Boeing Access Road Bridge Seismic Retrofit & Rehabilitation

Western Bridge Engineers' Seminar

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PRESENTATION OUTLINE

- Project Intro & Background
- Project Conditions & Issues
- Seismic Criteria
- Seismic Analysis
- Seismic Retrofit Concepts
- Bridge Rehabilitation Elements
- Summary

BRIDGE BACKGROUND

- Located in Tukwila, just south of downtown Seattle
- Original Bridge built in 1944 & widened in 1965
- Carrying more than 40,000 ADT with 10% ADTT
- 2 R/C girder spans + 3 Steel girder spans over Railroads
- Piers - Conc. columns & Conc. pier walls
- City originally wanted to replace but short of funding
- PS&E completed & construction just started

Challenges & Rehabilitation Solutions

Challenge:
Steep Slope with Liquefiable Soils

Solution:
- Assess foundation lateral and vertical capacity and need for structural upgrades.
- Investigate ground improvements as an alternative for structural upgrade.

Challenge:
Inadequate Pier Seismic Details and Foundations

Solution:
- Install steel- or carbon-fiber column jackets to improve column shear strength and ductibility performance.
- Upgrade foundation capacities by installing additional piles/shafts.
- Investigate bridge base isolation as an alternative to column and foundation retrofit to minimize work near Piers 4 and 5 (over railroads).

Challenge:
Poor Seismic Connectivity at Piers

Solution:
- Upgrade concrete pedestals, rocker bearings, steel end diaphragms, longitudinal seismic restrainers, and seat extensions.

Challenge:
Failing Transverse Expansion Joint/ Leaking Longitudinal Joint

Solution:
- Repair or replace transverse expansion joint to meet current standards.
- Seal longitudinal joint to minimize future maintenance.

Challenge:
Proximity to Railroad Tracks

Solution:
- Work closely with BNSF to coordinate design issues and construction activities. Provide solutions that meet BNSF Design Guidelines and American Railway Engineering and Maintenance-of-Way Association (AREMA) standards.
- Tailor the bridge rehabilitation solutions around BNSF's work schedule and accessibility needs.

Challenge:
Limited Sidewalk Width

Solution:
- Narrow 4 of the 6 existing lanes to establish a new traffic barrier at the existing southern curb line.
- Replace barrier on south side with 10-foot pedestrian/bicycle path and railing.

Challenge:
Damaged Concrete Barrier

Solution:
- Repair with appropriate materials to increase barrier longevity.
- Replace traffic barrier as part of the bridge widening, if necessary.

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EXISTING CONDITIONS

Expansion Joints – Transverse & Long.

Joints in Pavement

EXISTING CONDITIONS – Cont'd

Narrow Sidewalk

Concrete Barrier

EXISTING CONDITIONS – Cont'd

Transverse Joint at Pier 4

Longitudinal Joint

EXISTING CONDITIONS – Cont'd

Corroded Steel Girders

Concrete Spalls

EXISTING CONDITIONS – Cont'd

Wall Pier with Steel Bearing

Buried Existing Utilities

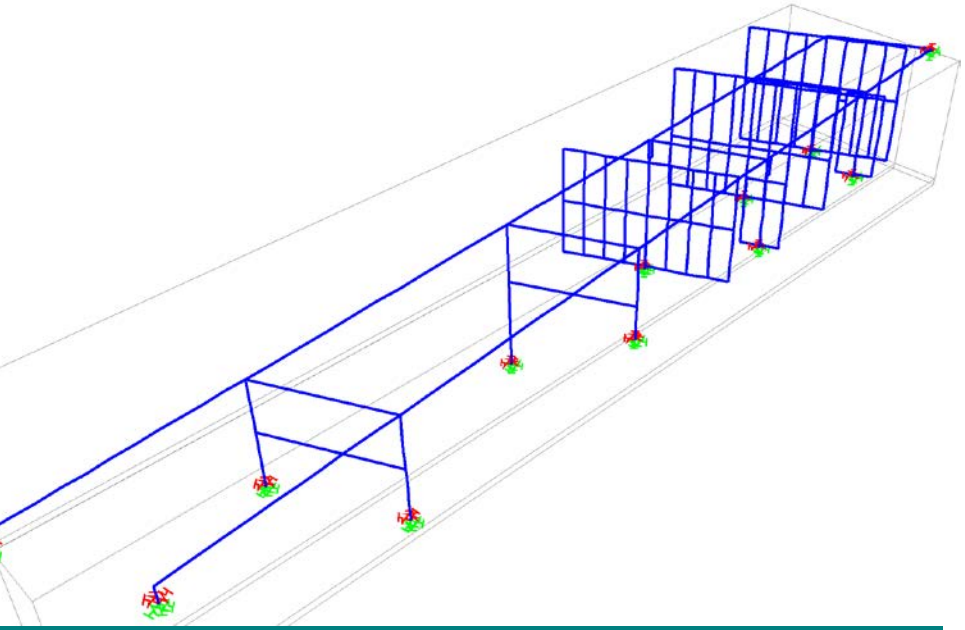
EXISTING CONDITIONS – Cont'd

Steep slope with Liquefiable Soils near Pier 5

PROJECT APPROACH

- ✓ Bridge deficiency assessment
- ✓ Non-motorized configuration
- ✓ Seismic analysis
- ✓ Feasible rehab/repair alternatives
- ✓ Railroad coordination
- ✓ Selection of alternative
- ✓ SEPA/NEPA/Permitting
- ✓ Final design/PS&E
- ✓ Railroad agreements
- ✓ Successful bidding for construction

SEISMIC ANALYSIS



- ✓ FHWA Seismic Retrofitting Manual
- ✓ AASHTO Manual for Bridge Evaluation
- ✓ Seismic Retrofit Category C – Life Safety for Upper Level Earthquake

- ✓ Response Spectrum Analysis used for demand calculations
- ✓ Pushover Analysis used for capacity calculations

SEISMIC ANALYSIS RESULTS

Seismic Inertial Loading

BRIDGE ELEMENT	Pier 1			Pier 2			Pier 3			Pier 4			Pier 5			Pier 6		
	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D	C	D	C/D
Foundation																		
Pile Axial Comp (kips)	N/A	N/A	N/A	180	222	0.81	180	222	0.81	180	521	0.35	180	449	0.40	180	339	0.53
Pile Shear (kips)	N/A	N/A	N/A	133	22	6.1	146	37	3.9	146	29	5.1	146	15	9.4	N/A	N/A	N/A
Pile Moment (kip.ft.)	N/A	N/A	N/A	60	25	2.4	63	55	1.2	63	34	1.9	63	15	4.3	N/A	N/A	N/A
Column / Wall																		
$\Delta_{Longitudinal}$ (in.)	N/A	N/A	N/A	8.7	8.5	1.0	14.7	8.3	1.8	7.77	6.28	1.2	5.5	5.8	0.95	13.3	6.6	2.0
$\Delta_{Transverse}$ (in.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.73	2.85	2.0	4.4	3.1	1.4	4.2	2.6	1.6
Shear (kips)	N/A	N/A	N/A	1668	1312	1.3	1684	1206	1.4	82	93	0.88	128	154	0.83	56	85	0.66
Superstructure Frame																		
Shear (kips)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	99	74	**1.3**	59	40	1.5
Moment (kip.ft.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1769	1736	**1.02**	N/A	N/A	N/A
Seat Width																		
Seat Width (in.)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	25.6	0.86	N/A	N/A	N/A	N/A	N/A	N/A

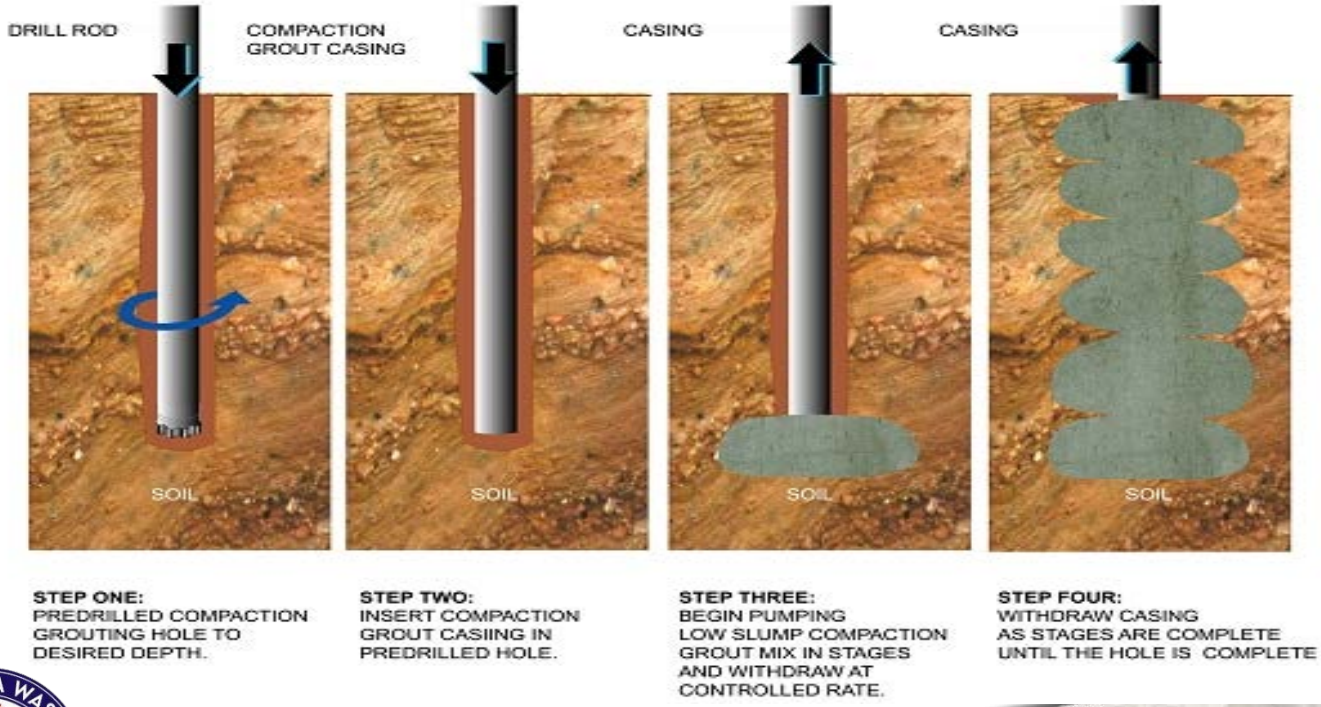
SEISMIC ANALYSIS RESULTS

Post-Liquefaction

BRIDGE ELEMENT	Pier 4			Pier 5			Pier 6		
	C	D	C/D	C	D	C/D	C	D	C/D
Foundation									
Pile Axial Comp (kips)	N/A	N/A	N/A	180	4832	0.04	180	9391	0.02
Pile Shear (kips)	N/A	N/A	N/A	133	78	1.7	133	225	0.59
Pile Moment (kip.ft.)	N/A	N/A	N/A	183	101	1.8	183	279	0.66
Column									
Shear (kips)	35	105	0.33	66.0	661.0	0.10	77	1443	0.05
Moment (kip.ft.)	1445	2796	0.52	821	14170	0.06	675	23470	0.03

SEISMIC RETROFIT CONCEPTS

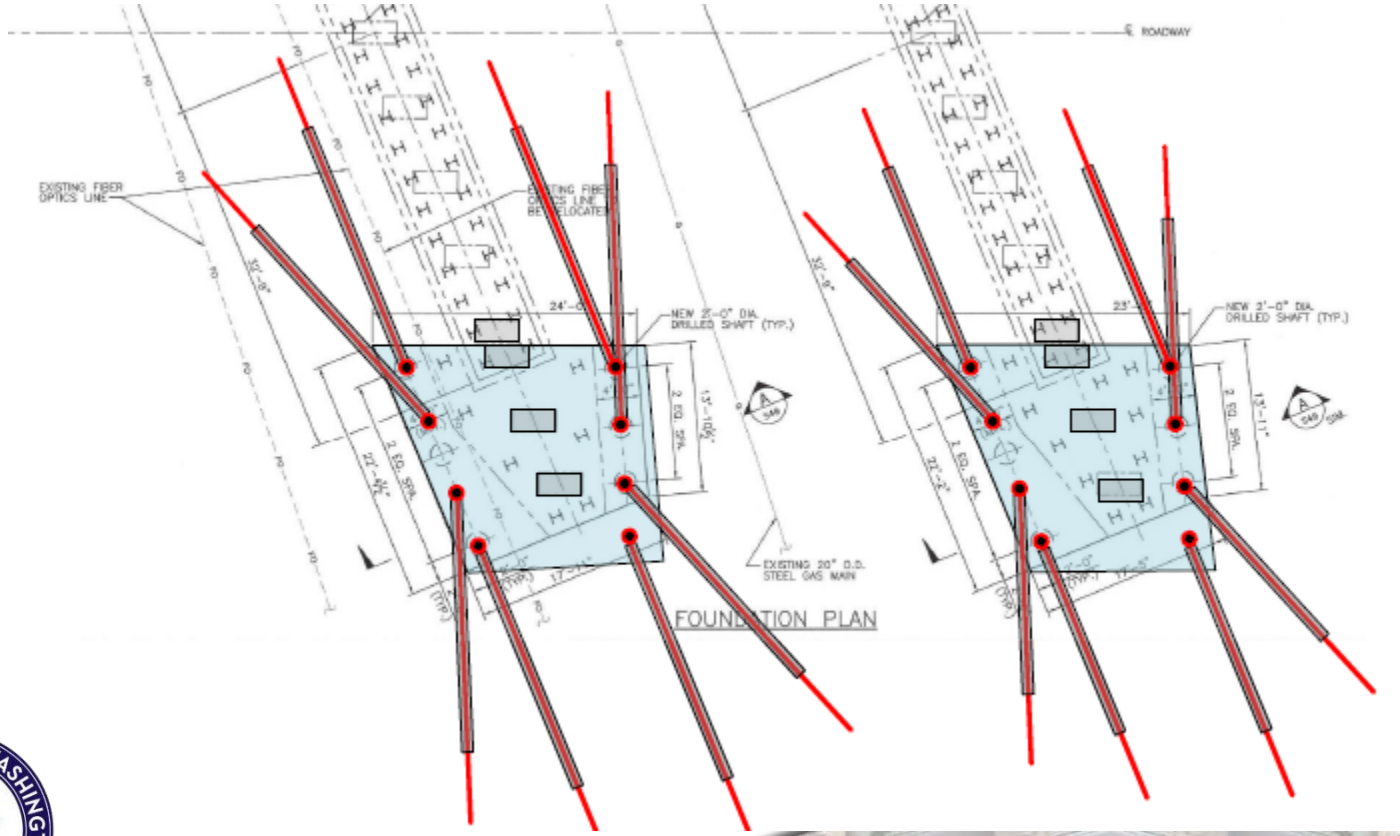
Compaction grouting for ground improvement



Reference: Lavne GeoConstruction

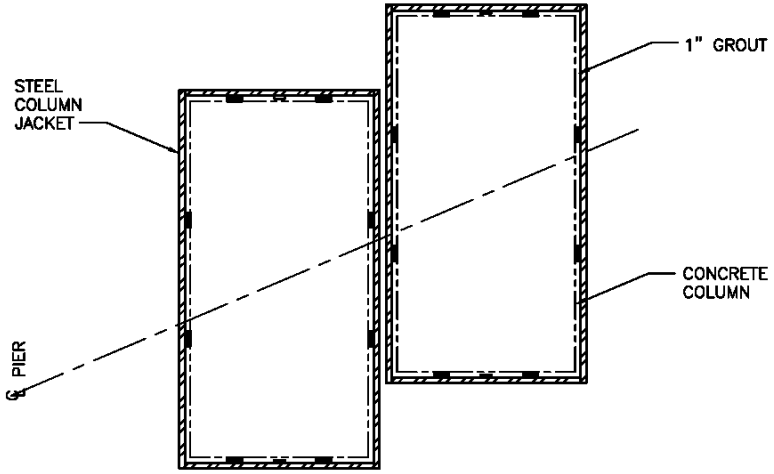
SEISMIC RETROFIT CONCEPTS

Foundation Retrofit at Piers 4 & 5 - Micropile



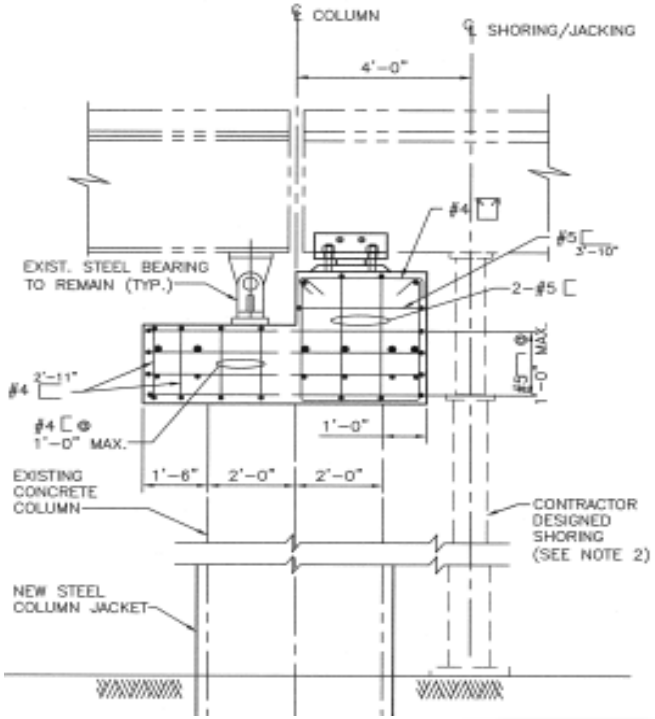
SEISMIC RETROFIT CONCEPTS

Steel Column Jacketing at Piers 4 & 5



SEISMIC RETROFIT CONCEPTS

Pier 4 Bearing Replacement & Seat Extension



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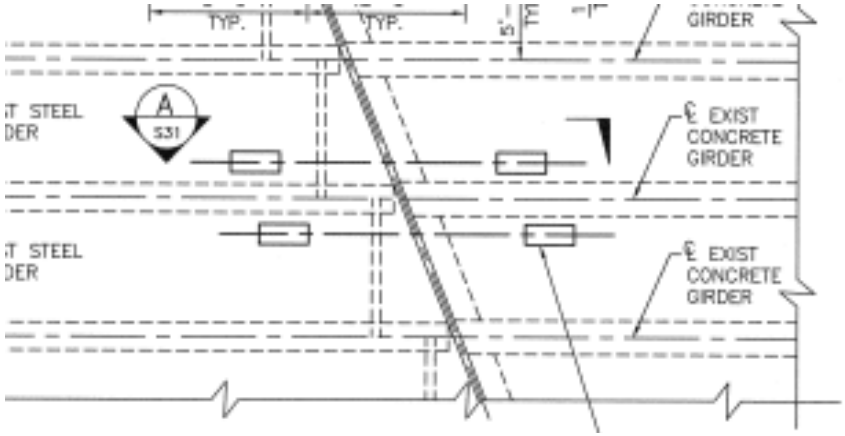
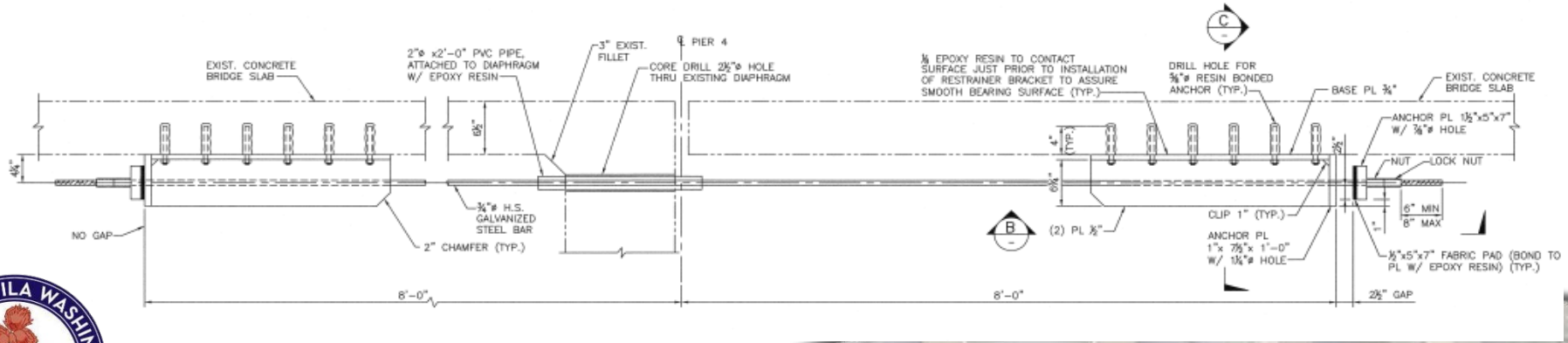
SEISMIC RETROFIT CONCEPTS

Pier 4 Seismic Restrainers





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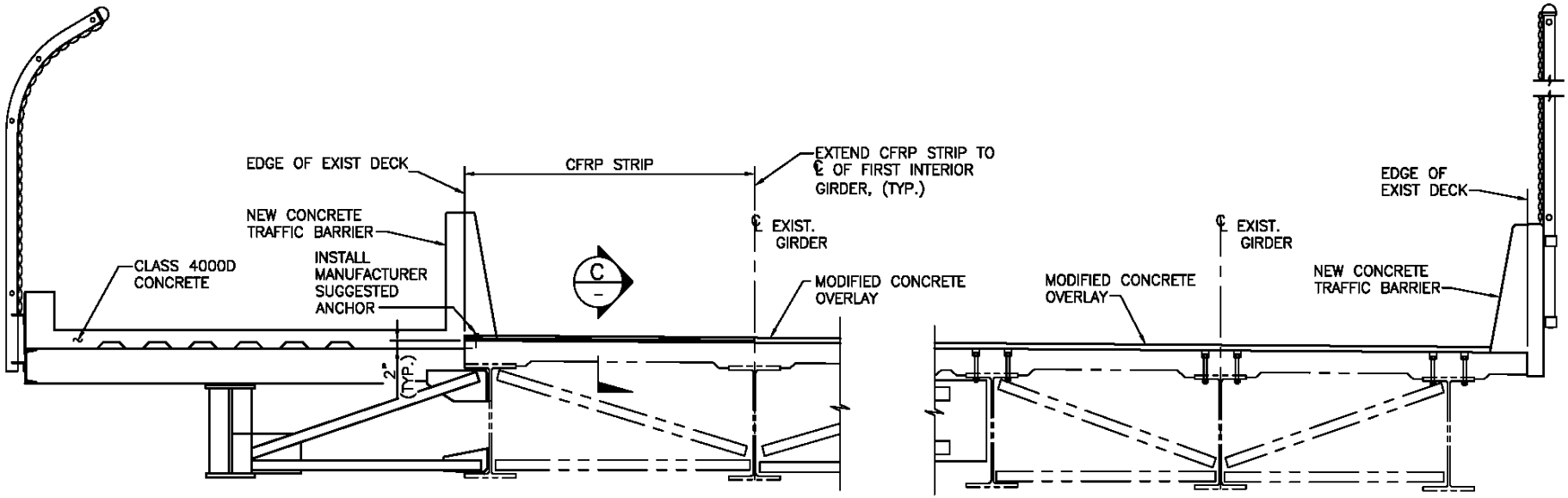
BRIDGE REHABILITATION



Bridge Typical Section

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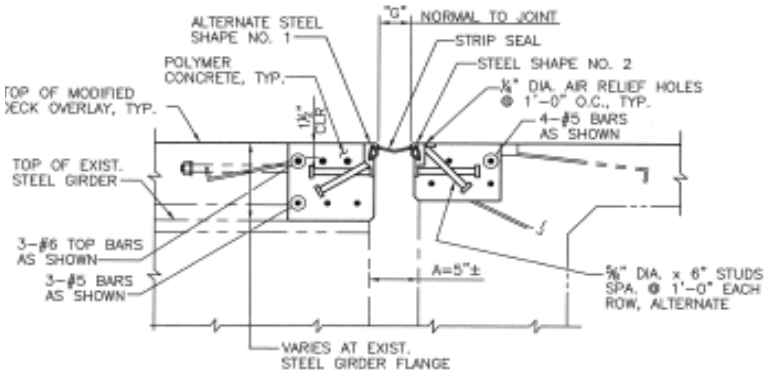
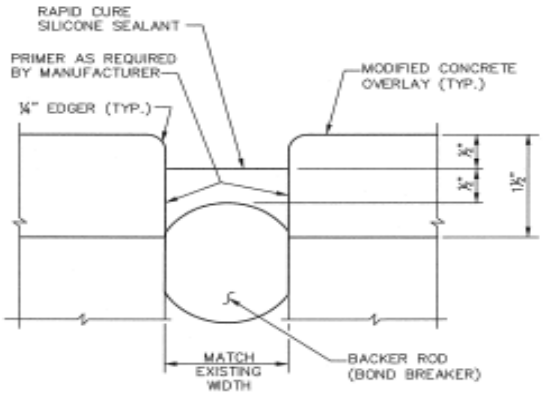
BRIDGE REHABILITATION

Expansion Joints



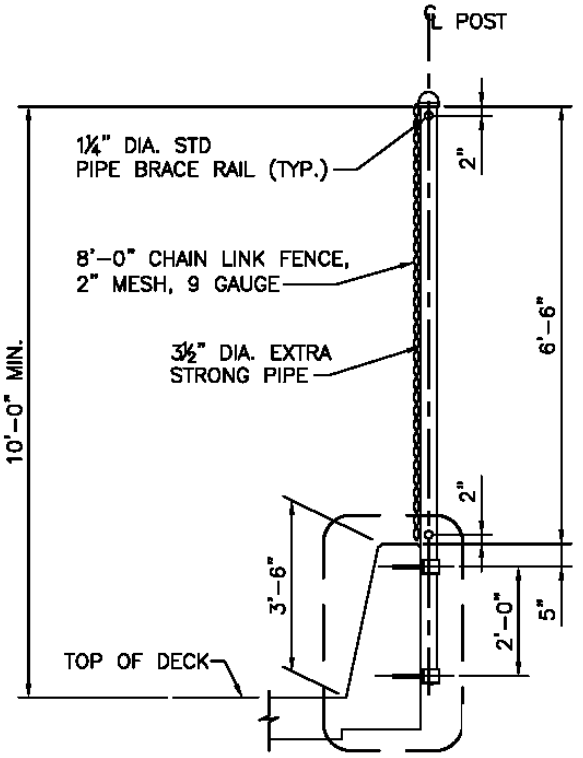
EXPANSION JOINT REPLACEMENT



LONGITUDINAL JOINT DETAIL

BRIDGE REHABILITATION

New Traffic Barrier with Fence Railing over Railroad



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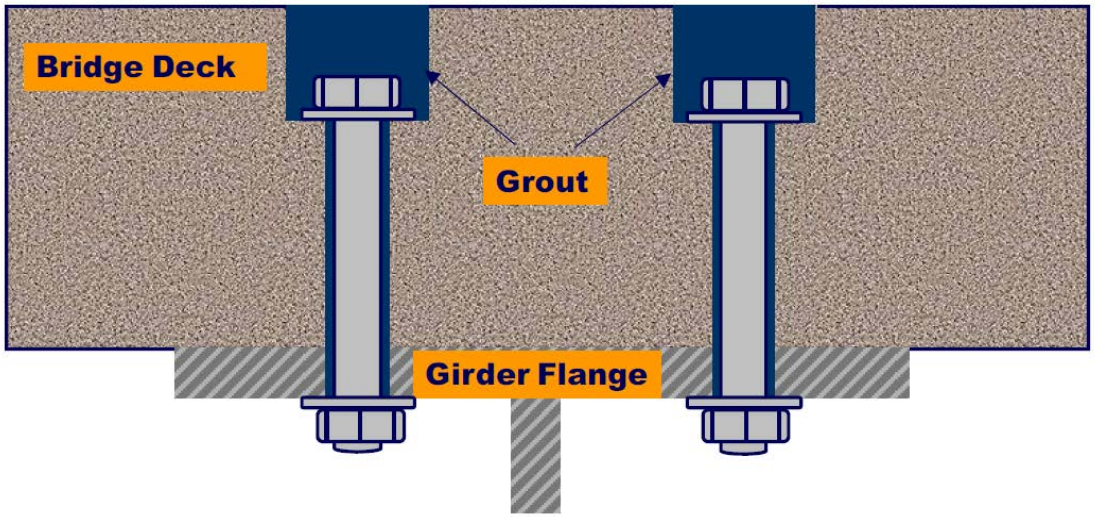
BRIDGE REHABILITATION

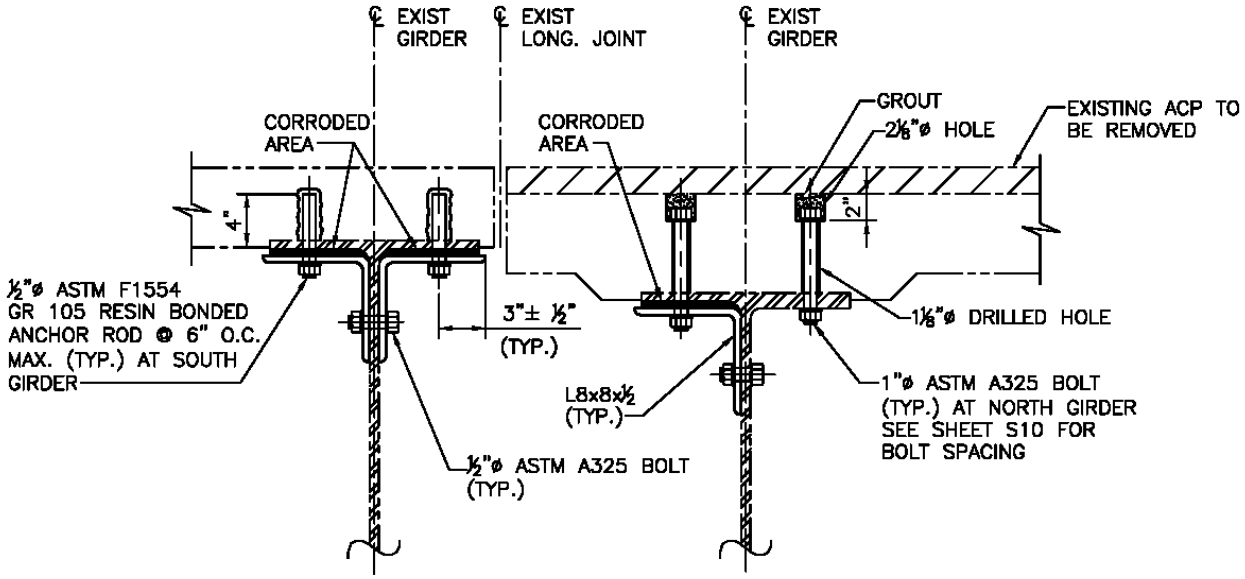
Girder Repair – Adding Shear Studs to Steel Girders



Reference: Report No. FHWA/TX-09/5-4124-01-1. "Implementation Project: Strengthening of a Bridge near Hondo, Texas using Post-Installed Shear Connectors"

BRIDGE REHABILITATION

Girder Repair – Steel Girders



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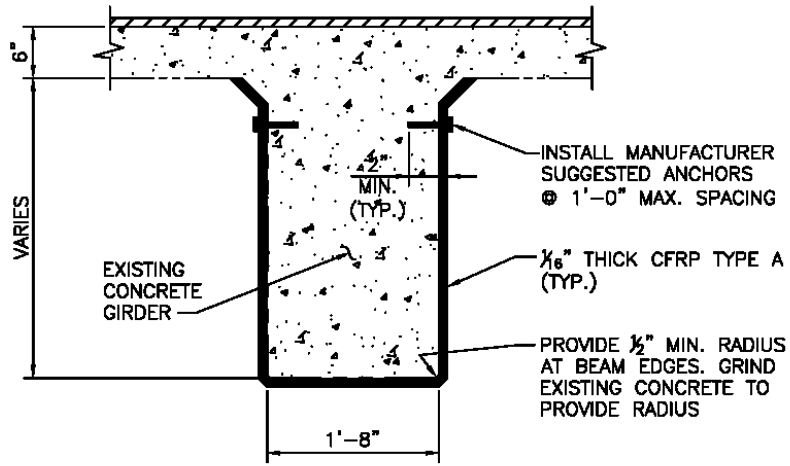
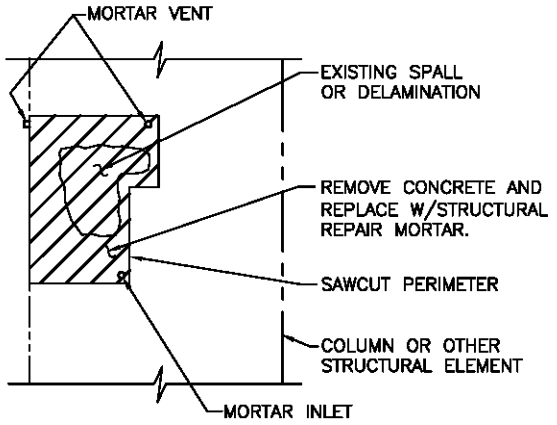
BRIDGE REHABILITATION

Girder Repair - Reinf. Concrete Girders

- ✓ CFRP strengthening
- ✓ Concrete Spall Repair





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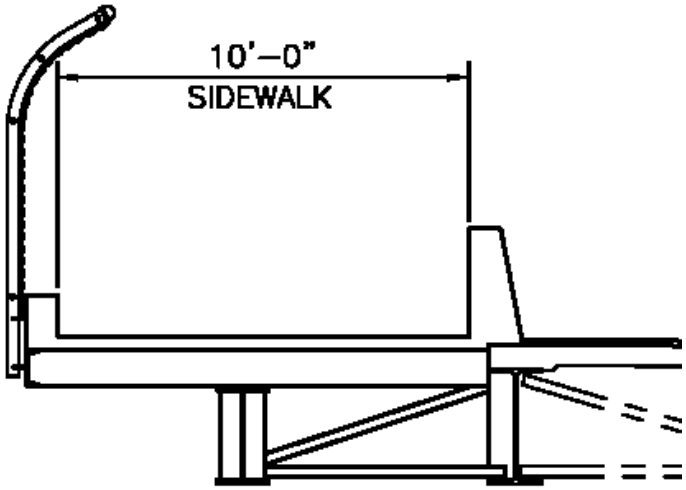
WIDENING FOR NON-MOTORIZED PATH



New Widening Section

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SUMMARY

- Comprehensive Seismic Retrofit & Rehabilitation
- Cost-effective solutions
- Providing multi-use path corridor
- Rigorous stakeholder coordination
- Funding strategy – maximizing federal funding
- Extension of City Staff – feasibility to construction

QUESTIONS?