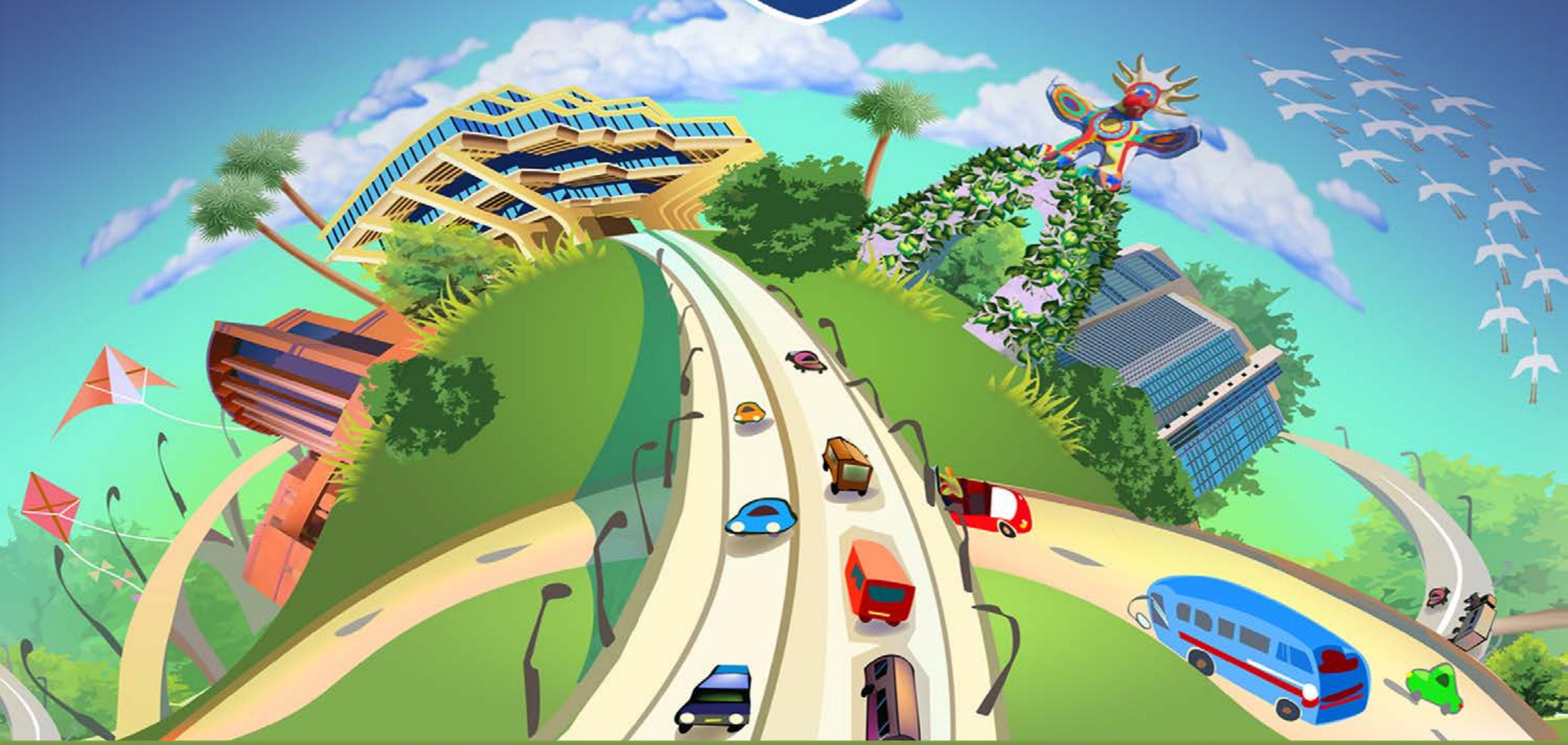
University of California
San Diego
UCSD

moffatt & nichol

GILMAN BRIDGE

INTERSTATE 5



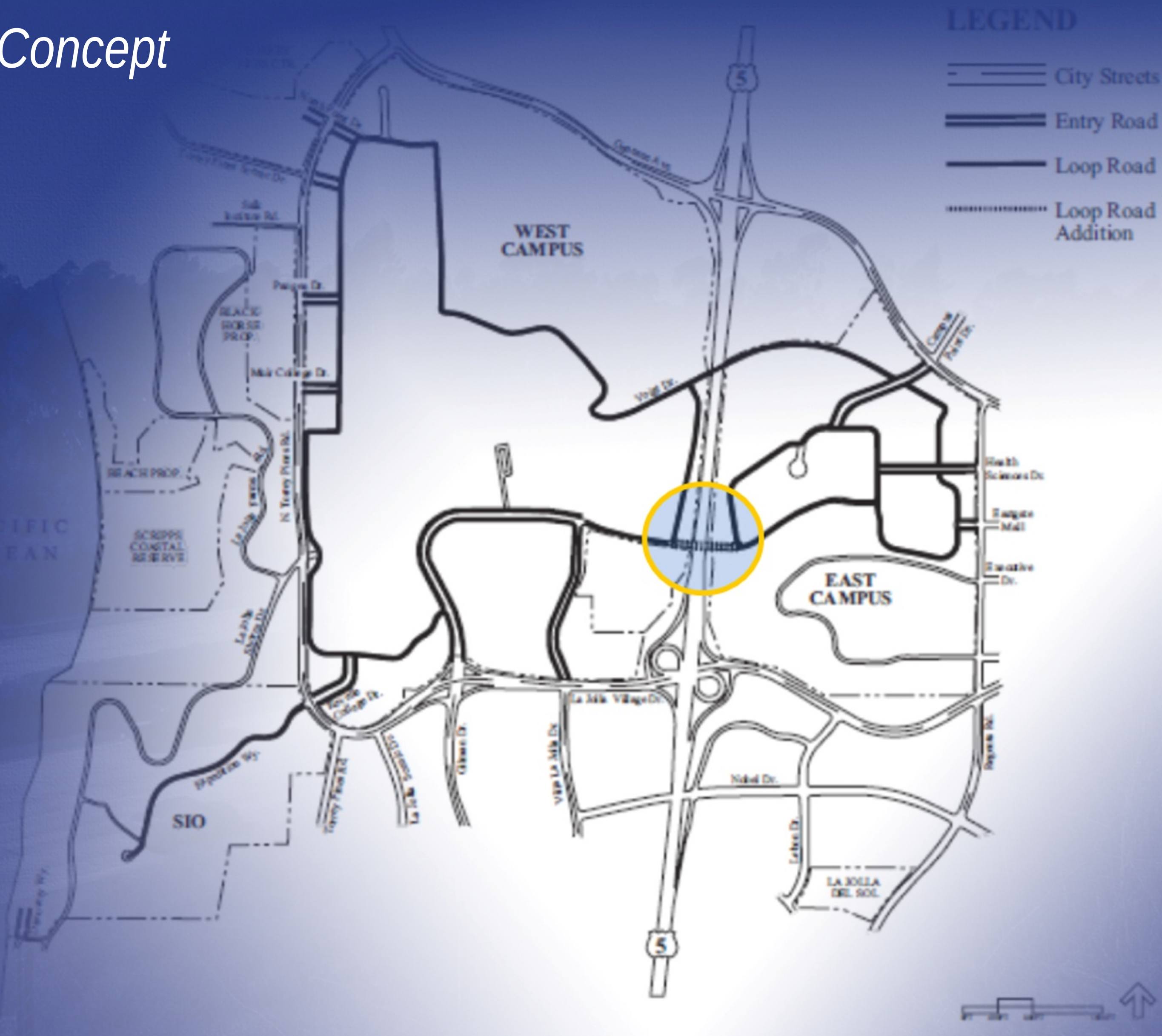
Western Bridge Engineers' Seminar

Reno Nevada, September 9, 2015

UCSD Gilman Bridge - Project Overview

UCSD Long Range Development Plan

Internal Loop Road Concept



UCSD Jacobs Medical Center

UCSD Medical East Campus Projects
(Over $2B New Construction)

- Jacobs Medical Center
- JMC Central Plant
- Altman Clinic & Translational Research
- East Campus Central Plant Expansion
- East Campus Parking Structure
- East Campus Pavilion
- BioMed 2 Building
- East Campus Office Building

Altman Clinic & Translational Research

BioMed 2 Building

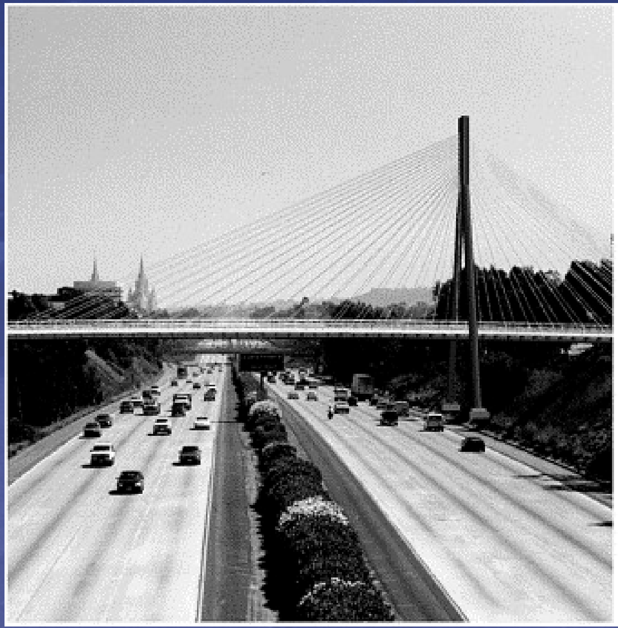
SANDAG Mid-Coast LRT

GILMAN BRIDGE

Project History

Advanced Technology Bridge

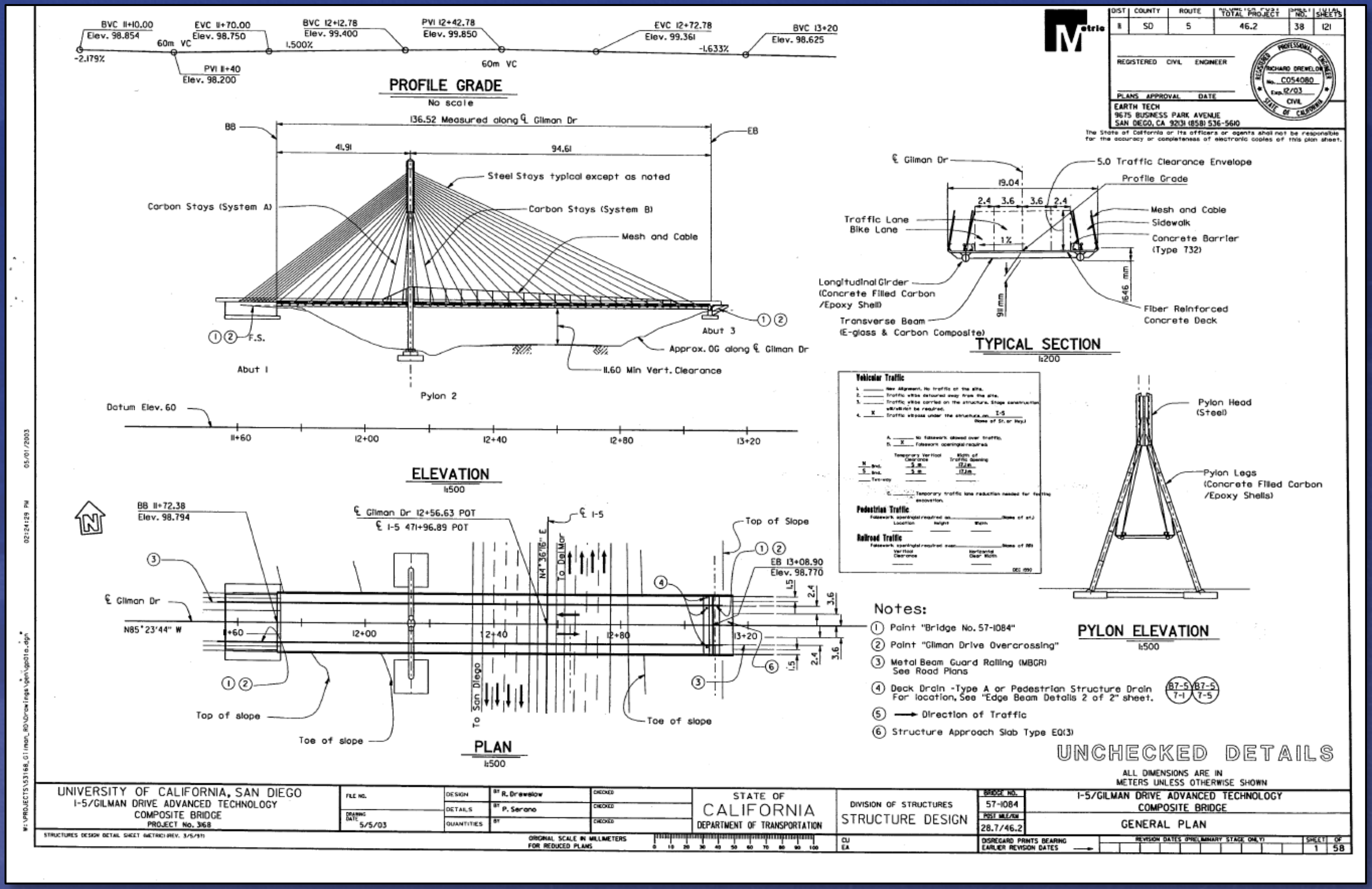





Project History

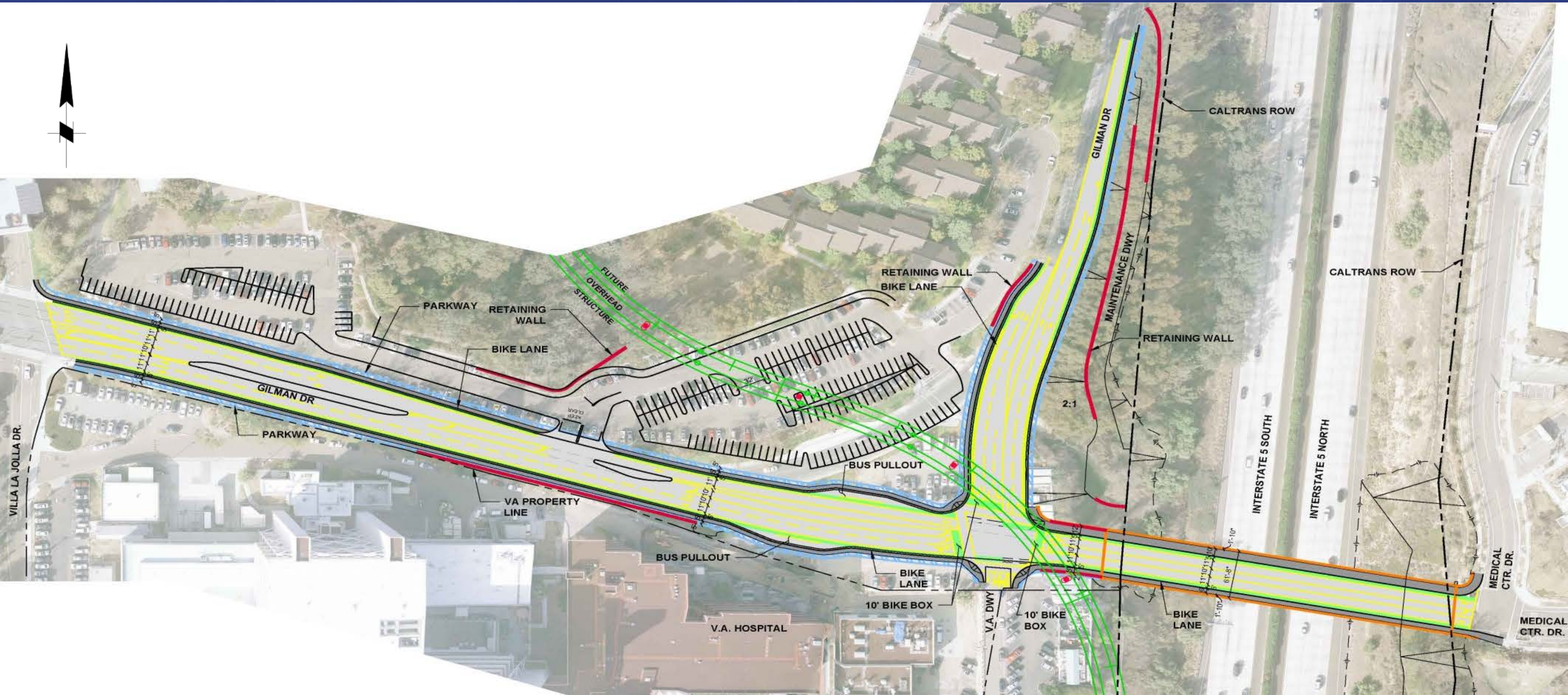
Advanced Technology Bridge

- 1990's - Conceptual Design, Lab Testing
- May 2003 – 65% Design $12M ($21M in 2015 dollars)
- Oct 2003 - Value Engineering
- Summer 2004 – Project Discontinued



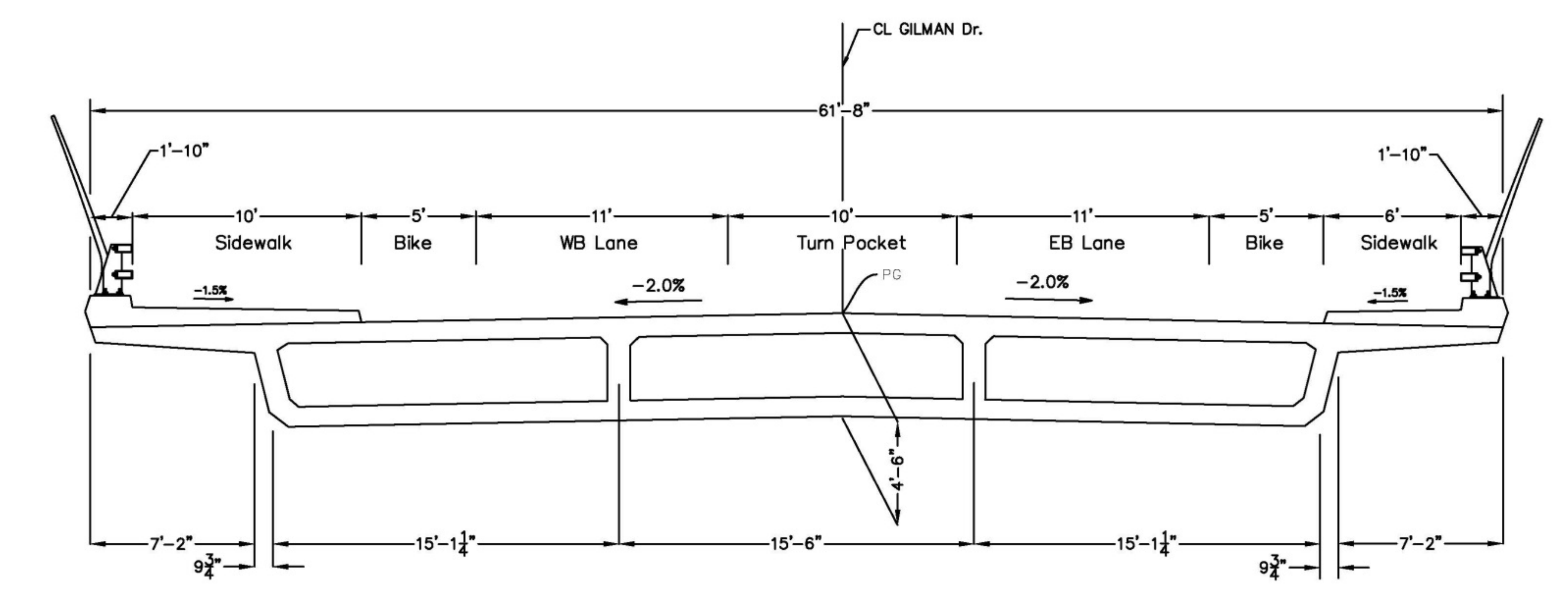
Project Limits and Design Concept

- Expand west and north legs of Gilman Drive to accommodate future traffic
- Tie into existing Medical Center Drive
- Tie into VA driveway to provide access to VA, but no construction on VA property
- Design is compatible with I-5 and LRT projects



Bridge Typical Section

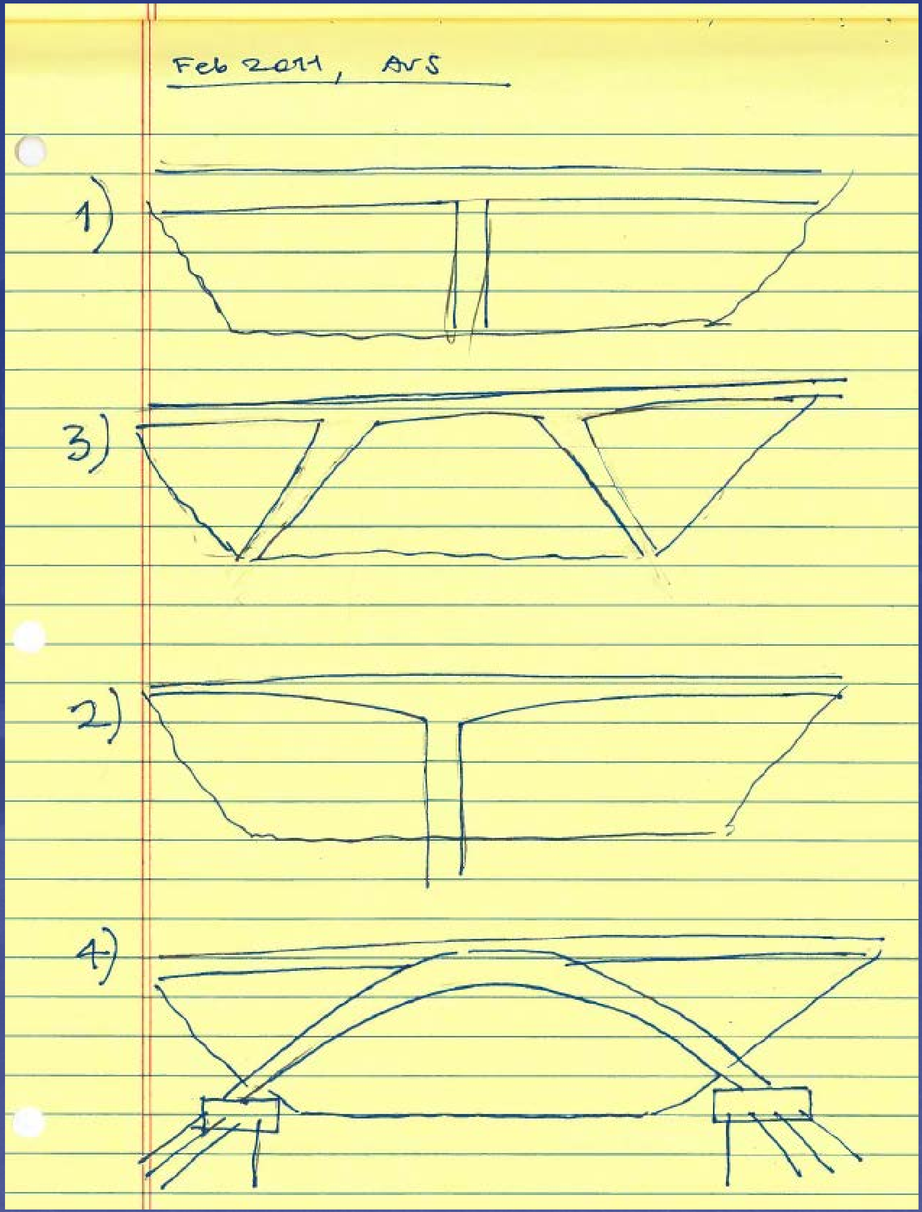
- Conforms to New Gilman Drive Roadway
- 11 ft through lanes, 10 ft turn lane
- 5 ft bike lanes
- 10 ft sidewalk on north, 6 ft sidewalk on south
- California ST-10 bridge rail modified with architectural details



Initial Bridge Concepts

Hand Sketches, Feb 2011

- Which bridge types are feasible?
- Most appropriate for the site?
- What would UCSD want?
- What would Caltrans approve?
- Simple concrete bridge:
  - Economical
  - Durable
  - Low maintenance
  - Proven system
  - Used elsewhere by Caltrans



moffatt & nichol

Bridge Concept 1

Standard Two-span Box Girder

UCSD

moffatt & nichol

Bridge Concept 2

Haunched Box Girder

moffatt & nichol

Bridge Concept 3
Three-span Frame with Inclined Legs

Bridge Concept 4
Three-span Arch

UCSD

moffatt & nichol

Is Arch Feasible at this Site?

GILMAN 5 BRIDGE

- Geometry is appropriate (40 ft height)
- Formation can support thrust
- Concrete in compression (durable)
- Has been used before by Caltrans locally
  - Adams Ave OC at I-15, 1970 (SR=98.3)
  - Eastgate Mall OC at I-805, 1971 (SR=95.1)
  - W Lilac Rd OC at I-15, 1978 (SR=99.9)

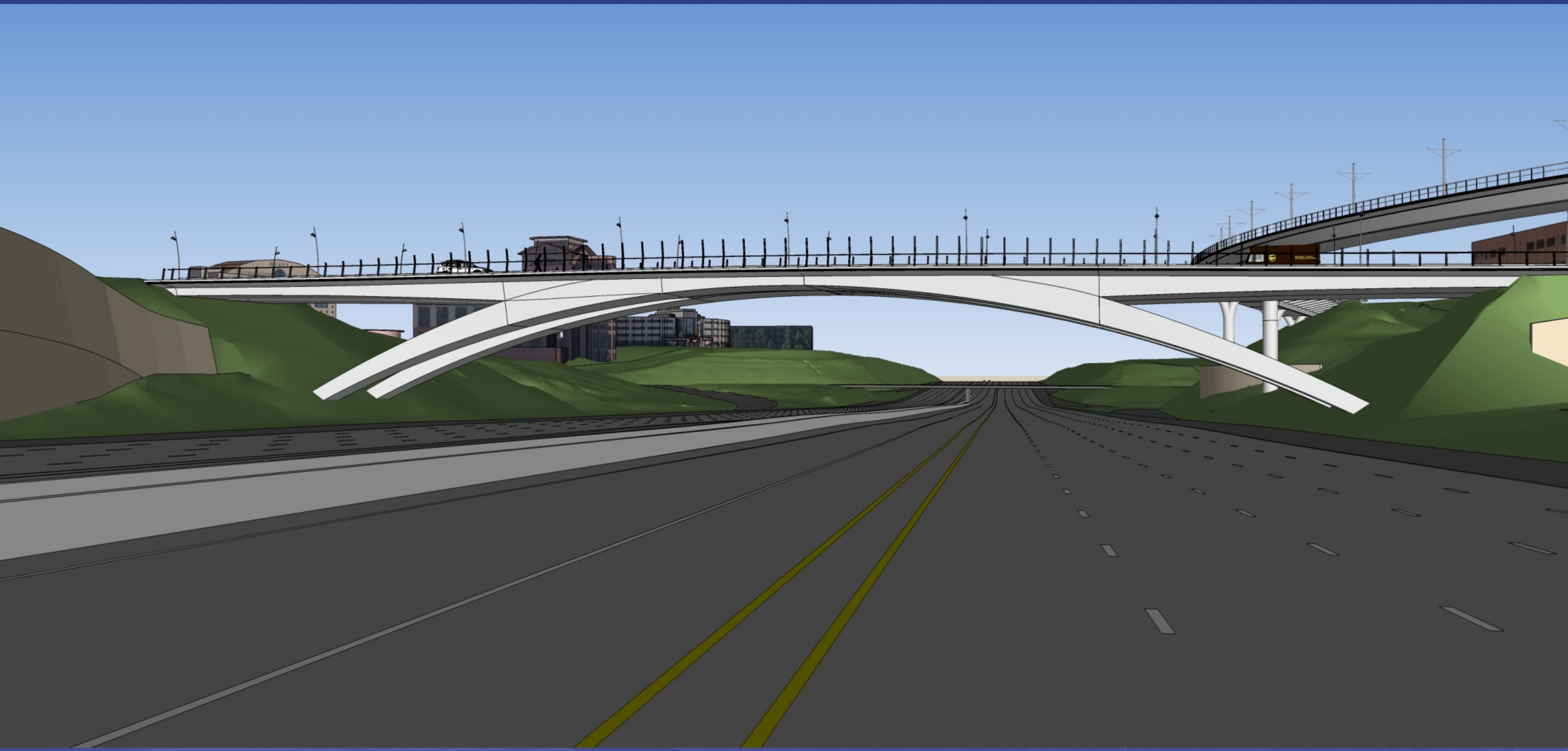
moffatt & nichol

Architectural Features and Site Influence

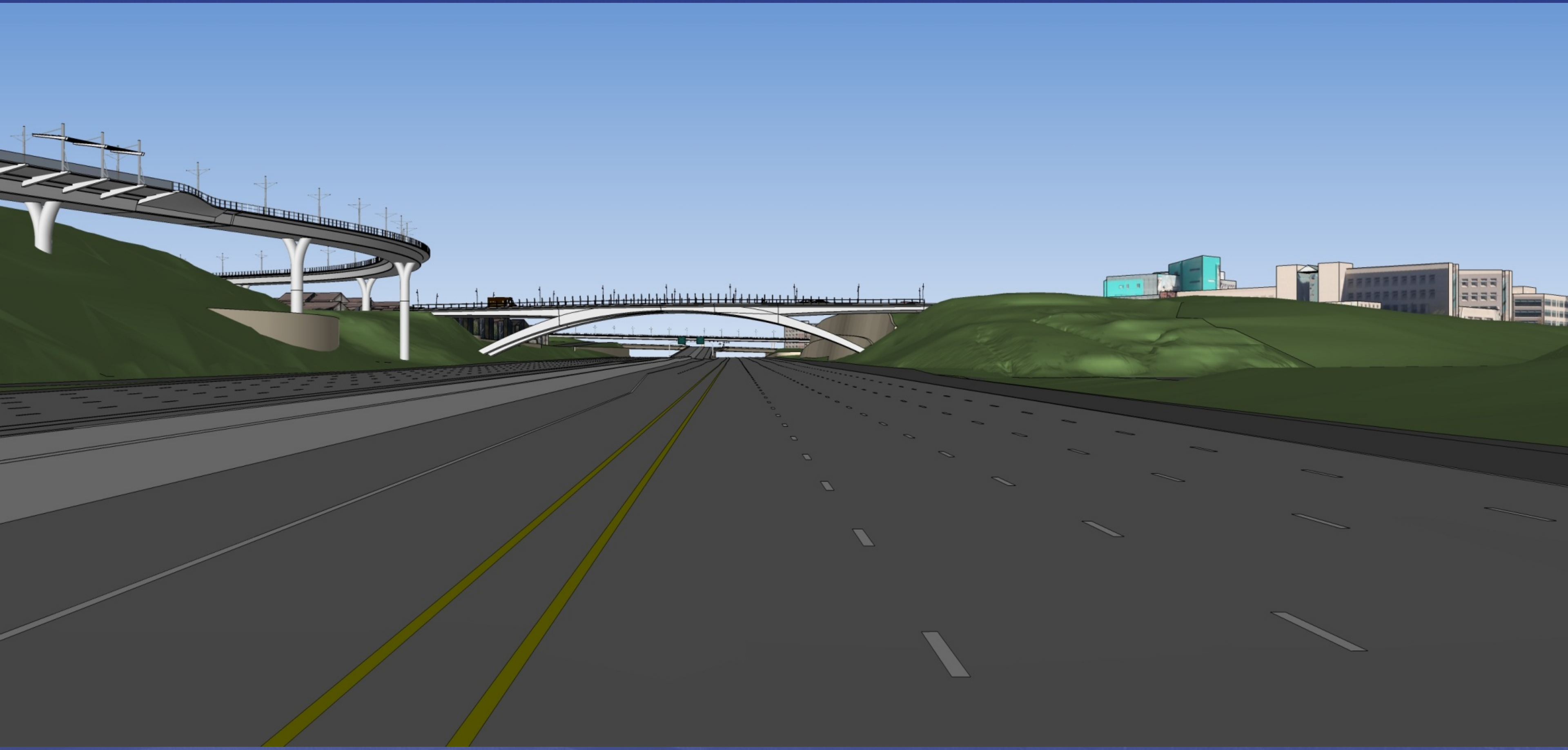
moffatt & nichol

***SAFDIE RABINES** ARCHITECTS*

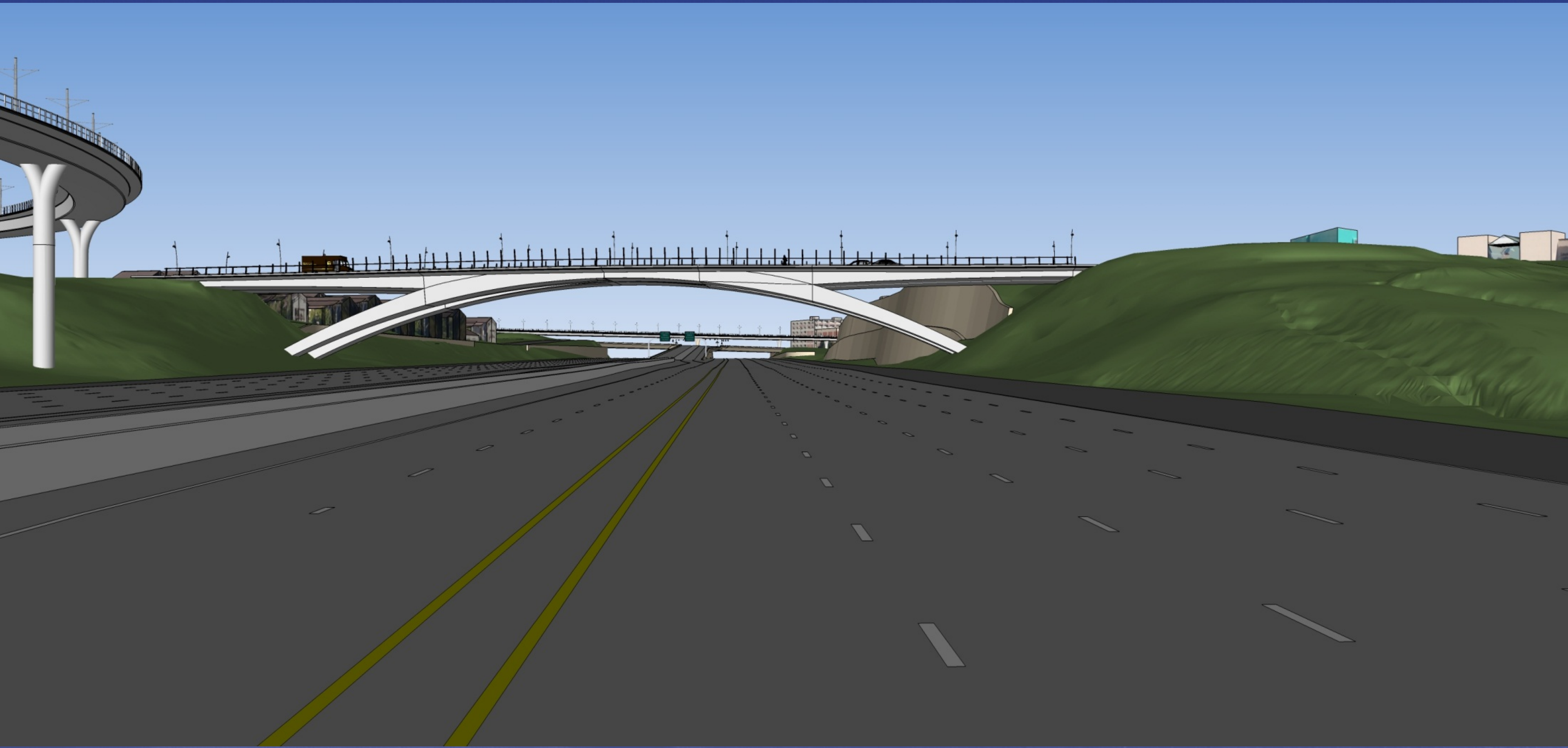
UCSD GILMAN BRIDGE



Future I-5 Corridor
Heading South



Future I-5 Corridor
Heading North – View 1



Future I-5 Corridor
Heading North – View 2

Photo Simulations

UCSD GILMAN BRIDGE

Existing

Interstate 5 Northbound

Photo Simulations

UCSD GILMAN BRIDGE

Interim

Interstate 5 Northbound

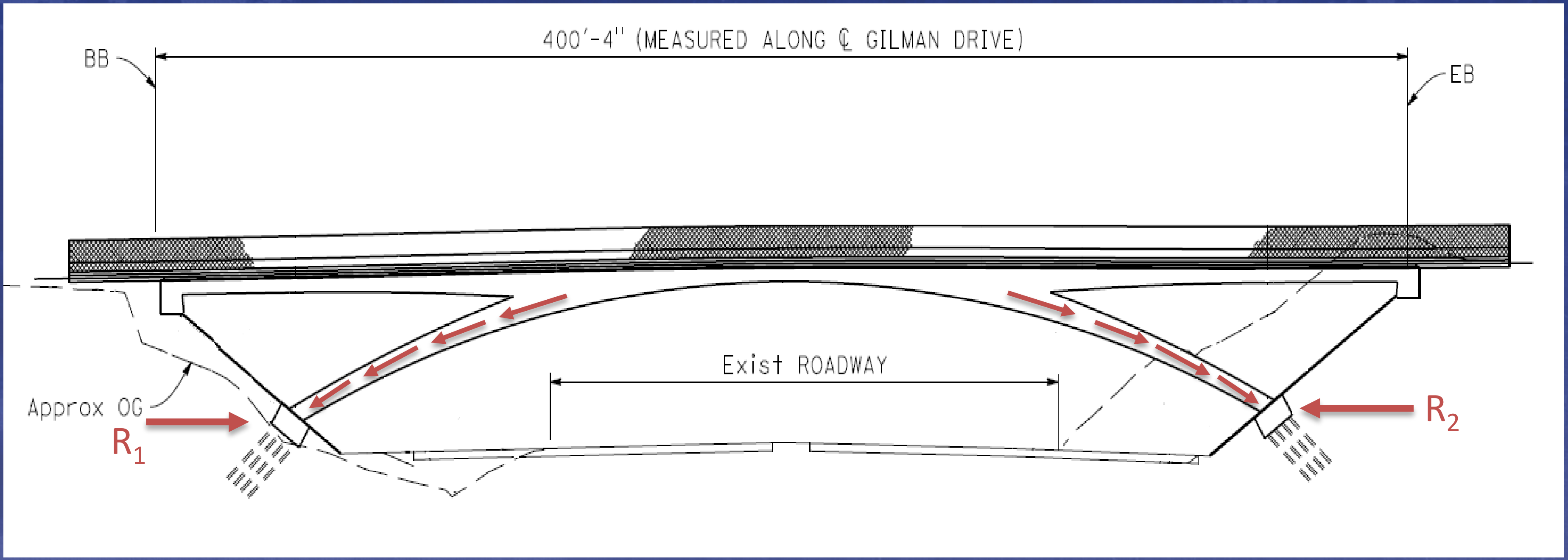
Photo Simulations

Ultimate

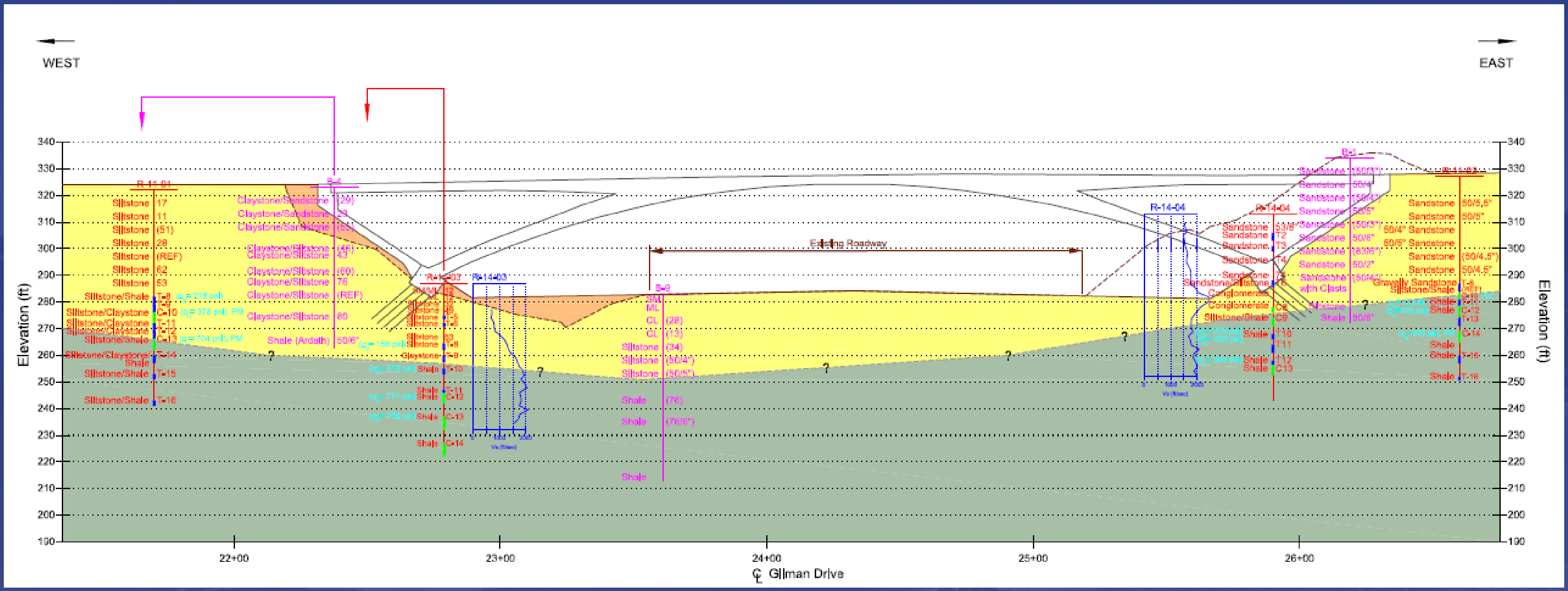
Interstate 5 Northbound

Structural Design

- Low profile arch will have large horizontal thrust on the foundations



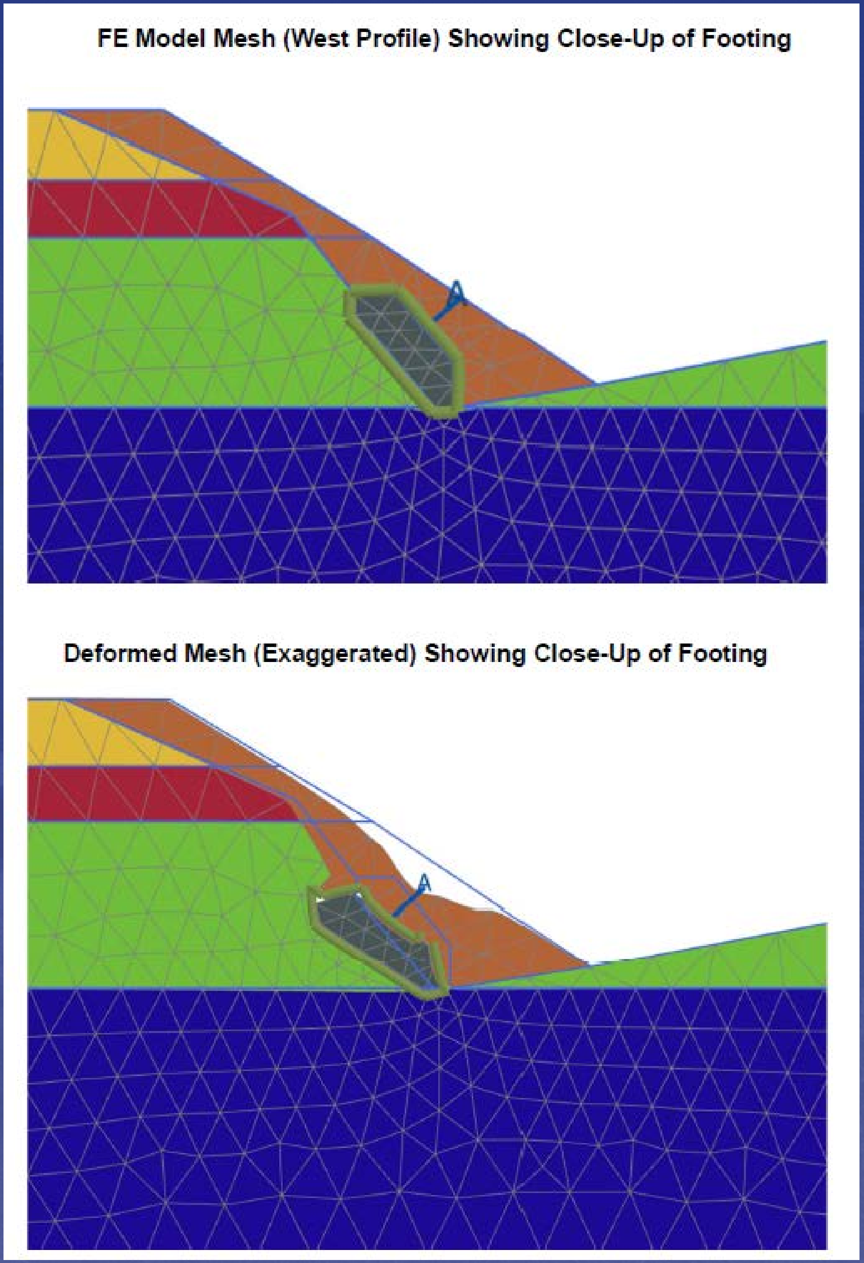
Geotechnical Conditions



- Borings at abutments and arch foundations
- Scripps Formation (siltstone/claystone/sandstone)
- Ardath Shale
- Formation can provide required strength
- Stiffness varies and is relatively low

Finite Element Modeling with Plaxis

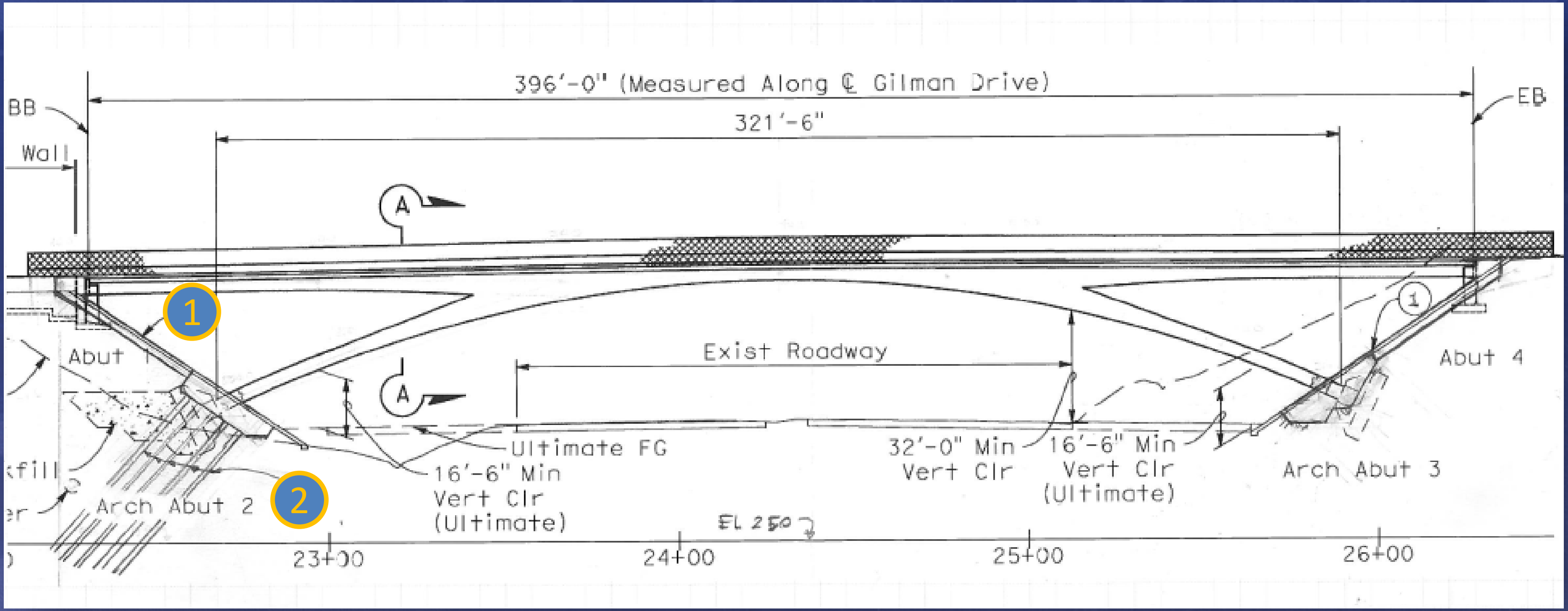
- Model subsurface geometry and arch footings with 2D plane strain model
- Calibrate soil parameters based on in-situ and lab tests
- Apply footing load
- Check footing displacements against bridge performance requirements



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Structure and Foundation Concepts

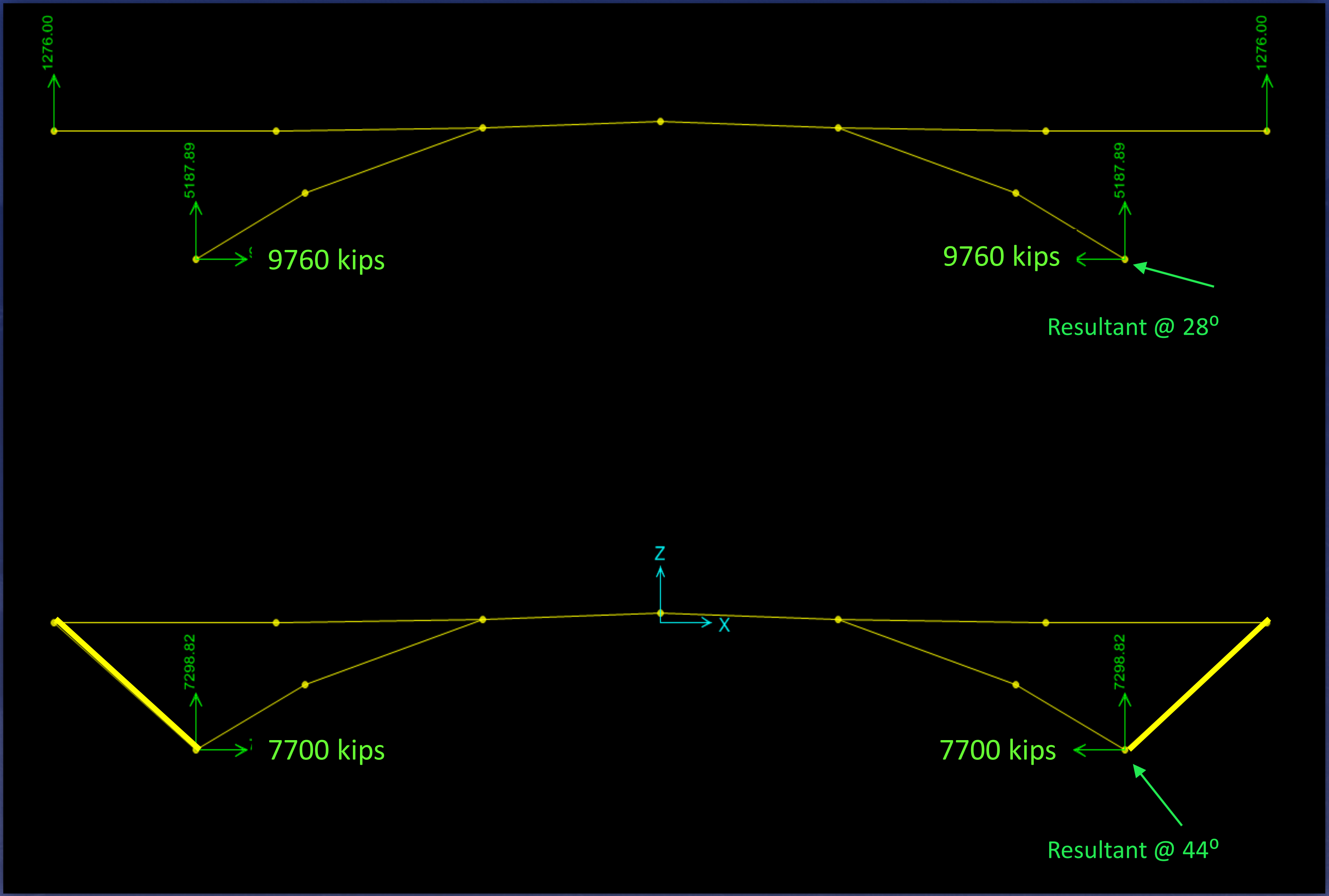
1. Connect abutment to arch foundation with inclined strut
2. Use micropiles in lieu of slurry backfill



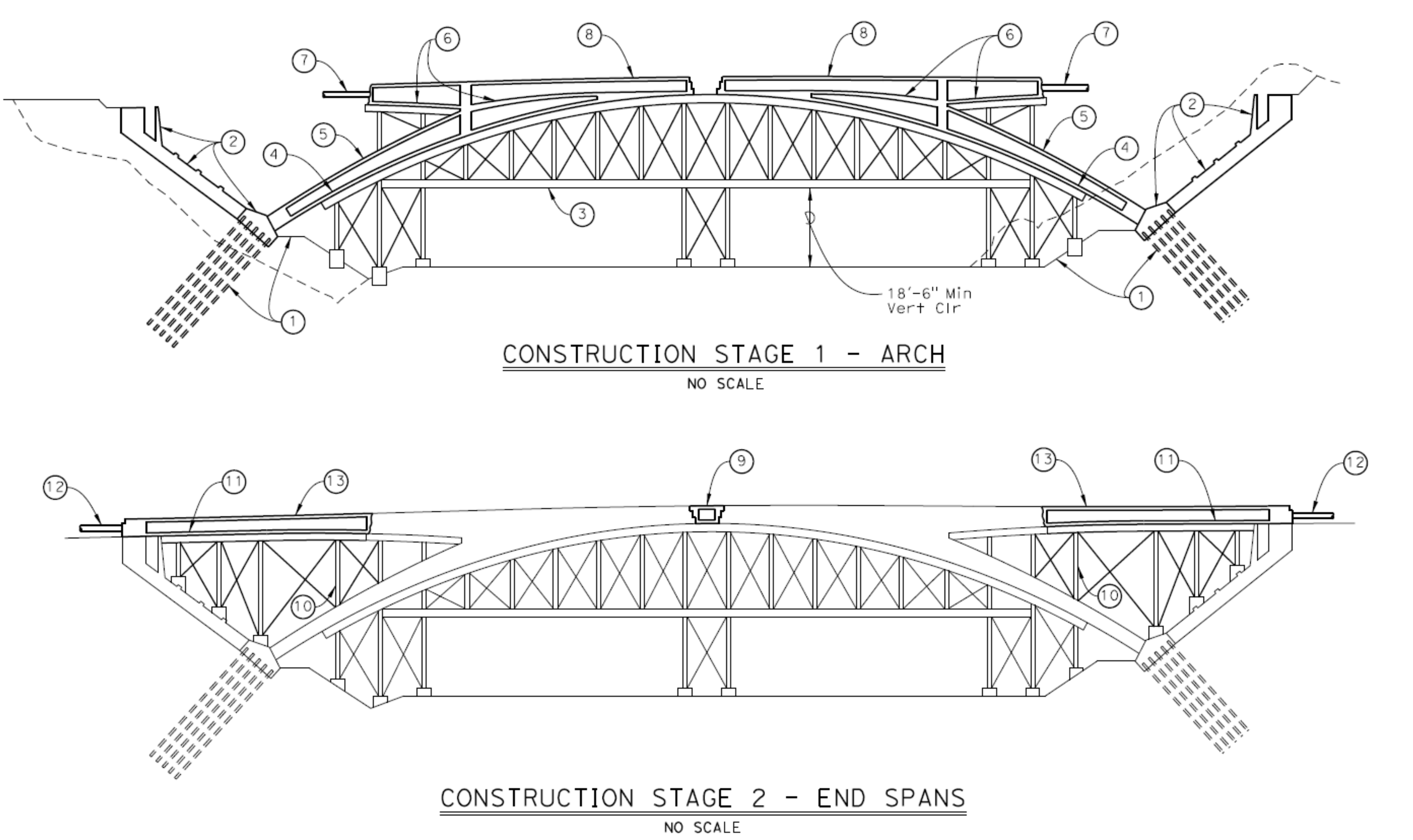
moffatt & nichol

Design Refinement

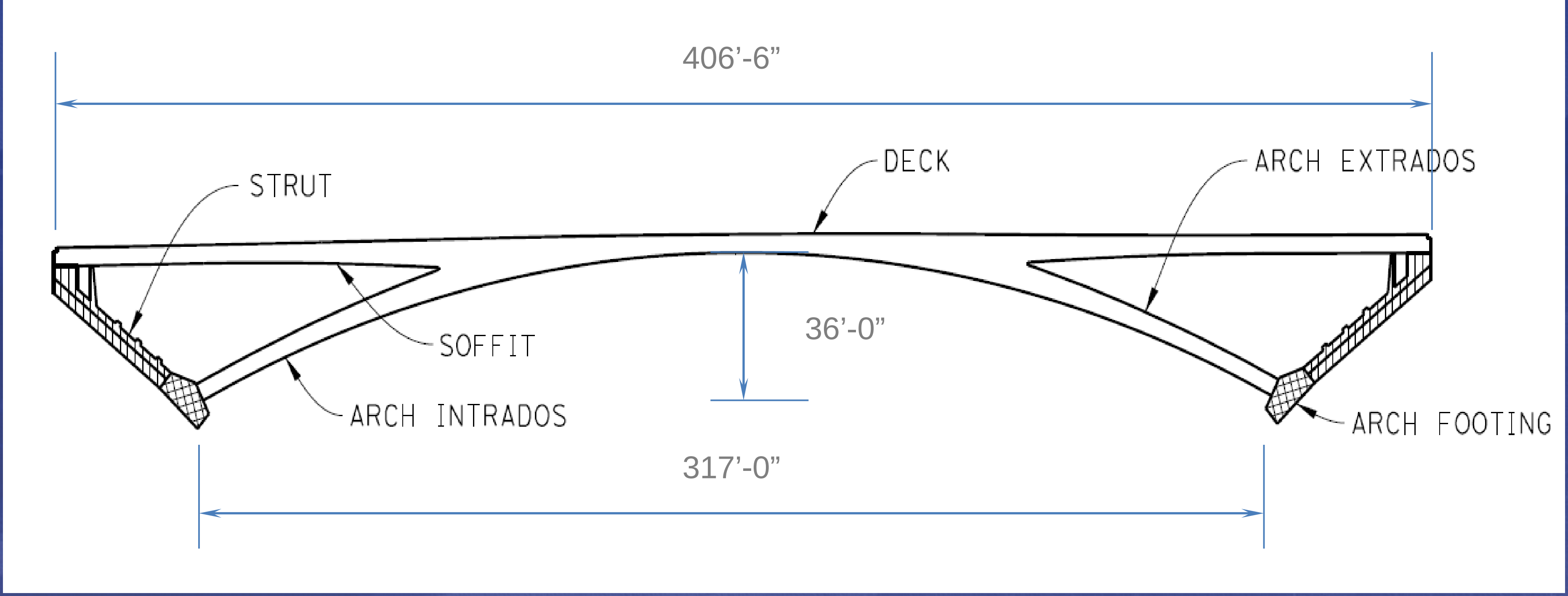
- Struts connect superstructure to foundations to reduce arch thrust



Construction Sequence

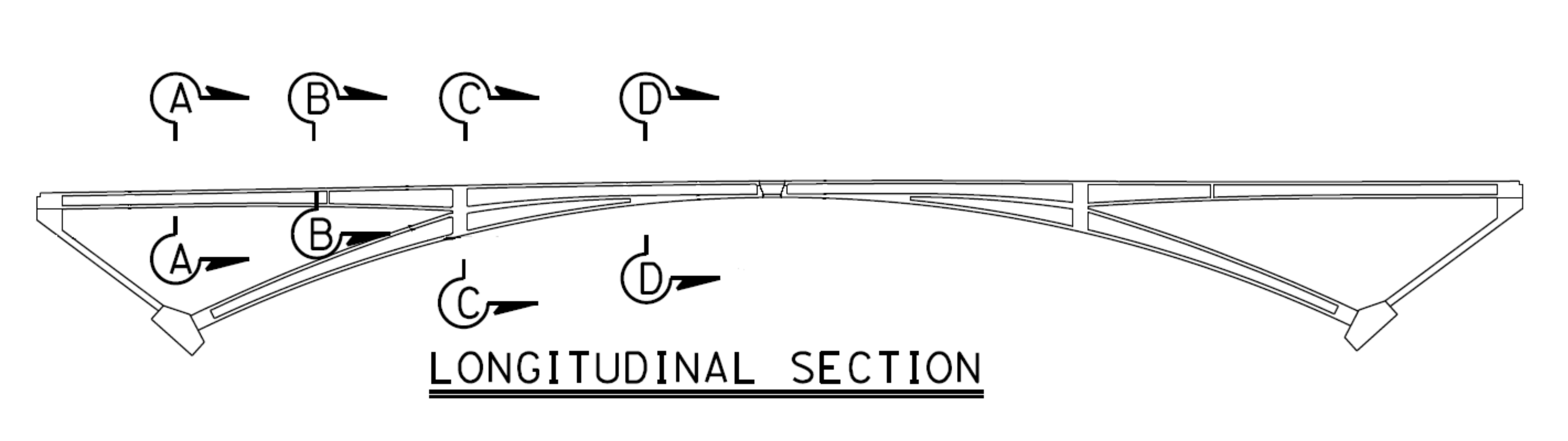


Bridge Layout and Geometry



moffatt & nichol

Superstructure Geometry

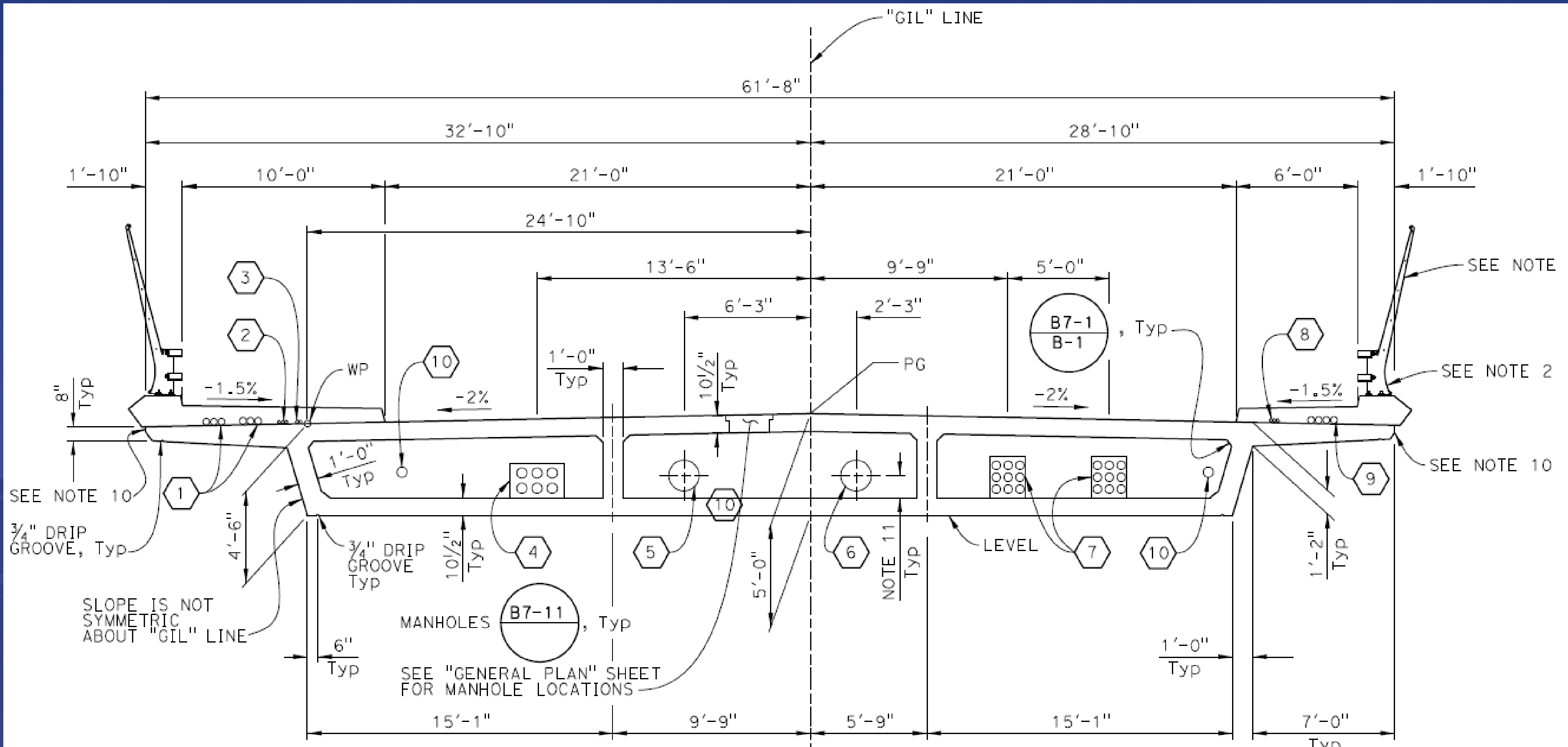


Section A-A: Backspan, constant depth

Section B-B: Backspan, variable depth

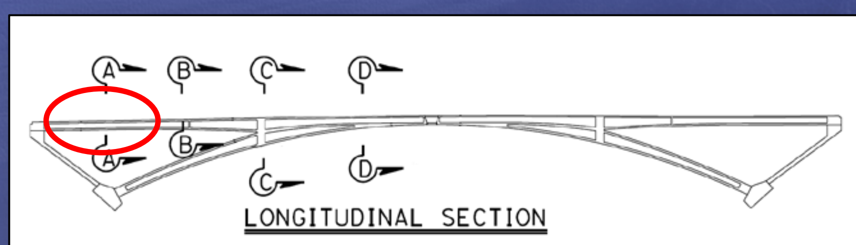
Section C-C: Mainspan, variable depth, stacked cells, arch legs frame into superstructure

Section D-D: Mainspan, variable depth

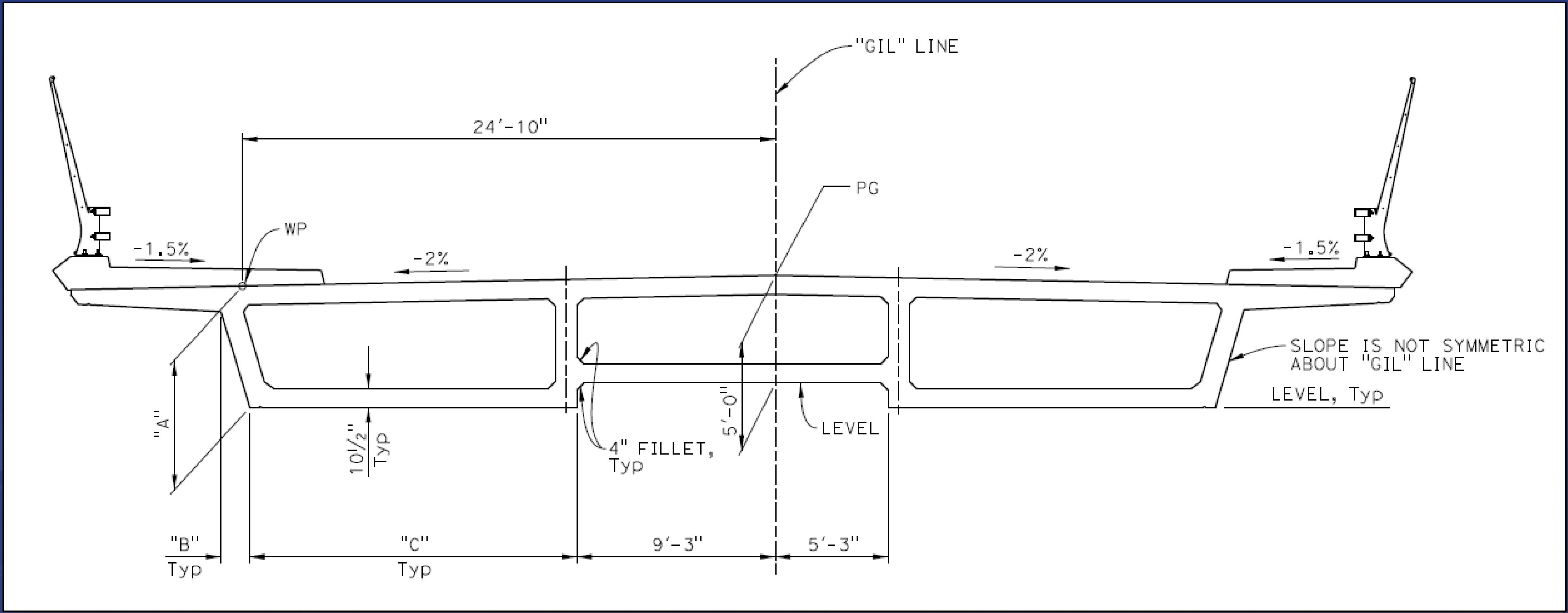


SECTION A-A

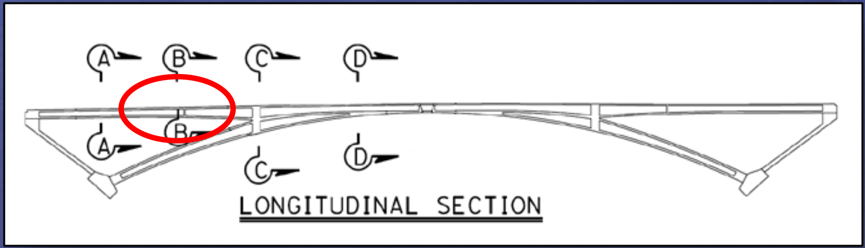
(Back Spans, Constant Depth)



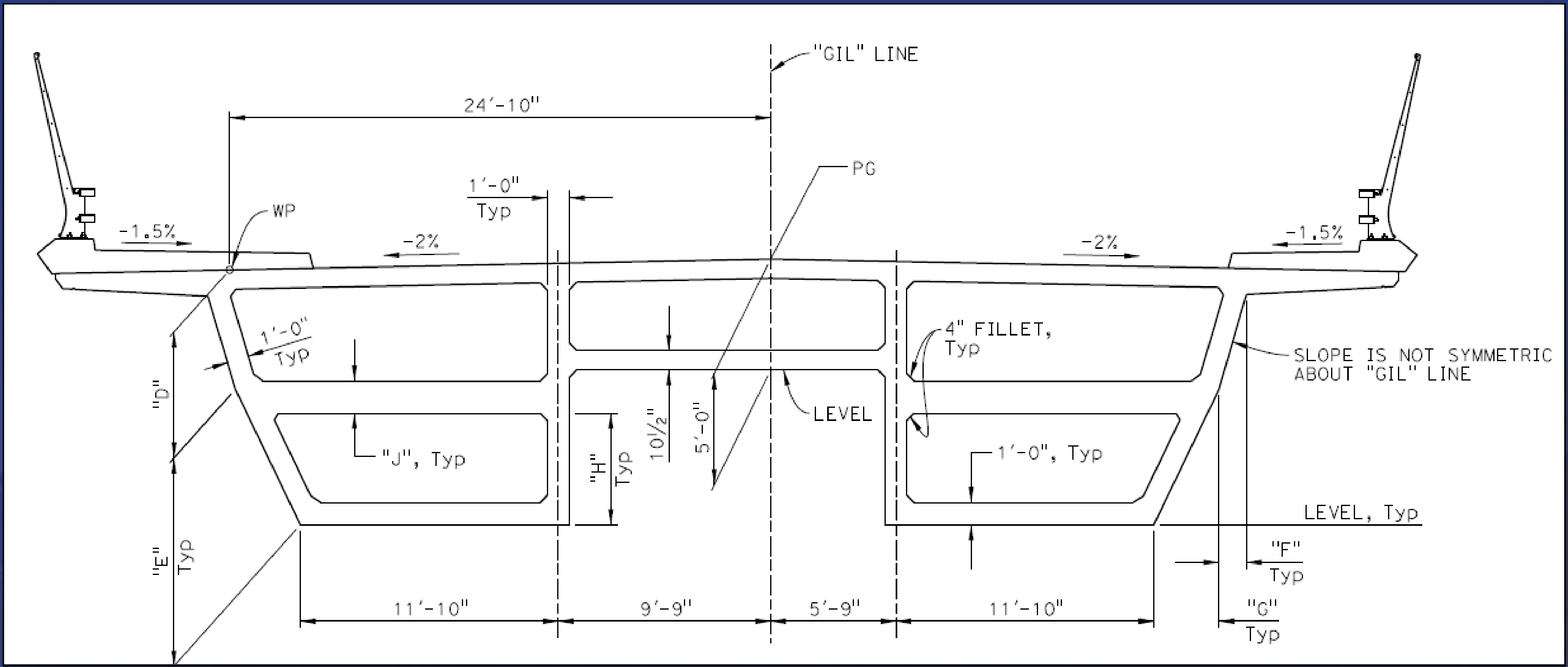
moffatt & nichol



SECTION B-B
(Back Spans, Variable Depth)

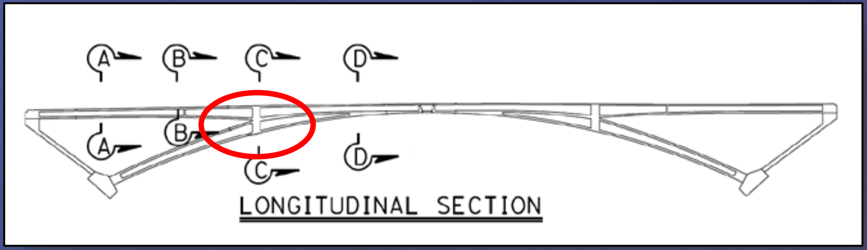


moffatt & nichol

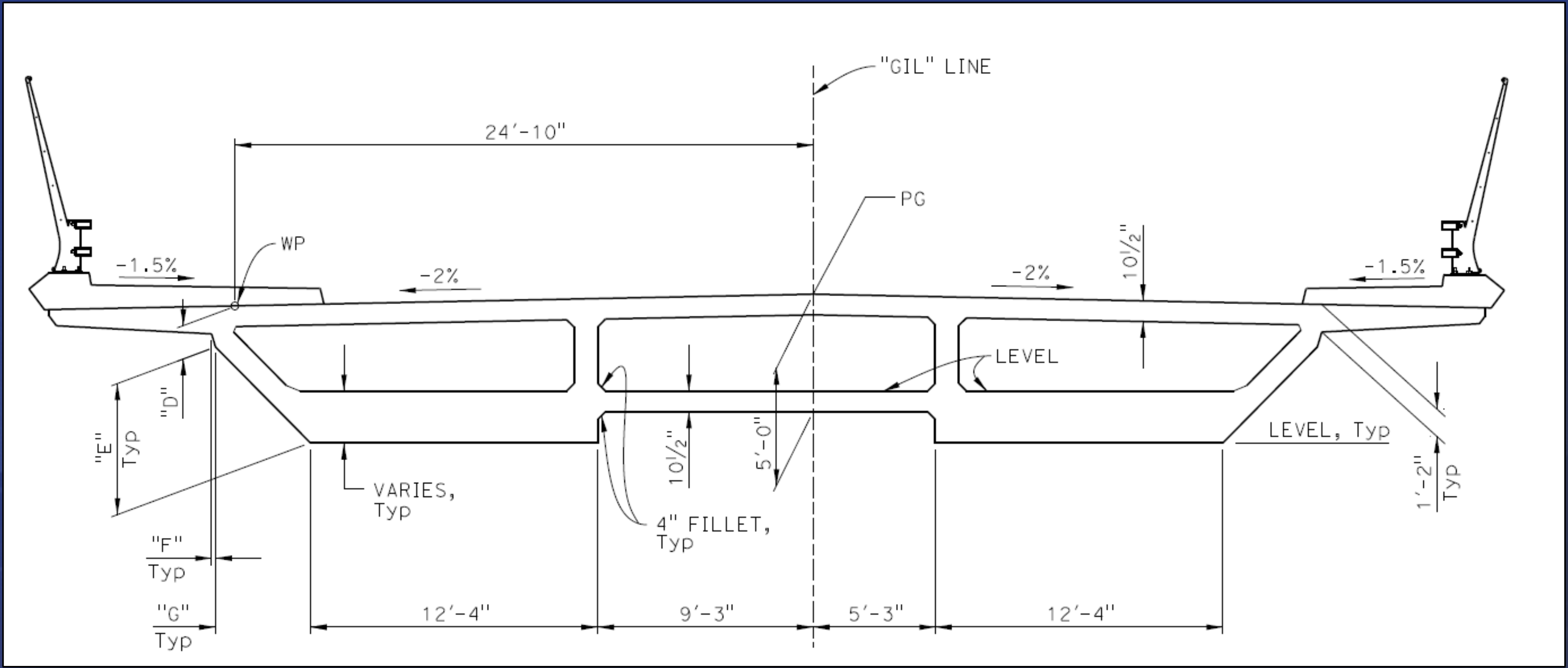


SECTION C-C

(Main Span, Variable Depth, Arch Legs and Deck Merge)

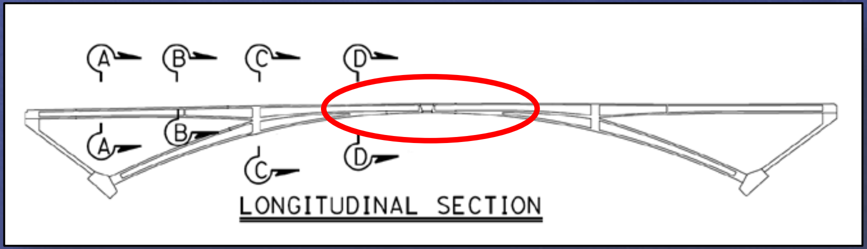


moffatt & nichol



SECTION D-D

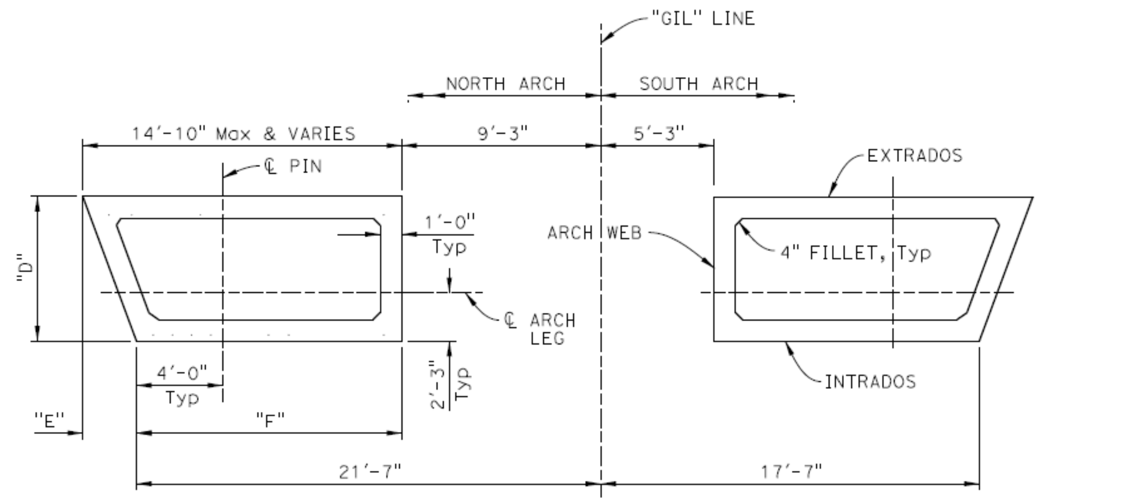
(Main Span, Variable Depth, Near Arch Crown)



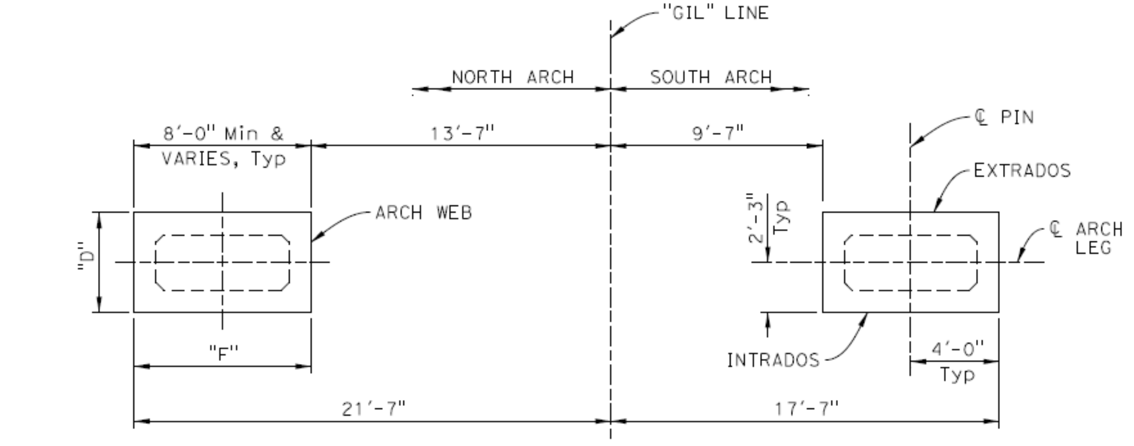
moffatt & nichol

Arch Geometry

- Arch Legs
  - Exterior corner of intrados constant (21'-7") from "GIL" Line
  - Arch width and depth varies
  - Increasing slope at exterior face

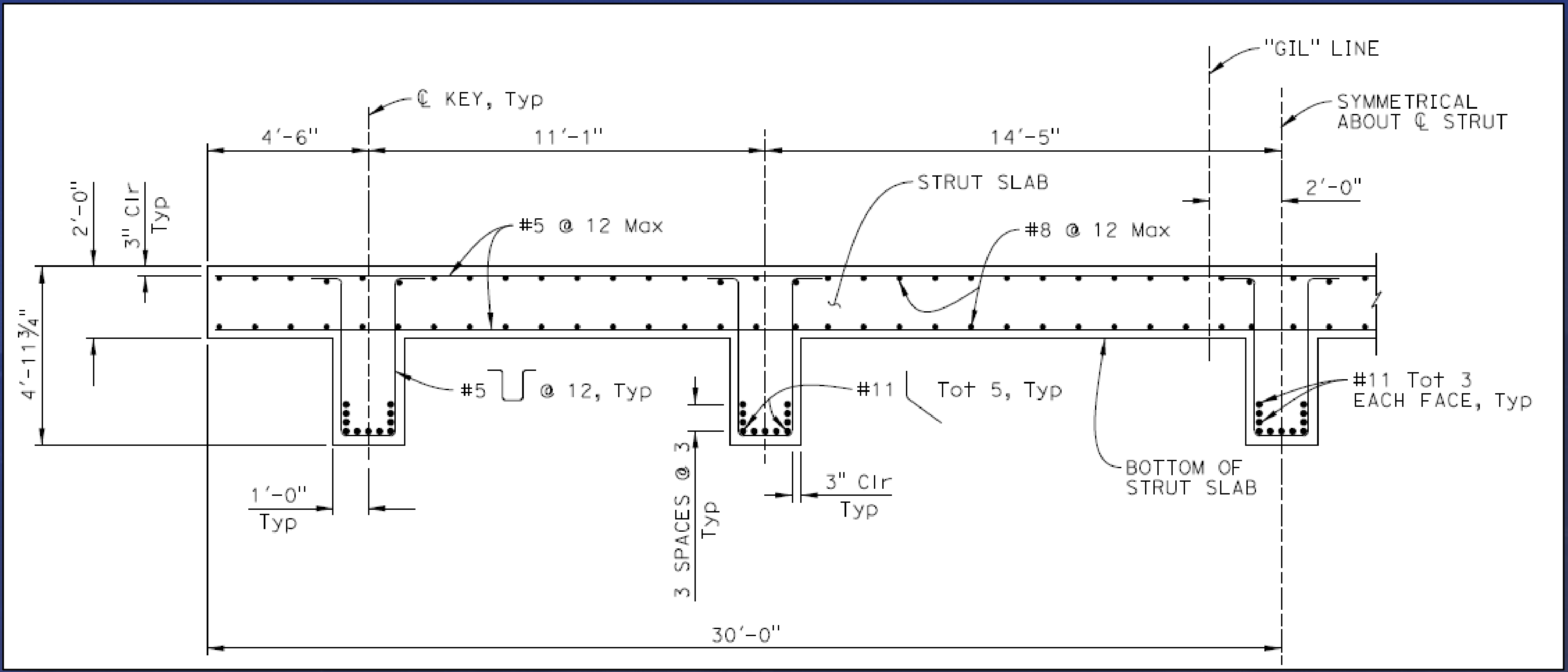


SECTION @ SUPERSTRUCTURE

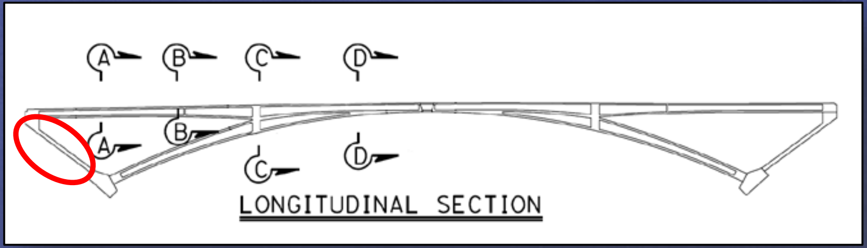


SECTION @ ARCH BASE

Foundation Geometry

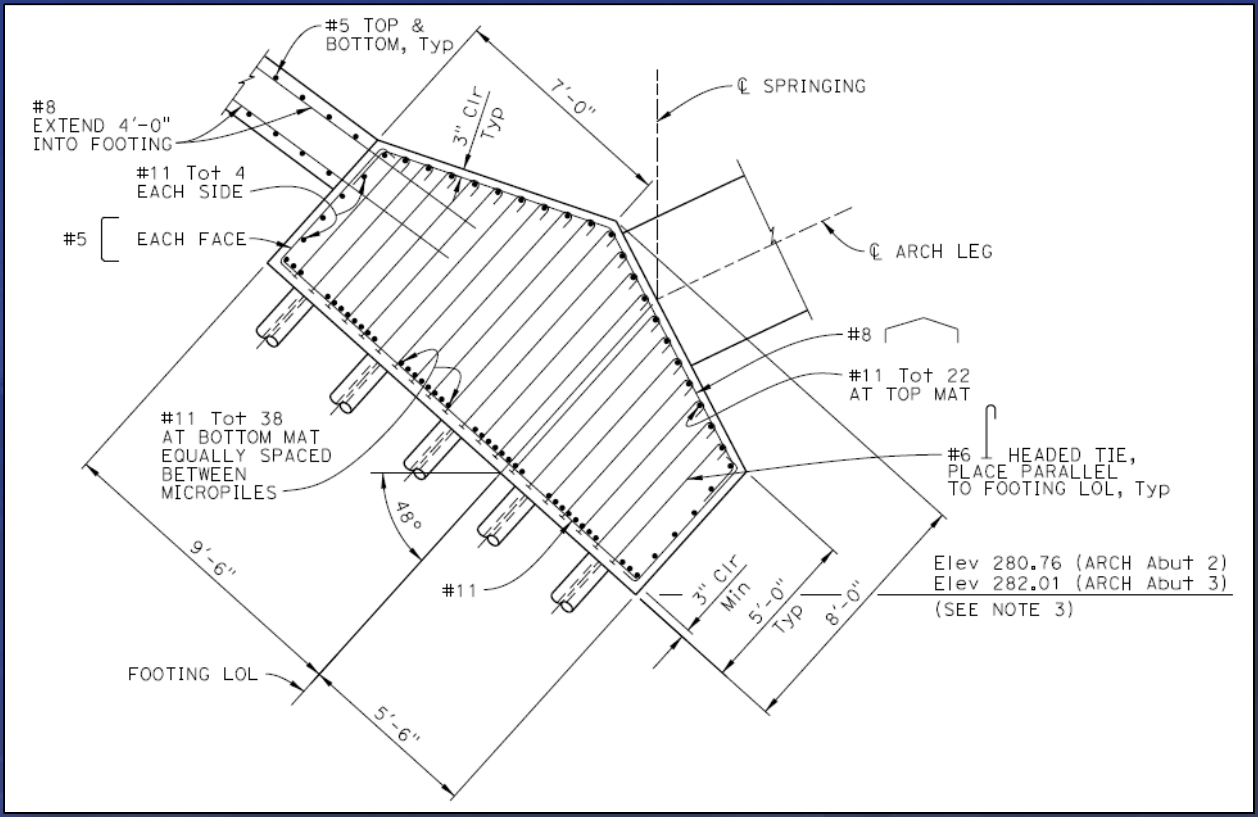


INCLINED STRUT – PART SECTION

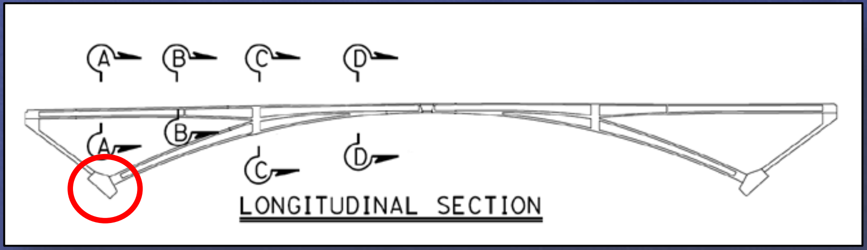


moffatt & nichol

Foundation Geometry



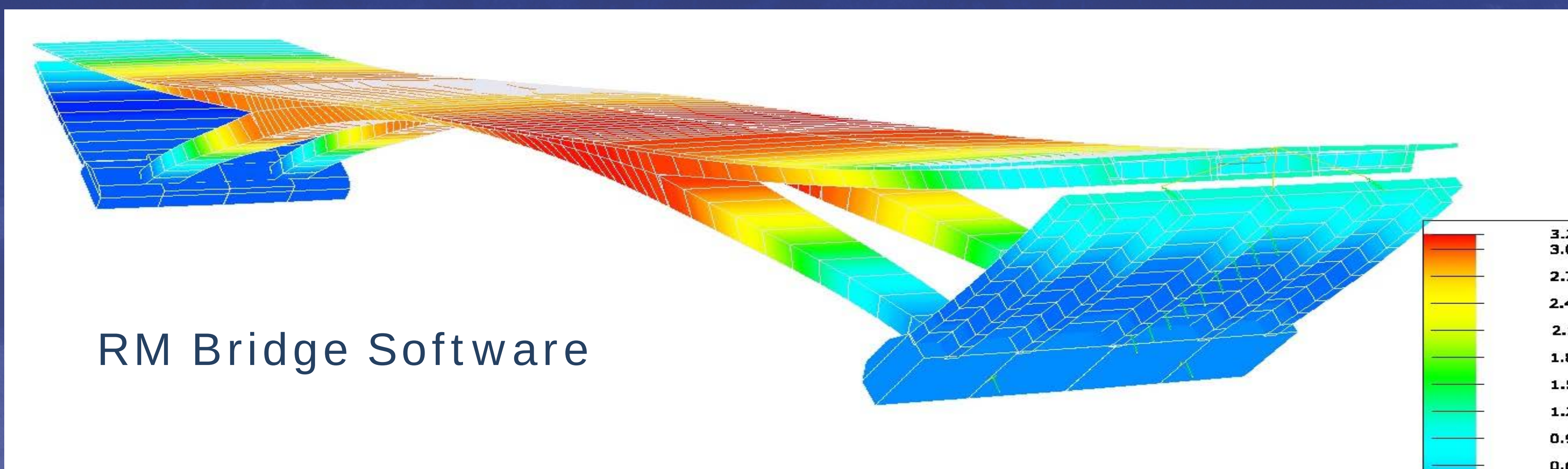
PILE CAP - SECTION



moffatt & nichol

UCSD GILMAN BRIDGE

Structural Model



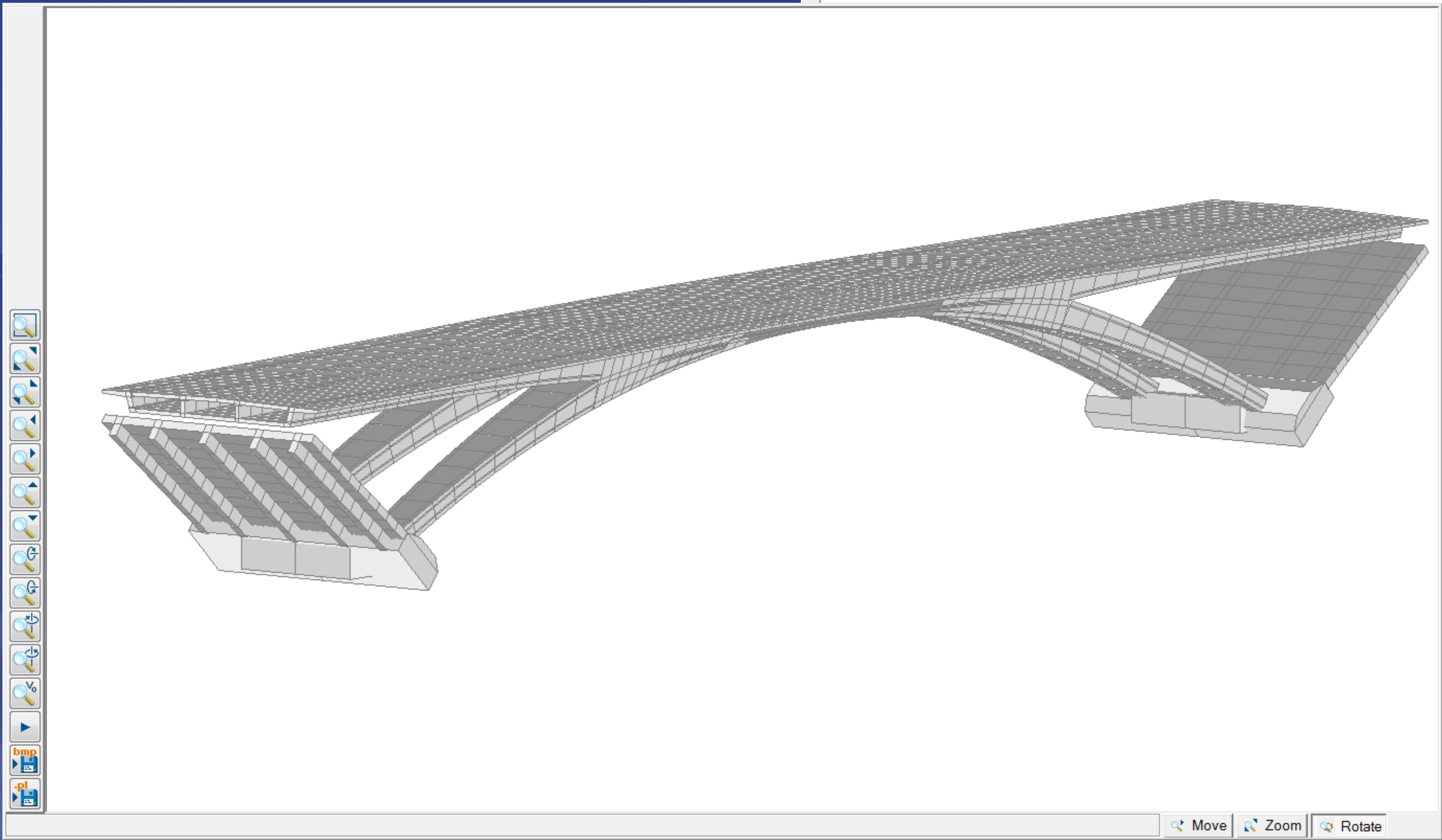
RM Bridge Software

RM Bridge Overview

- **All Types of Bridges**
  - Reinforced and Pre-stressed Concrete
  - Steel and Composite
  - Arch Bridges
  - Cable Supported Bridges
- **Any Erection Method**
  - Span-by-Span
  - Advanced Shoring
  - Incremental Launching
  - Pre-cast Segmental
  - Balanced Cantilever Bridges
  - Cast-in-Place

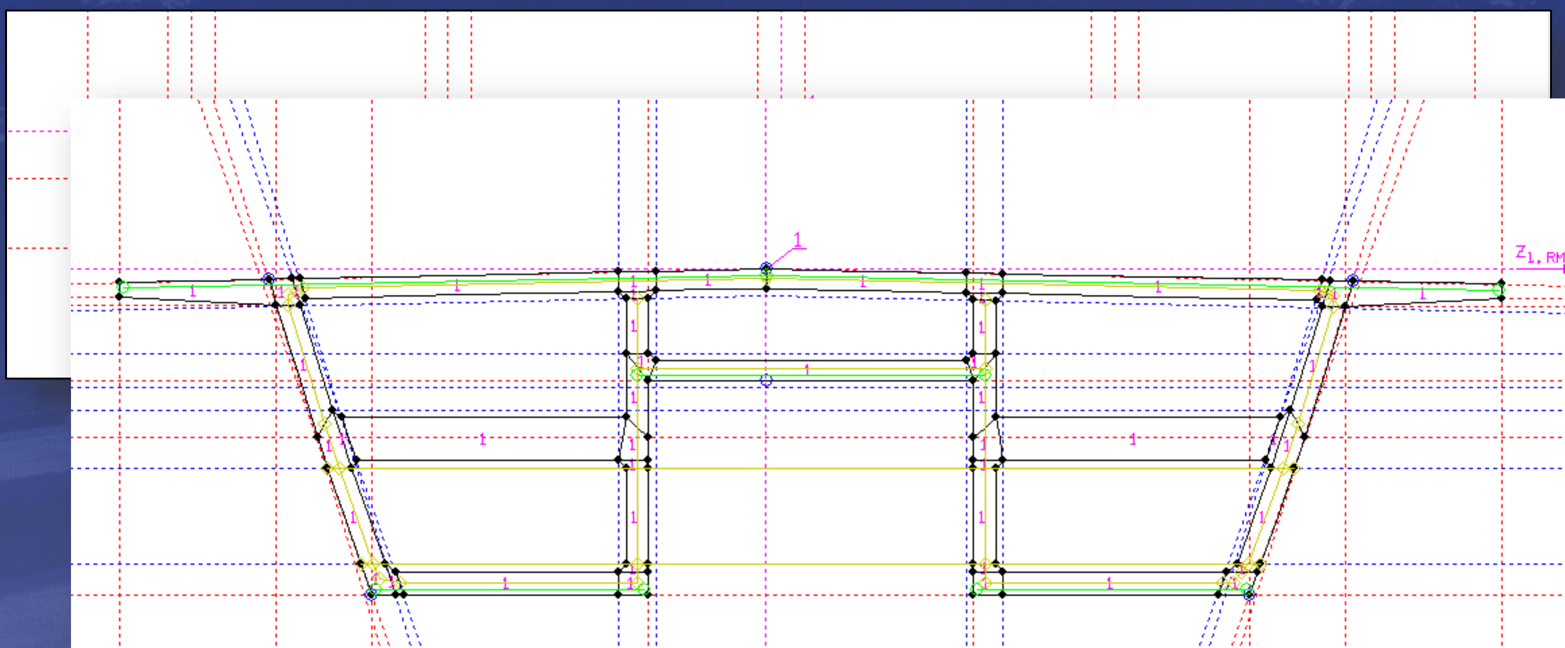
RM Bridge Modeler

Gilman Drive Arch Bridge



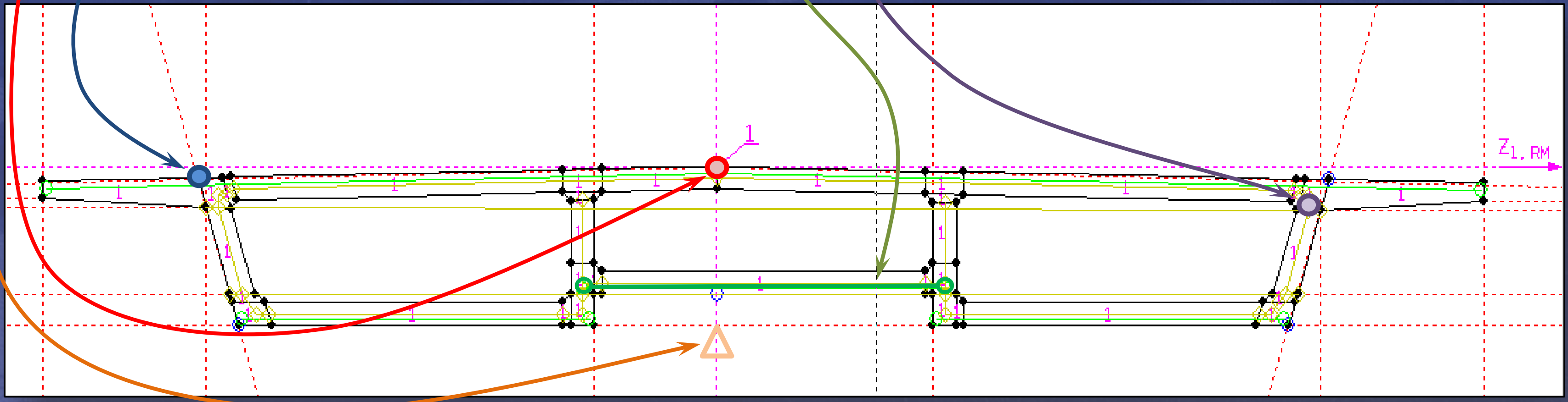
Define Bridge Cross Sections

- Use construction lines to define every surface of a desired cross sectional shape



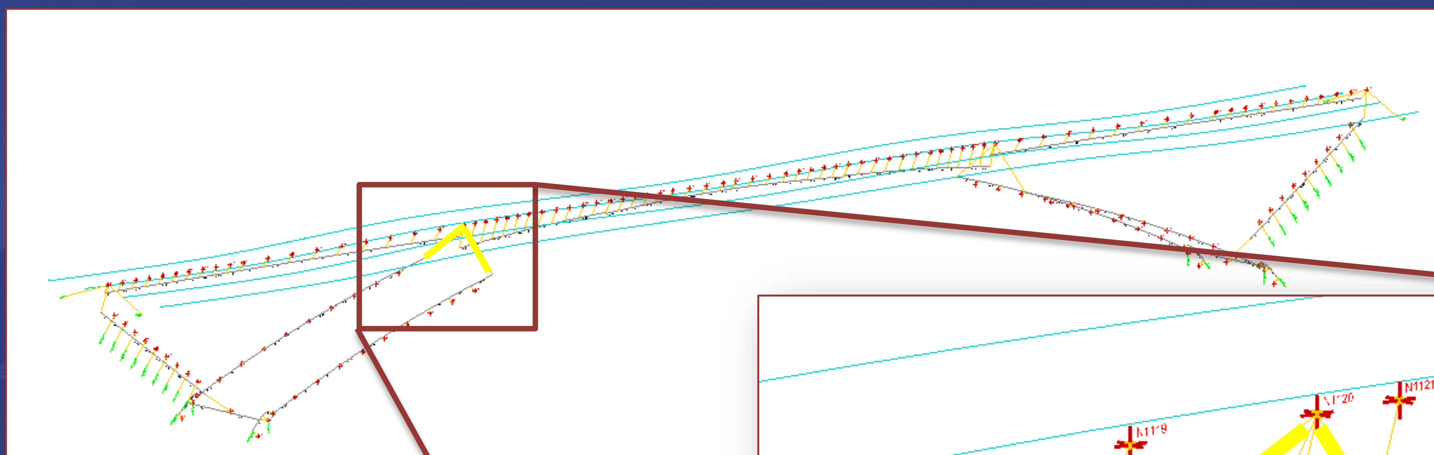
Define Reference Sets

- Reference Sets are points defined within a cross section for the definition of:
  - Spring Locations
  - Connection Points
  - Stress Points
  - Rebar
  - Post-Tensioning Path

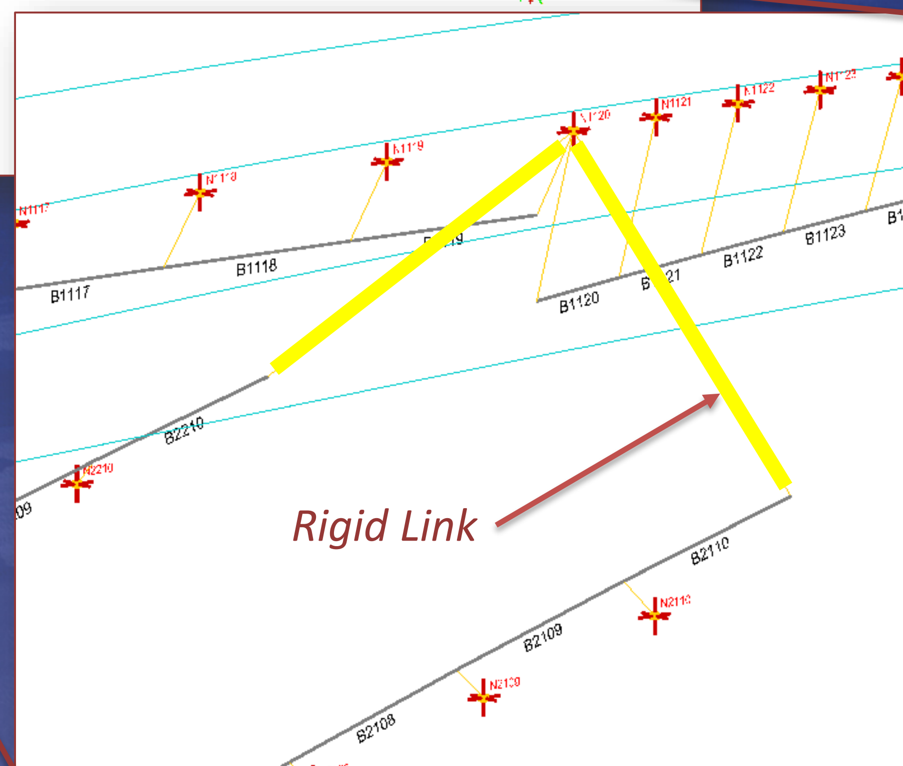


UCSD GILMAN BRIDGE

Connect Segments



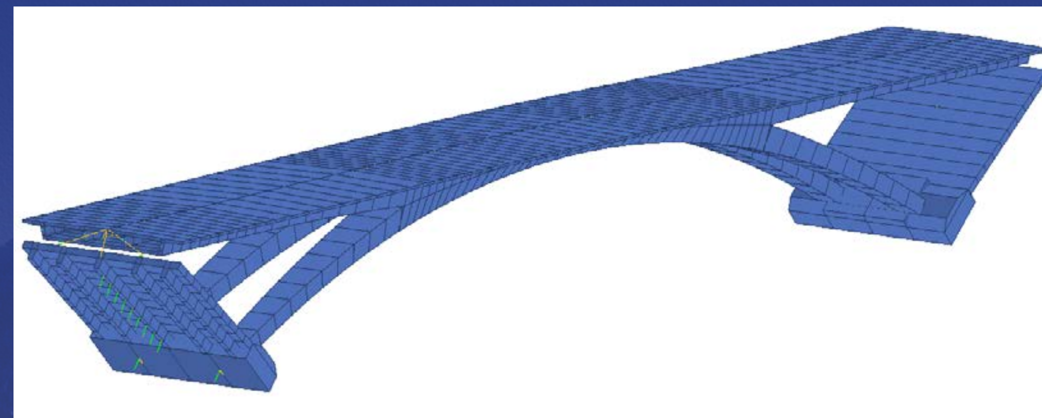
Arch legs are connected to the superstructure with rigid links

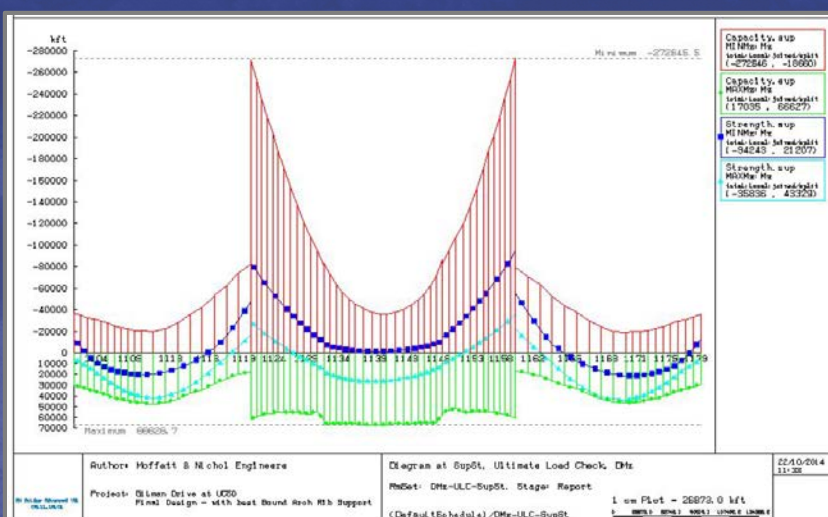


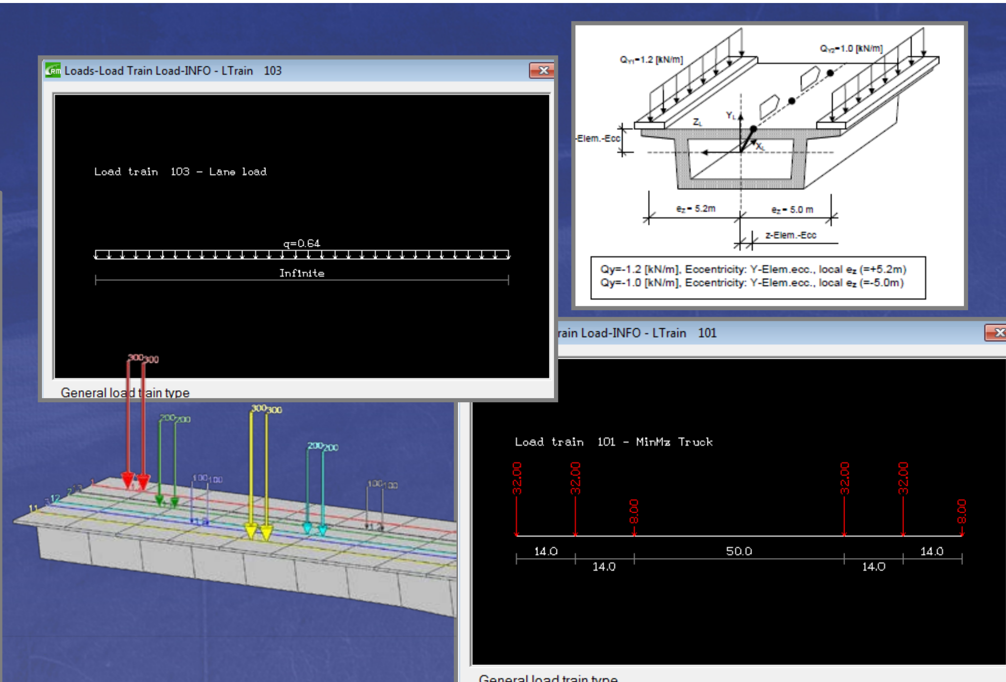
moffatt & nichol

RM Bridge – Analysis / Design

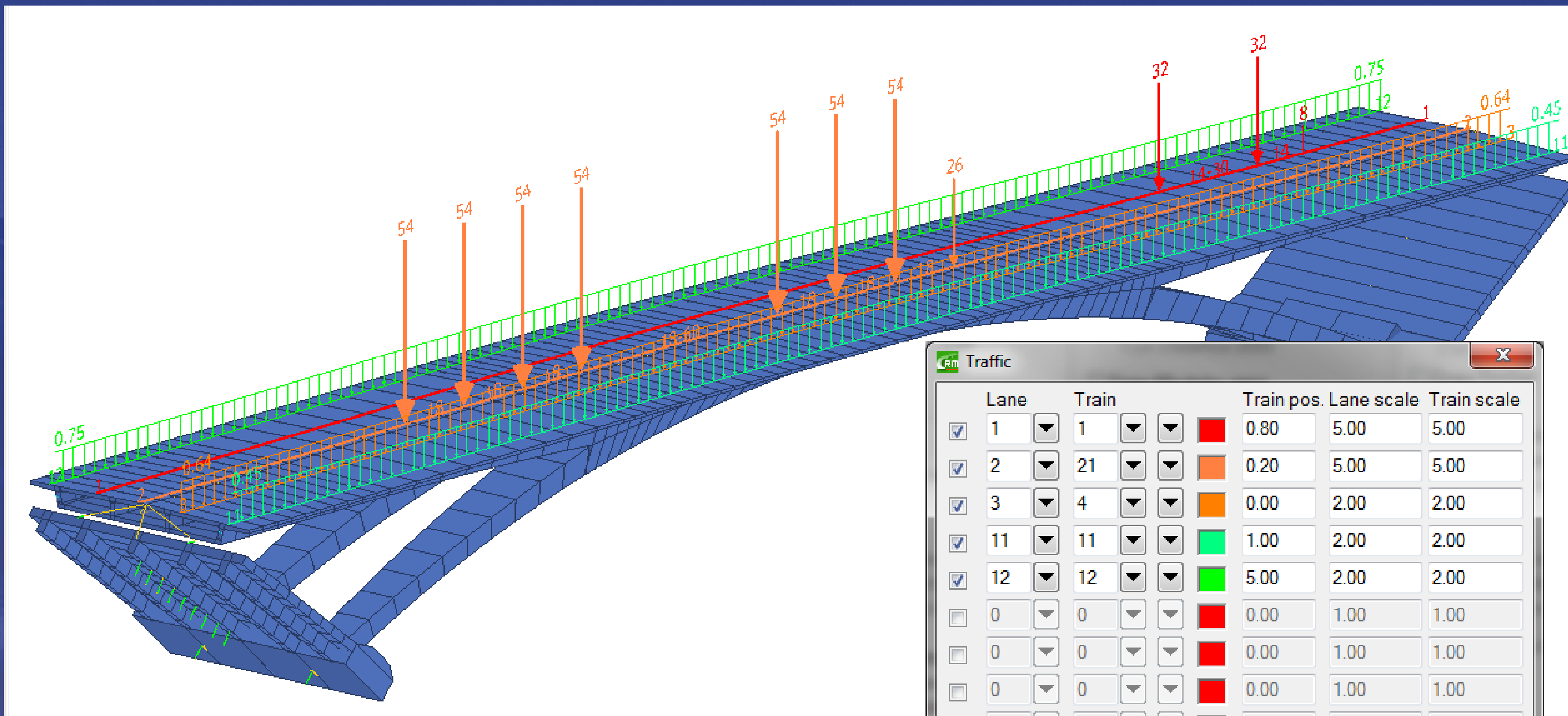
- Additional Definition
- Set-up activation
- Define load cases
- Define live load cases
- Define scheduled actions
- Design code checks







Live Load Lanes & Live Load Trains



Traffic

	Lane	Train	Train pos.	Lane scale	Train scale
☑	1	1	0.80	5.00	5.00
☑	2	21	0.20	5.00	5.00
☑	3	4	0.00	2.00	2.00
☑	11	11	1.00	2.00	2.00
☑	12	12	5.00	2.00	2.00
☐	0	0	0.00	1.00	1.00
☐	0	0	0.00	1.00	1.00
☐	0	0	0.00	1.00	1.00
☐	0	0	0.00	1.00	1.00
☐	0	0	0.00	1.00	1.00

☑ Draw lane text

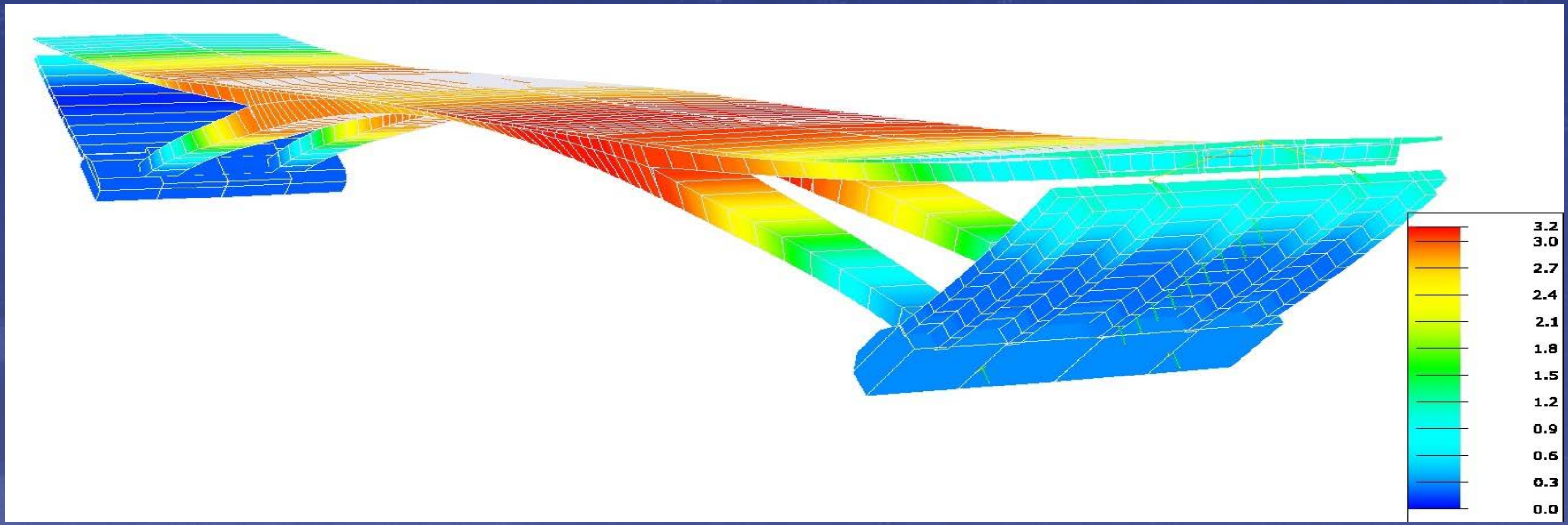
☑ Draw live load text

Text scale: 10.00

Ok Cancel

LRFD Design Code Checks

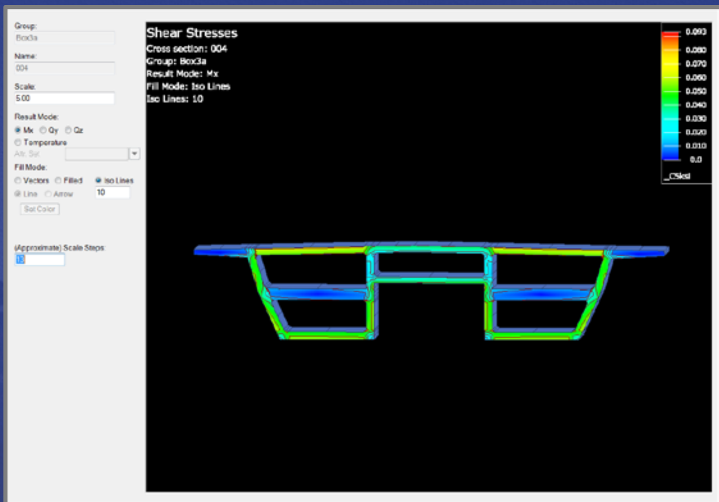
- Stress Check
- Ultimate Load Check
- Shear Capacity Check
- Reinforced Concrete Design
- Crack Control Check

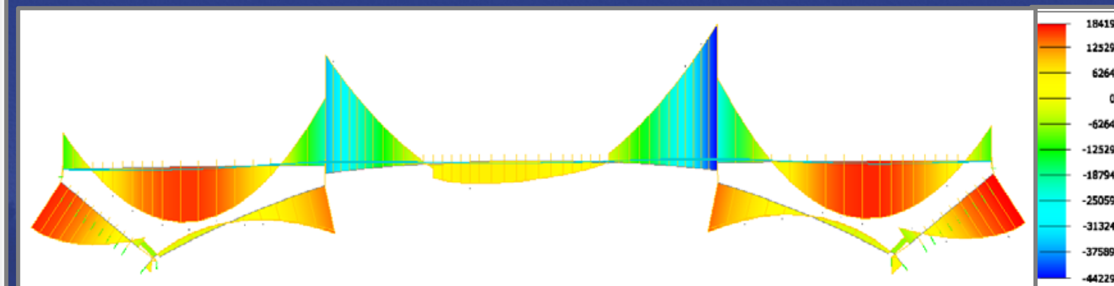


moffatt & nichol

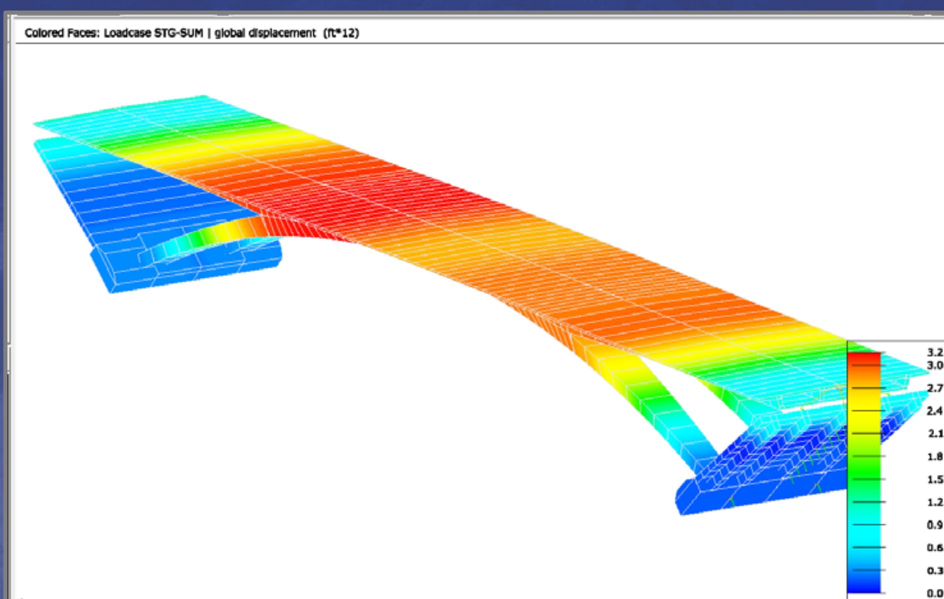
Complies with Design Code

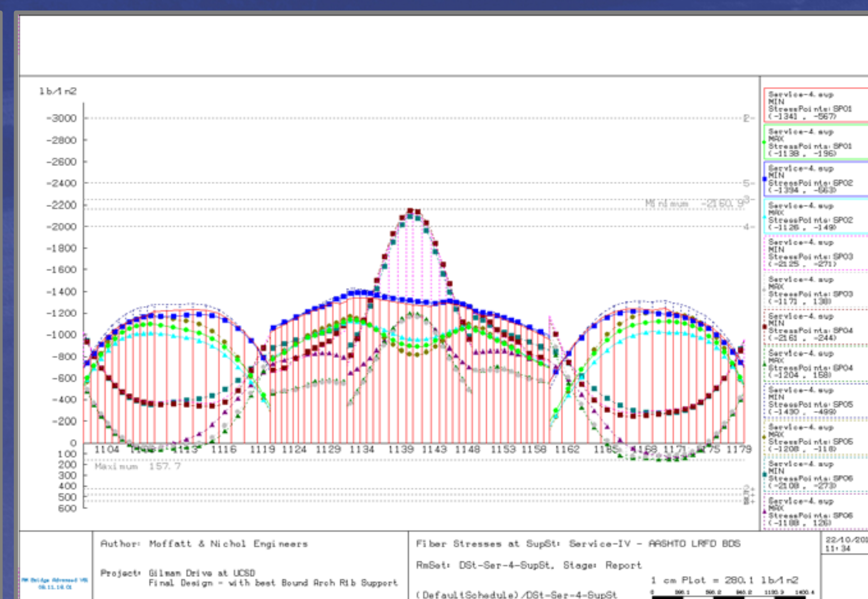
(LRFD, CA Amendments, Caltrans SDC)





- Forces
- Displacements
- Stresses
- Reinforcement, …

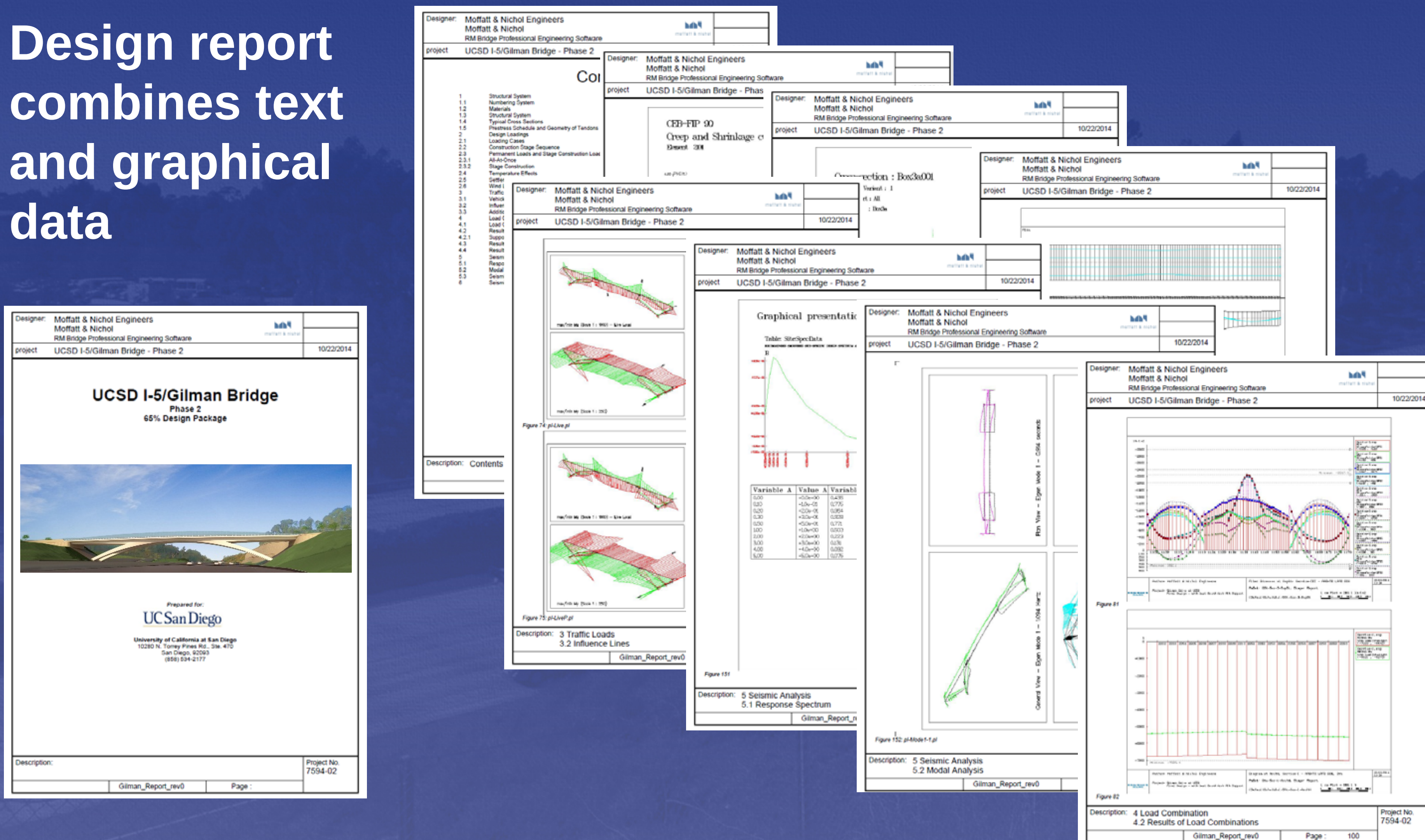




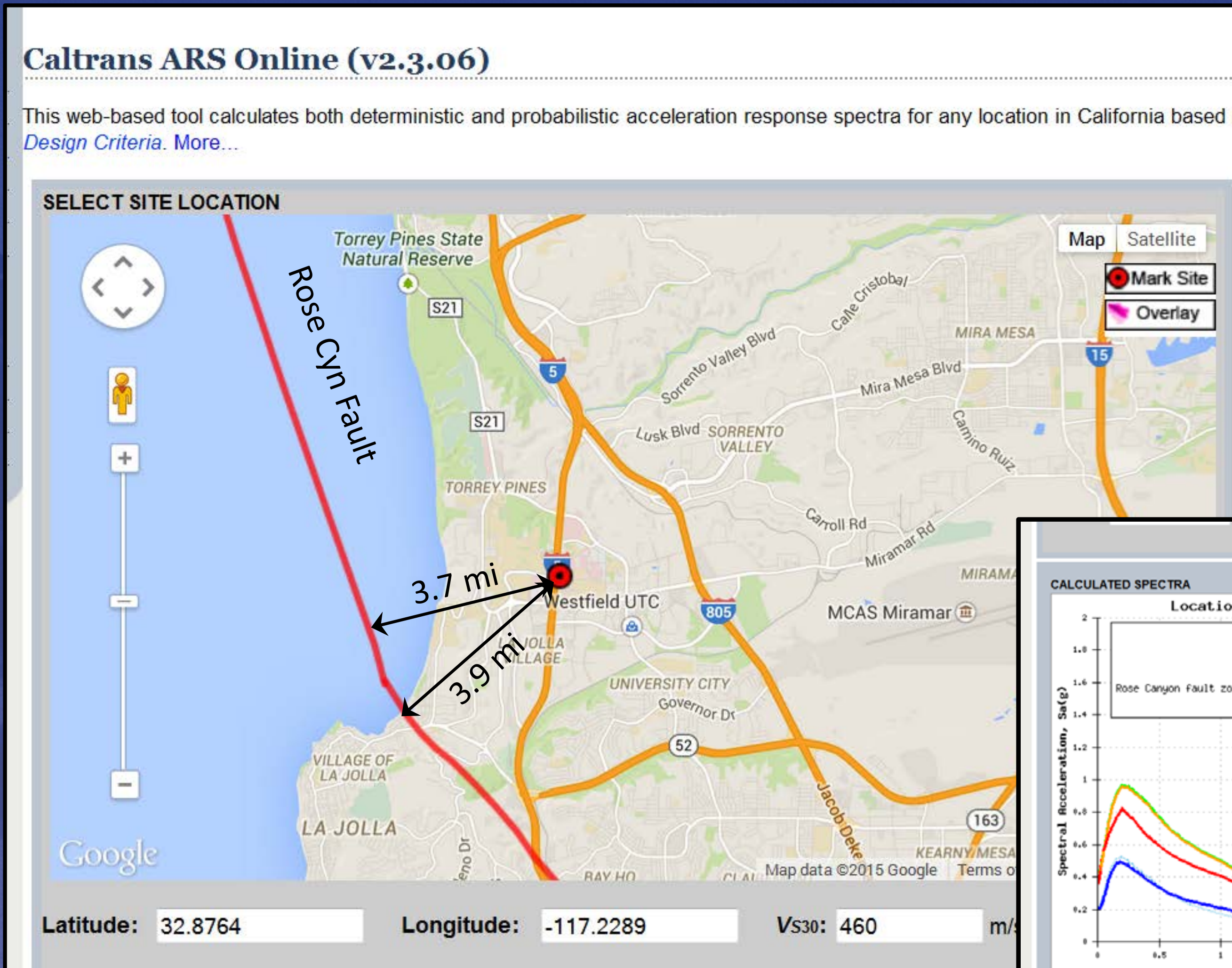
Post Processing – Design Report

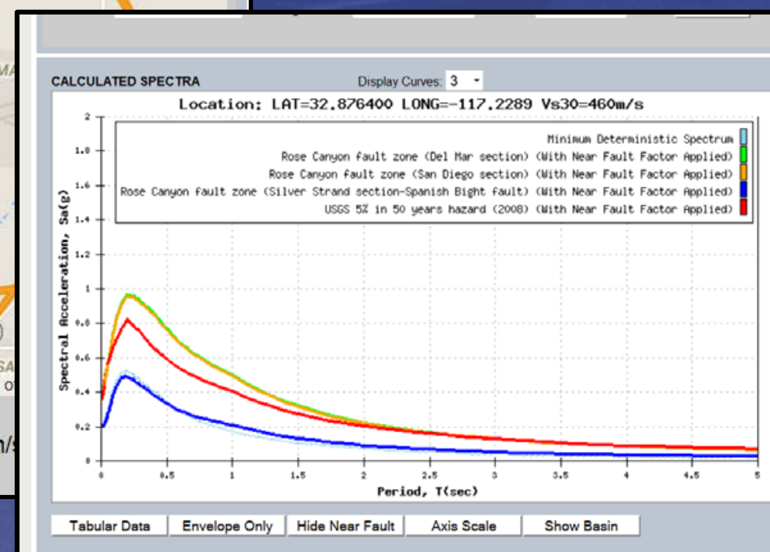
UCSD GILMAN BRIDGE

Design report combines text and graphical data



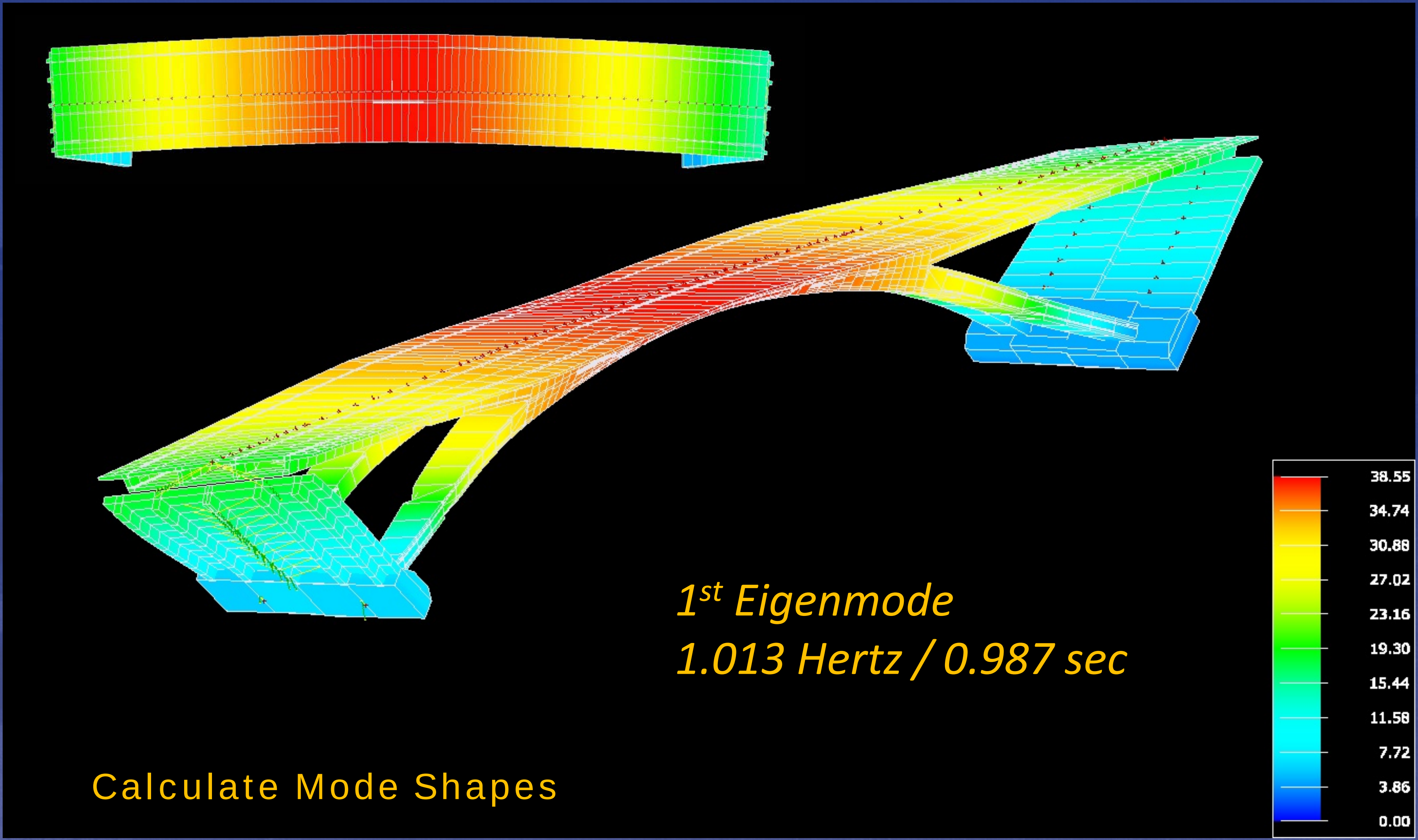
Seismic Design – Site Seismicity





- Vs30 = 460 m/s
- Type C Soil

Seismic Design



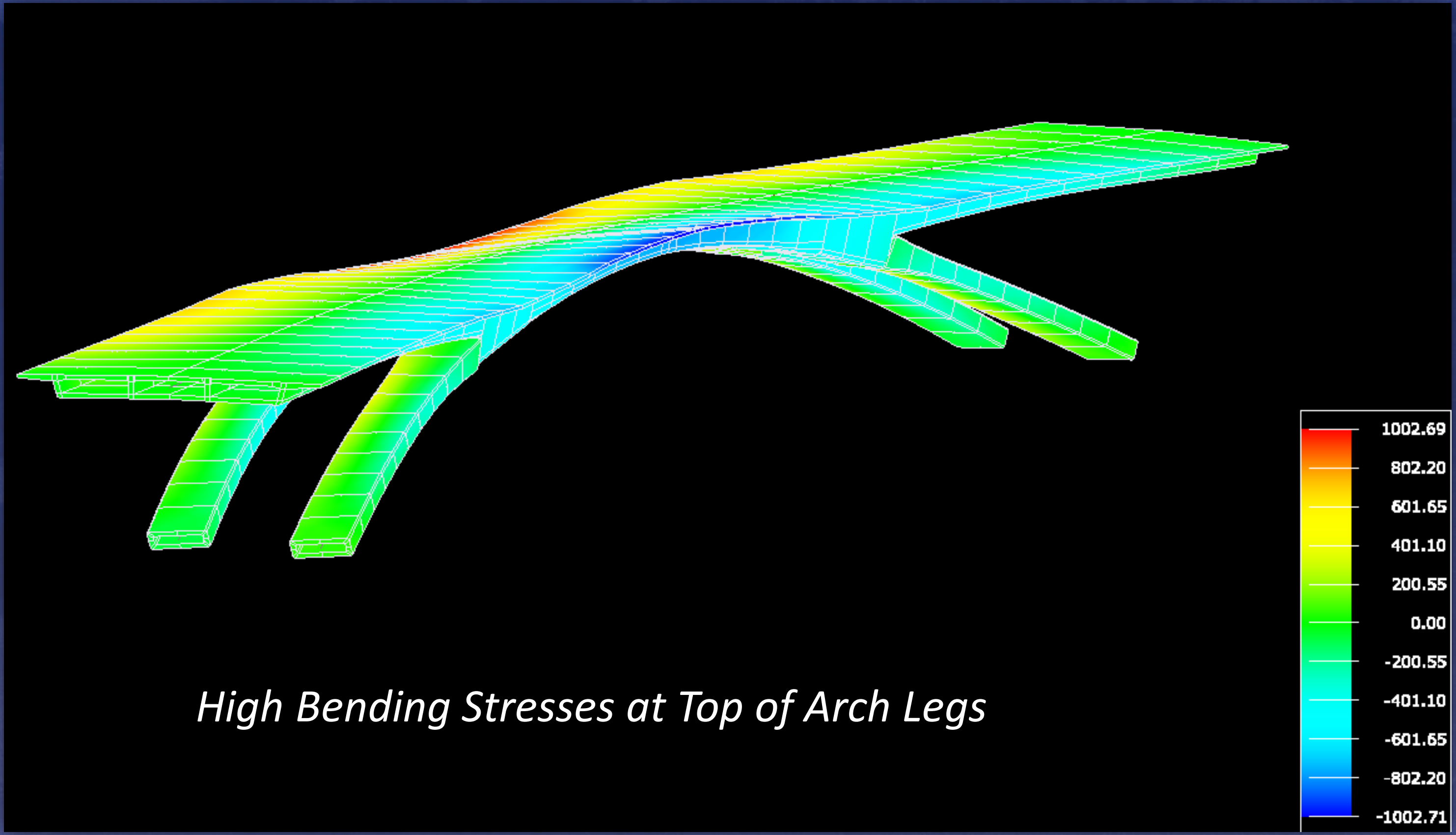
1st Eigenmode

1.013 Hertz / 0.987 sec

Calculate Mode Shapes

Seismic Design

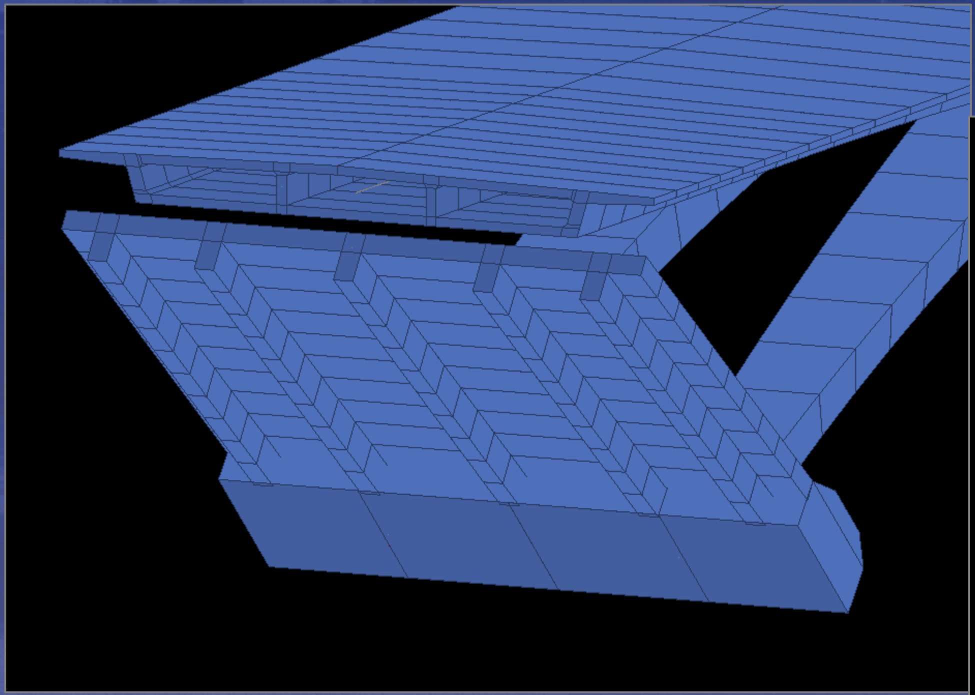
- Preliminary design with no Strut
- Plastic hinges form at top of arch legs

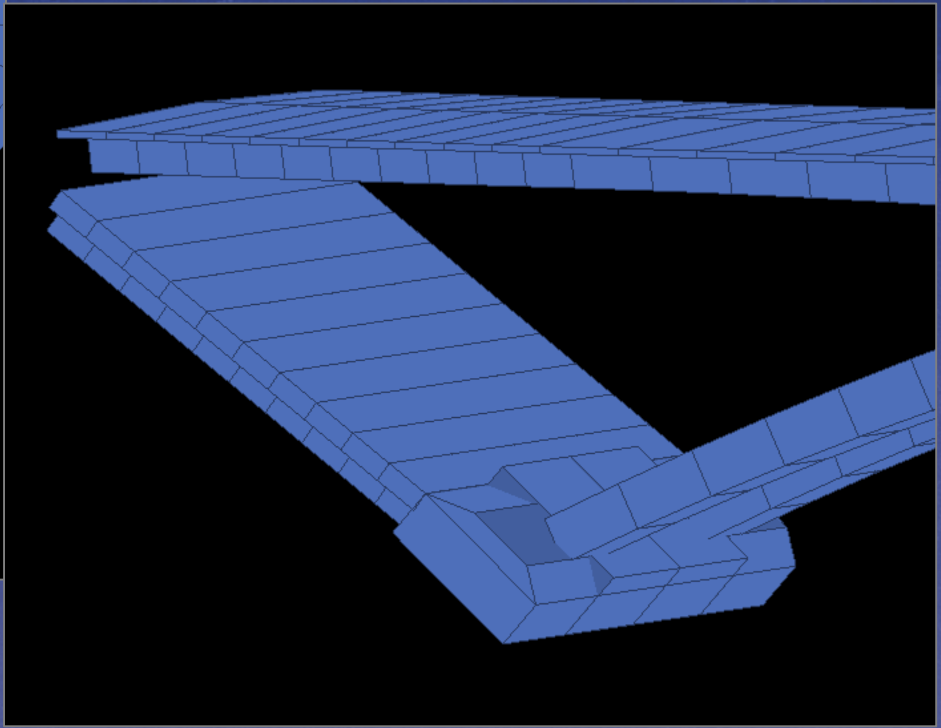


High Bending Stresses at Top of Arch Legs

Struts Have a Beneficial Effect on the Seismic Performance

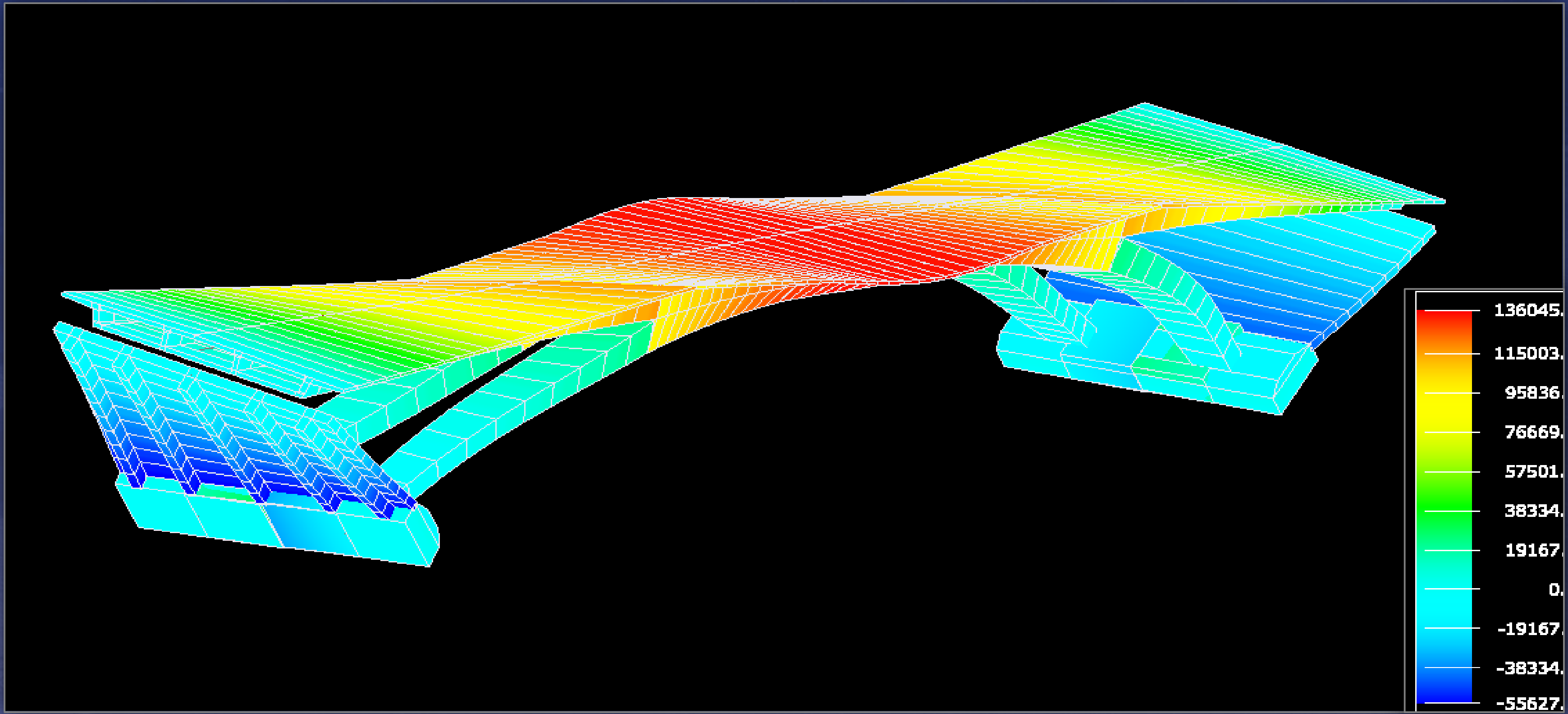
- A strut was added between the superstructure and foundation to reduce arch thrust





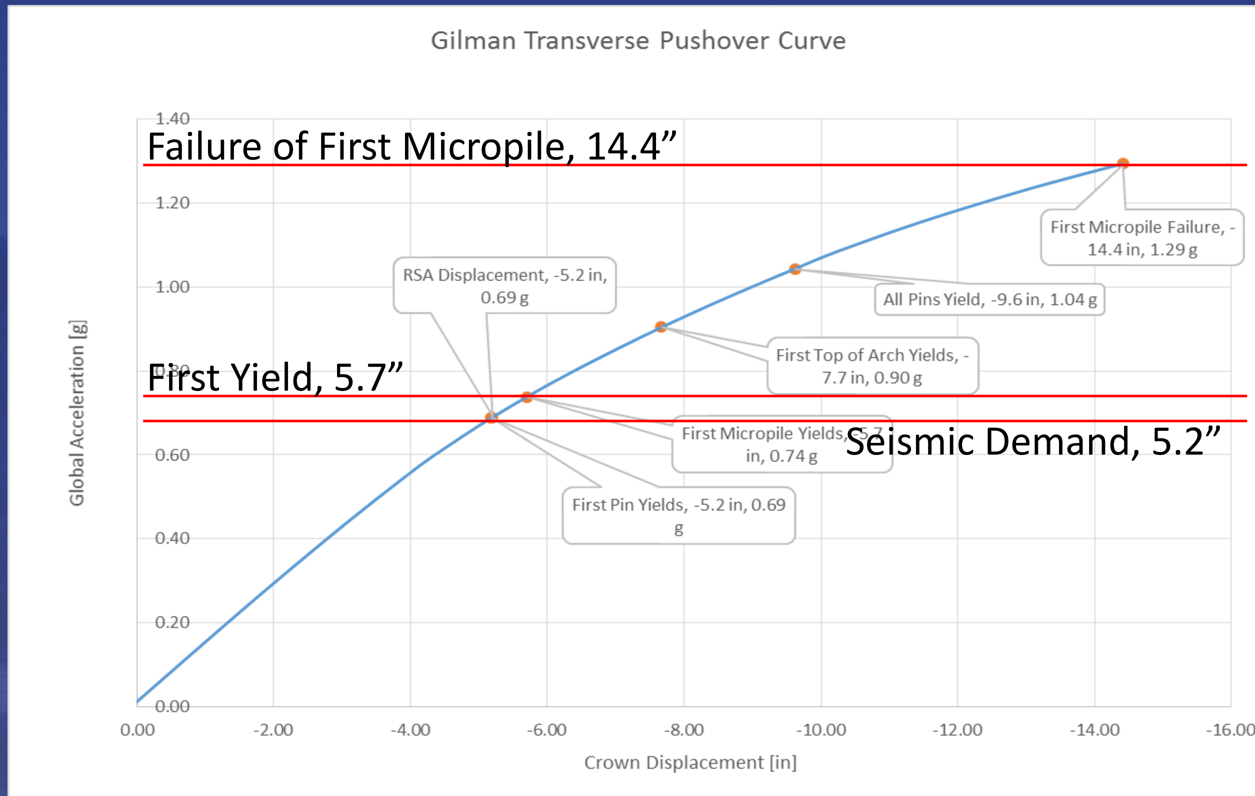
Seismic Response Including Inclined Struts

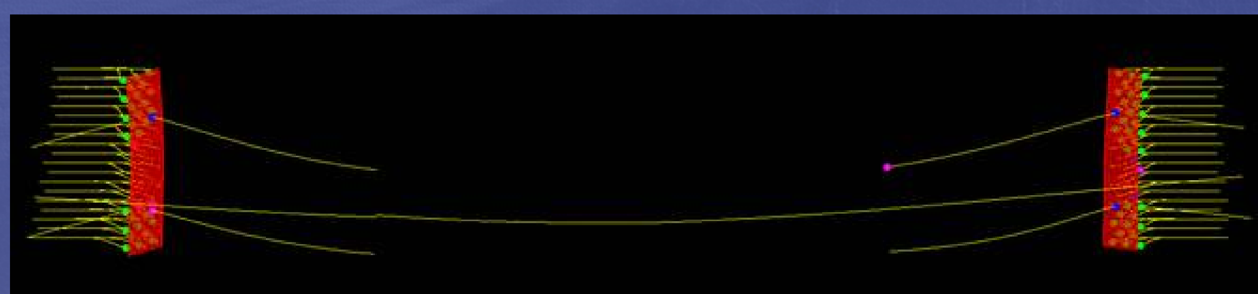
- Struts stiffened the bridge in both directions
- Δ_{trans} = 9” (before), 5” (after)
- Superstructure acts as diaphragm (plenty of capacity)
- Arch legs now stay elastic



Seismic Design – Transverse Pushover Results

- Displacement Capacity vs. Demand = 14.4/5.2 = 2.8
- EQ would have to develop 2.8 times the intensity to fail one pile
- 96 micropiles used
- Ductility Demand = 5.2/5.7 = 0.9 (Bridge stays elastic, no damage)
- SDC allows Ductility Demand of 5.0





Bridge Renderings

UCSD GILMAN BRIDGE

Looking North

SAFDIE RABINES
ARCHITECTS

moffatt & nichol

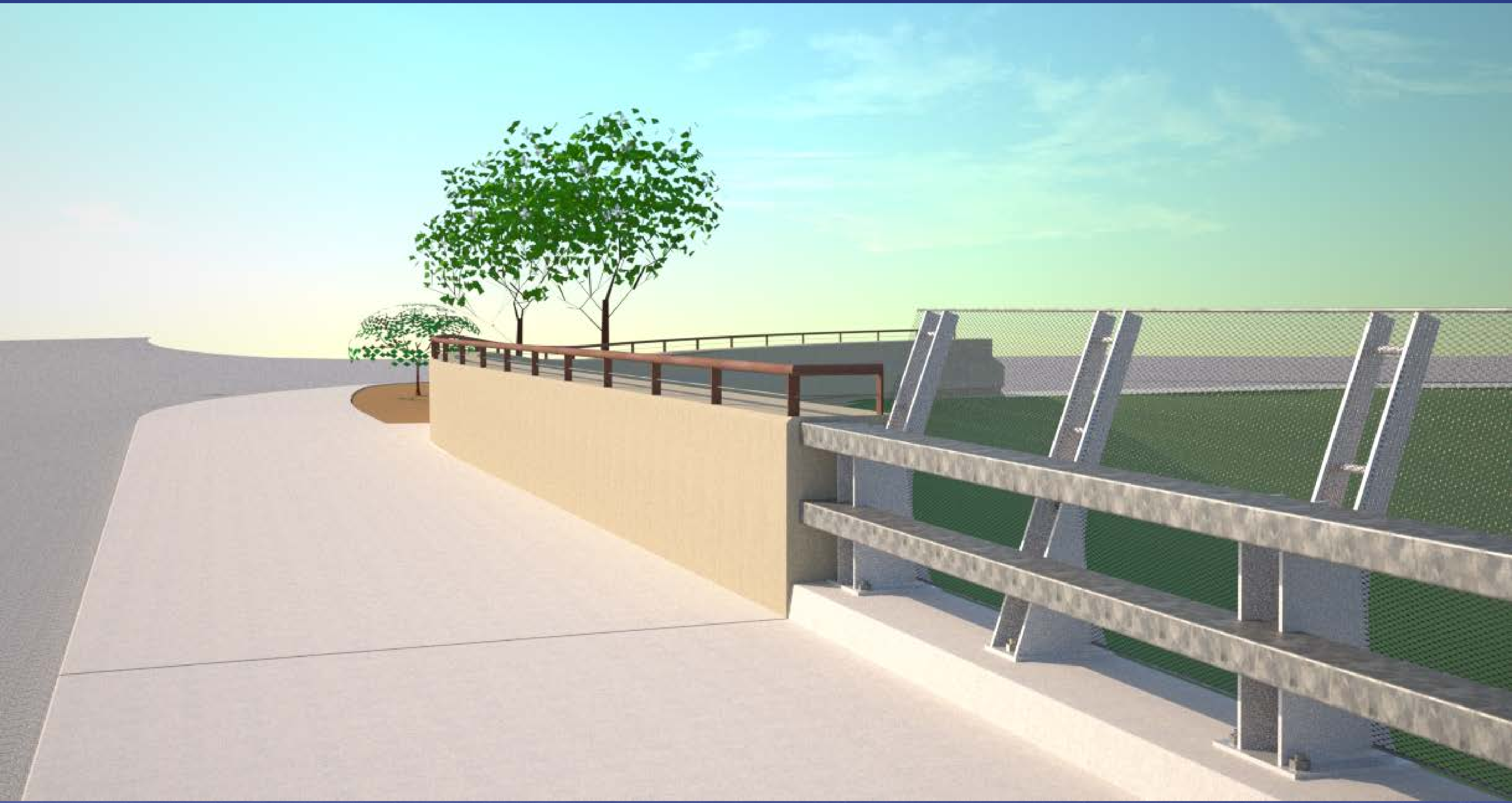
UCSD

GILMAN BRIDGE

Looking East

SAFDIE RABINES ARCHITECTS

moffatt & nichol



Rail Transition at Ends of Bridge

Project Team

- UCSD - Project Management, Environmental
  Anka Fabian, Robin Tsuchida, Cathy Presmyk
- Caltrans – Design Oversight
  Arturo Jacobo, Kareem Scarlet, Shahbaz Alvi, Dave Stebbins, Norbert Gee
- Moffatt & Nichol – Civil, Roadway & Bridge Engineering
  Tony Sánchez, Perry Schacht, Victor Tirado, Mitch Duran, Debbie Ramirez, Arash Monsefan, Garrett Dekker, Elena Pleshchuk, Gernot Komar, Jason Hong, Bob Dameron, Al Ely, Patrick Chang, Amanda Del Bello
- Safdie Rabines Architects – Architecture
  Eric Lindebak, Brer Marsh, Ricardo Rabines
- Earth Mechanics – Geotechnical Engineering
  Eric Brown, Patrick Wilson

Thank You !

Questions ?