East Garden Grove-Wintersburg Channel Bridges

- Warner Avenue
- Springdale Street
- Edwards Street

SEPTEMBER 2023

Western Bridge Engineers' Seminar

COUNTY OF ORANGE CALIFORNIA

PRESENTED BY:

DOKKEN ENGINEERING

Aziz Gulistani, PE
Associate Bridge Engineer

Presentation Content

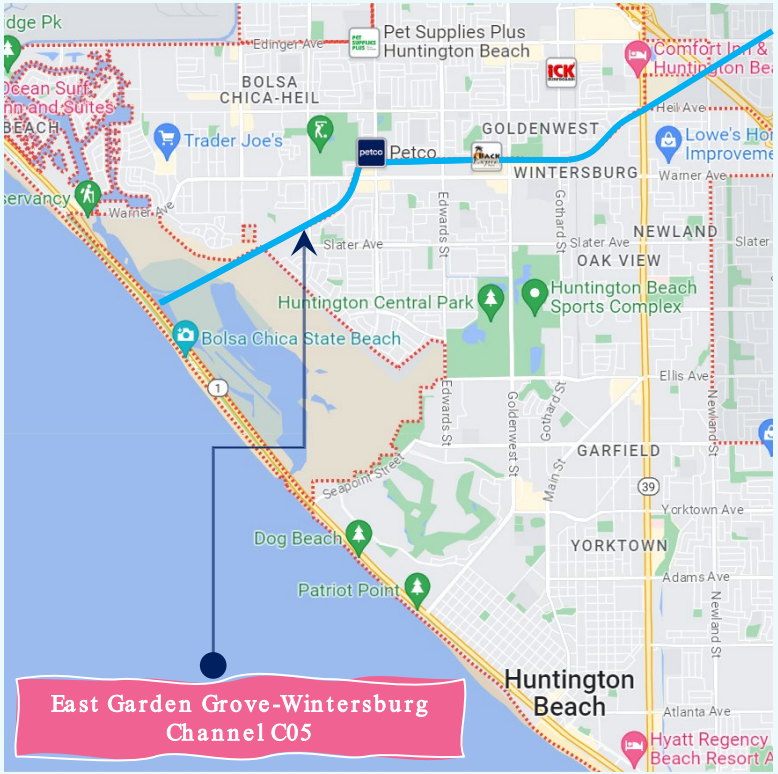
- Existing Conditions
- Purpose and Need
- Design Alternatives

- Girder Design
- Transverse Design
- Design of Dowels
- Design of Floodwalls
- Overlay

- Pile Caps
- Piles

- Project Delivery Method
- Constructability Measures
- Project Timeline and Cost

Project Location



City of Huntington Beach

Location of Bridges

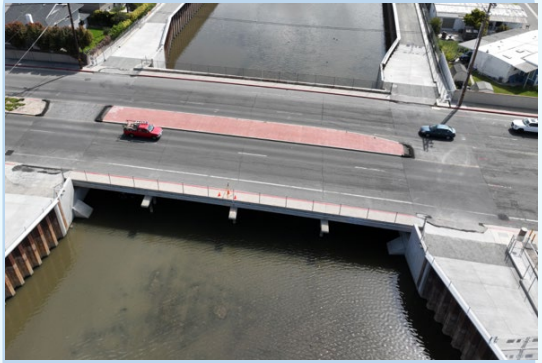
Project Background

WARNER AVE BRIDGE

4-Span Bridges

- 3 lanes in each direction
- Raised median
- 140.25’ long; 117.33’ wide
- Up to 20° skew angle
- Multiple utilities

SPRINGDALE ST BRIDGE



Constructed 1960

- 2 lanes in each direction
- Raised median
- 132.25’ long; 97’ wide
- Up to 6° skew angle
- Multiple utilities

EDWARDS ST BRIDGE

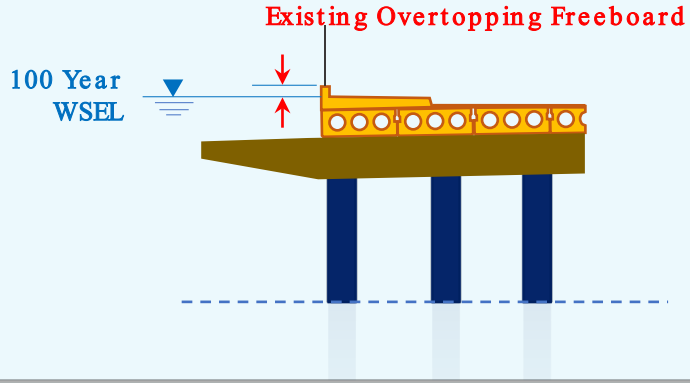
Widened 1967 - 1969

- 2 lanes in each direction
- 132.25’ long; 80’ wide
- Multiple utilities

Purpose & Need

Channel walls are being raised by OCFCD

Existing bridges do not meet FEMA freeboard requirements*



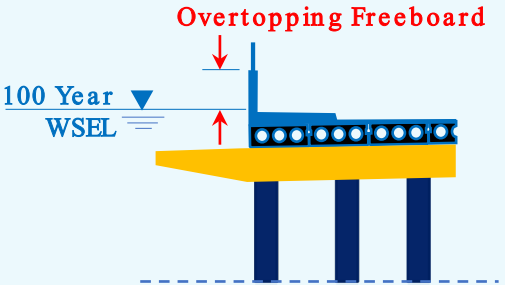
Freeboard at the Existing Bridges

Bridge Location	100 Year Water Surface Elevation (WSEL) (ft)	Bridge Soffit Elevation (ft)	Existing Parapet Top Elevation (ft)	Existing Overtopping Freeboard (ft)
Warner Avenue	12.77	10.13	13.19	0.42
Springdale Street	13.31	10.90	14.08	0.77
Edwards Street	14.00	11.42	14.60	0.60

* A minimum of 4 feet bridge overtopping freeboard is required by FEMA.

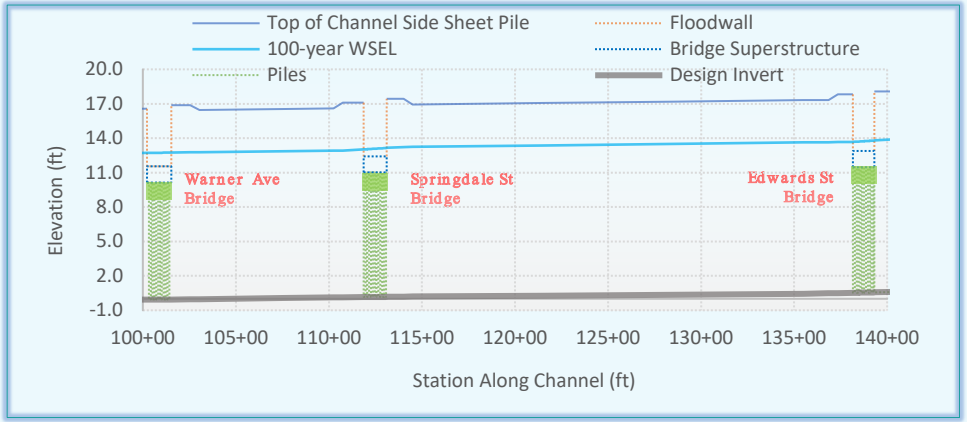
Purpose & Need

Provide the required freeboard, floodwalls are needed along both sides of the bridges



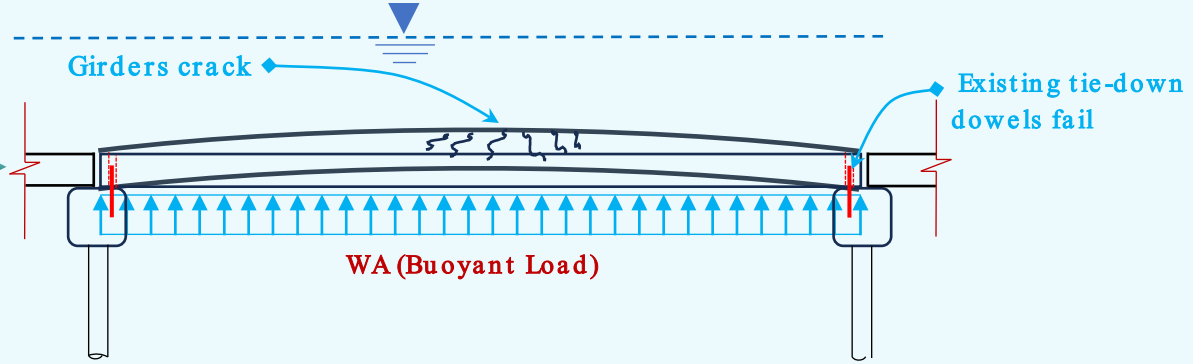
Top of Floodwall Elevation and Freeboard

Bridge Location	Ultimate 100 Year Water Surface Elevation (WSEL) (ft)	Bridge Soffit Elevation (ft)	Top of Wall Elevation (ft)	Overtopping Freeboard (ft)
Warner Avenue	12.77	10.13	16.88	4.11
Springdale Street	13.31	10.90	17.44	4.13
Edwards Street	14.00	11.42	18.09	4.09

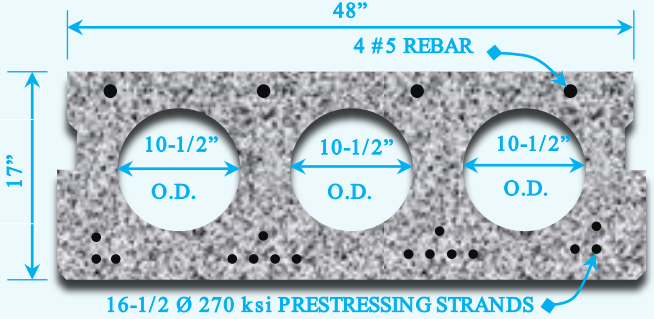


Purpose & Need

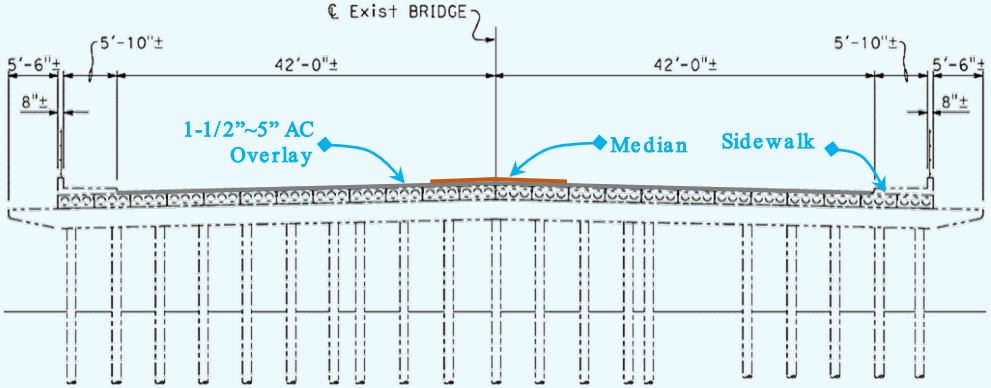
Floodwalls will cause buoyancy force (net uplift force on girders)



Voided Precast Prestressed Slab [From As-Built]



Typical Section [Springdale St Bridge]



Improvement Alternatives

Three Improvements Alternatives Investigated

1. Install floodwalls, secure the existing bridge girders, and strengthen existing girders a structural concrete overlay — *Adding weight (overloading existing foundations and would increase seismic vulnerabilities) and raising existing profile (affecting approach roadway)*

2. Install floodwalls and replace only the existing bridge voided slab girders (pile caps and pile extensions remain) — *Selected Alternative*

3. Completely replace the bridges — *Costly*

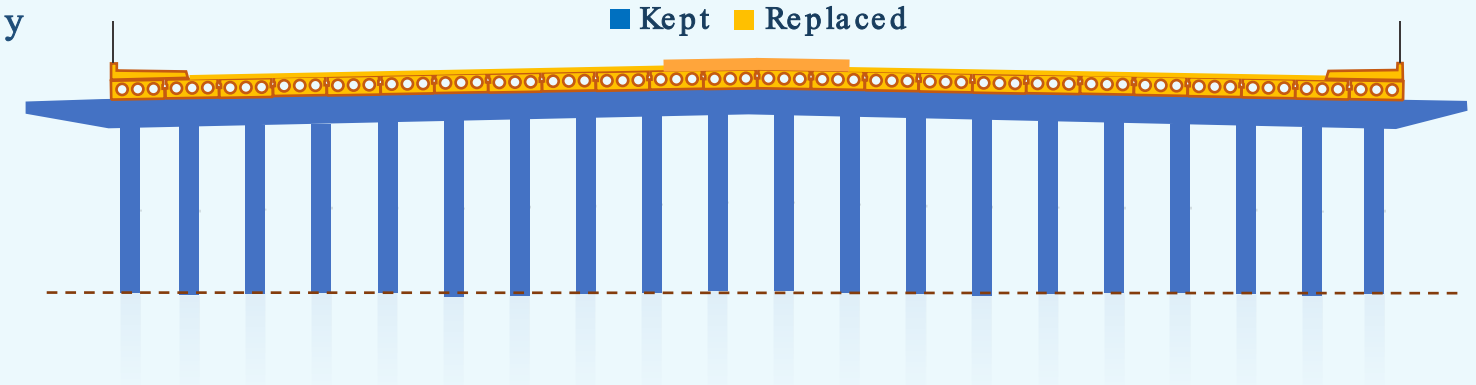
Selected Alternative (Redecking)

Designed (Added/Replaced)

- Voided Precast Prestressed Slab Girders
- Support Dowels
- Transverse Post-Tensioning Tie Rods
- Floodwalls/Barriers
- Overlay

Checked (Kept in Service)

- Pile Caps
- Pile Extensions
- Seismic Check



Design of Voided Precast Prestressed Slab Girder

Service and Strength Limit States (Downward Loads)

Design Reference:

AASHTO LRFD Bridge Design Specifications, 8th edition with the 2019 Interims and the California Amendments

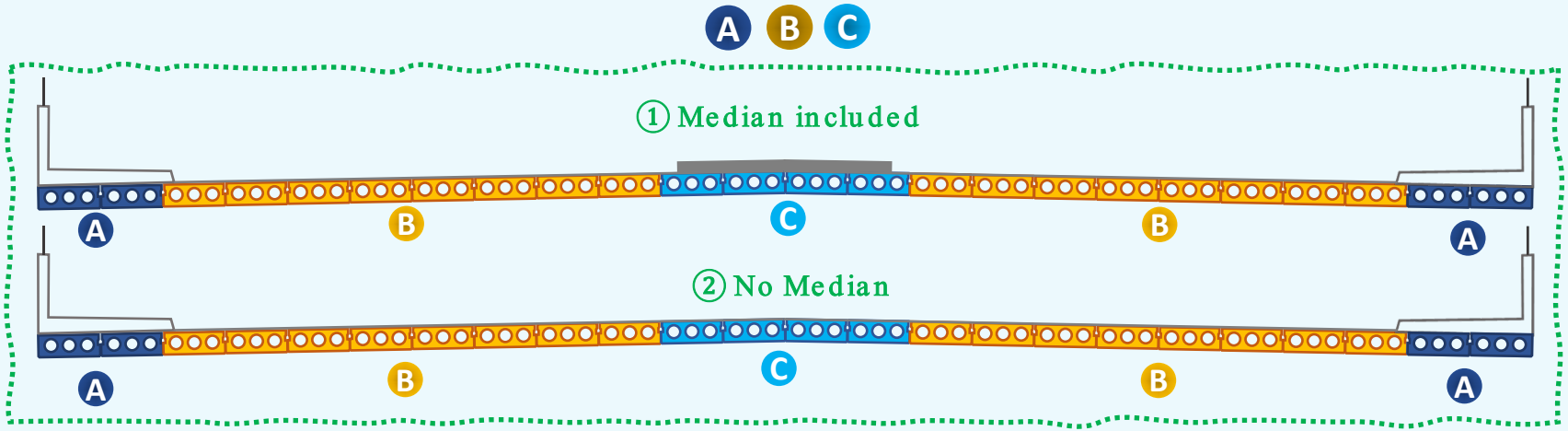
Design Software and Modeling:

- PGSuper
- Models ① and ② below

Loads:

- Dead Load: Includes 1-1/2" polyester concrete overlay
- Live Load: HL93, permit design load
- Live Load Distribution: Tables for Live Load Distribution Factors (AASHTO 4.6.2.2)

Girder Design Grouping:



Design of Voided Precast Prestressed Slab Girder

Load Cases:

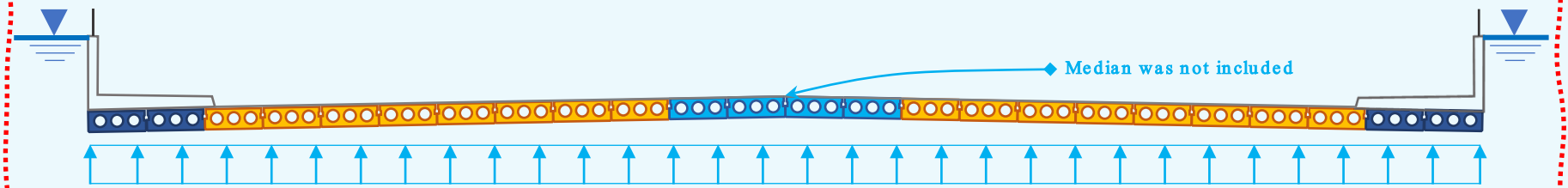
- 100-Year Storm Event
- Extreme Event (water reaches top of wall)

Load Factors:

USACE EM 1110-2-2104 (Strength Design for Reinforced Concrete Hydraulic Structures)

Storm Event (Upward Loads)

Buoyancy & Factor of Safety (48" wide Concrete Deck Unit)	Warner Ave Bridge		Springdale St Bridge		Edward St Bridge	
	100-Year Storm	Extreme Event	100-Year Storm	Extreme Event	100-Year Storm	Extreme Event
Water Surface Elevation [ft]	12.77	16.88	13.31	17.44	14.00	18.09
Soffit Elevation [ft]	10.13	10.13	10.90	10.90	11.42	11.42
Height of Water Above Soffit [ft]	2.64	6.75	2.41	6.54	2.58	6.67
Factor for Buoyancy Load	1.60	1.00	1.60	1.00	1.60	1.00
Factored Buoyancy Load (uplift)[kips]	-36.90	-58.97	-31.76	-53.87	-34.00	-54.94
Net Uplift Load (kip)	**-14.18**	**-36.25**	**-10.25**	**-32.36**	**-12.72**	**-33.65**

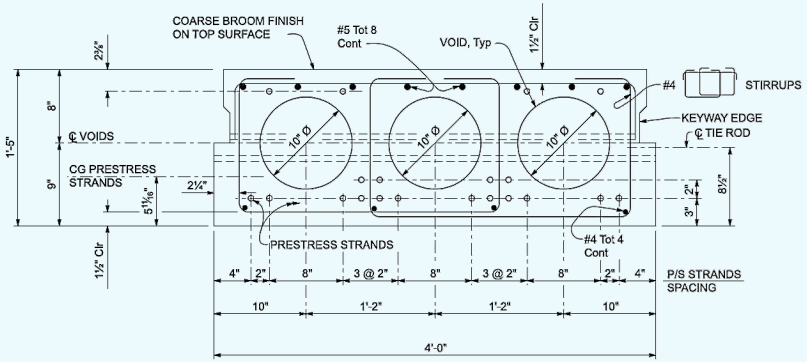


④ 0.90 (DC + DW) + 1.0 (Buoyant Loads)

Design of Voided Precast Prestressed Slab Girder

Key Considerations on Girder Design:

- The design envelop for balancing between downward and upward loads was very small.
- In addition to bottom strands, steel rebars and prestressing strands are added at top to resist flexure and control camber.
- Void diameter decreased to 10” to increase clearance.



Typical Interior Girder Section

B

Materials:

Concrete: $f'_c = 5$ ksi, $f_{ci} = 4$ ksi

Steel: $f_y = 60$ ksi

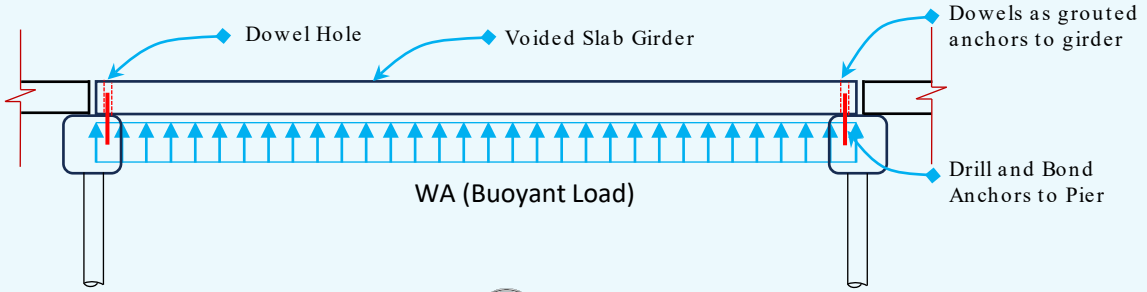
Prestressing strands: 270 ksi Low Relaxation

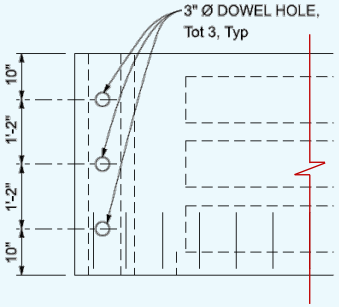
0.6 Ø strand

Design of Dowels at Girder Supports

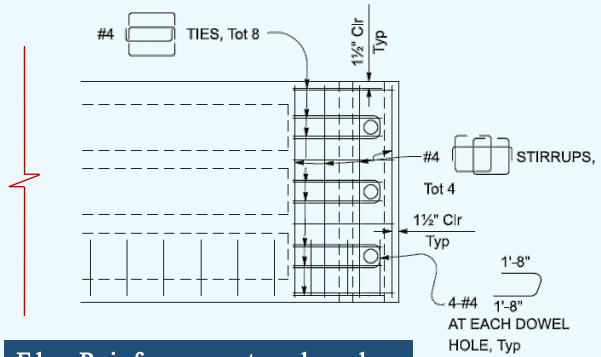
Demand Forces:

1. Tension Force (Buoyant Load)
2. Shear Force (Seismic Load)

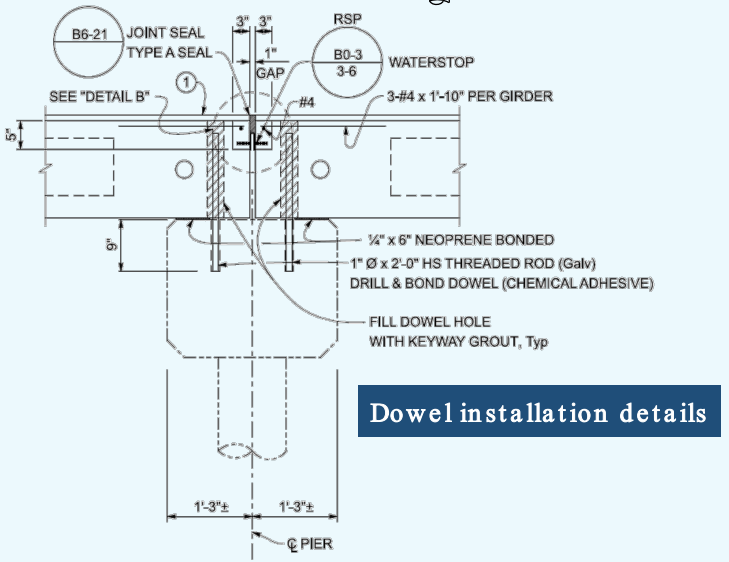




3 Dowels Per Support



Edge Reinforcement and anchor reinforcement for shear



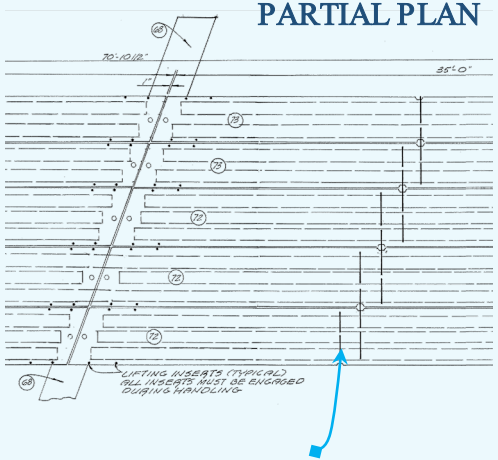
Dowel installation details

Transverse Design

Existing

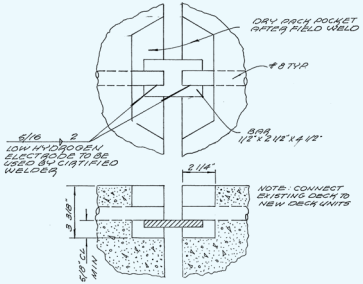
- No post-tensioning tie rods
- Only #8 rebars used as transverse girder connectors
- AC cracking observed at the bridges

PARTIAL PLAN



#8 Rebar Transverse Ties

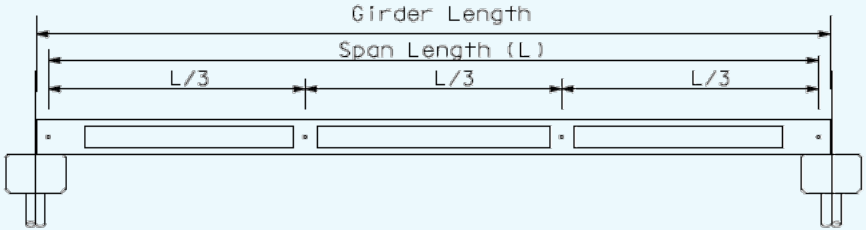
Welded Transverse Tie



Proposed Design

- Post-tensioned transverse diaphragms designed to transfer loads between adjacent girders to prevent differential settlement, increase bridge capacity and prevent cracking.
- Four diaphragms are provided at a spacing equal to one third of the span.

Location of Diaphragms

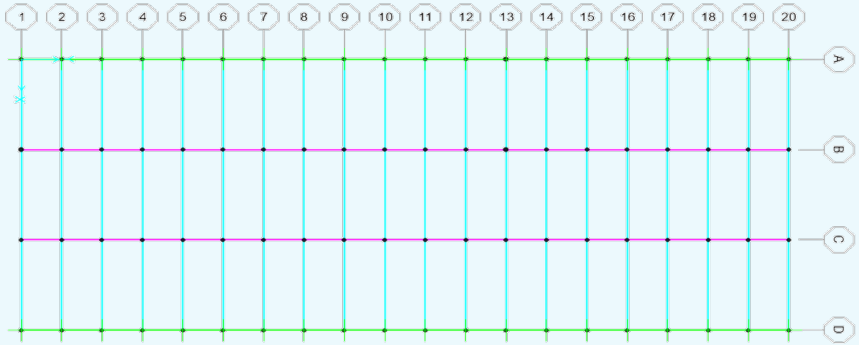


- 1.25-inch diameter and 1.75-inch diameter of 150 ksi tie rods at end diaphragms and mid-diaphragms, respectively.

Transverse Post-Tensioning Tie Rods

Analysis Grid Model:

- Grid analysis was performed to compute bending moments in the diaphragms.

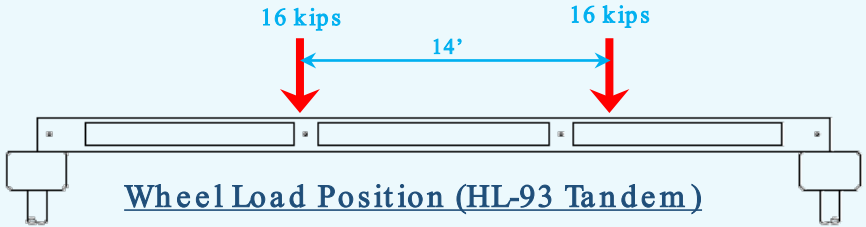


Vertical and horizontal elements represents girders and diaphragms, respectively.

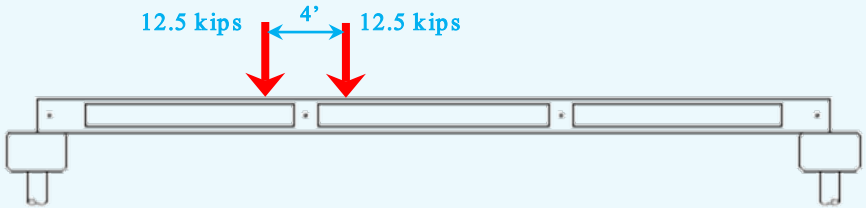
Loadings:

- DL: Concrete barriers/floodwall /utilities applied as superimposed dead load. Other dead loads are uniformly distributed.
- LL: Live loading positioned to produce maximum moment (negative or positive) in diaphragms.

Wheel Load Position (HL-93 Truck)



Wheel Load Position (HL-93 Tandem)

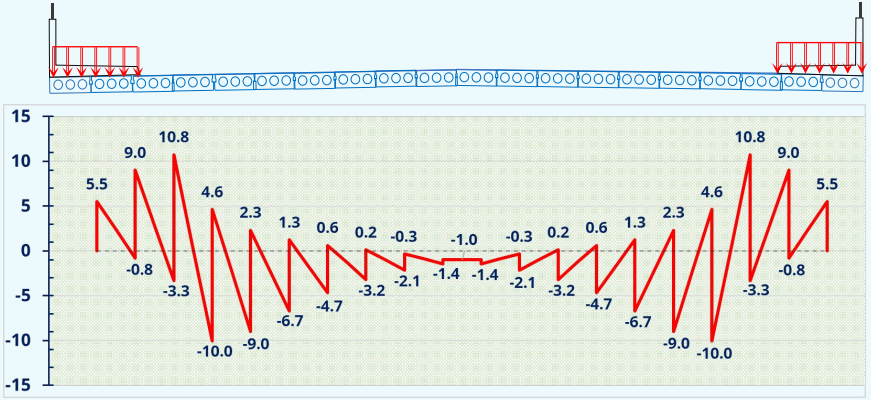


Transverse Post-Tensioning Tie Rods

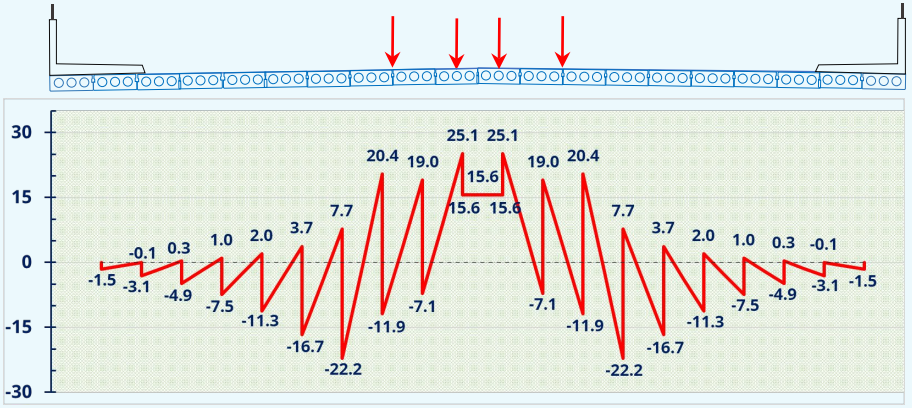
Controlling Moments

- DL: Floodwall/barrier loads develop moments
- LL: Two-lane loadings at bridge middle lanes and edge lanes control moments
- Tandem loading controls over truck loading

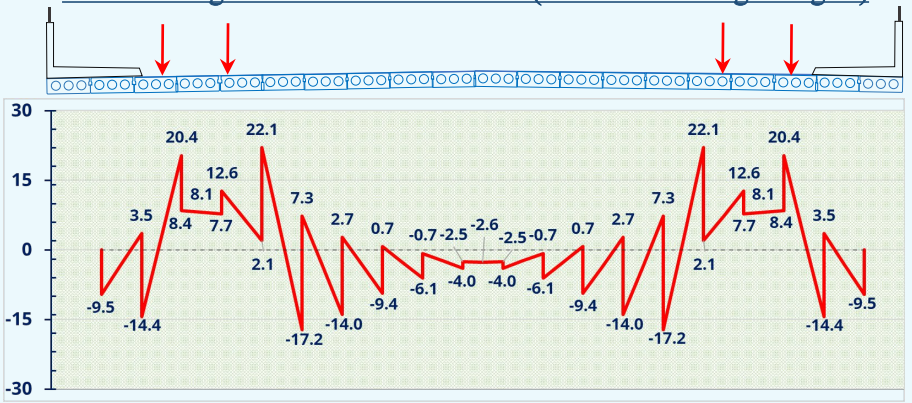
Unbalanced Dead Load Moments [kip-ft]



Controlling Live loads Moments (Loads at Bridge Center)



Controlling Live loads Moments (Loads at Bridge Edges)

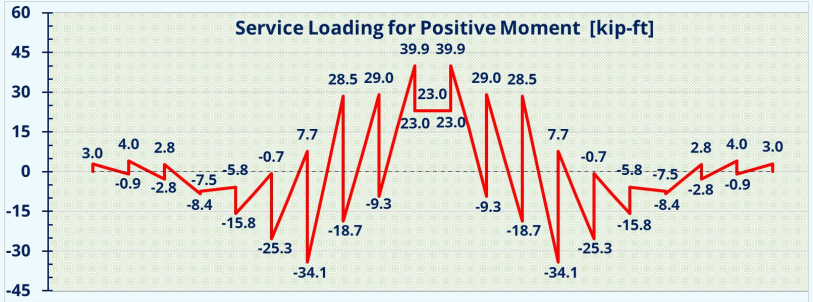


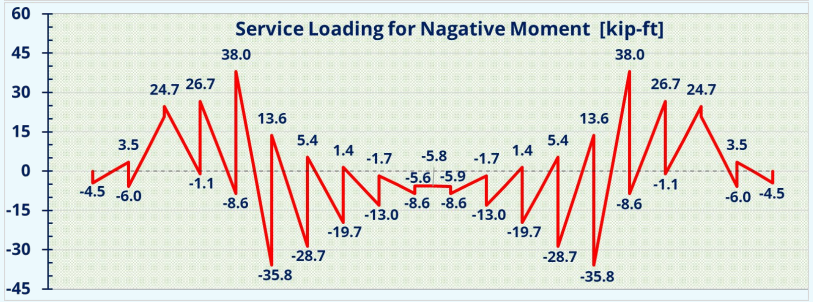
Edwards St Bridge shown, other two bridges are similar

Transverse Post-Tensioning Tie Rods

Stress Analysis and Check

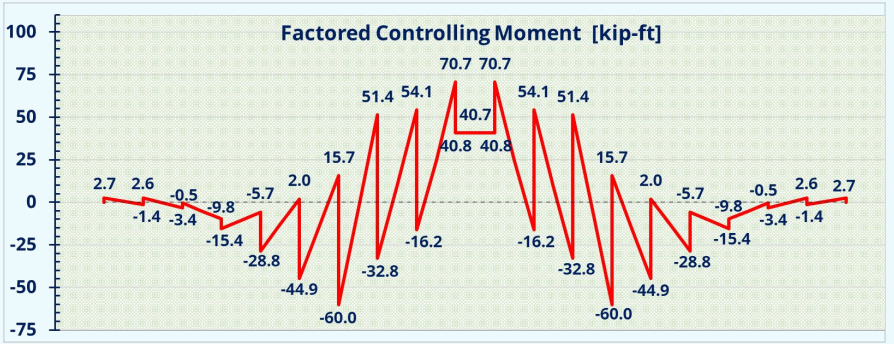
- Stresses are calculated based on controlling moments
- Post-tensioning is added to limit tension stress to zero and compressive strength to 0.60 concrete compressive strength.





Flexural Strength Check

- Flexural strength was checked for factored controlling moment

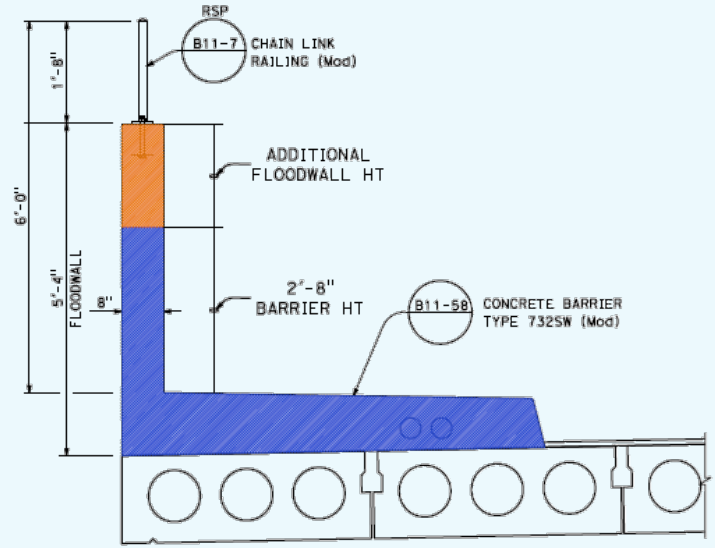


Edwards St Bridge shown, other two bridges are similar

Floodwall / Barrier

Floodwall/Barrier

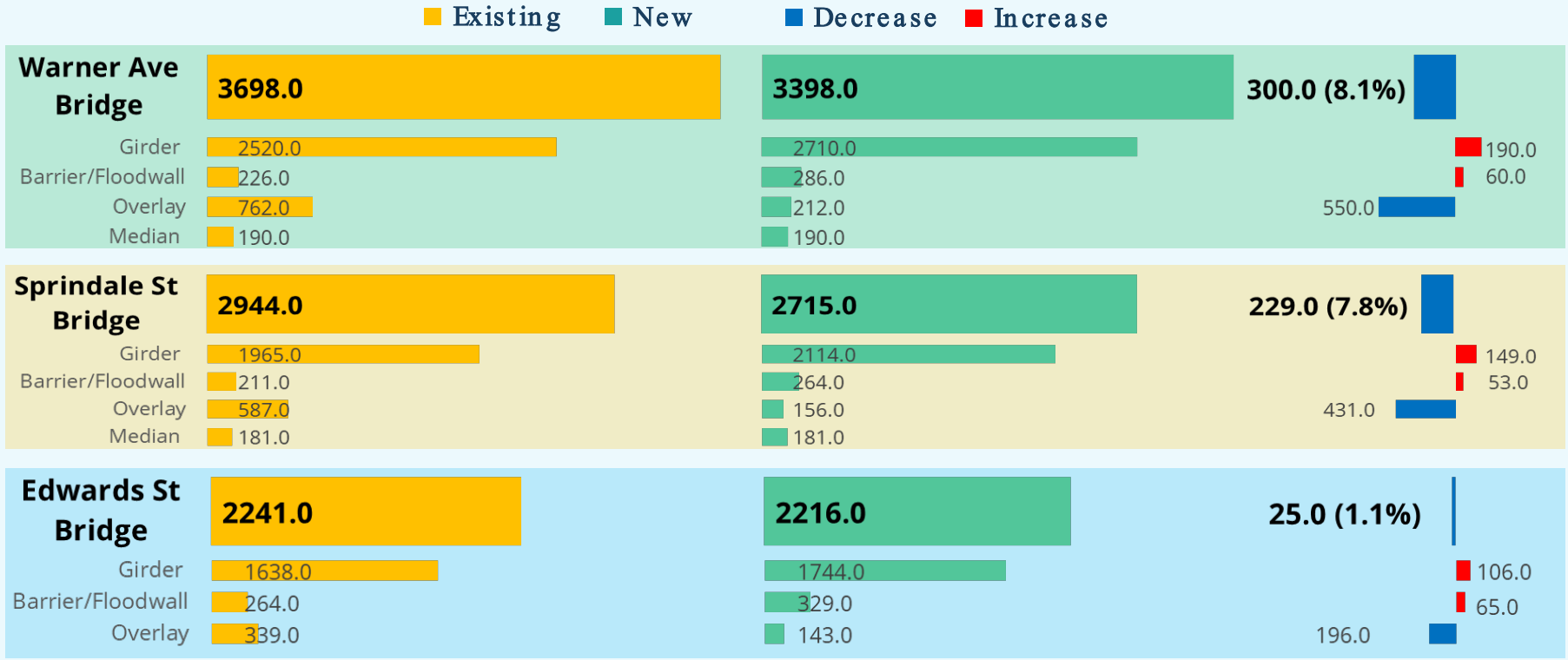
- Modified Caltrans Standard Type 732SW Barrier
- Lightweight concrete to decrease loads on piles
- Multi-purpose function



FLOODWALL SECTION
1" = 1'-0"

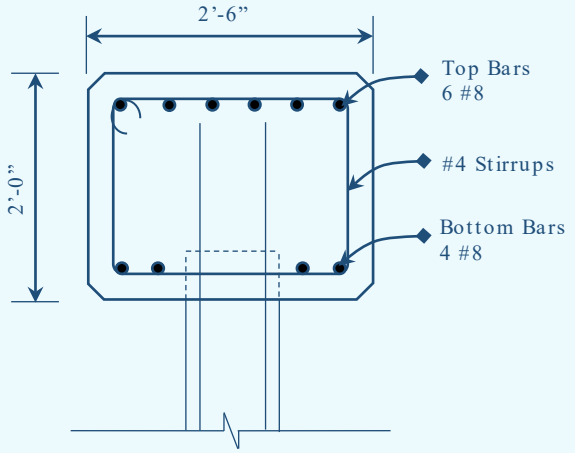
Weight Comparison

To minimize overlay weight, 1.5-inch-thick polyester concrete overlay is considered in design.



Capacity Check of Pile Cap

- Pile caps not originally designed for uplift (upward) loads
- Pile caps were checked for buoyancy loads
- All specification checks passed (shear, flexure and torsion)



Pile Cap Cross-Section

Check of Pile Capacity

Demand:

- Axial compression forces are determined based on the revised dead load and live loads.
- Axial tension forces are determined considering upward buoyant forces on girders and overturning effects due to lateral water pressure on floodwalls.

Pile Loads after Redecking

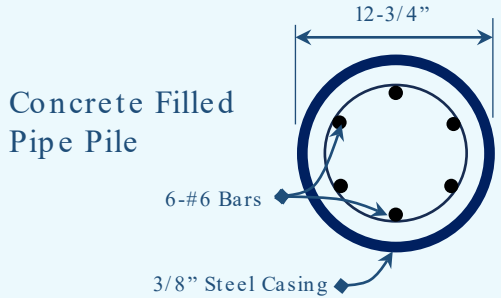
Bridges	Maximum Axial Compression (kips)		Maximum Axial Tension (kips)
	Strength	Service	Extreme Event
Edwards Street	141	95	35
Springdale Street	117	78	32
Warner Avenue	134	81	19

Capacity:

- The as-built drawings only present compression capacity of piles.
- Tension capacity of piles was computed and reported by Geotech during design phase.

Single Pile Existing Axial Load Capacity

Pile Type	Axial Capacity (kips)	
	Compression	Tension
12.75-inch pipe, concrete-filled, conical-tipped	Ultimate: 200	Ultimate: 60
	Factored: 140	Factored: 42



Seismic Design/Check

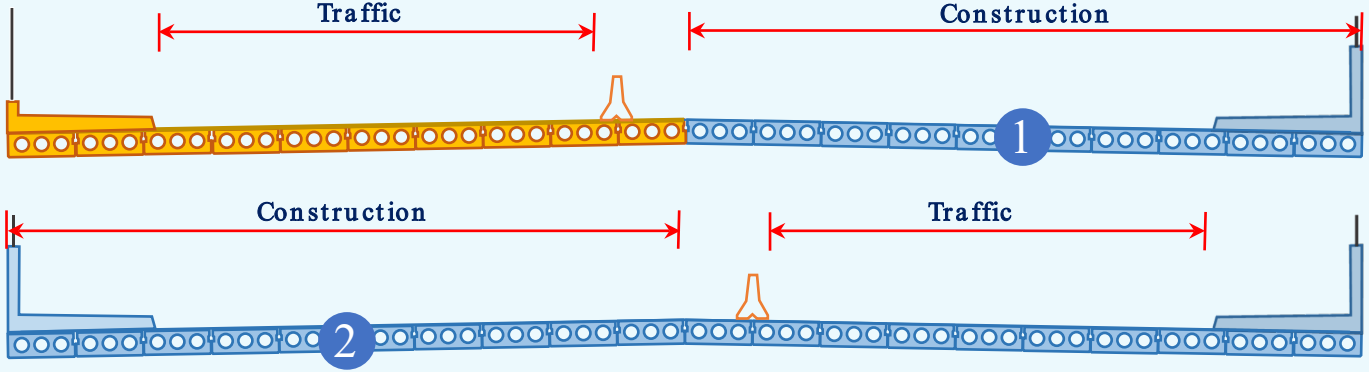
Seismic Retrofit Assessment

- HDR assessment concluded seismic retrofit not required for (selected) Alternative 2
- Dokken analysis confirmed retrofit not required for final bridge conditions
- Not increasing bridge dead load

Construction Staging

EDWARDS STREET BRIDGE

Total of 2 Construction Stages



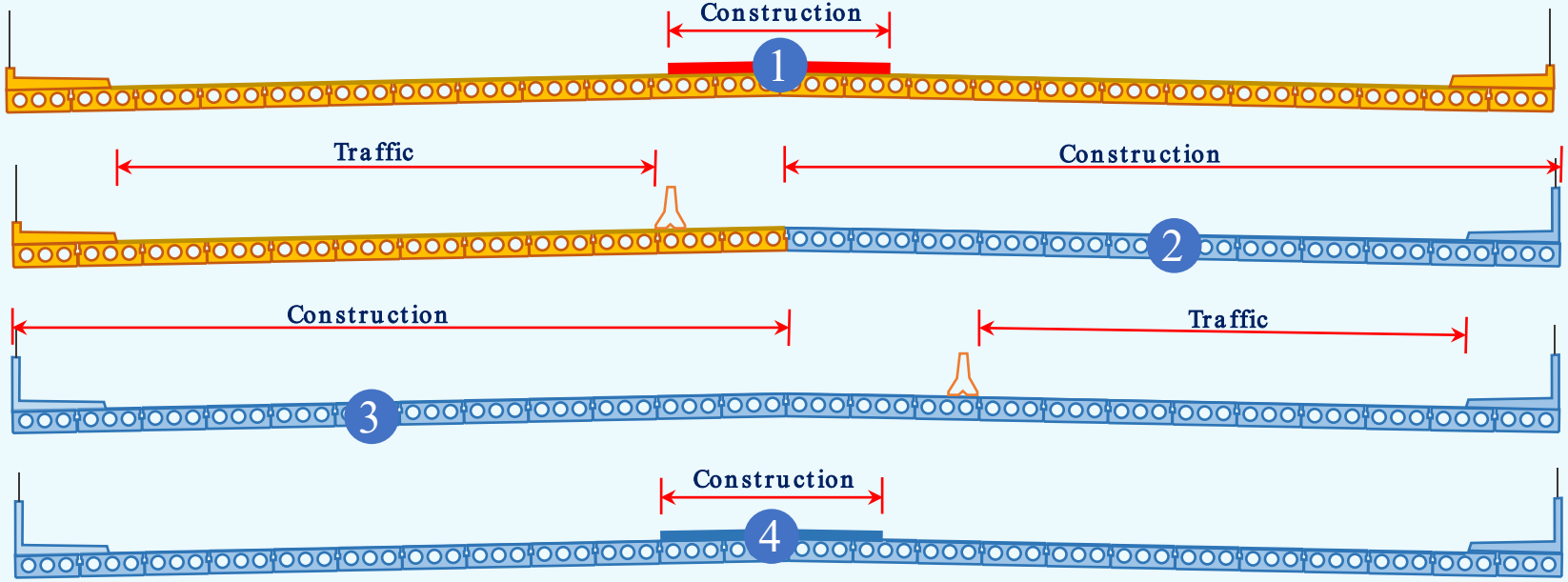
- Two traffic lanes will remain open
- Temporary barrier will be used to separate traffic from construction zone

LEGEND: Existing Removal New

Construction Staging

SPRINGDALE STREET BRIDGE

Total of 4 Construction Stages



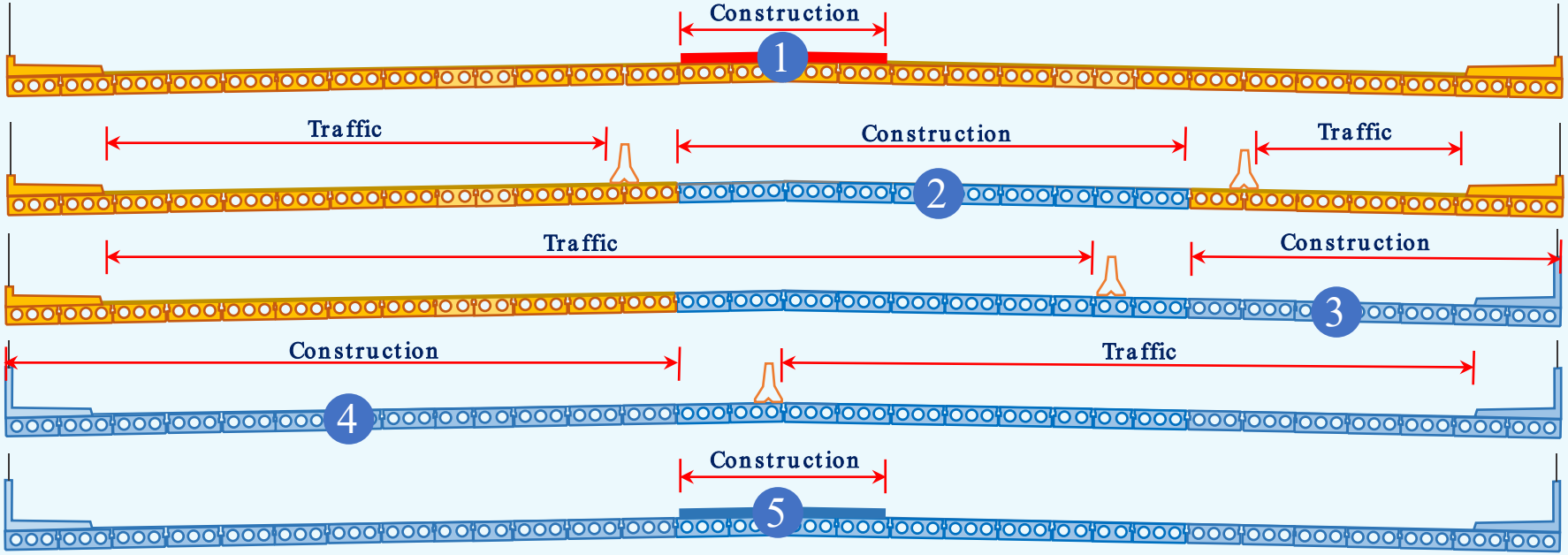
LEGEND: Existing Removal New

- Two traffic lanes will remain open
- Temporary barrier will be used to separate traffic from working zone

Girder Replacement

EAST GARDEN GROVE-WINTERSBURG CHANNEL BRIDGES
Orange County, CA

WARNER AVENUE BRIDGE
Total of 5 Construction Stages

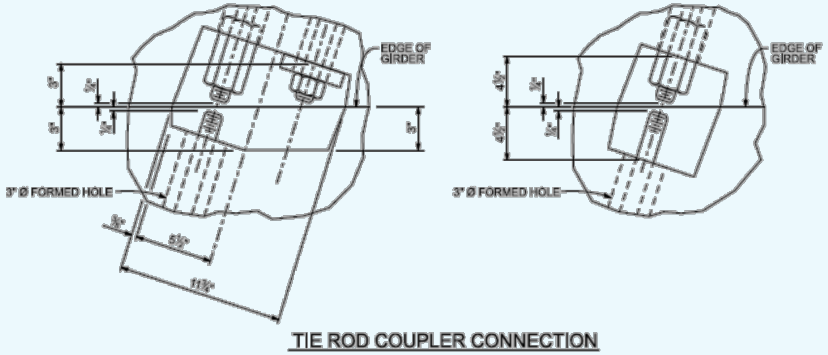


LEGEND: Existing Removal New

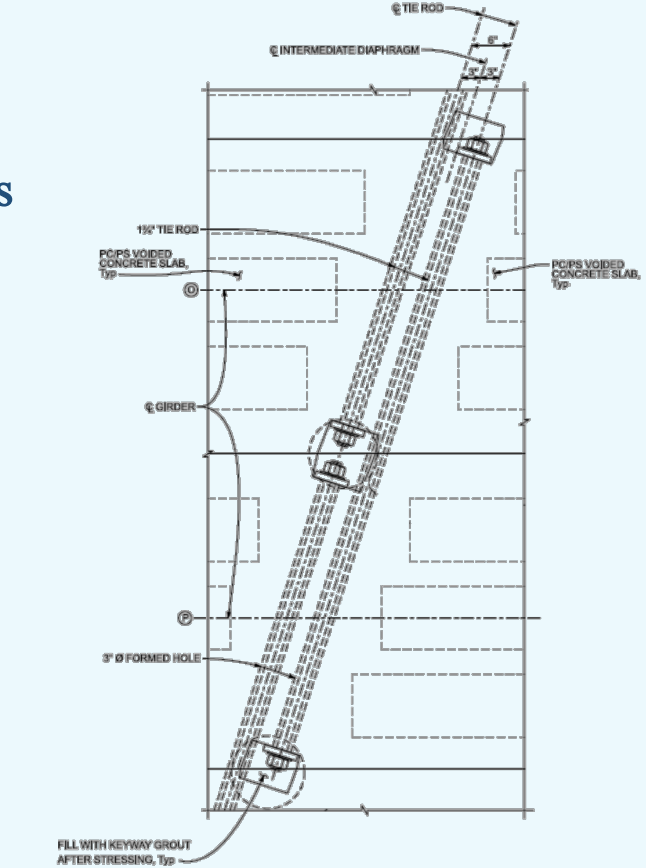
- Four traffic lanes will remain open
- Temporary barrier will be used to separate traffic from construction zone

Post-Tensioning Staging

- Transverse tie rods will be installed in stages
- Tie rod coupler connection and blockouts to allow for phasing post-tensioning
- Two sets of parallel tie rods are designed to connect girders at bridge crown

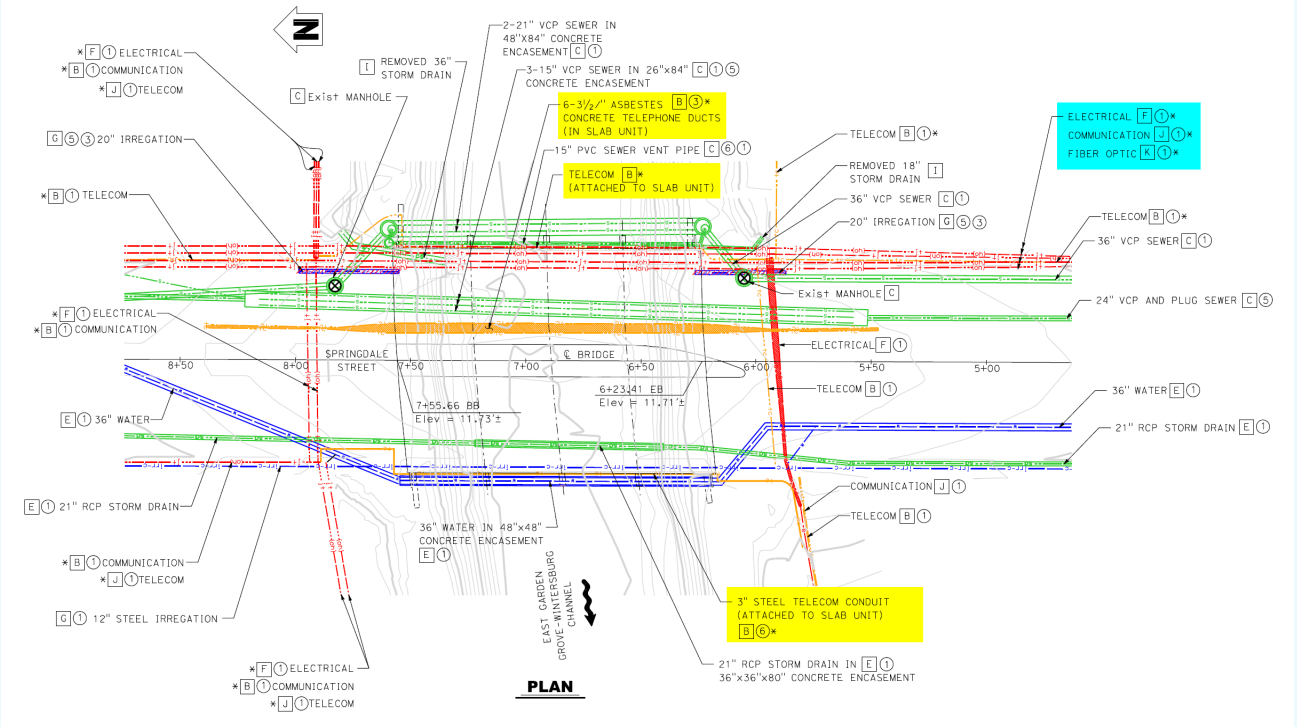


TIE ROD COUPLER CONNECTION



Utilities

- Several utilities are within the bridge limit
- These utilities will either be protected in place or be relocated

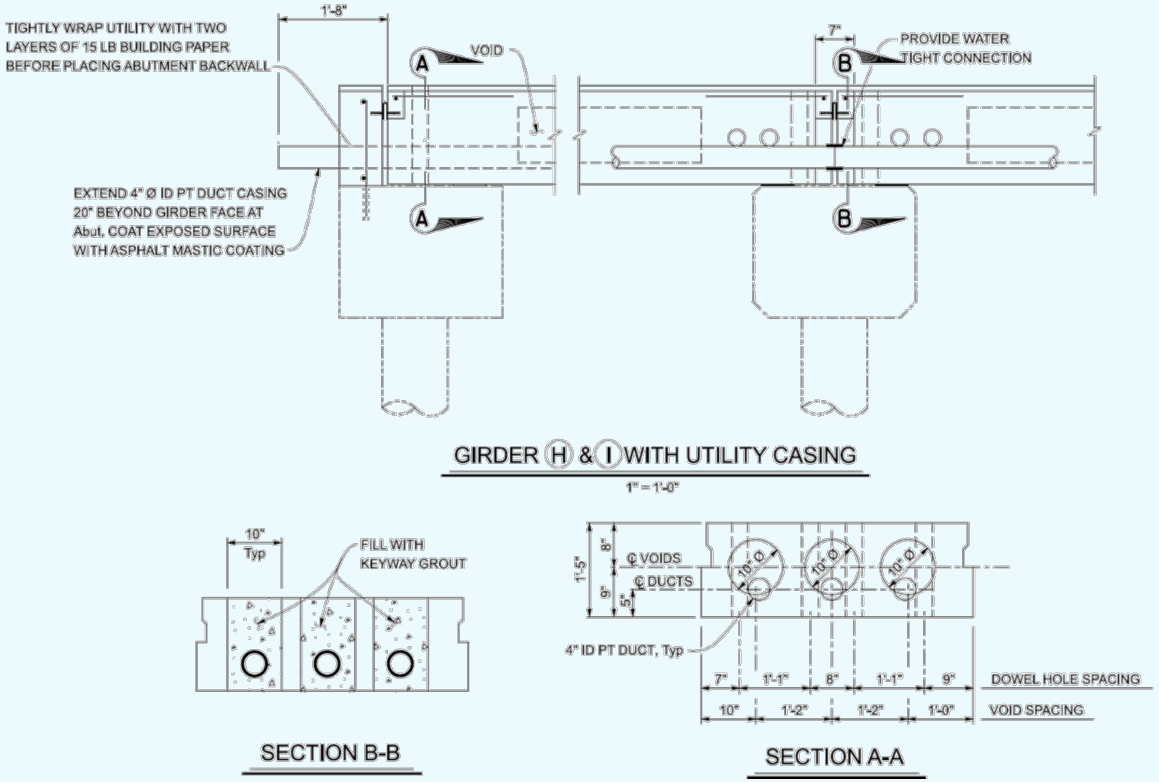


Springdale Utility Exhibit

Utilities

- To prevent conflict to transverse post-tensioning ties, utility ducts are placed at the bottom of voids
- Four support dowels are designed for girders with utility ducts

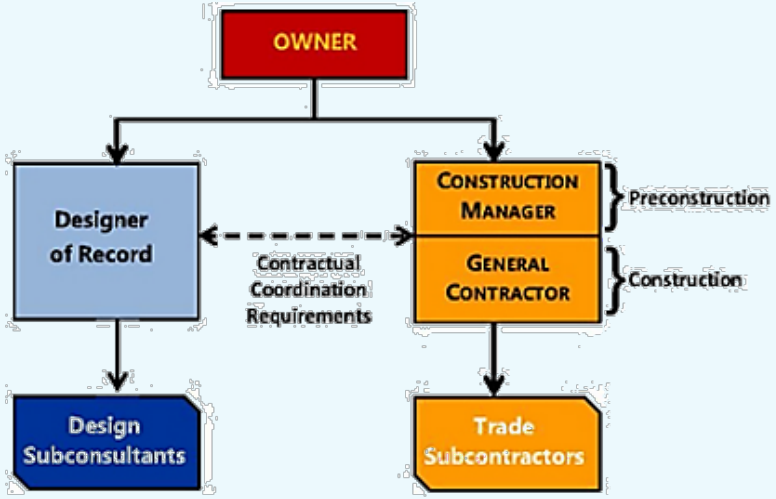
In-Slab-Unit Utility



Project Delivery Method

Construction Management at Risk (CMAR)

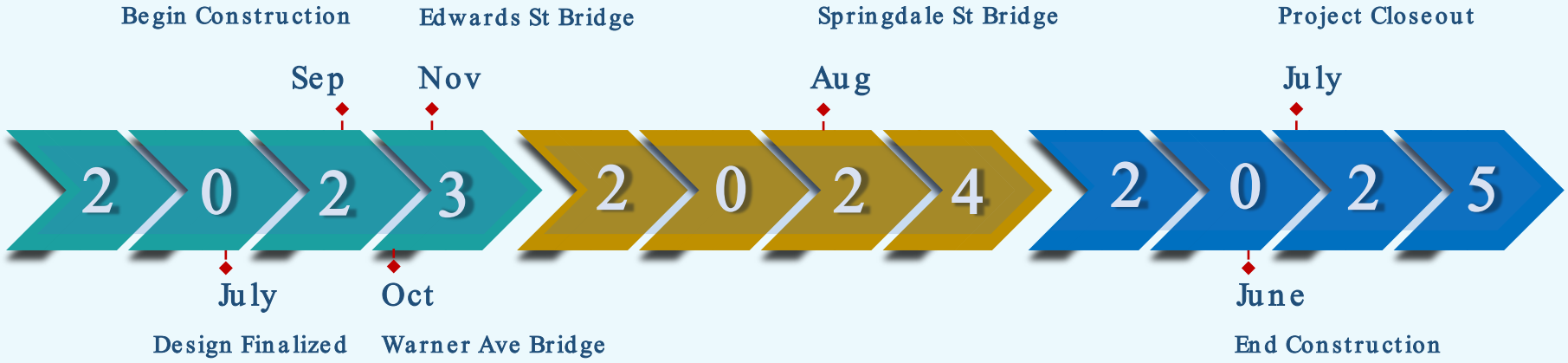
- Very similar to Construction Manager/General Contractor (CM/GC)
- CMAR establishes a Guaranteed Maximum Price (GMP)
- Construction Manager selected during design
- Contractor provides scheduling, pricing, phasing and other input that helps the owner design a more constructible project
- Myers and Sons selected contractor



Project Cost & Timeline

COST: Guaranteed Maximum Price: $18.3 M

PROJECT SCHEDULE:



Q and A's