

# Boeing North Bridge: Lessons Learned in Accelerated Bridge Construction

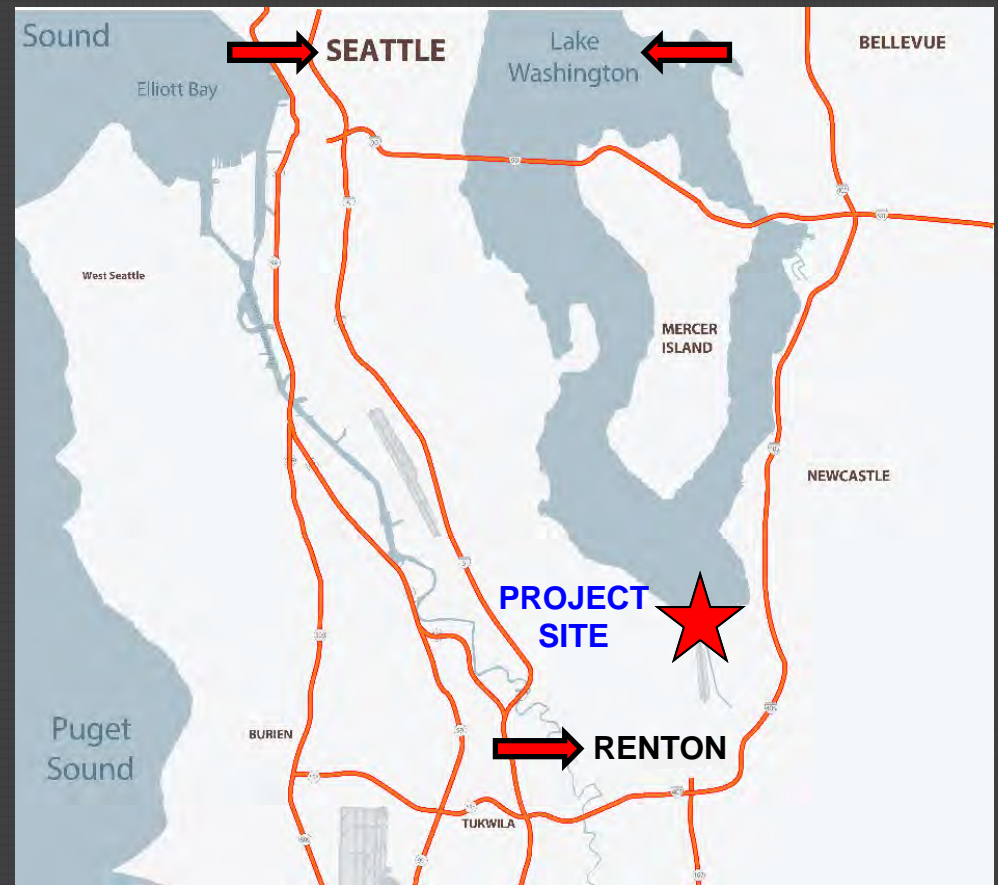
Gregory A. Banks, Myles Parrish,  
Charles W. Spry



WSDOT ABC Workshop  
April 2015

# Project Overview - Location

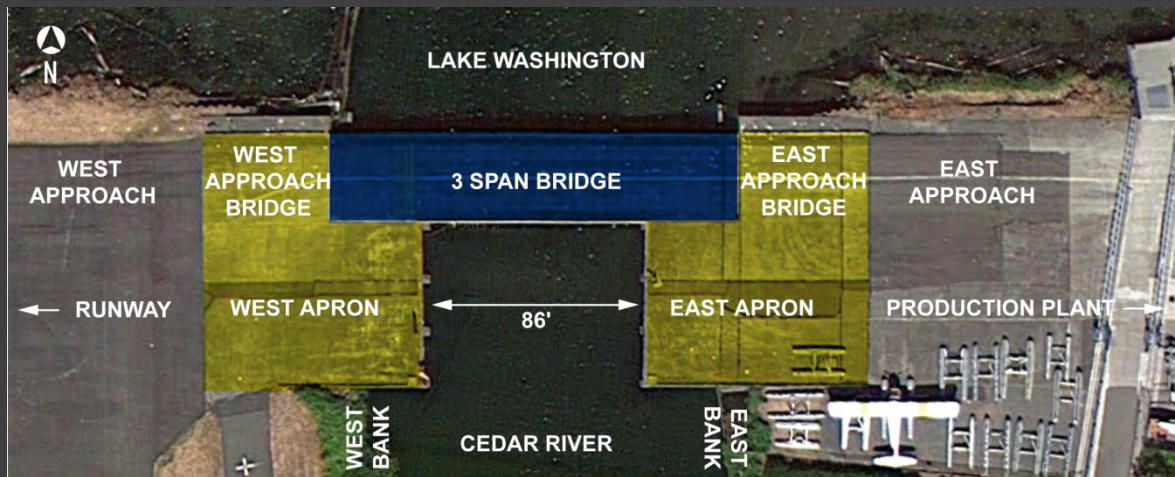
- Located in Renton, WA


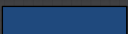


# Project Overview – Site Layout



# Project Overview – Existing Bridge Condition



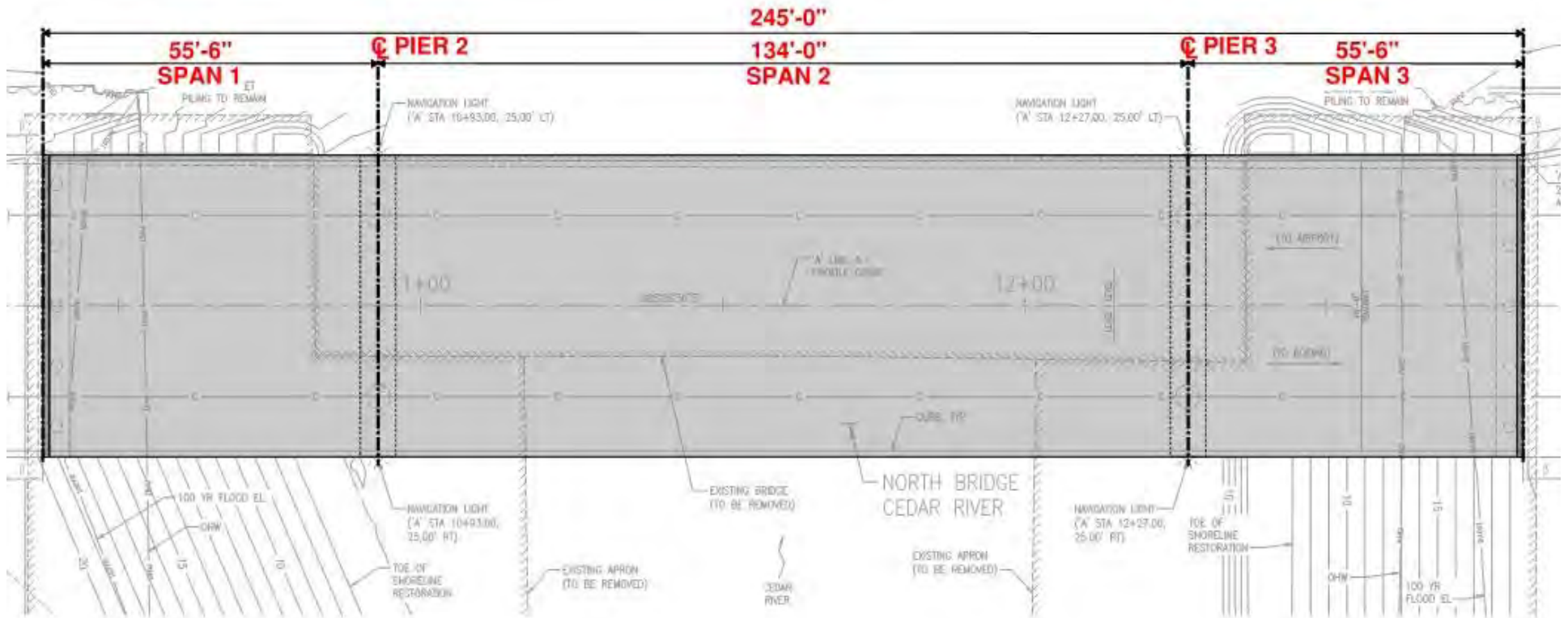
 1940 Construction  
 1969 Construction

- *Bridge Seismically Deficient*
- *Bridge is on critical path for production*
- *Damage or loss poses economic risk*



# Project Overview – Replacement Bridge General

- 3-Span Continuous (245-foot total length)
  - Main Span: 134'-0" | End Spans: 55'-6"

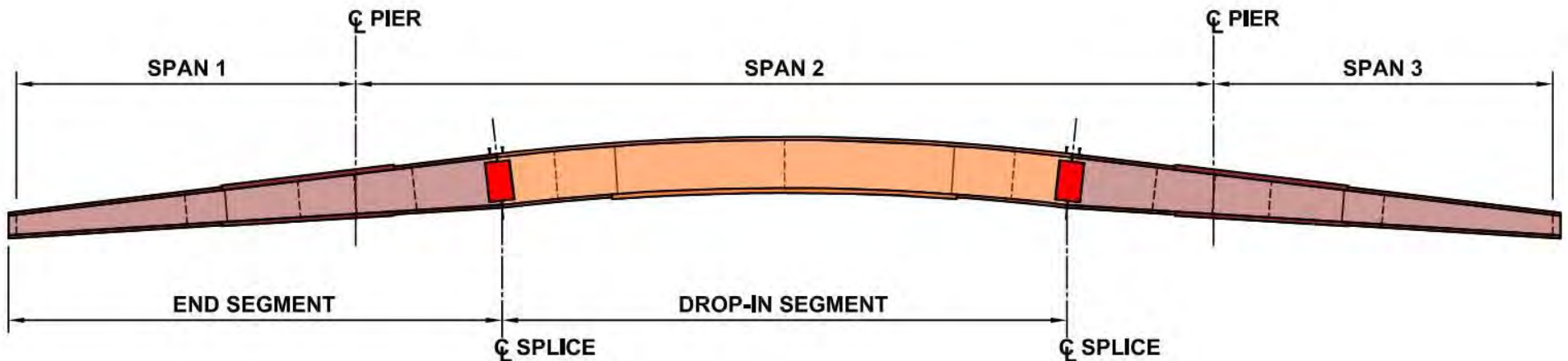
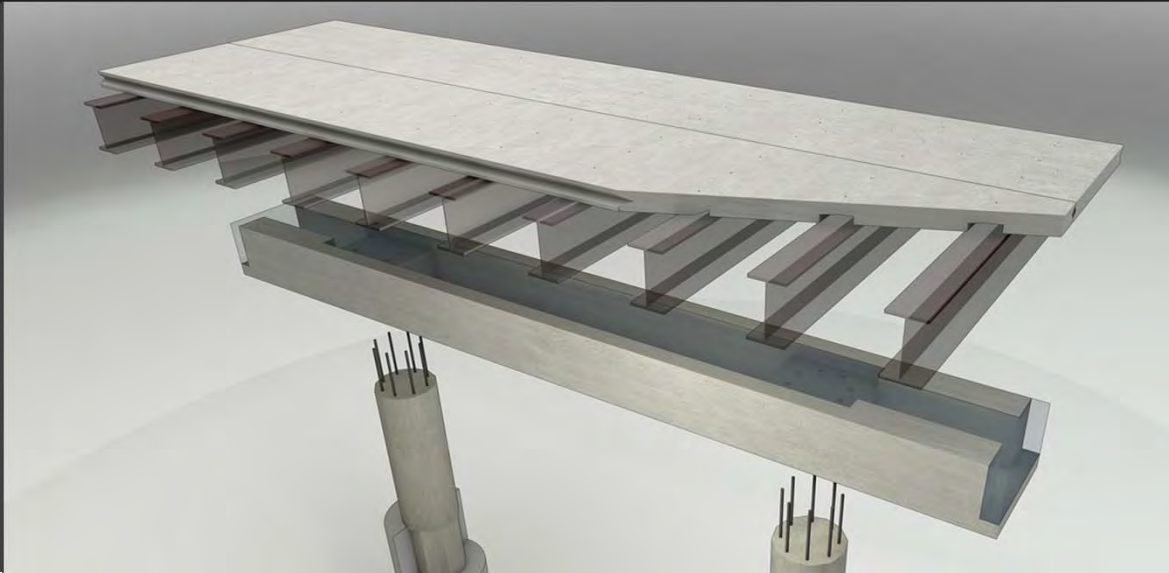


# Project Overview – Replacement Bridge

## General

- Prefabricated Bridge Elements
  - Steel Plate Girders
  - Full depth precast deck panels
  - Columns and Crossbeams

# Project Overview – Replacement Bridge Steel Plate Girders

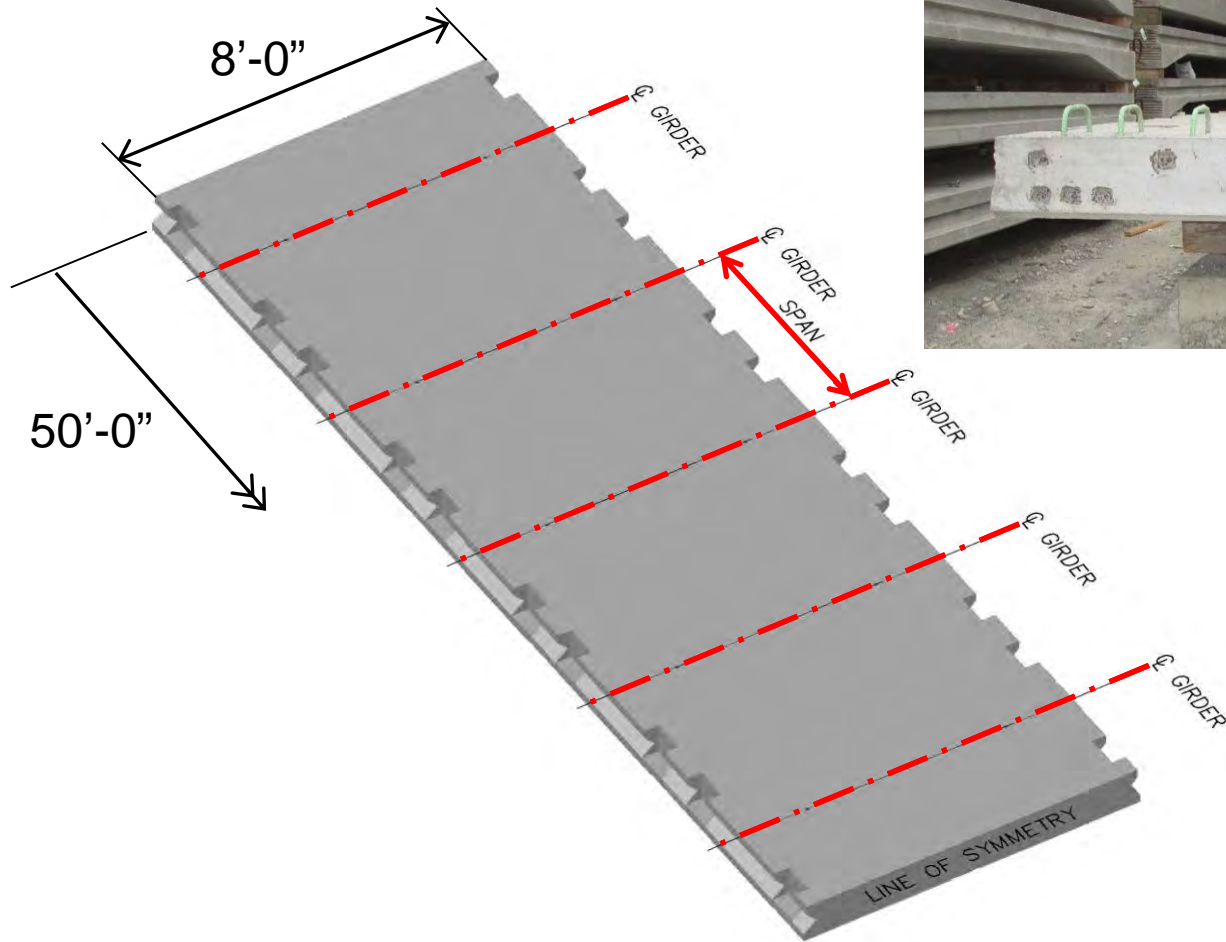


# Project Overview – Replacement Bridge Full Depth Precast Deck Panels

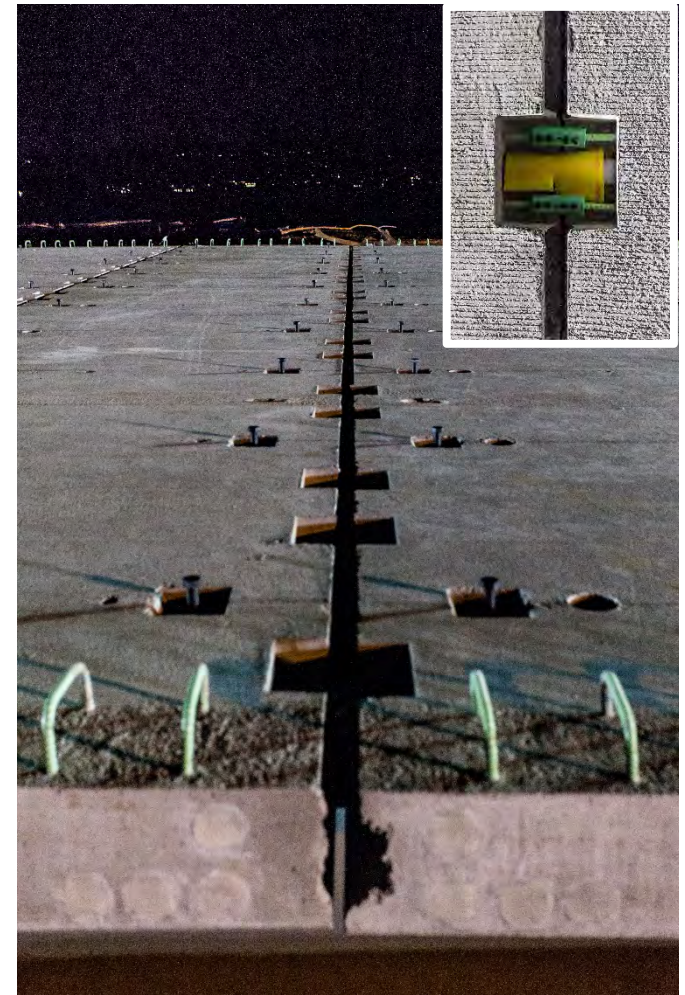
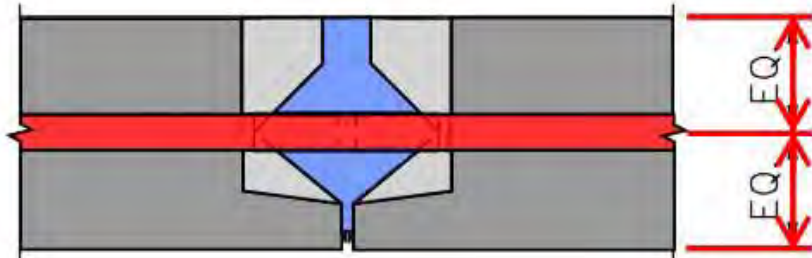




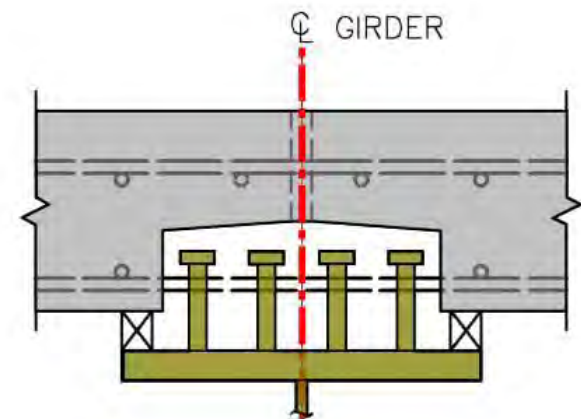
# Project Overview – Replacement Bridge Full Depth Precast Deck Panels



# Project Overview – Replacement Bridge Full Depth Precast Deck Panels

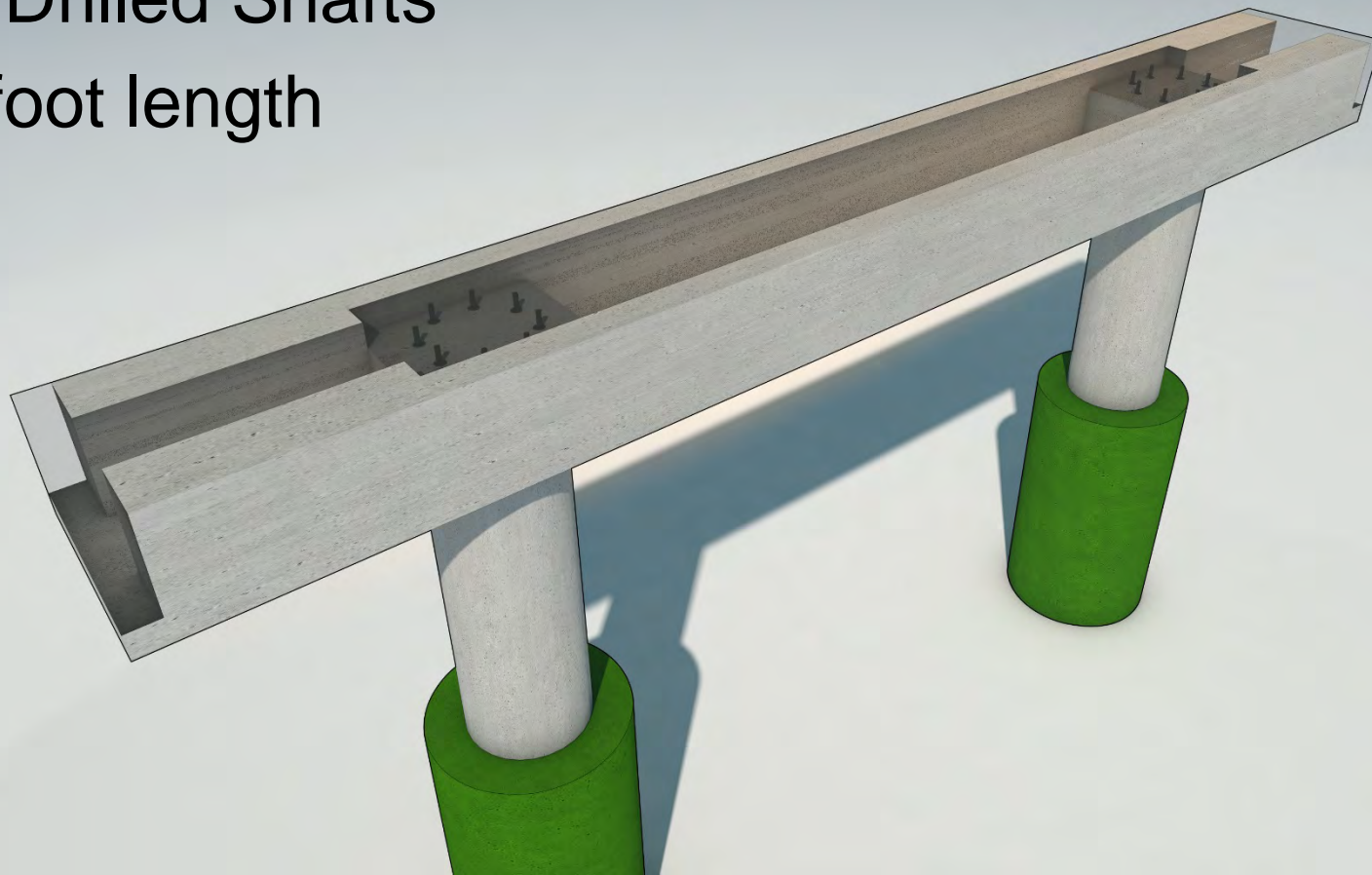


# Project Overview – Replacement Bridge Full Depth Precast Deck Panels



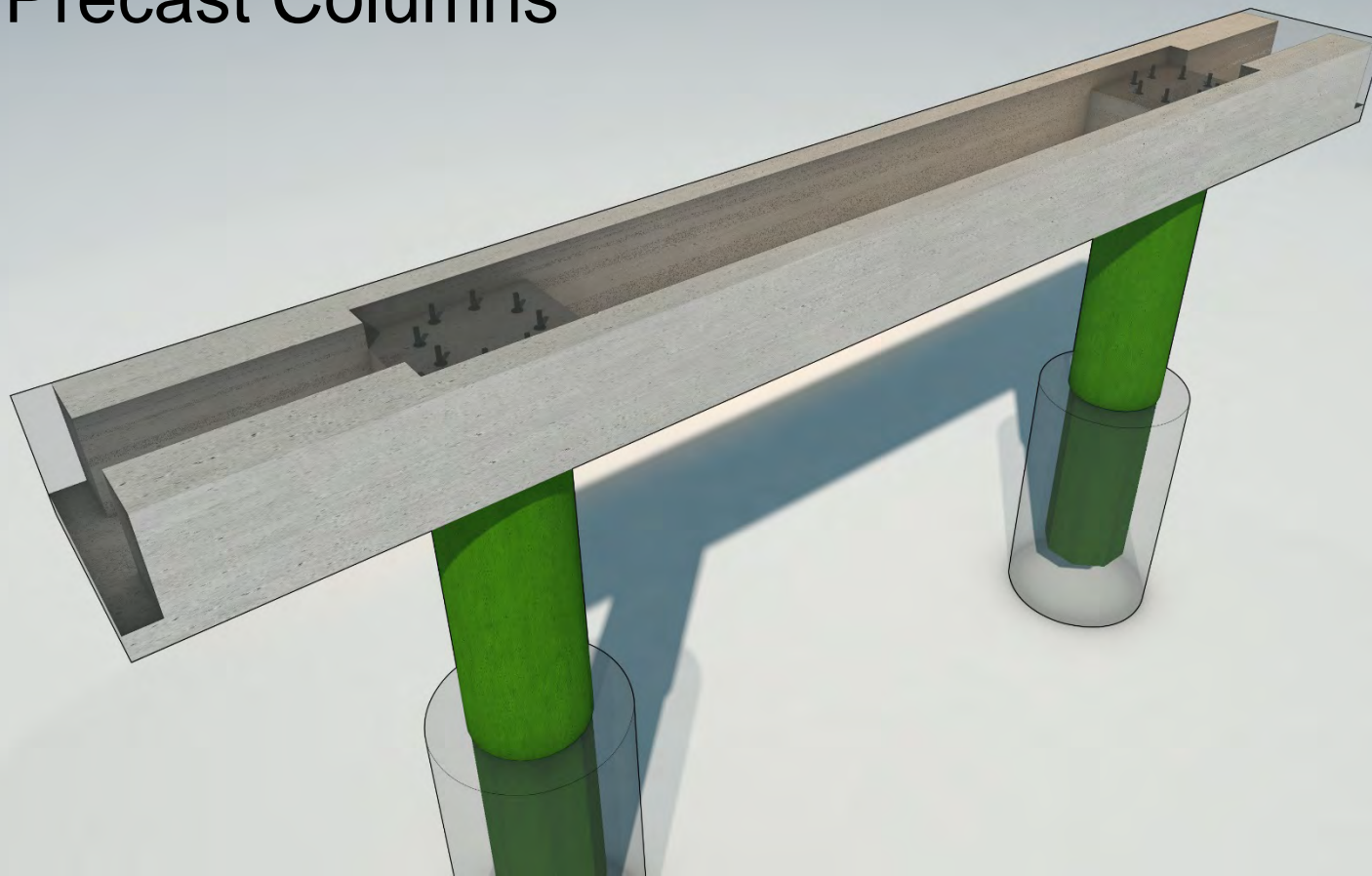
# Project Overview – Replacement Bridge Columns and Crossbeams

6'-6" Drilled Shafts  
150-foot length



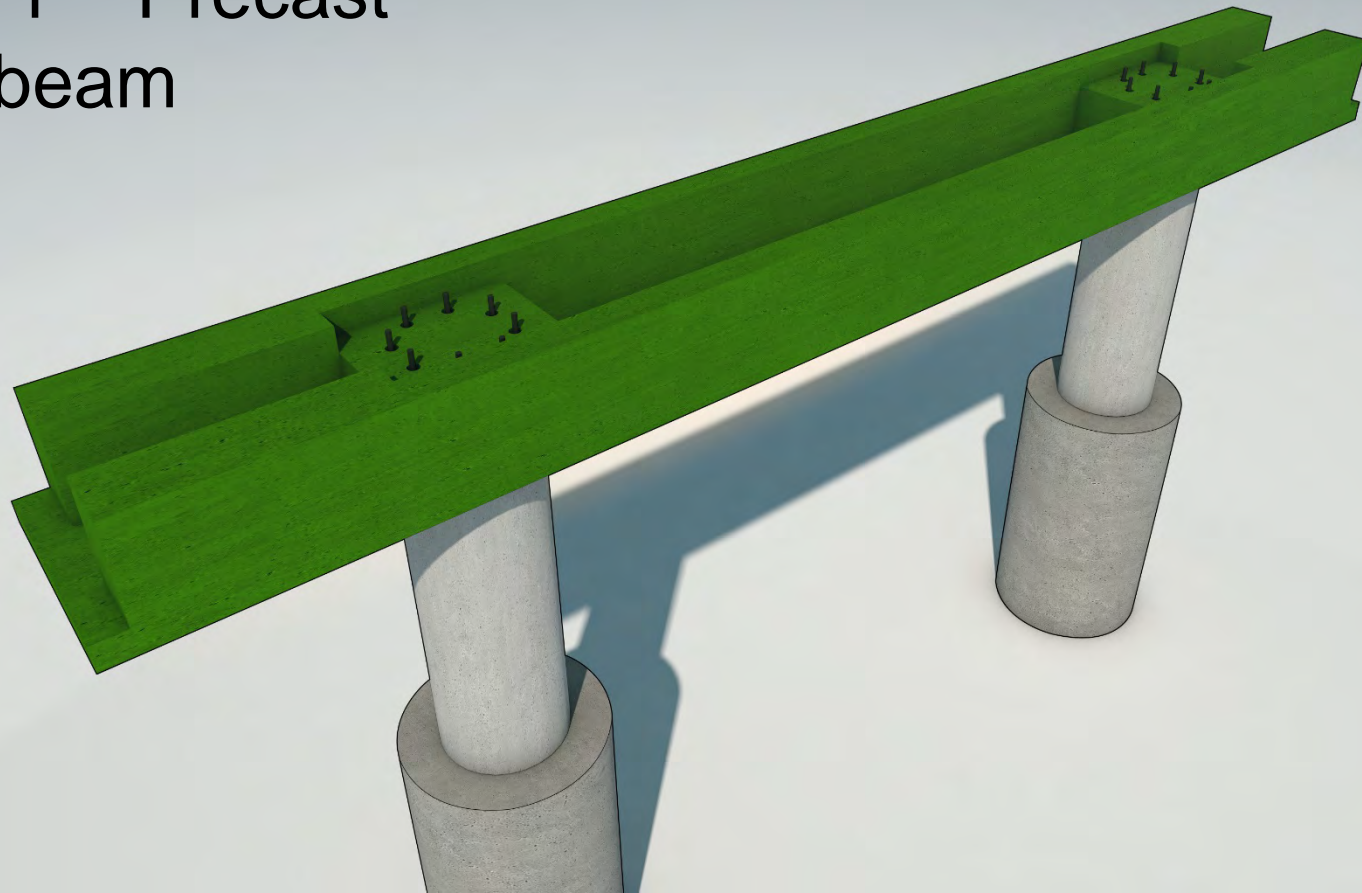
# Project Overview – Replacement Bridge Columns and Crossbeams

4'-0" Precast Columns



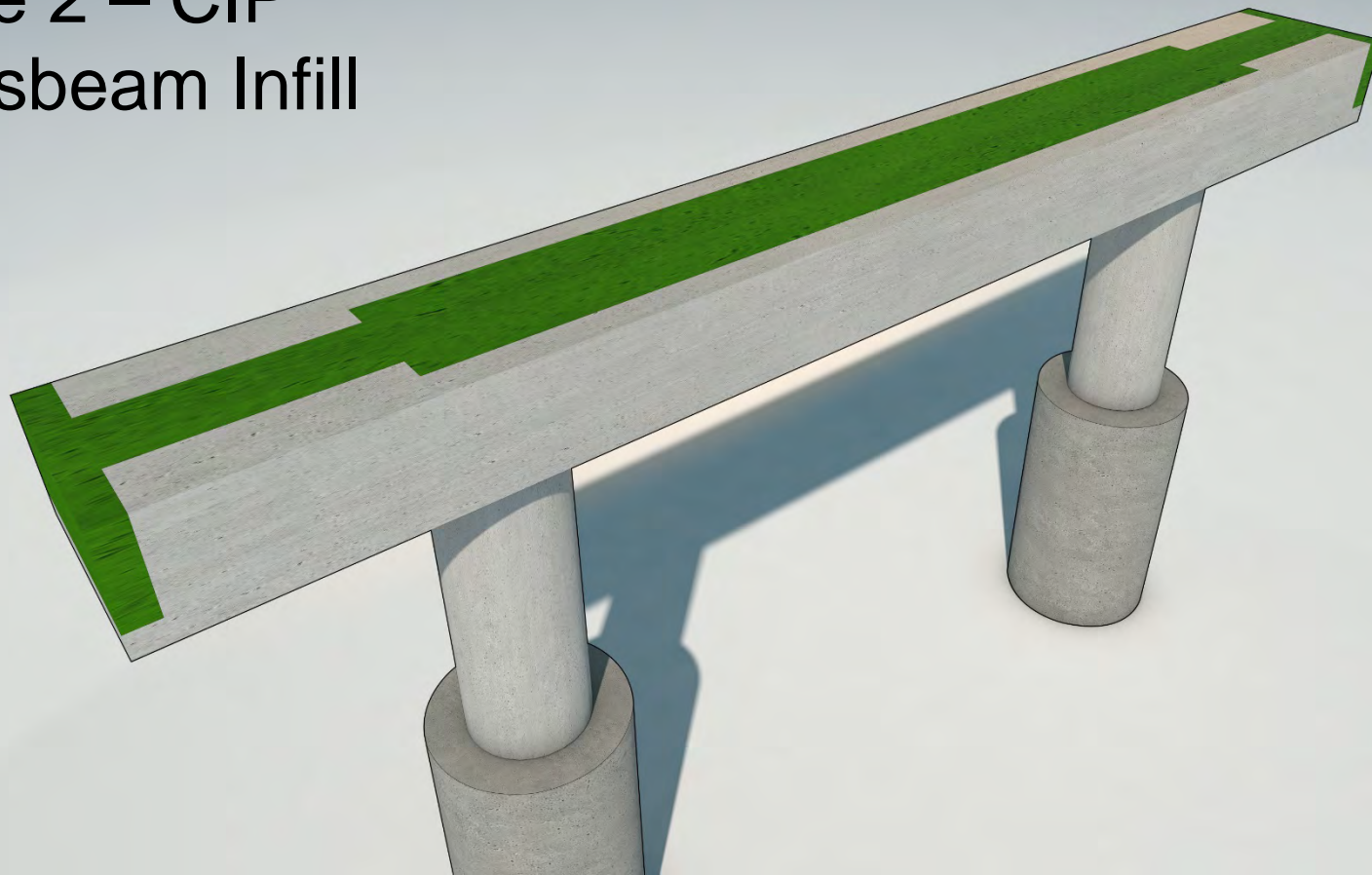
# Project Overview – Replacement Bridge Columns and Crossbeams

Stage 1 – Precast  
Crossbeam



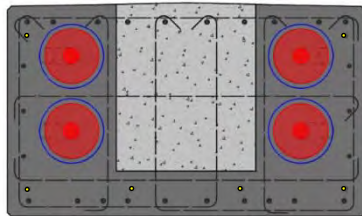
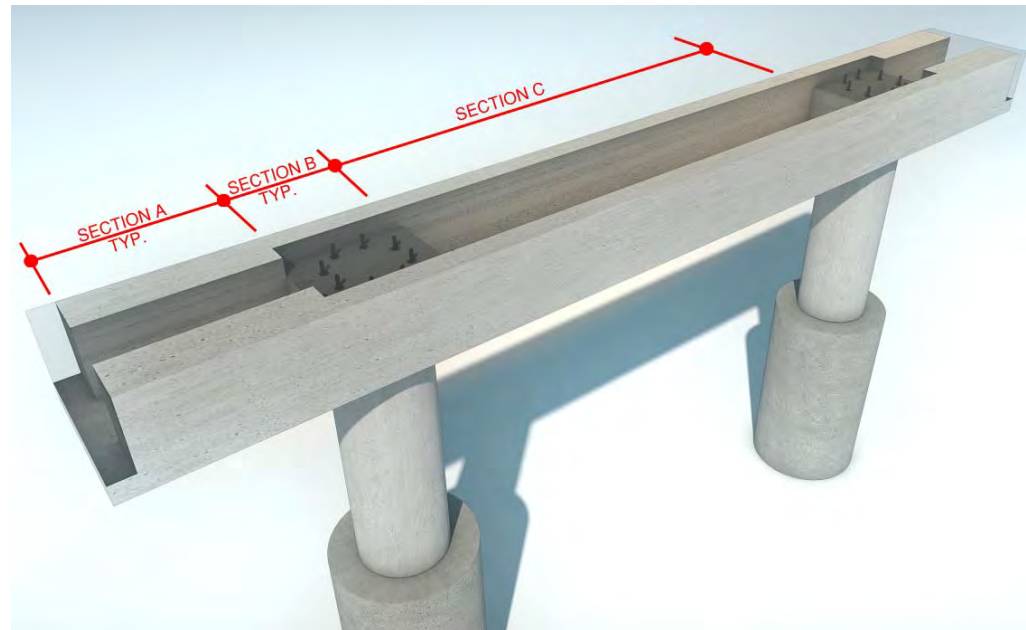
# Project Overview – Replacement Bridge Columns and Crossbeams

Stage 2 – CIP  
Crossbeam Infill

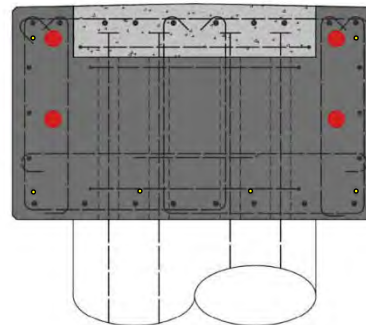


# Project Overview – Replacement Bridge Columns and Crossbeams

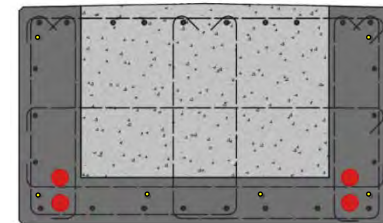
- Straight
- Pre-tensioning
- Draped
- Post-tensioning



**SECTION A**



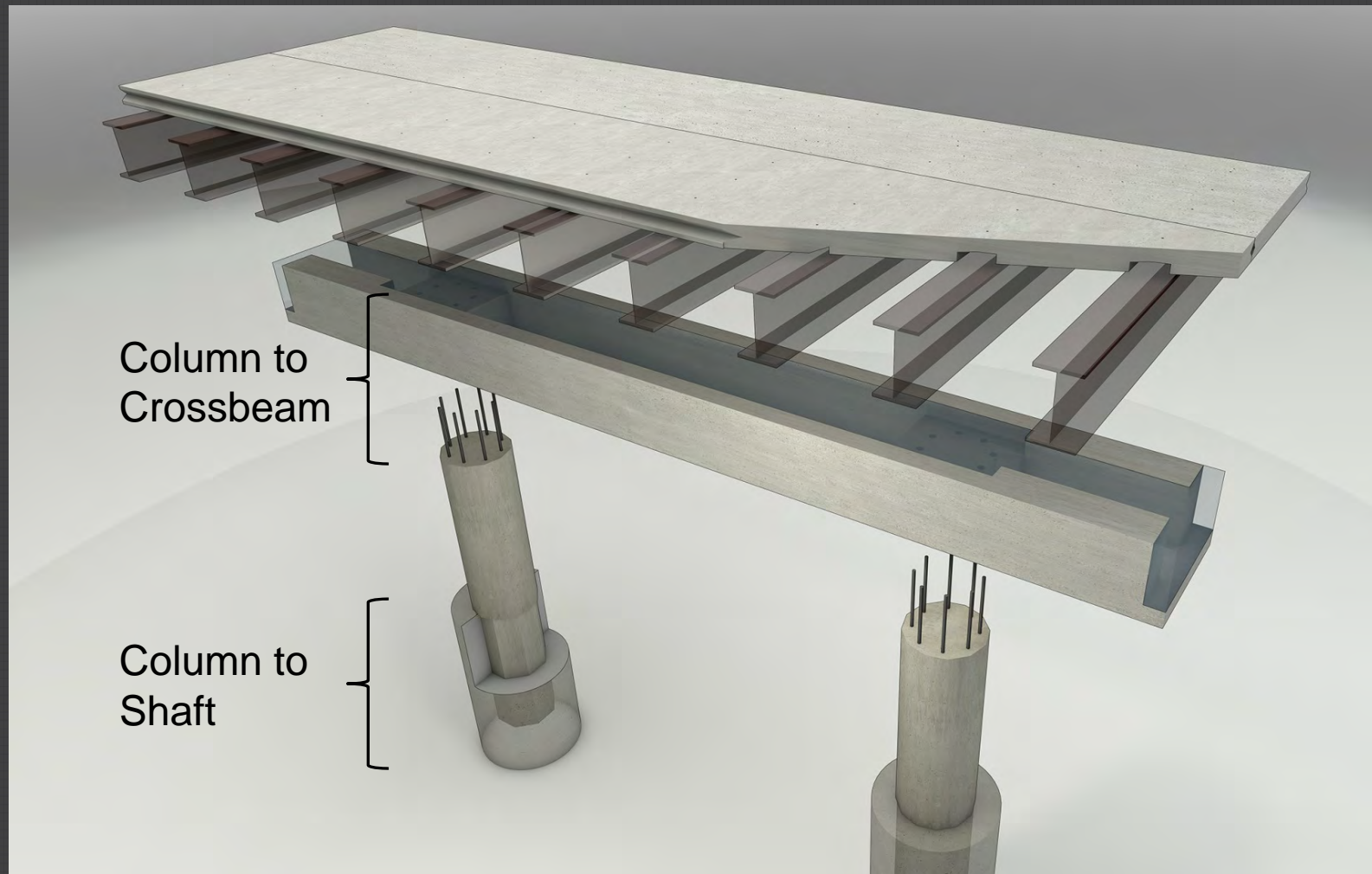
**SECTION B**



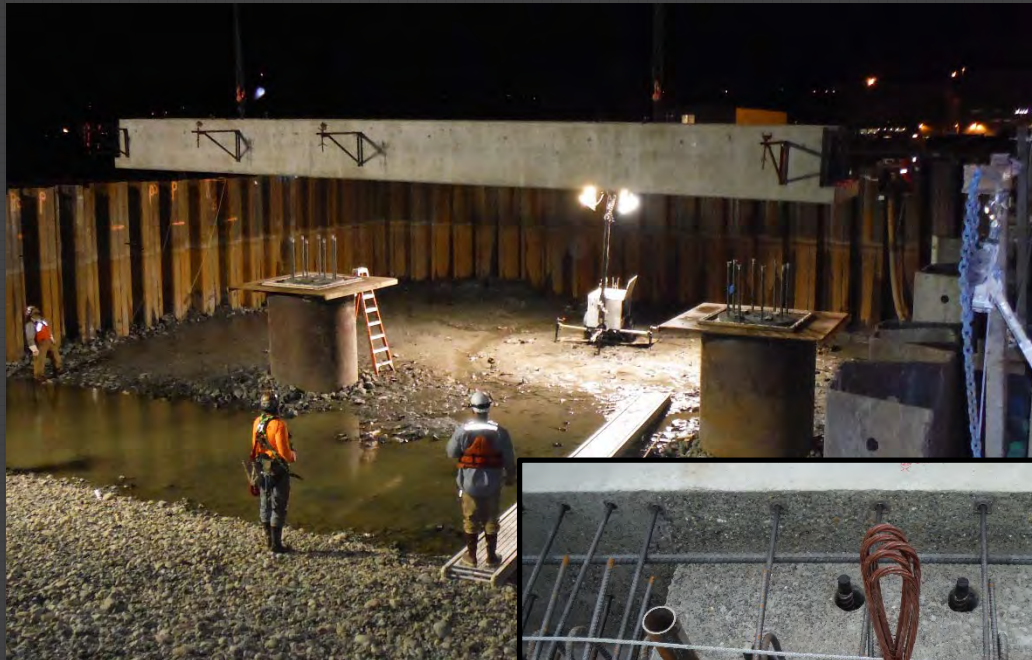
**SECTION C**



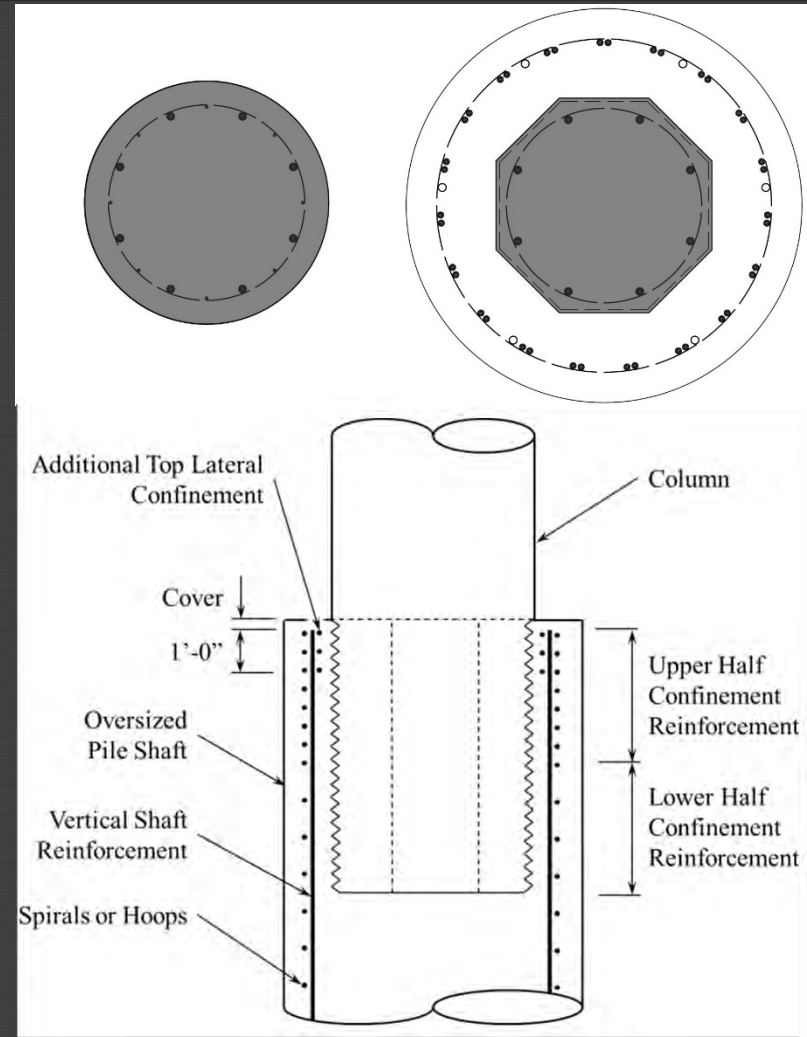
# Project Overview – Replacement Bridge Connections



# Project Overview – Replacement Bridge Connections: Column-to-Cap Beam



# Project Overview – Replacement Bridge Connections: Column-to-Shaft



# Why ABC?

- Schedule Savings
- Bridge on critical path for 737MAX rollout
- Prefabricated elements
  - Added float to the construction schedule
  - Environmental benefits with reduced CIP concrete over salmon bearing waters



# Construction Constraints/Schedule

## Boeing Production



# Construction Constraints/Schedule Environmental

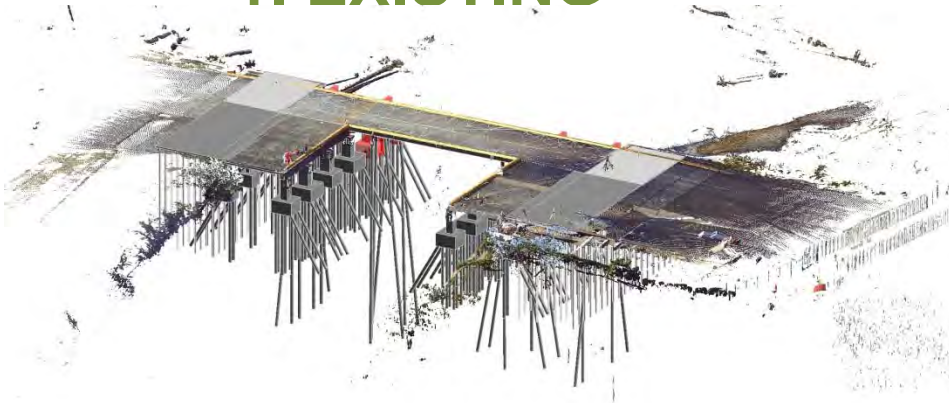
Activity ID	Original Duration	Start	Finish	2013												2014												2015											
				J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
<b>North Boeing Bridge</b>	<b>747</b>	<b>22-Jan-13</b>	<b>2-Dec-15</b>																																				
PRE-CONSTRUCTION Advertise, Bid Award, Mobilize	47	22-Jan-13	27-Mar-13																																				
PRE-FISH WINDOW 1 Demo Existing Bridge Construct Temp Bridge Approach	42	27-Mar-13	24-May-13																																				
FISH WINDOW 1 Construct Temporary Bridge Demolish Portion of Existing Bridge	54	1-Jun-13	15-Aug-13																																				
PRE-FISH WINDOW 2 Demolish Existing Bridge Above OHW Drive Piles Outside OHW	206	15-Aug-13	30-May-14																																				
FISH WINDOW 2 Complete Demo of Existing Bridge Install Work Platforms, Shafts & Crossbeams - New Bridge	55	1-Jun-14	15-Aug-14																																				
PRE FISH WINDOW 3 Complete Construction - New Bridge	200	15-Aug-14	22-May-15																																				
FISH WINDOW 3 Complete Re-grading, Armory & Restoration (East/West) Demolish Temporary Bridge	55	1-Jun-15	17-Aug-15																																				
POST FISH WINDOW 3 Punchlist Final Lanscape	77	17-Aug-15	2-Dec-15																																				

**SCHEDULED  
737MAX  
ROLL-OUT**

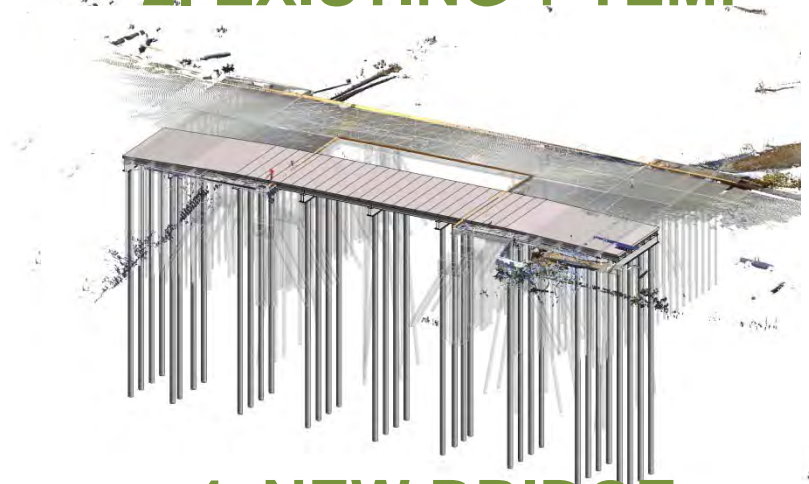


# Construction Constraints/Schedule

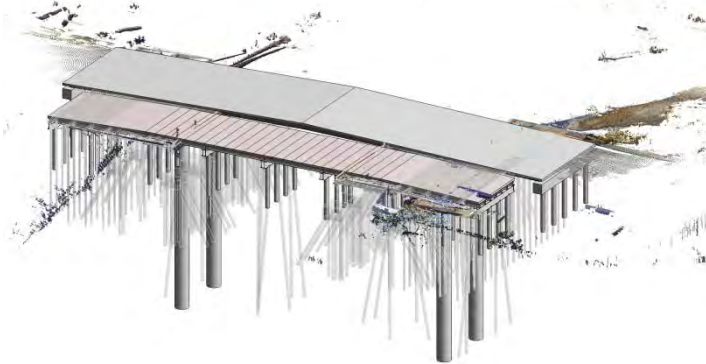
**1. EXISTING**



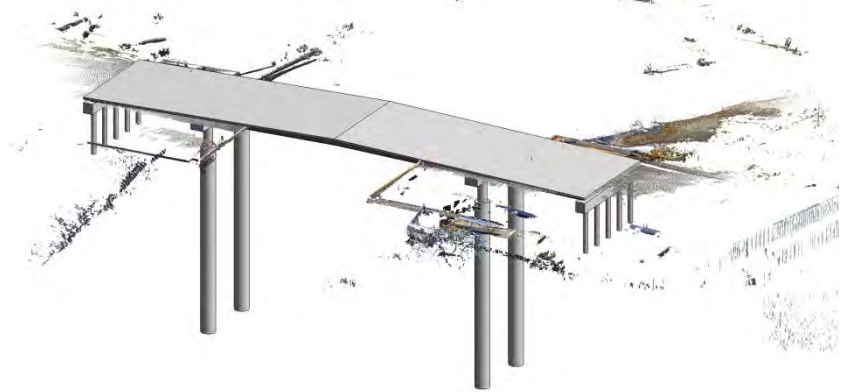
**2. EXISTING + TEMP**



**3. NEW BRIDGE + TEMP**

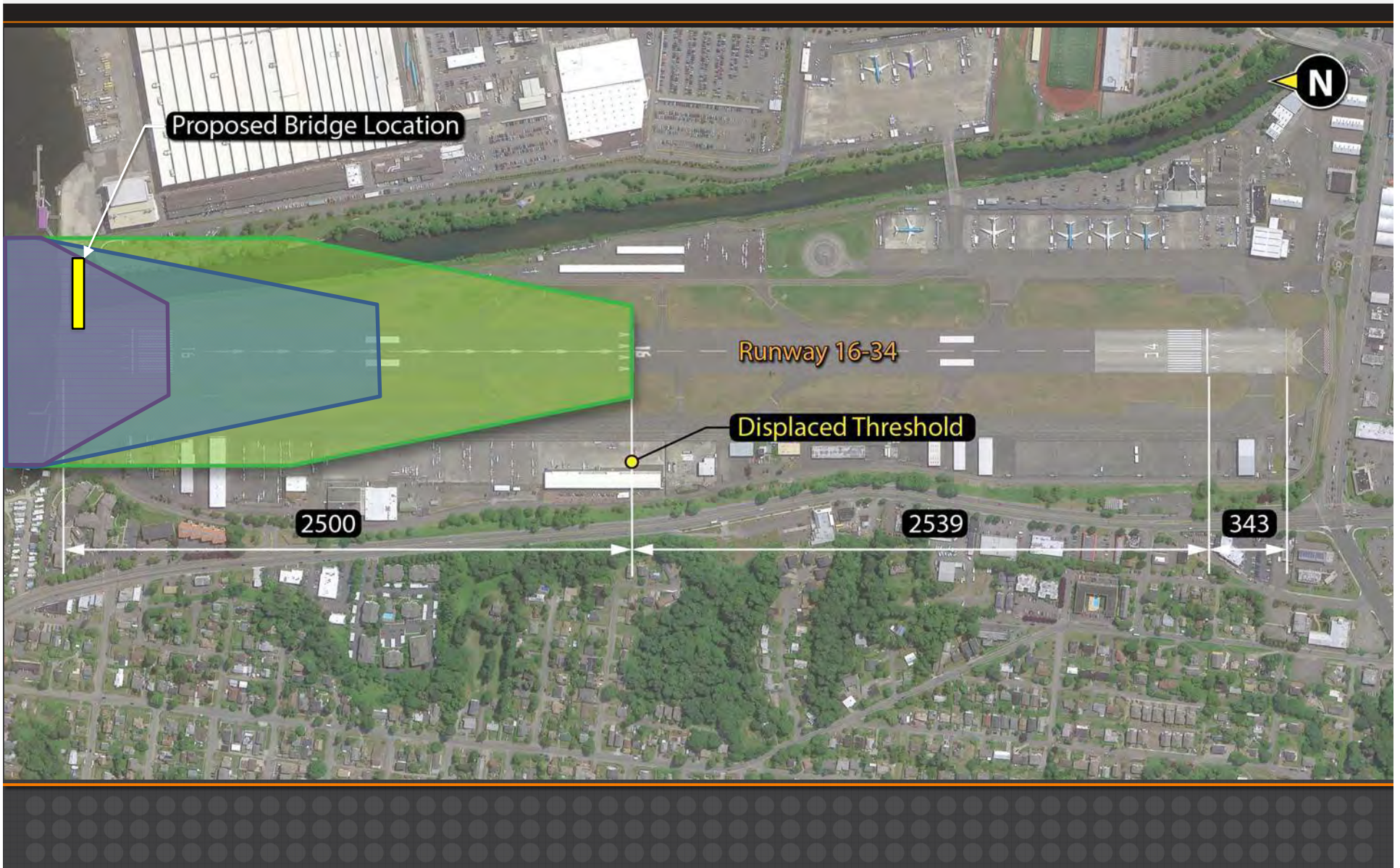


**4. NEW BRIDGE**



# Construction Constraints/Schedule

## Renton Airport Height Threshold





# Construction – Change Proposal

- Slow Start-Up
  - Delayed Permits
  - Coordination (Airport requiring night work)
  - Late commissioning of temporary bridge
- Permit Adjustment
  - Allowed for large cofferdams
  - Allowed for falsework at Piers 2 & 3
  - Contractor submitted a no-cost change proposal to switch substructure to CIP

# Construction – Change Proposal

- Change Proposal Details
  - Safety Concerns
  - Quality Concerns
  - Schedule Concerns

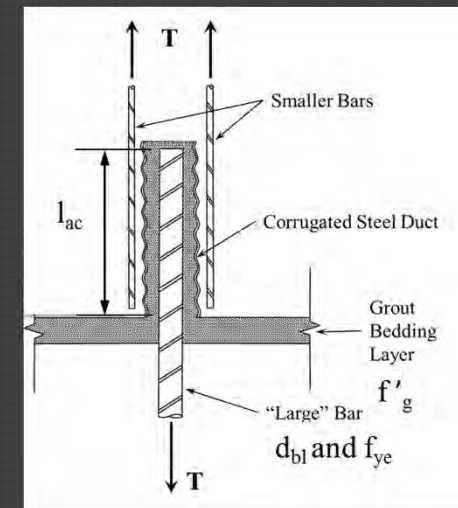
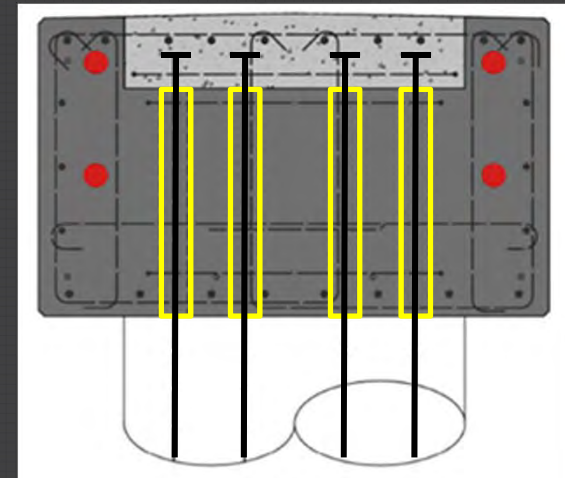
# Construction - Change Proposal

- Safety Concern:  
Setting of precast crossbeam



# Construction - Change Proposal

- Quality Concern:  
Grouting, # Joints, Tolerances



# Construction - Change Proposal

- Schedule Concern:  
Night work with no time savings

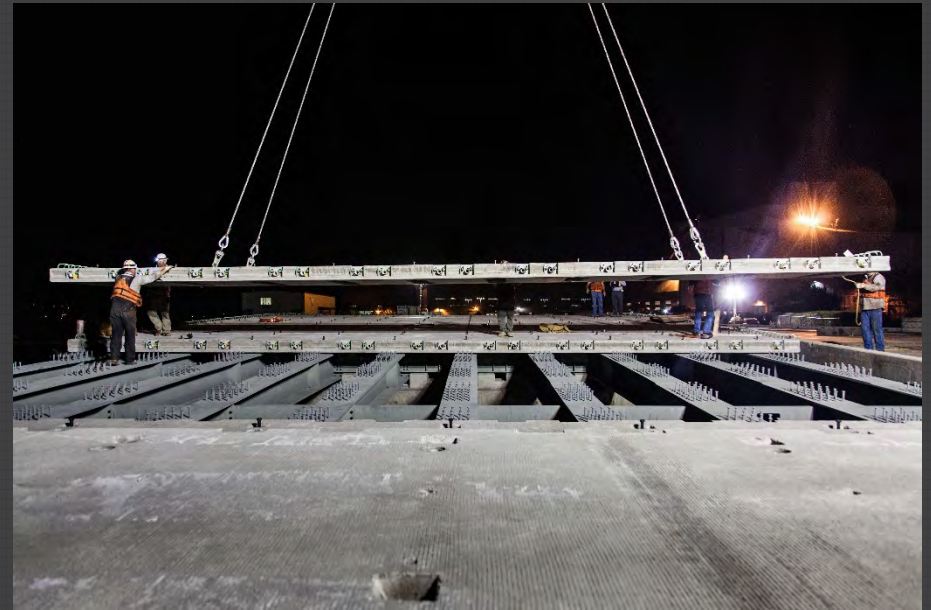


# Construction - Change Proposal

- Schedule Concern:
  - Night work with no time savings
- Response:
  - Several opportunities for time savings
  - Crane required regardless

# Construction - Precast Deck Panels

- Precast Deck Construction Details
  - UHPC (Ultra High Performance Concrete)
  - Girder Fabrication and Panel Erection



# Lessons Learned

- Understand Construction Constraints/Risks
- Cost Savings with Standards & Repetition
- Certified PCI Prefabricator Required?
- Required Equipment Size



# Questions?



# Design Examples

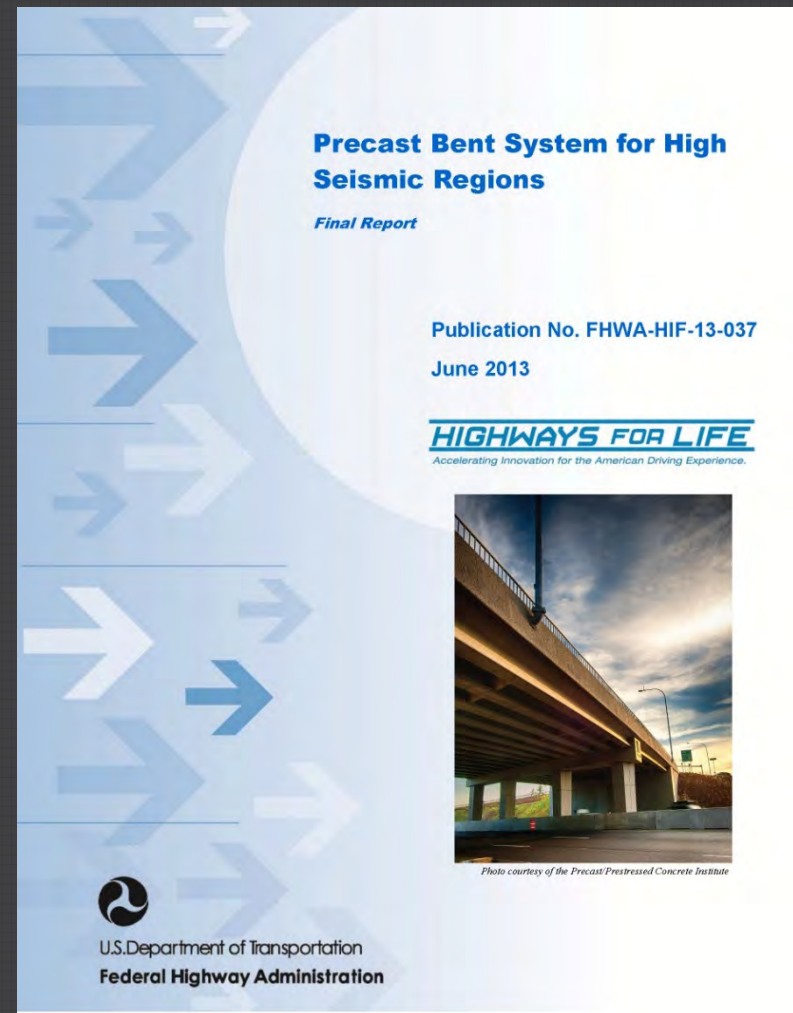
- Developed for the FHWA Technology Partnership Program
- Culminated in demonstration project completed by WSDOT.
- Marked excellent collaboration between Owner, Researchers, Designers, Precaster, and Contractor



# Reports Available from FHWA – Highways for LIFE

<http://www.fhwa.dot.gov/hfl/>

- Final Report
- Appendices
  - A. Design Specifications
  - B. Design Example No. 1
  - C. Design Example No. 2
- Testing Report – Spread Footings
- Testing Report – Drilled Shafts

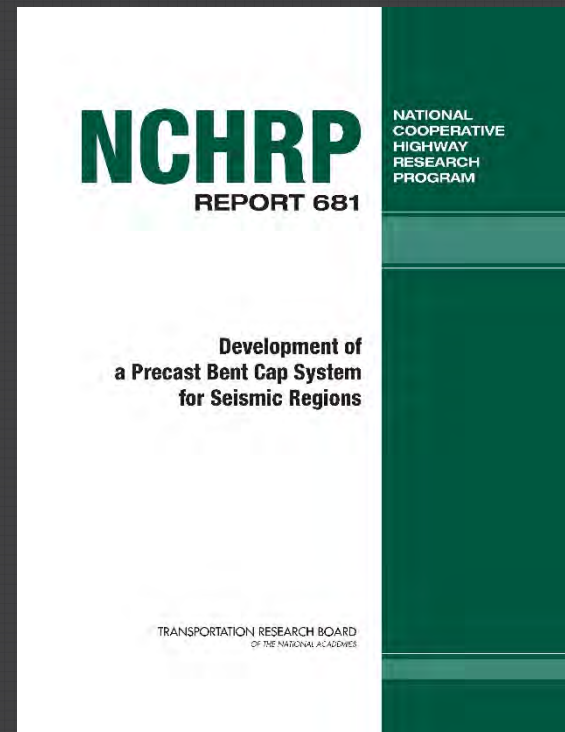
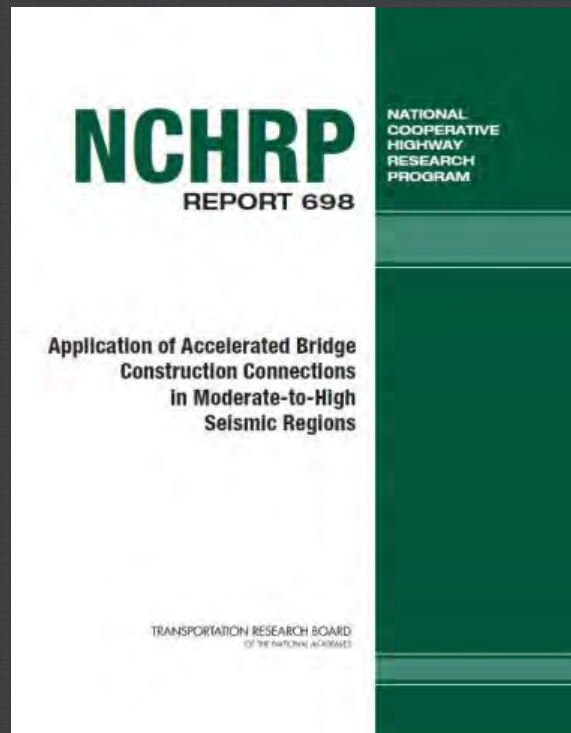


# Reports Available from FHWA – Highways for LIFE

- Design Specifications
  - Formatted in AASHTO Guide Spec Language
  - Address design with HfL bent details
- Construction Specifications
  - Material controls
  - Tolerance control
  - Recommendations for contract control

# Example Resources – NCHRP Precast Bridge Elements and Systems (PBES)

ABC – PBES is now widely deployed  
in lower seismic regions



A challenge for ABC is development  
of PBES for higher seismic regions

# Concept of “Technology Readiness Level”

		Bar Couplers				Grouted Ducts				Pocket Conns.			
Technology Readiness Level (TRL)		% of development complete				% of development complete				% of development complete			
TRL	Description	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1	Concept exists												
2	Static strength predictable												
3	Non-seismic deployment												
4	Analyzed for seismic loading												
5	Seismic testing of components												
6	Seismic testing of subassemblies												
7	Design & construction guidelines												
8	Deployment in seismic area												
9	Adequate performance in EQ												

		Socket Conns.				Hybrid Systems				Integral Conns.				Emerging Technology			
TRL		% of development complete				% of development complete				% of development complete				% of development complete			
		0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
1																	
2																	
3																	
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5																	
6																	
7																	
8																	
9																	

1. Reference: NCHRP 698 – Red fill blocks = work done since report was published.
2. NCHRP 12-102 – Current project to address TRL 7, Design & Construction Guidelines

# Additional Helpful Resources

## TRB AFF10(3): Subcommittee for ABC

<https://sites.google.com/site/trbaff103/home>

Welcome

Registration

Members

News/Events 2014

▼ ABC Research  
Projects

Project Tracker

▼ Annual Meetings  
2014

Comments

### TRB

#### Committee on General Structures (AFF10)

#### Subcommittee on Accelerated Bridge Construction (AFF10-3)

*Approximately one-fourth of the Nation's 600,000 bridges require rehabilitation, repair, or total replacement. The construction-related work used to address these needs can have significant impact to the surrounding area including mobility, safety, and other social-economic related impacts. Throughout the U.S., owner agencies are realizing that the results of using ABC strategies not only help address onsite related constraints, but can also improve how a bridge program is delivered when used in a more routine, programmatic manner.*

**Scope:** The TRB Accelerated Bridge Construction (ABC) Subcommittee supports research, technology transfer, and implementation to advance ABC technologies related to policy, planning, procurement, design, materials, construction and contracting. The **objective** of the subcommittee is to expand the knowledge and expertise to foster the implementation of ABC related technologies.