Genesee Avenue Pedestrian Overcrossing

(a concrete bridge with a high degree of curvature)

PRESENTED BY:

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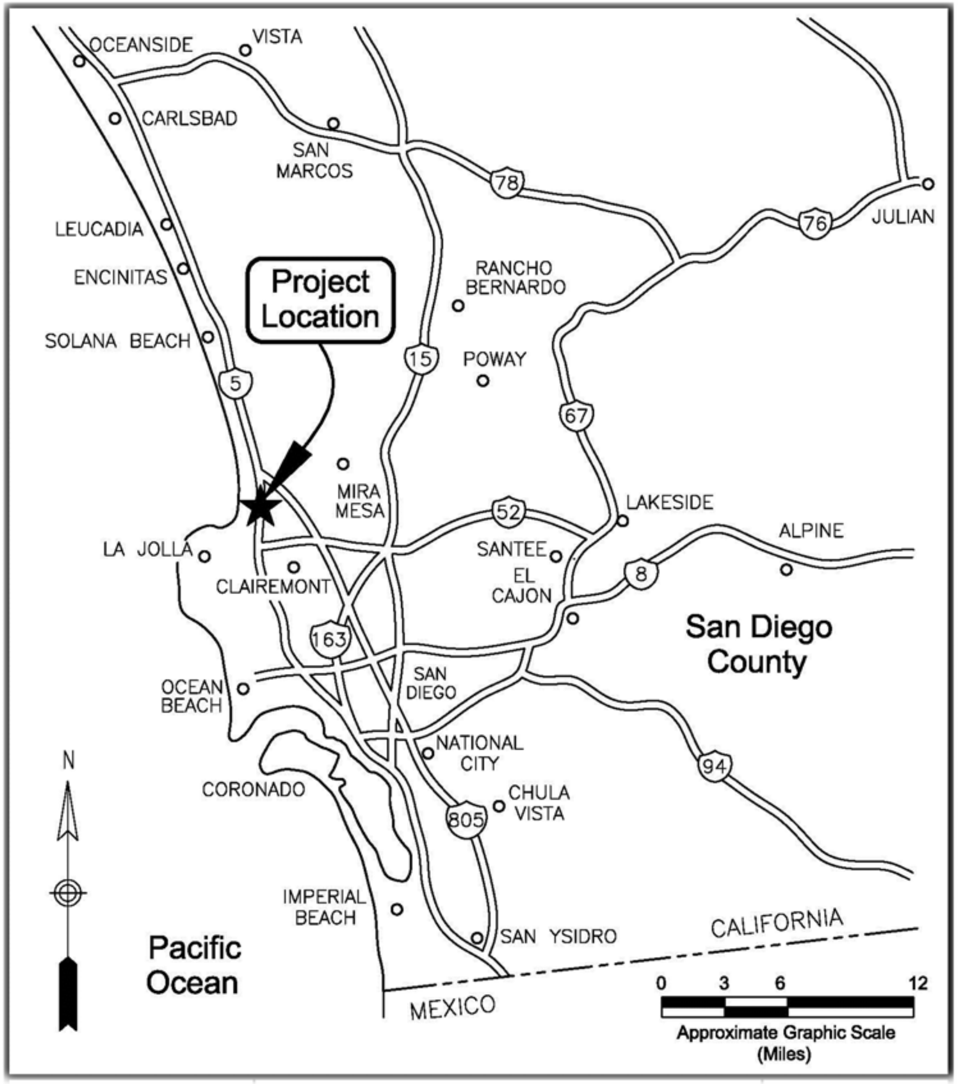
KLEINFELDER | Simon Wong Engineering

Project Location

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



Genesee POC Overview

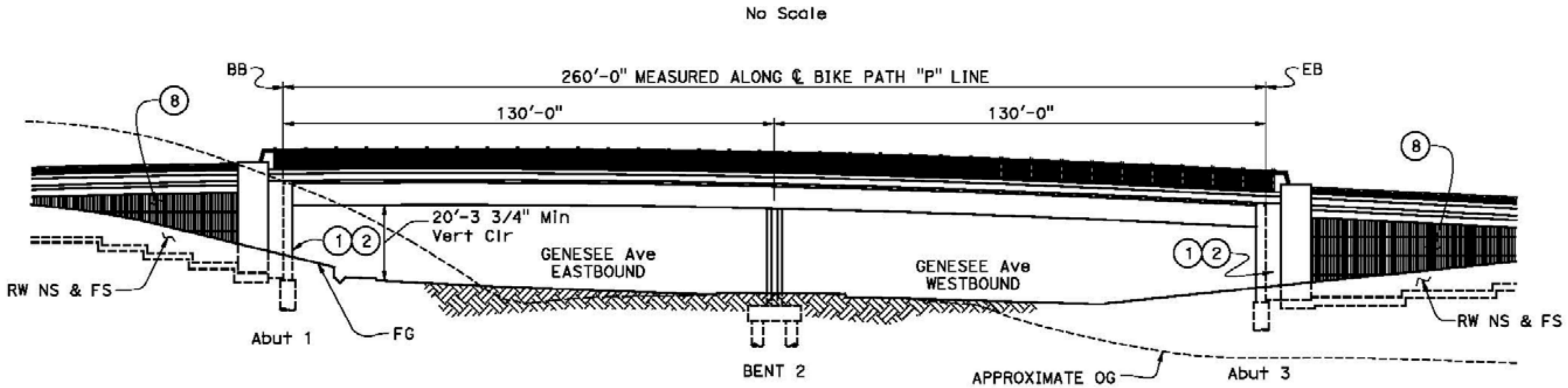
- Component of the I-5 / Genesee Ave Interchange Project
- Will serve as a grade separation to carry pedestrians and bicycles over Genesee Avenue
- Unique project due to high curvature

The Design Team

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

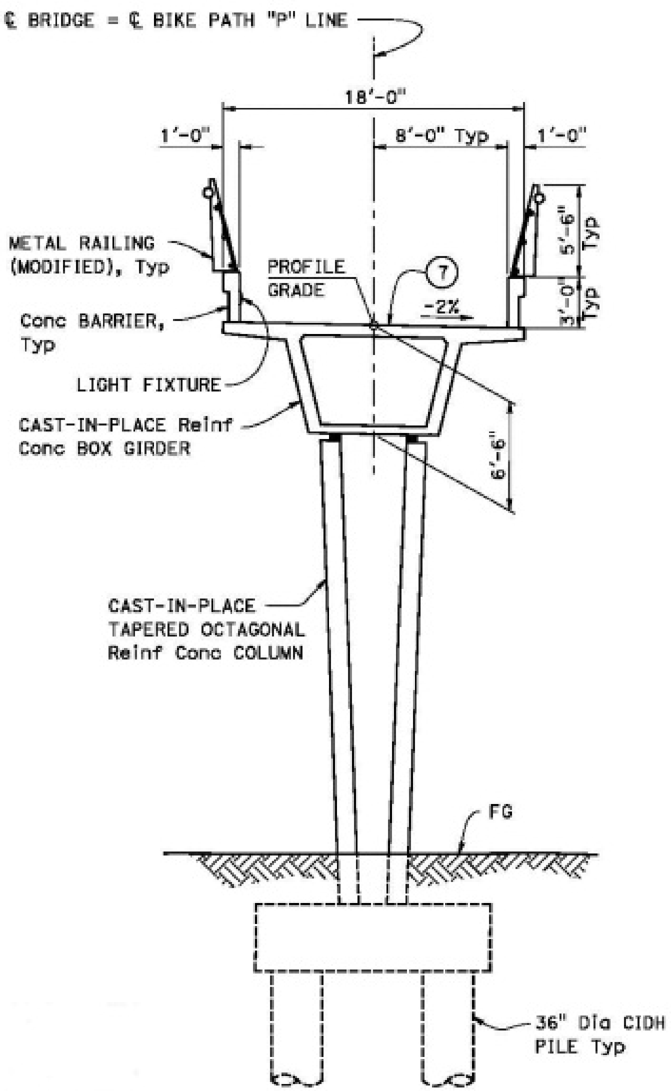
Bridge Description

- 2-span CIP reinforced concrete box girder
- Two equal spans of 130'-0"



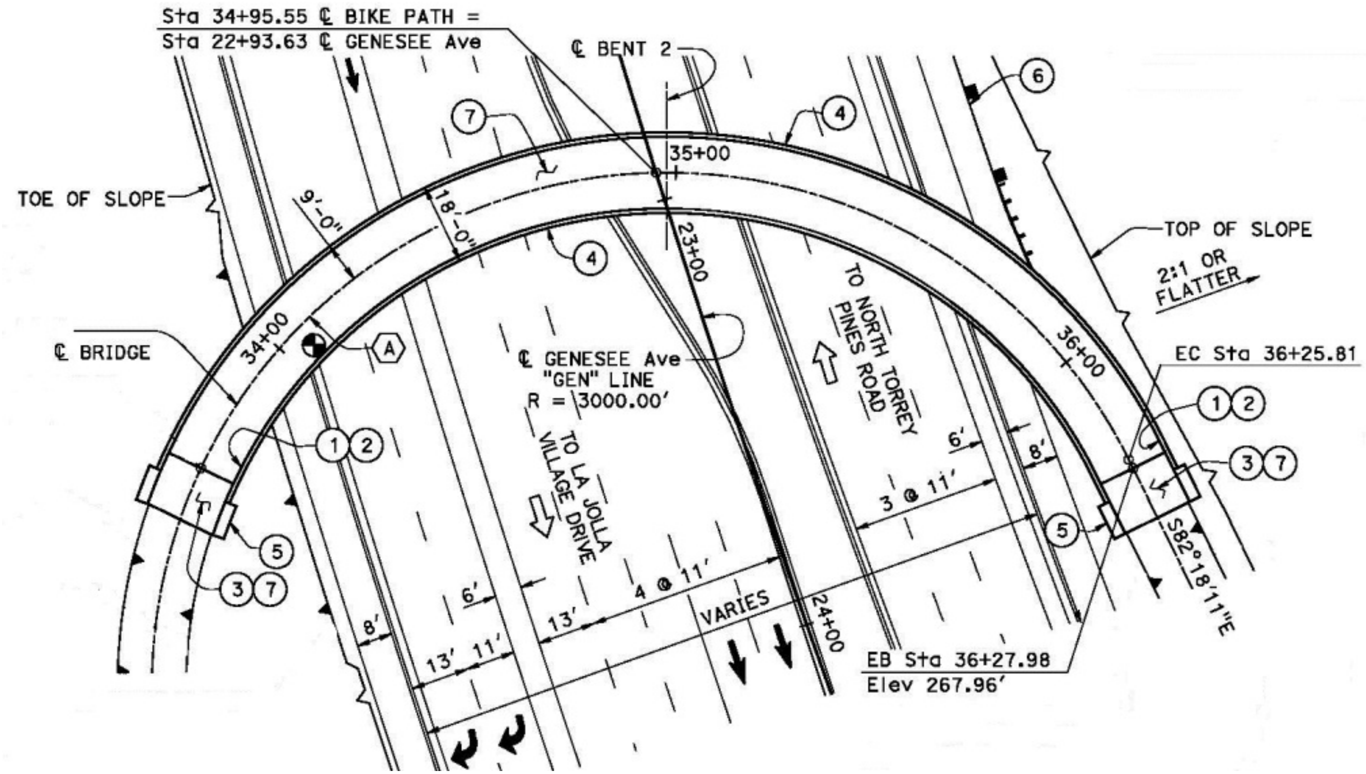
Bridge Description

- Supported on a single-column bent and diaphragm abutments



Bridge Description

- Highly curved R = 115’-0”



Architectual Features

- Curve to provide a uniquely shaped signature structure

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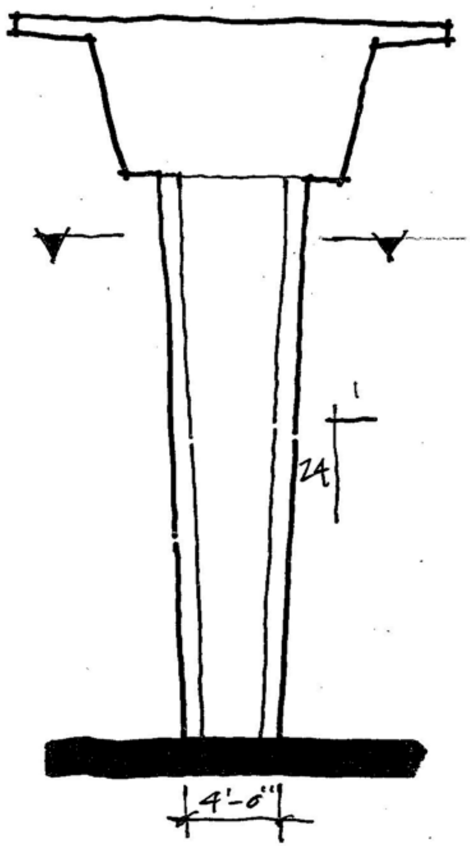
- Can we clear span the roadway?

Architectural Features

- Tapered octagonal column



SECTION

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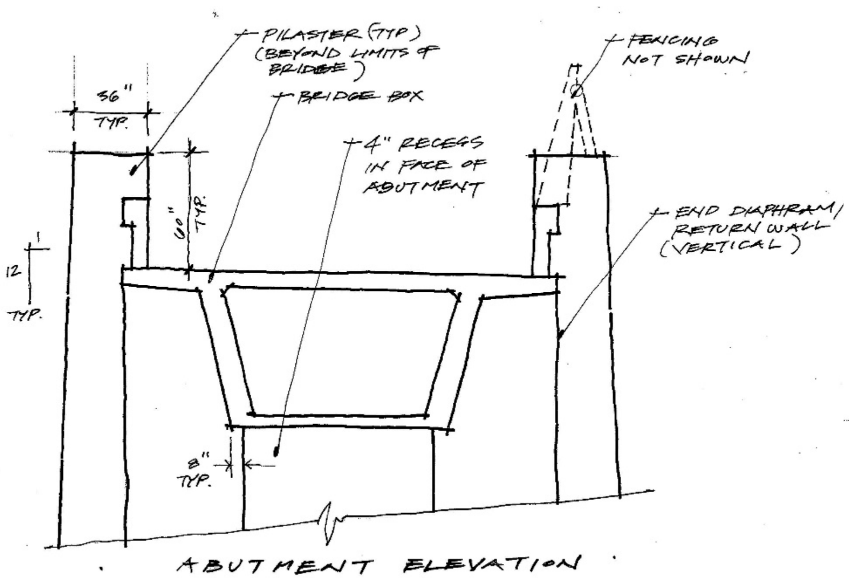
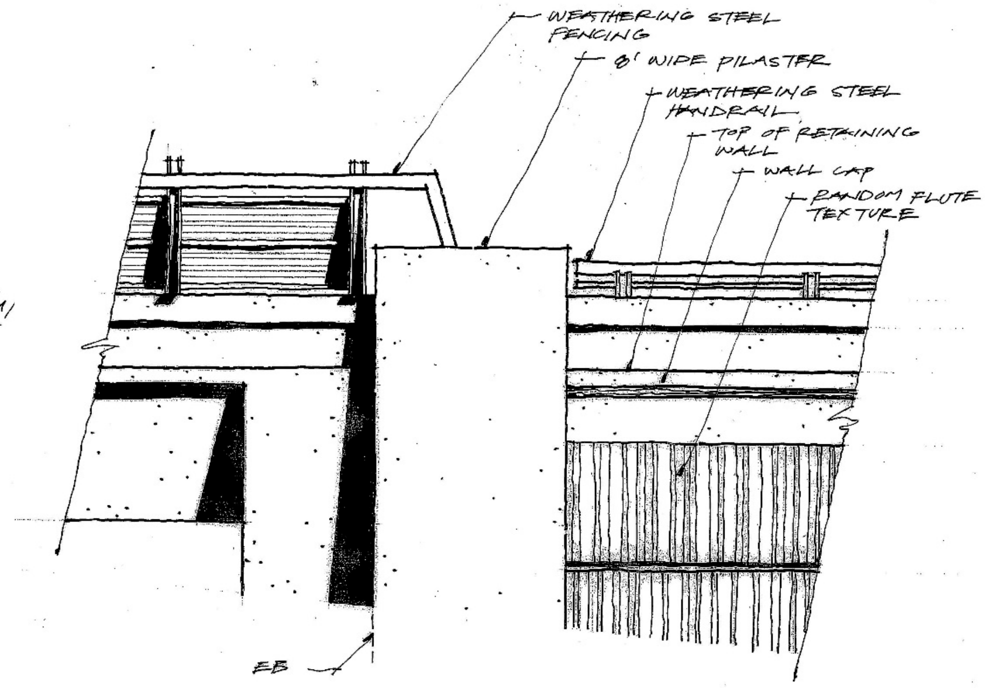
Architectural Features

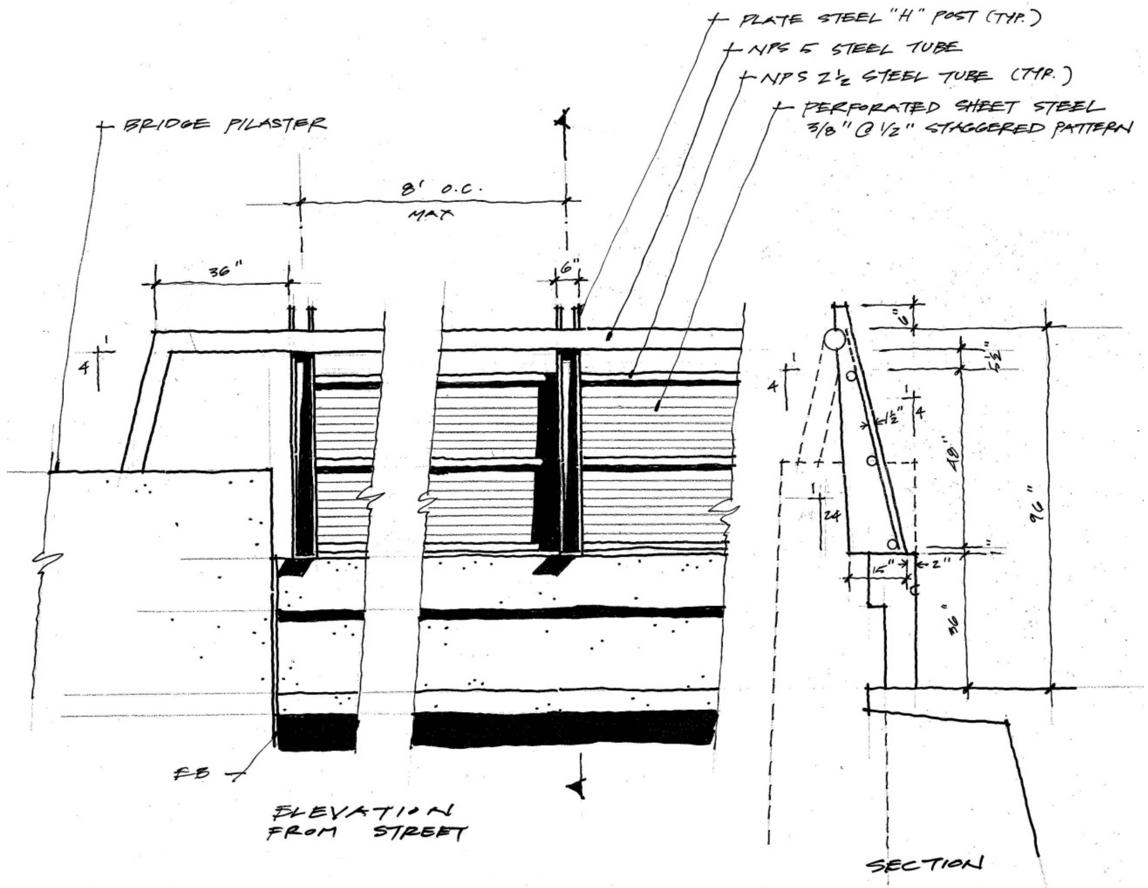
- Pilasters behind each abutment

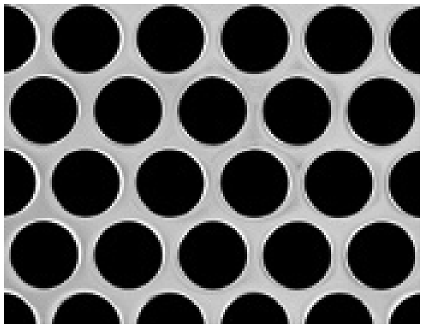




Architectural Features

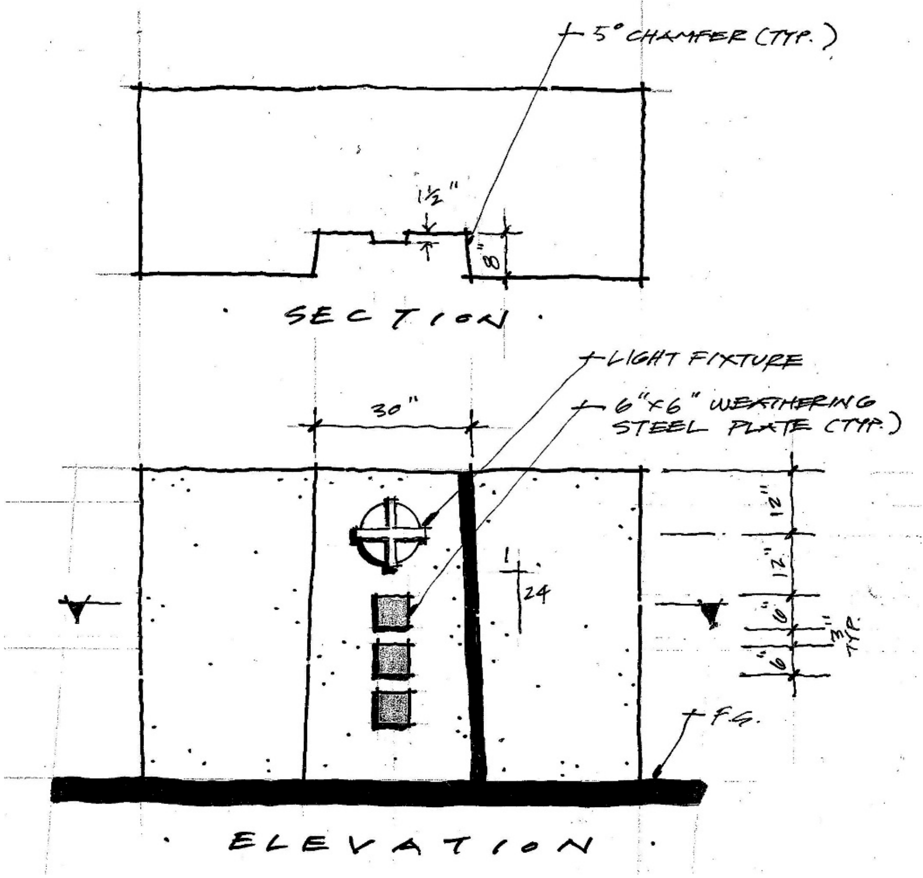
- Weathering “Cor-ten” steel railing

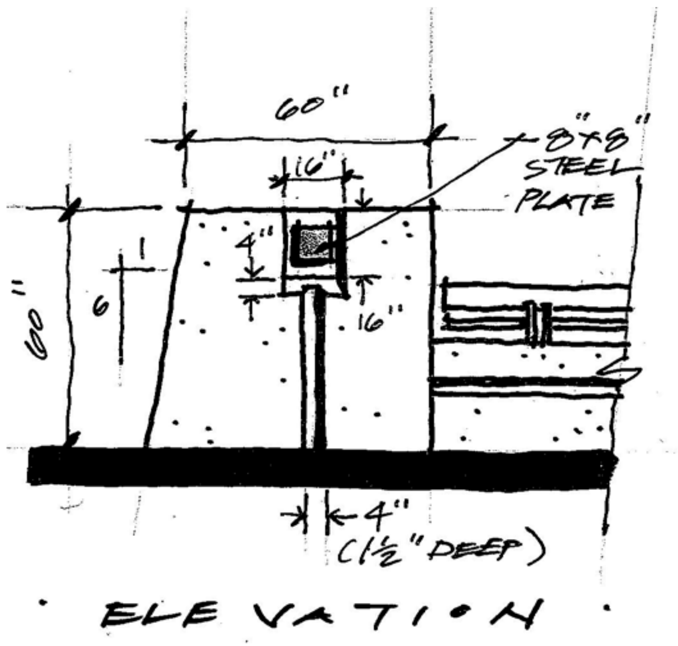




Architectural Features

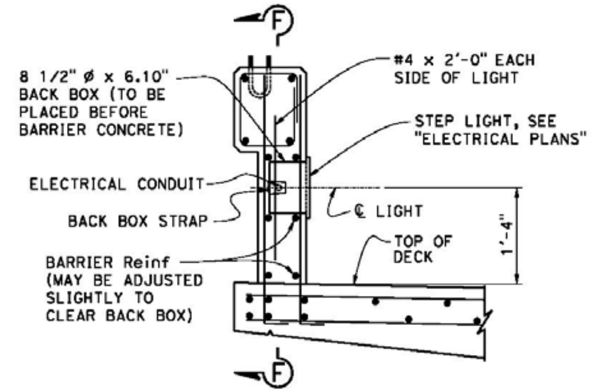
- Weathering steel plates and lights in pilaster recess





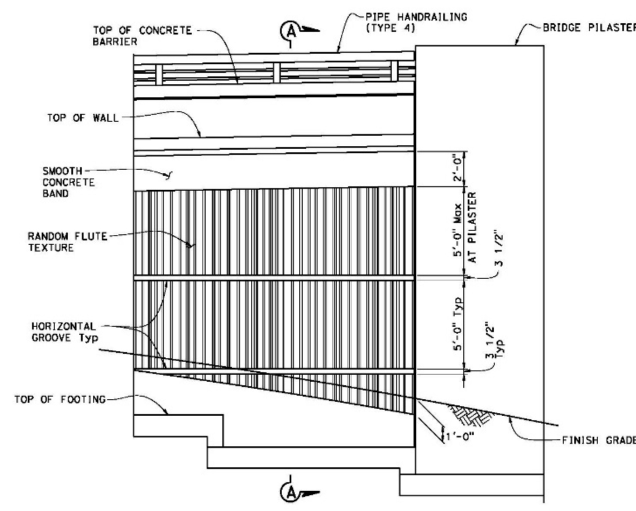
Architectural Features

- Lighting integrated into exterior concrete barrier face



LIGHTING DETAIL
1" = 1'-0"

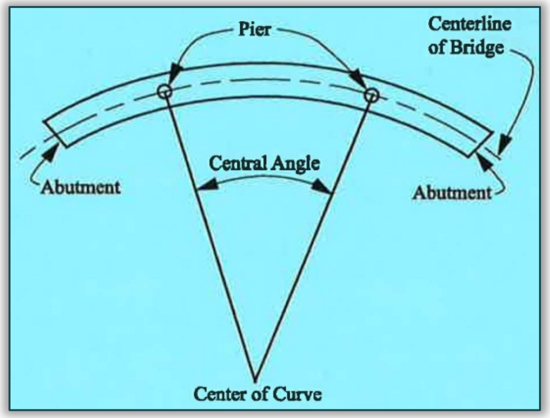
- Formliners
  "Random Flute Texture"



ARCHITECTURAL DETAILS ELEVATION
No Scale

- Integral color concrete
  "Mesa Buff"

Design Methodology



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

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

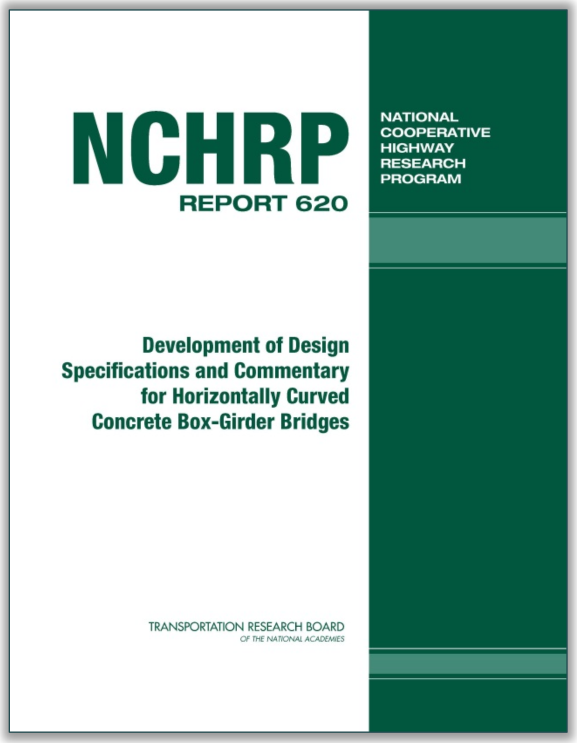
- AASHTO Commentary refers to NCHRP Report 620 as the basis for this new requirement

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

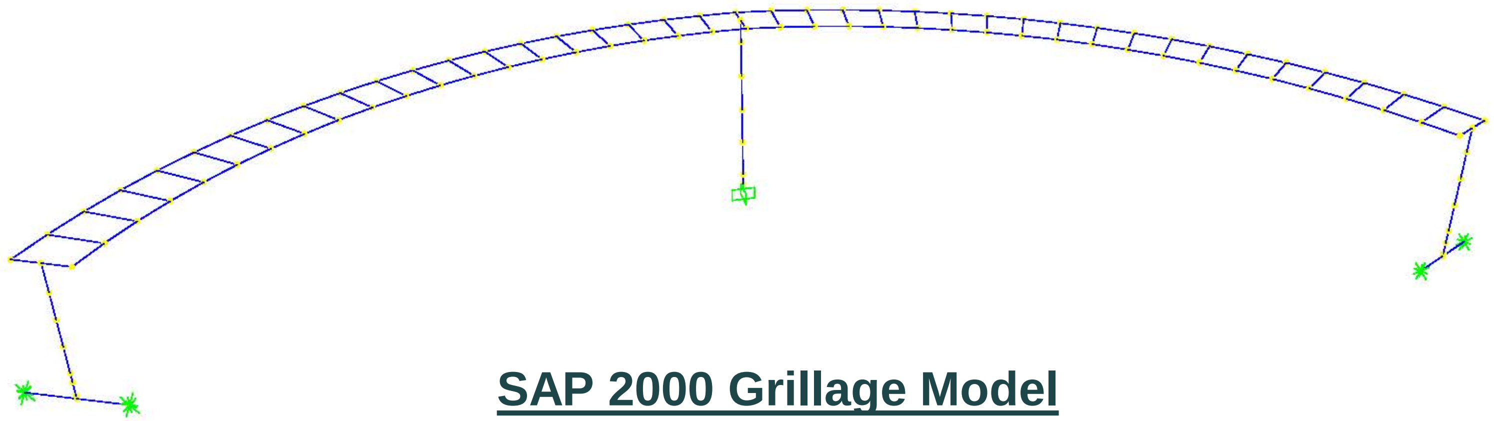
Grillage Model Used for Design

3-D Finite Element Model Used for Independent Check



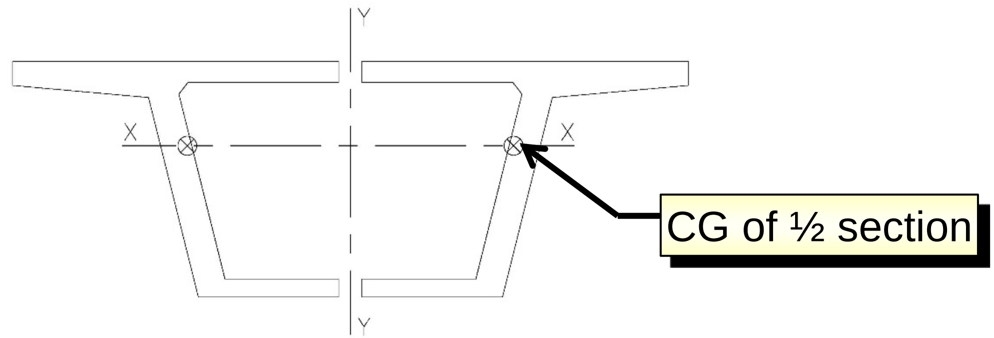
Grillage Model

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

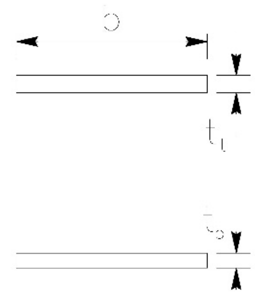


SAP 2000 Grillage Model

Grillage Model

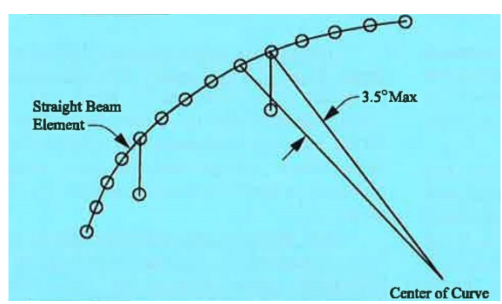


- Longitudinal elements:



- Transverse elements:

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



Grillage Model

- Using gross section properties:

$$T_{permanent} = 90\%\ T_{crack}$$

$$T_{serv\ I} = 120\%\ T_{crack}$$

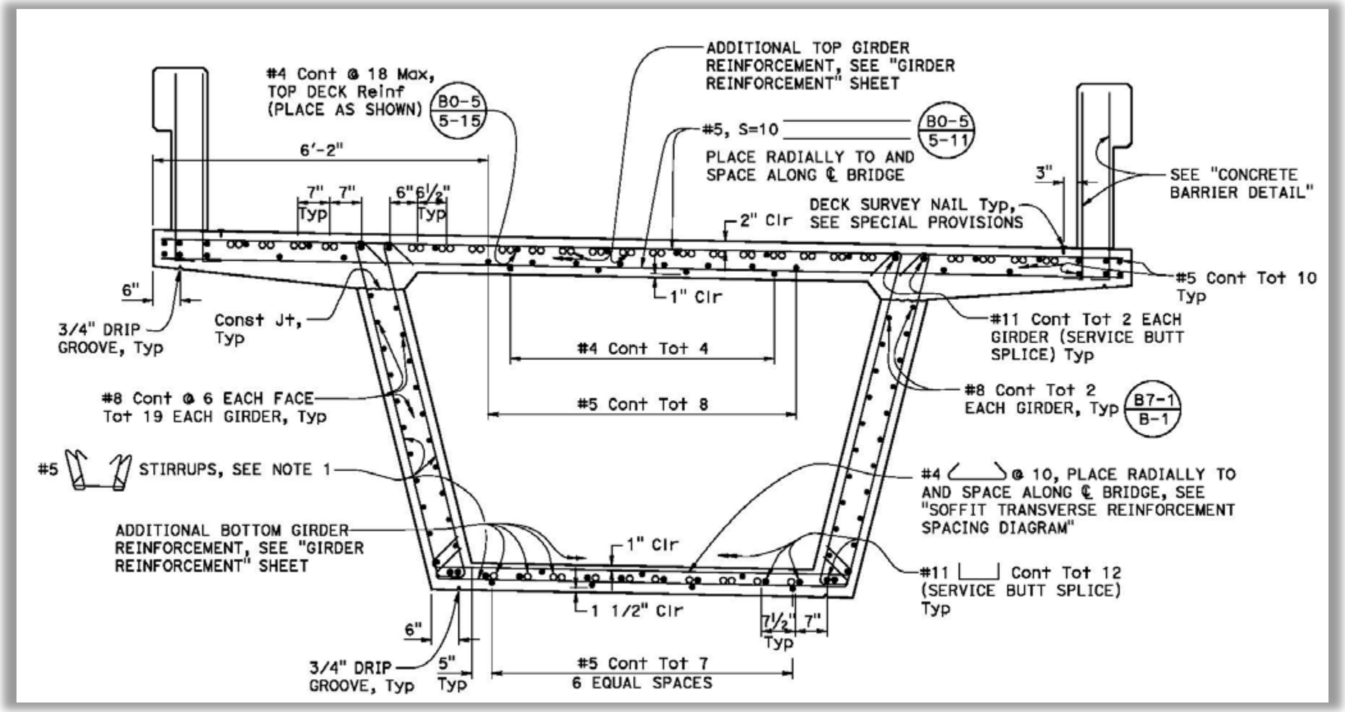
What torsional stiffness to use?

Grillage Model

- 2 boundary conditions to design for shear and torsion:
  - ➔ J_{crack} = 5% J_{gross} (typically used for seismic design)
  - ➔ J_{crack} = 20% J_{gross}

Detailing for Torsion

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

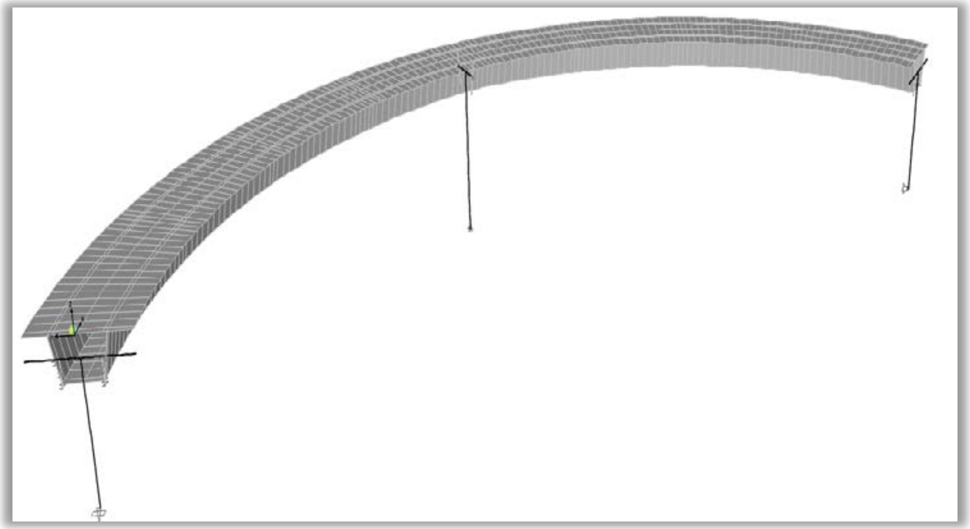


Camber

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

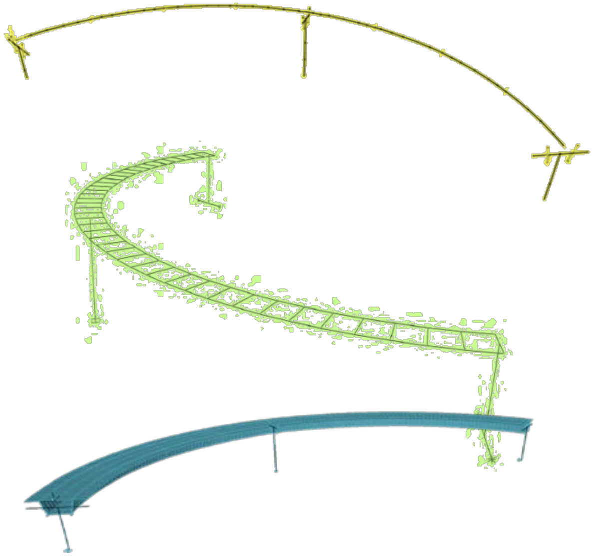
3-D Finite Element Model

- 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

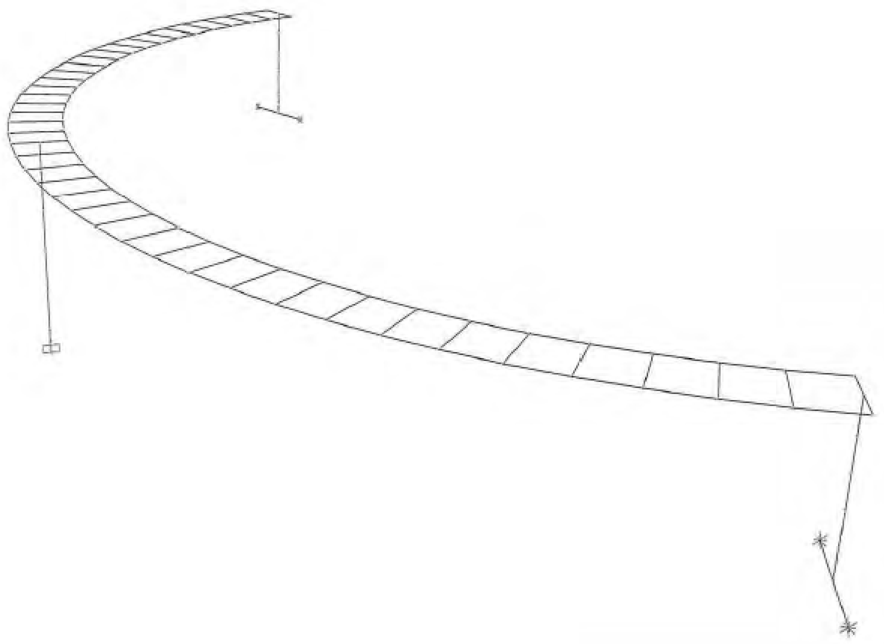
Initial Vertical Deflection Comparison



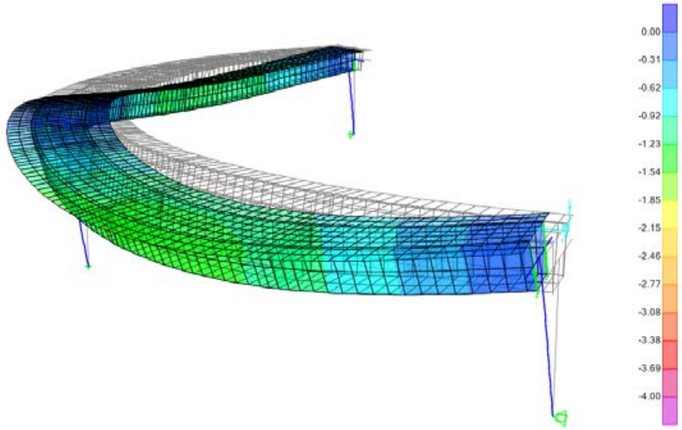
Analysis Method	Stiffness Modification	D Average (in)
Spine model	Jeff = 0.05*J	**-1.98**
Grillage model	Jeff = 0.05*J	**-1.45**
Shell model	F12eff = 0.05*F12	**-3.33**

- Grillage vs. Spine – grillage 30% lower
- Shell vs. Spine – shell 68% higher
- Qualitatively should be Spine < Grillage < Shell →?!?%?#?

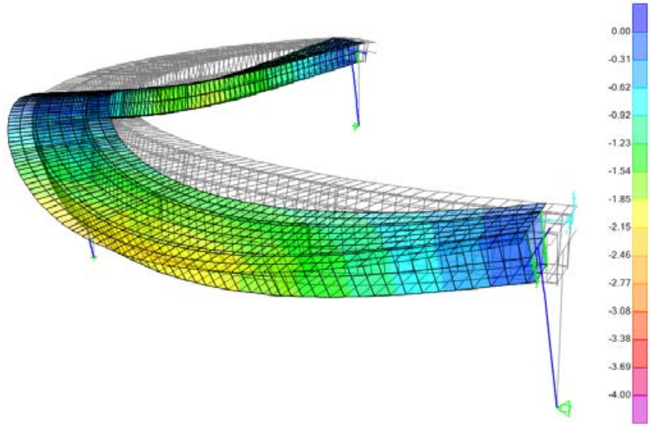
- Initial approach for grillage based was only softening “J” for longitudinal girder elements.
- Also need to reduce vertical shear stiffness of longitudinal members



Vertical & Torsional Deflection Comparison



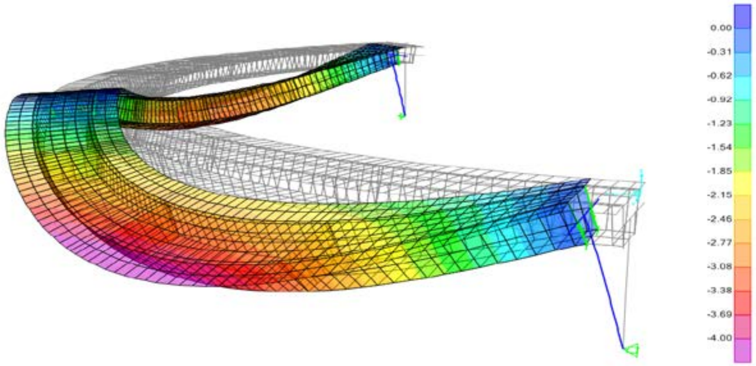
Analysis Method	Stiffness Modification	D Interior Girder (in)	D Exterior Girder (in)
Spine model	None (gross)	-1.10	-1.33
Grillage model	None (gross)	-1.09	-1.32
Shell model	None (gross)	-1.19	-1.41



Analysis Method	Stiffness Modification	D Interior Girder (in)	D Exterior Girder (in)
Spine model	Jeff = 0.2*J	-1.16	-1.69
Grillage model	Jeff = 0.2*J, Aveff = 0.2*Av	-1.44	-1.90
Shell model	F12eff = 0.2*F12	-1.58	-2.10

Dead load deflection (x50 scale) of shell model

Vertical & Torsional Deflection Comparison



Analysis Method	Stiffness Modification	D Interior Girder (in)	D Exterior Girder (in)
Spine model	Jeff = 0.05*J	-1.45	-1.62
Grillage model	Jeff = 0.05*J, Aveff = 0.05*Av	-2.95	-3.43
Shell model	F12eff = 0.05*F12	-3.335	-3.90

- 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 (4^{th} 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?