 12 #5</td>
</tr>
<tr>
<td>$A_{iv}^j$</td>
<td>0.744</td>
<td>0.88 &amp; 0.77</td>
<td>Vertical bars 8 #3 for area 3 and 4, 7 #3 for area 1 and 2</td>
</tr>
<tr>
<td>$A_{ih}^j$</td>
<td>0.37</td>
<td>0.88</td>
<td>Horizontal bars 2 set of 4 #3 on each side of column</td>
</tr>
<tr>
<td>$A_{sf}^j$</td>
<td>0.2</td>
<td>0.33</td>
<td>Side bars 3 #3 each side</td>
</tr>
</tbody>
</table>
COMPONENT TEST

Test Setup
Construction sequence
1- Deck
2- Cap-beam and Diaphragm
3- Column
COMPONENT TEST

Construction

Step 1: Deck
COMPONENT TEST

Construction

Step 2: Cap-beam & Diaphragm
COMPONENT TEST

Construction

Step 2: Cap-beam & Diaphragm
COMPONENT TEST

Construction

Step 2: Cap-beam & Diaphragm
COMPONENT TEST

Construction

Step 3: Column
COMPONENT TEST

Construction
COMPONENT TEST

Test Setup
COMPONENT TEST

Test Setup

Lateral load

Axial load
COMPONENT TEST
Results
COMPONENT TEST

Results

- First observed crack in Cap-beam at $3\Delta_y$ displacement

Crack on Cap Beam
COMPONENT TEST

Results

- Cracks propagating in cap-beam
COMPONENT TEST: SDCL-SEISMIC

Results

- Failure mode
- Buckling and fracture in reinforcing bars (column)
- 20% strength degradation
COMPONENT TEST: SDCL - SEISMIC

Results

- Load-Displacement Curve
COMPONENT TEST

Results

- Strain measurements in column
COMPONENT TEST

Results

- Strain measurements in cap-beam dowel bars (south)
COMPONENT TEST

Results

- Strain measurements in deck
COMPONENT TEST

Results

- No cracks formed in deck
- Picture taken under the specimen
COMPONENT TEST

Results

- Curvatures at different displacement levels
CONCLUSIONS FROM COMPONENT TEST

• The envisioned connection detail to extend SDCL steel bridge system to high seismic areas behaved as designed.
• Plastic hinge formed at the end of column and connection design prevented the cap beam (capacity protected element) from damaging.
• The cracking at the cap beam is believed to be result of scaling. However, this needs to be further investigated.
CONCLUSIONS FROM COMPONENT TEST

- Conducting non-linear finite element analysis of the proposed connection detail continues and necessary adjustment to the connection detail will be incorporated before shake table test.

- Shake table test on 1/3 scale model of the prototype bridge will be conducted late this year or early next year.
At the conclusion of project, complete details, design and construction recommendations will be developed to extend the application of SDCL to high seismic areas.
THANK YOU!