Genesee Avenue
Pedestrian Overcrossing
(a concrete bridge with a high degree of curvature)

PRESENTED BY:
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Project Location

- Interstate 5
- City of San Diego (Between La Jolla & Del Mar)
Genesee POC Overview

- Component of the I-5 / Genesee Ave Interchange Project
- Will serve as a grade separation to carry pedestrians and bicycles over Genesee Avenue
- Unique project due to high curvature
The Design Team

- Kimley-Horn: Prime Consultant – Civil Design
- Simon Wong Engineering: Major Sub – Structures Design
- Caltrans District 11
  - Geotechnical
  - Landscape
  - ROW
  - Existing Utilities
Bridge Description

- 2-span CIP reinforced concrete box girder
- Two equal spans of 130’-0”
Bridge Description

- Supported on a single-column bent and diaphragm abutments
Bridge Description

- Highly curved $R = 115' \text{-} 0''$
Architectural Features

- Curve to provide a uniquely shaped signature structure
Can we clear span the roadway?
Architectural Features

- Tapered octagonal column
Architectural Features

- Pilasters behind each abutment
Architectural Features

- Weathering “Cor-ten” steel railing
Architectural Features

- Weathering steel plates and lights in pilaster recess
Architectural Features

- Lighting integrated into exterior concrete barrier face

- Formliners
  “Random Flute Texture”

- Integral color concrete
  “Mesa Buff”
Design Methodology

- AASHTO LRFD Bridge Design Specifications (4th Edition) with Caltrans Amendments
- Central angle of each span ($64^\circ$) > $34^\circ$

2011 CA Amendment to AASHTO 4.6.1.2.3 requires the use of a 6 degrees of freedom 3-D analysis method

- AASHTO Commentary refers to NCHRP Report 620 as the basis for this new requirement
Design Methodology

- NCHRP Report 620 was adopted as a design guideline
- Report shows that results of 3-D finite element models and grillage models under gravity loads are close

Grillage Model Used for Design
3-D Finite Element Model Used for Independent Check
Grillage Model

- Longitudinal beams along each girder line located at the CG of half-section
- Transverse beams model bridge deck, soffit and all diaphragms along span
Grillage Model

- Longitudinal elements:

- Transverse elements:

- b tributary such that each segment central angle < 3.5°
Grillage Model

- Using gross section properties:

\[ T_{\text{permanent}} = 90\% \ T_{\text{crack}} \]
\[ T_{\text{serv I}} = 120\% \ T_{\text{crack}} \]

What torsional stiffness to use?
Grillage Model

- 2 boundary conditions to design for shear and torsion:

\[ J_{\text{crack}} = 5\% \ J_{\text{gross}} \] (typically used for seismic design)

\[ J_{\text{crack}} = 20\% \ J_{\text{gross}} \]
Detailing for Torsion

- Torsional reinforcement forms a closed loop
- Anchored by 135° standard hooks
Camber

- Long-term creep factor of 4.0 applied to deflections calculated with $J_{\text{gross}}$
- Two camber diagrams provided (one for each girder)
- Additional deflections due to cracked torsional stiffness checked, but not applied to camber
3-D Finite Element Model

- Created with CSI Bridge using thin shell elements
- Used to confirm adequacy of grillage
- Used for independent check

CSI Bridge 3-D Finite Element Shell Model
Initial Vertical Deflection Comparison

- **Grillage vs. Spine** – grillage 30% lower
- **Shell vs. Spine** – shell 68% higher
- **Qualitatively should be** Spine < Grillage < Shell

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<thead>
<tr>
<th>Analysis Method</th>
<th>Stiffness Modification</th>
<th>D Average (in)</th>
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</thead>
<tbody>
<tr>
<td>Spine model</td>
<td>Jeff = 0.05*J</td>
<td>-1.98</td>
</tr>
<tr>
<td>Grillage model</td>
<td>Jeff = 0.05*J</td>
<td>-1.45</td>
</tr>
<tr>
<td>Shell model</td>
<td>F12eff = 0.05*F12</td>
<td>-3.33</td>
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- Initial approach for grillage based was only softening “J” for longitudinal girder elements.
- Also need to reduce vertical shear stiffness of longitudinal members
Vertical & Torsional Deflection Comparison

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<th>D Exterior Girder (in)</th>
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<tr>
<td>Spine model</td>
<td>None (gross)</td>
<td>-1.10</td>
<td>-1.33</td>
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<tr>
<td>Grillage model</td>
<td>None (gross)</td>
<td>-1.09</td>
<td>-1.32</td>
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<tr>
<td>Shell model</td>
<td>None (gross)</td>
<td>-1.19</td>
<td>-1.41</td>
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<tr>
<td>Spine model</td>
<td>$\text{Jeff} = 0.2\times J$</td>
<td>-1.16</td>
<td>-1.69</td>
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<tr>
<td>Grillage model</td>
<td>$\text{Jeff} = 0.2\times J, \text{Aveff} = 0.2\times Av$</td>
<td>-1.44</td>
<td>-1.90</td>
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<tr>
<td>Shell model</td>
<td>$F_{12\text{eff}} = 0.2\times F_{12}$</td>
<td>-1.58</td>
<td>-2.10</td>
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Dead load deflection (x50 scale) of shell model
Comparison of deflections showed reasonably close results between grillage and 3-D model for all torsional stiffness assumptions.
Since deflections of grillage are similar to shell model, grillage approach is appropriate
→ Use grillage for design (with spreadsheets)

Use solid CSIBridge model for Independent Check (superstructure design)
Peer Review

- Performed by bridge expert from University of Nevada, Reno
- Reviewed analysis of grillage and 3-D finite element models
- Reviewed deflections and flexure/shear/torsion demands
- Provided recommendations for box girder detailing
References

- AASHTO LRFD Bridge Design Specifications (4th Edition) with Caltrans Amendments
- NCHRP Report 620
- “Bridge Deck Behavior” by Edmund Hambly
- “ACI Shear and Torsion Provisions for Prestressed Hollow Girders” by Thomas Hsu
Lessons Learned

- Design beyond what common software can handle
  - Use of spreadsheets → budget
- Variation of approach for non-standard design
  - (Grillage vs. FEM, etc.) → methodology check
- Value of Independent Check
- Value of Peer Review Process

Future Work

- Monitor torsional deflections and disseminate case study information
Questions?