Outline of the Presentation

1. Preview of the paper
   • Seismic demand: development of design ground motions
   • Seismic performance: global bridge modeling

2. Project innovations
   • Unique form
   • Seismic isolation
   • Secondary system
   • Grade 80 reinforcement
   • PT couplers
Original 6th Street Viaduct

- Iconic structure
- 1932 – 2016
- 45 spans
- 3,180 feet long
- 4 traffic lanes
- Deterioration (ASR)
- Design contest
Winning Replacement Concept

Structure Design: HNTB
Architect: Michael Maltzan Architecture
PM: City of LA Bureau of Engineering
Geotechnical: EMI
Seismic Design

- High seismic demands (M6.5 – 7.5 events at < 10 km)
- Challenging architectural features – laterally unbraced canted arch ribs
- Base isolation
- Global bridge modeling
Development of Multiple-Support Ground Motions

- Ground shaking will not be uniform along length of bridge or depth of piles
- Multiple-support excitations & depth-varying motions
  - Develop ARS at target rock elevation (below pile tip)
  - Select startup time histories, rotate to principal directions
  - Perform spectrum matching to target rock spectra

10’ Drilled Shafts: ~150 ft deep

Target Rock Elevation

> 3,000 ft
Site Response and Pile-Soil Interaction

Site Response Analysis

Model of Soil Profile

Fill
Alluvium
Upper Fernando
Lower Fernando

Input rock motions

Depth-Varying Motions along Piles

Pile-Soil Interaction

Spectral Acc. (g)

Kinematic motion
Free-field motions

Period (sec)

Horizontal Soil Springs (p-y)

Arches
Roadway Deck

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

HNTB
Global Bridge Modeling

• Assume elastic response & verify later
  • Exceptions: nonlinear soil springs, isolation bearings, hangers (tension-only)
• Time histories input to ground node of soil springs (3 components)
• Modal analysis with bearings locked (non-isolated): fundamental $T = 2.5$ seconds
• With base isolation system active, vibrational period function of displacement
  • Typical isolation mode periods range from about 3.9 to 4.3 seconds

Pile foundations included with nonlinear soil springs ($p-y$, $t-z$, $q-z$)

3-component excitation (2 horiz & 1 vert)
Global Bridge Model Results

- Evaluate overall performance
- Verify elastic response in structural components (D/C < 1)
- Determine extreme event loading for sizing and detailing
- Verify size of isolation bearings

**Maximum Isolator Bearing Displacements**
Project Innovations

1. Unique Bridge Form
   - Canted Unbraced Concrete Network Arch
   - Seismic Isolation
   - Isolation Bearings Placed at Mid-Height of Column
   - Continuous Framing – 3060’ Between Expansion Joints

2. Use of SERS with Seismic Isolation

3. Grade 80 Reinforcement

4. Post Tensioning Couplers
Unique Bridge Form Led to Seismic Innovations

Frame Construction Joint with PT Coupler

Continuous PT Over 10 Arch Spans and 9 Jump Spans = 2870'

Region of Grade 80 Reinforcement in Capacity Protected Members

SERS Plastic Hinge in CIDH Pile

Y-Bent Arm
EPS Developed New Bearing Concept

- Inner slider
- Limit of stainless steel liner
- Yielding mechanism at inner concave slider
- Outer concave plate – small 12½” radius used at exterior
- Typical restraining ring not used
Outer Concave Plate after 50” Equivalent Displacement

Equivalent 50” Displacement = 3.0TDD

Deformed Outer Concave Plate
Conclusions

• Unique bridge for the City of Los Angeles
• High seismic demands & challenging architectural features
• Base isolation & several other innovations
• Seismic design by global bridge model analysis
• Accounted for SSI, multiple-support & depth-varying excitations
• Performance exceeds design criteria – seismic safety above & beyond
• Currently in construction – expected completion 2020