Western Bridge Engineers' Seminar

SEPTEMBER 25 - 28, 2011 | SESSION 5B | PHOENIX, ARIZONA

Highways for Life Demonstration Projects and Accelerated Bridge Construction in Washington State

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Washington State
Department of Transportation

Presentation Outline:

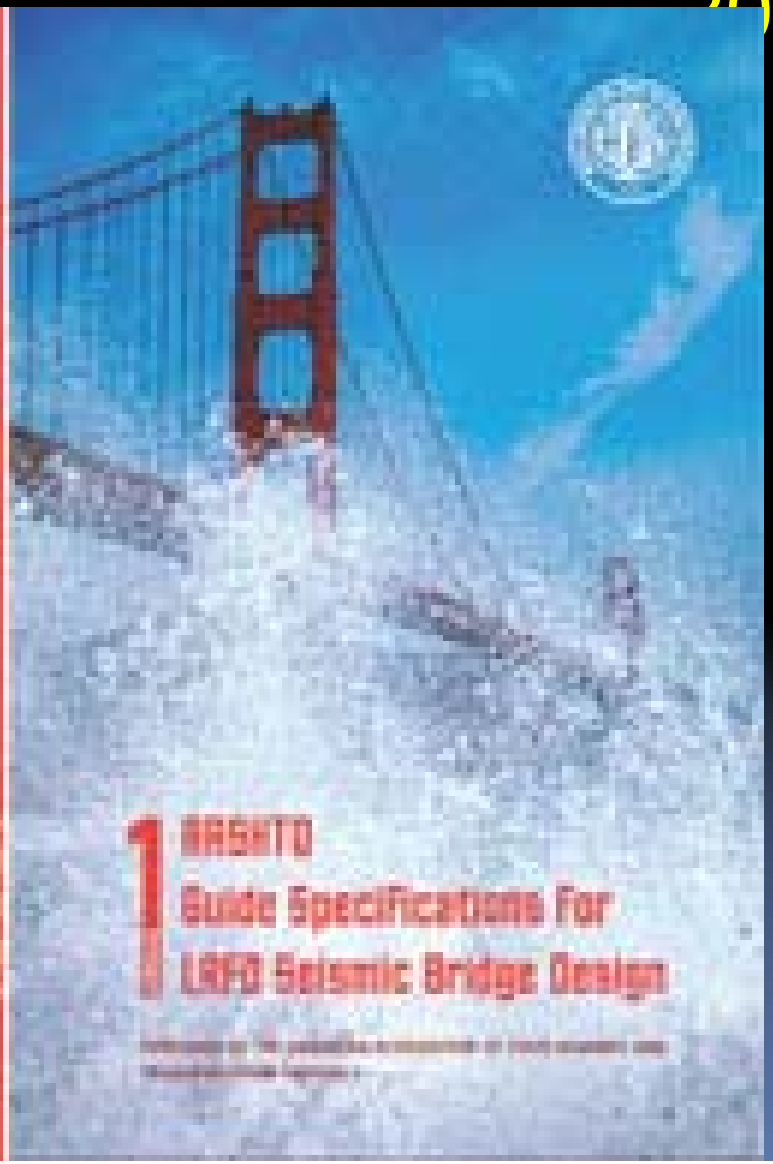
- Need for ABC
- HFL Demonstration Project
  - Connection Design and Testing
  - Column-to-Cap Beam
  - Column-to-Spread Footing and Shaft
  - Segmental Column
- HFL Bridge Construction
- Lessons Learned

WSDOT Advisory Committee and Strategic Plan for ABC

ABC Advisory Committee	Members
WSDOT Bridge Office	Jugesh Kapur, Ron Lewis, DeWayne Wilson, Bijan Khaleghi
WSDOT Construction Office	Mark Gaines
WSDOT Research Office	Kim Willoughby
WSDOT Regions	MaryLou Nebergall, Mike Morishige
FHWA - Washington	Debbie Lehmann, Barry Brecto
University of Washington	John Stanton, Marc Eberhard
Bridge Consultants	Lee Marsh, Scott Phelan, Yuhe Yang
Bridge Contractors	Tim Loucks
Precast Concrete Plants	Steve Sequirant, Chuck Prussack
HFL Proposal Submitted by:	**Marsh, Stanton, Eberhard, Khaleghi**
HFL Bridge Design Team:	**Eric Schultz, Hsieh, Collins, Sargent**

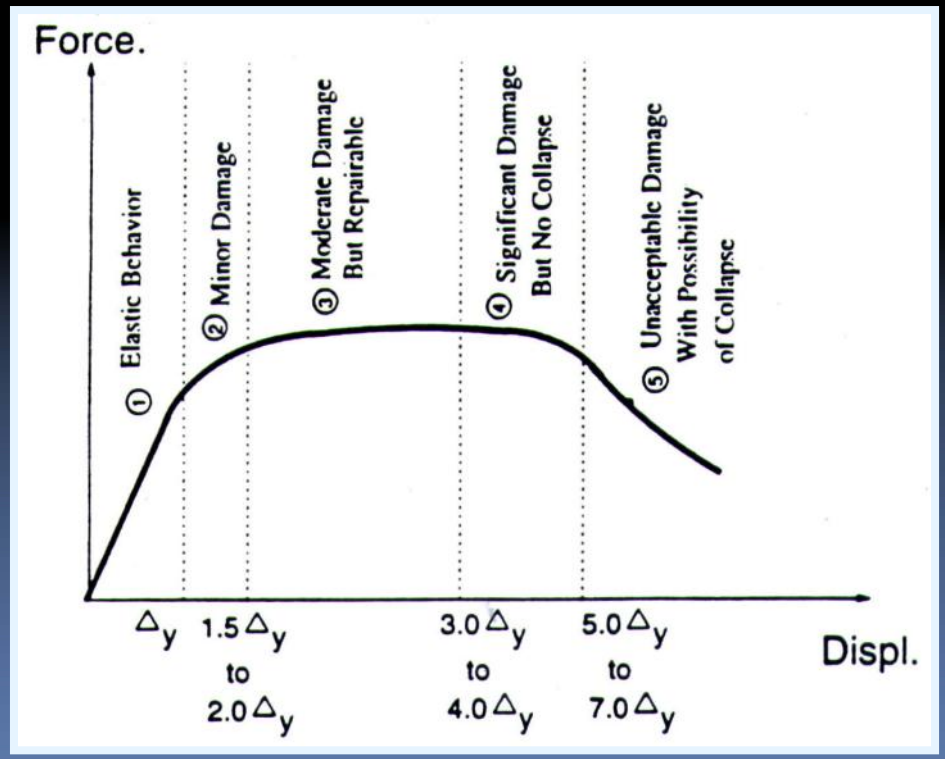
Bridge Seismic Design

LRFD Seismic Guide Specs (SGS) Since 2008

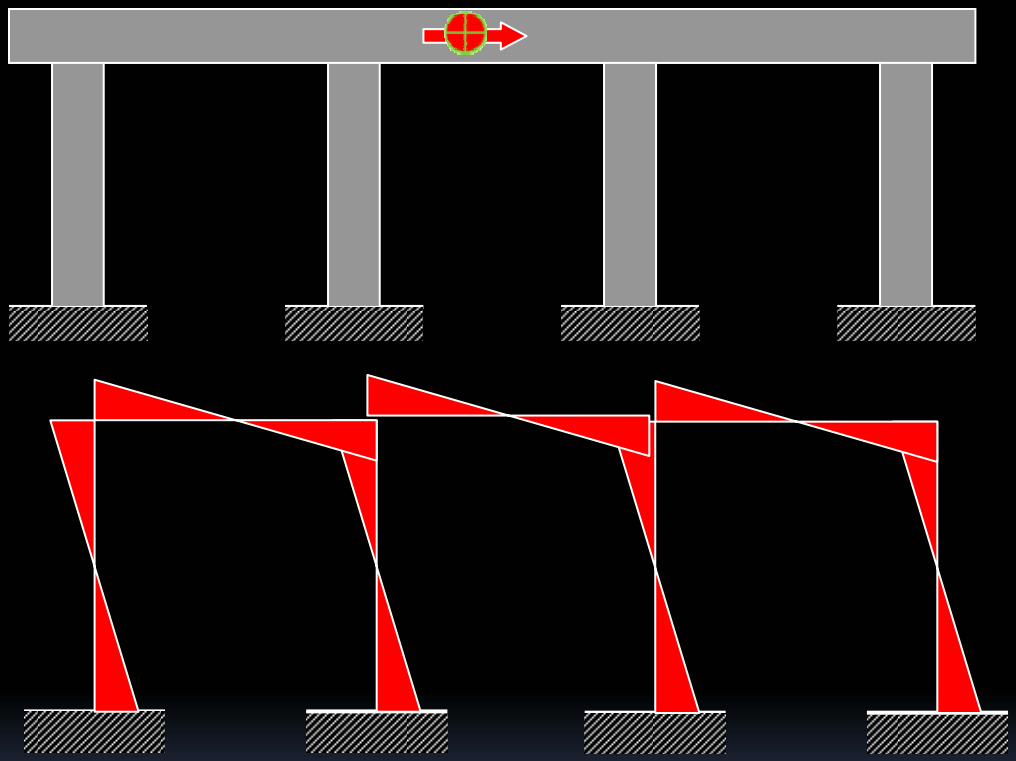


Typical WSDOT Design Strategy:

Type 1: Ductile Substructure with Essentially Elastic Superstructure



Bridge Substructure Seismic Design



Connections need to be:

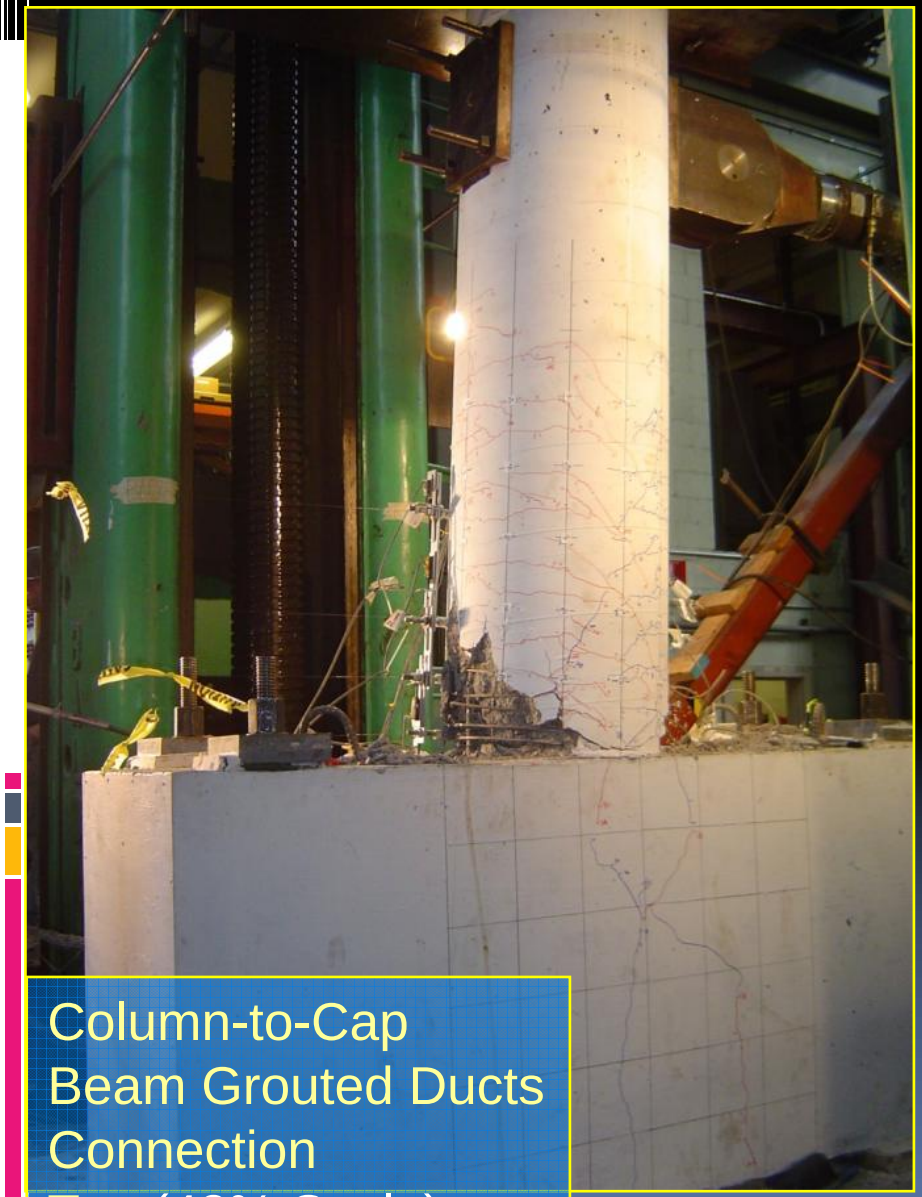
Constructible

Long term Performance and

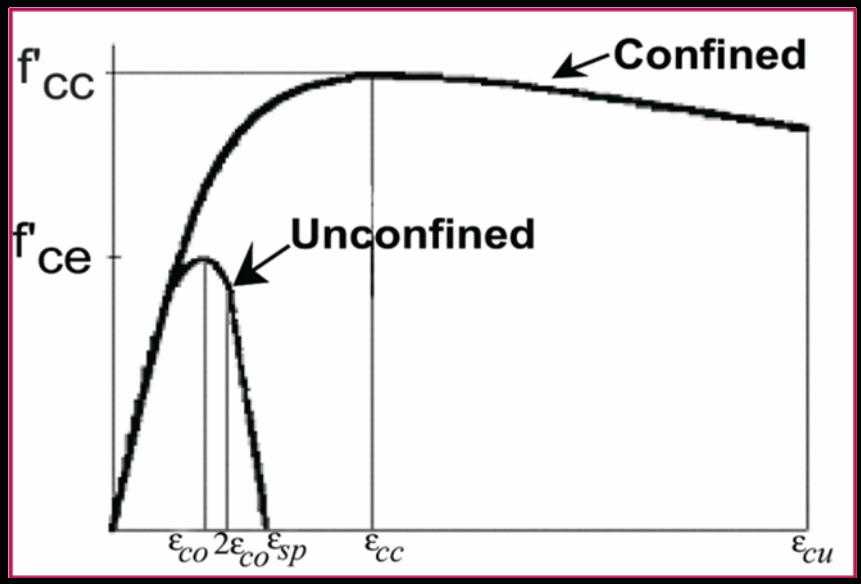
Adequate For Seismic

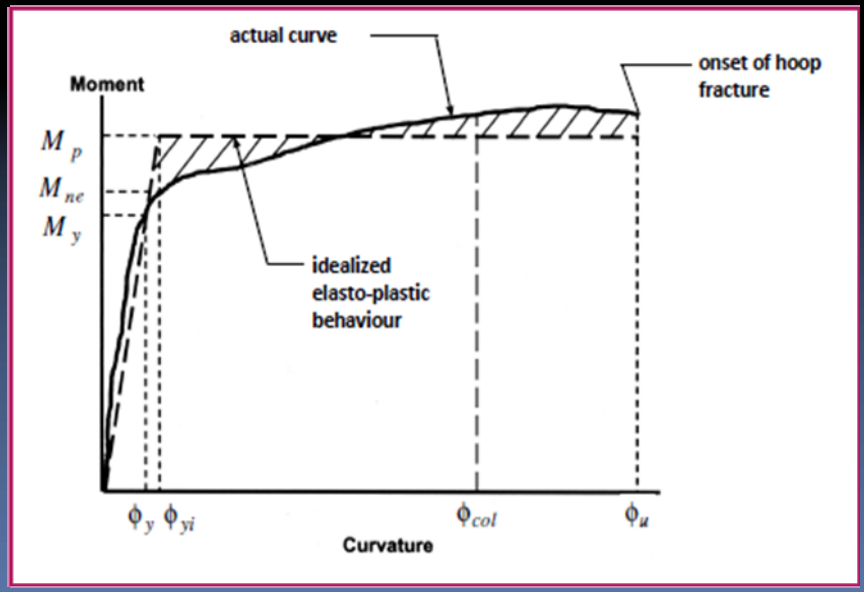
Typical WSDOT Precast prestressed girder bridge with dropped bent cap

Ductility: Confinement and Moment Curvature



Column-to-Cap Beam Grouted Ducts Connection Test(42% Scale)





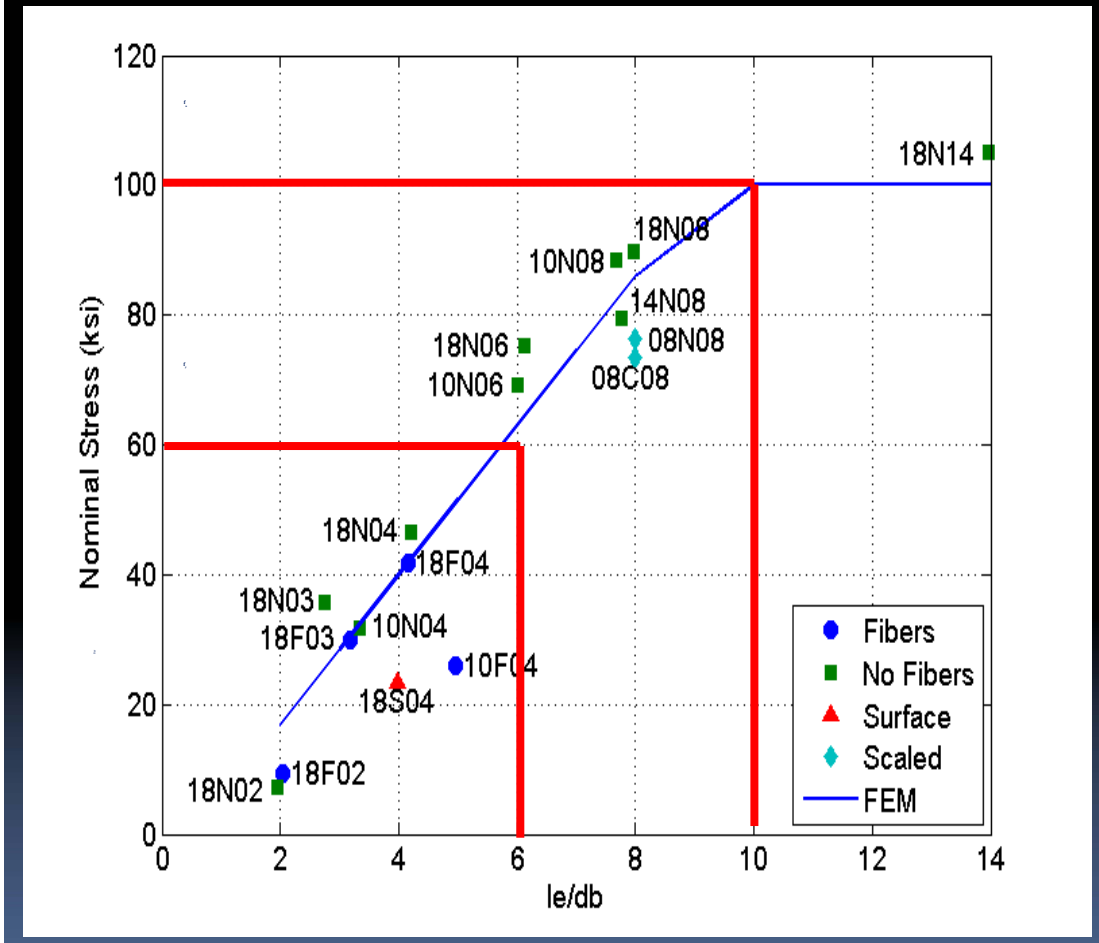
Full-Scale #18 Bar Anchorage Tests

Short l_e: pullout failure

Long l_e: bar fracture

WSDOT Research Project - UW

Bar Size - Duct Size - Embedment Length



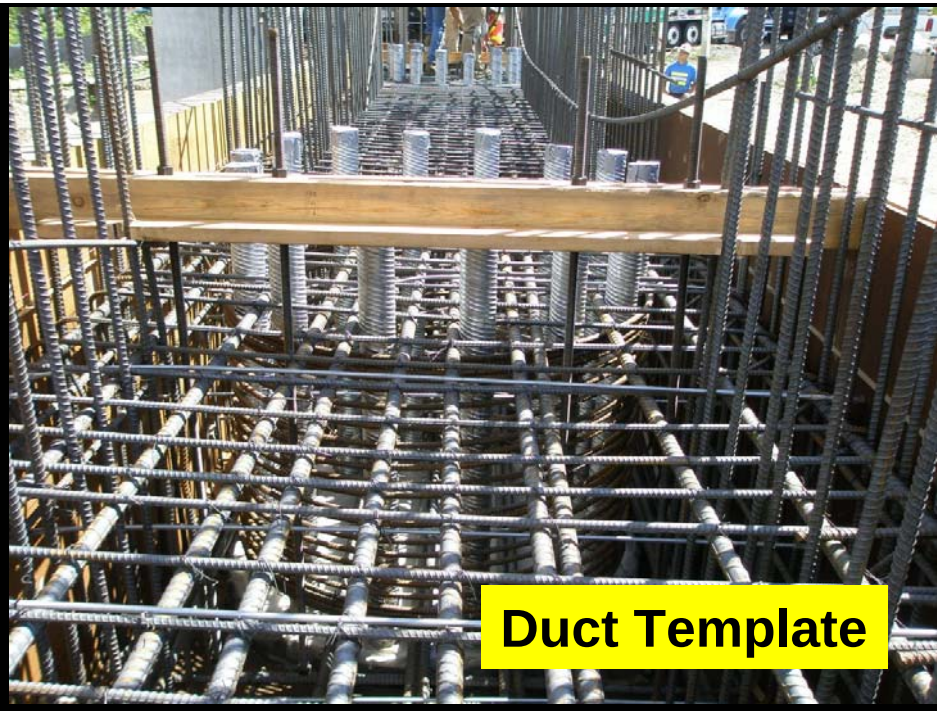
$$L_d = 1.5\left[\frac{f_e}{4\sqrt{f'_g}}d_b + \frac{d_{duct} - d_{bar}}{2}\right]$$

Bar Size	Nominal Duct Size, in.	Embedment Length, in.	Embedment / Bar Diameter
#3	2	12	29
#4	2.5	15	27
#5	3	15	21
#6	3	15	18
#7	3	20	21
#8	3.5	20	18
#9	3.5	20	16
#10	3.5	25	18
#11	4	25	16
#14	4	30	16
#18	4.5	40	16

WSDOT ABC Project: Precast Bent cap

SR 202 / SR 520

Tolerances - Tack Weld



Duct Template

Spirals

WSDOT ABC Project: Precast Bent cap

SR 202 / SR 520

$1^{1/2}$ Hours +/-
Bent Cap Erection

Highways for Life (HFL) Project

- Funded by FHWA's Highways for Life Technology Partnerships Program

Project Team:

- BergerABAM – Lee Marsh (PI)
- University of Washington - John Stanton and Marc Eberhard
- Concrete Technology Corp. – Steve Seguirant
- Washington State DOT - (Bridge-Construction and Regions)

August 18, 2011 Webinar:
http://fhwa.adobeconnect.com/n134083201108/

WSDOT Research Project:
FHWA – HFL (ABAM –UW-WSDOT)
Fully Precast Bridge in Seismic Regions

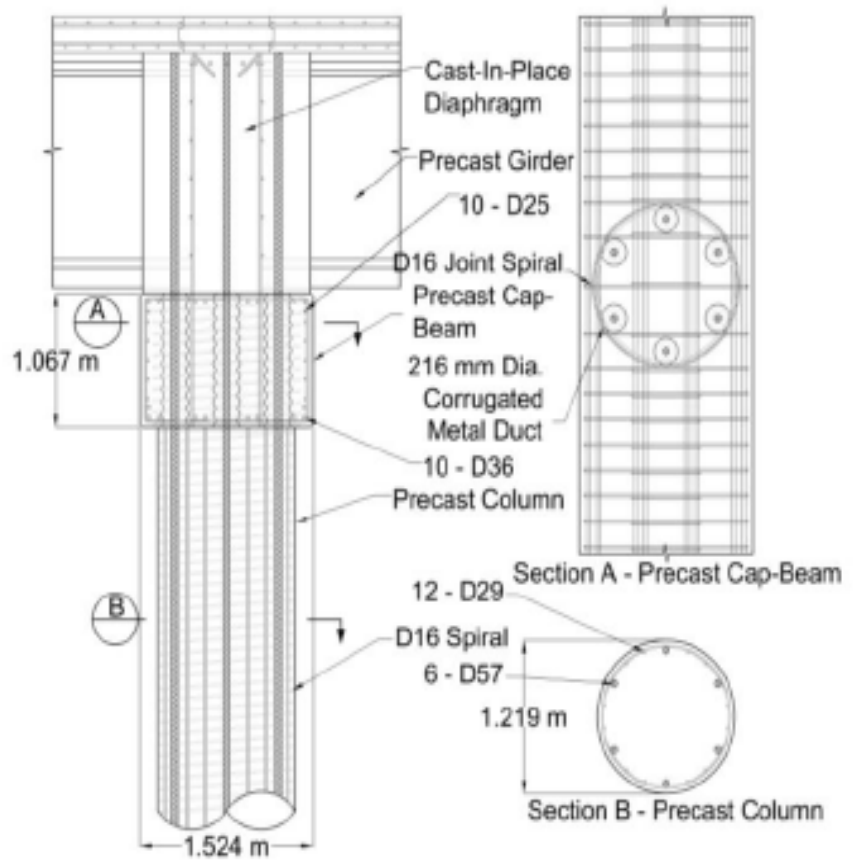


Figure 1. Typical Implementation of Product Concept

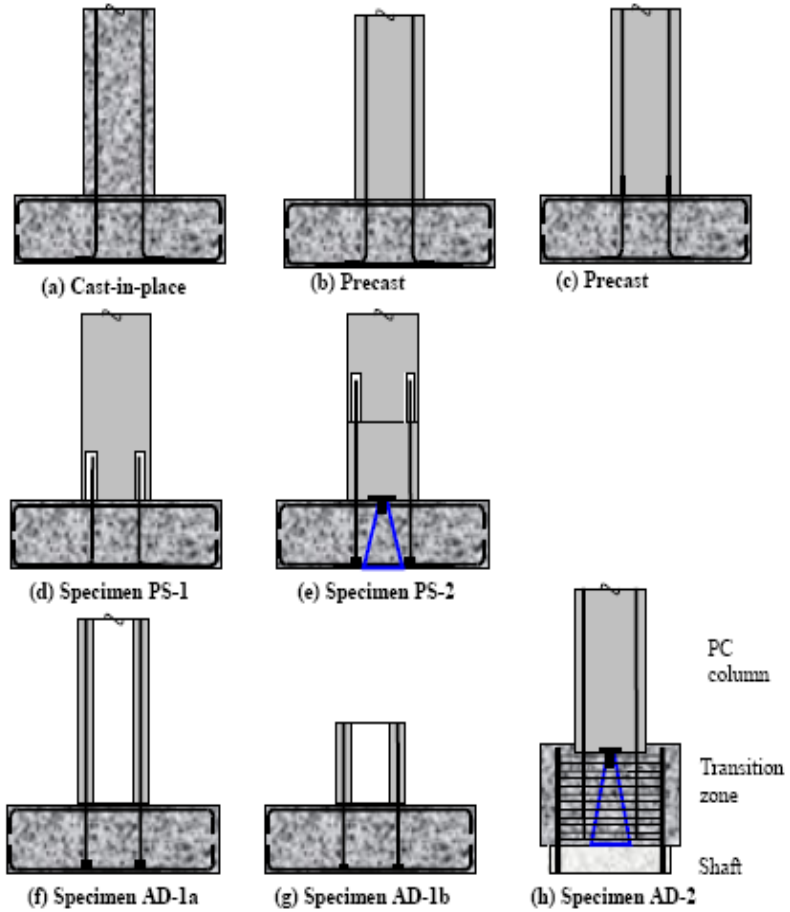


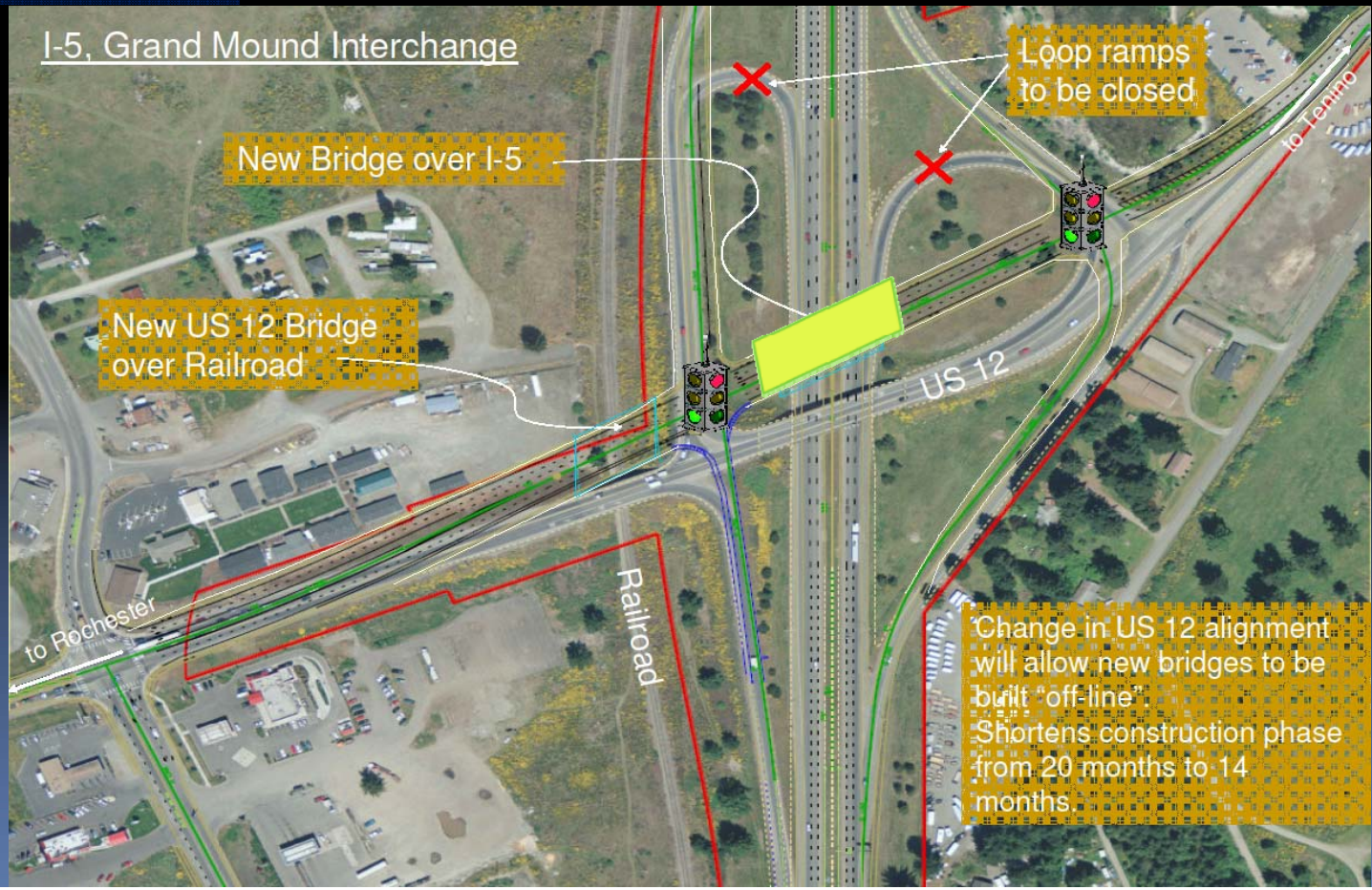
Figure 3. Test Specimens

WSDOT HFL Project:

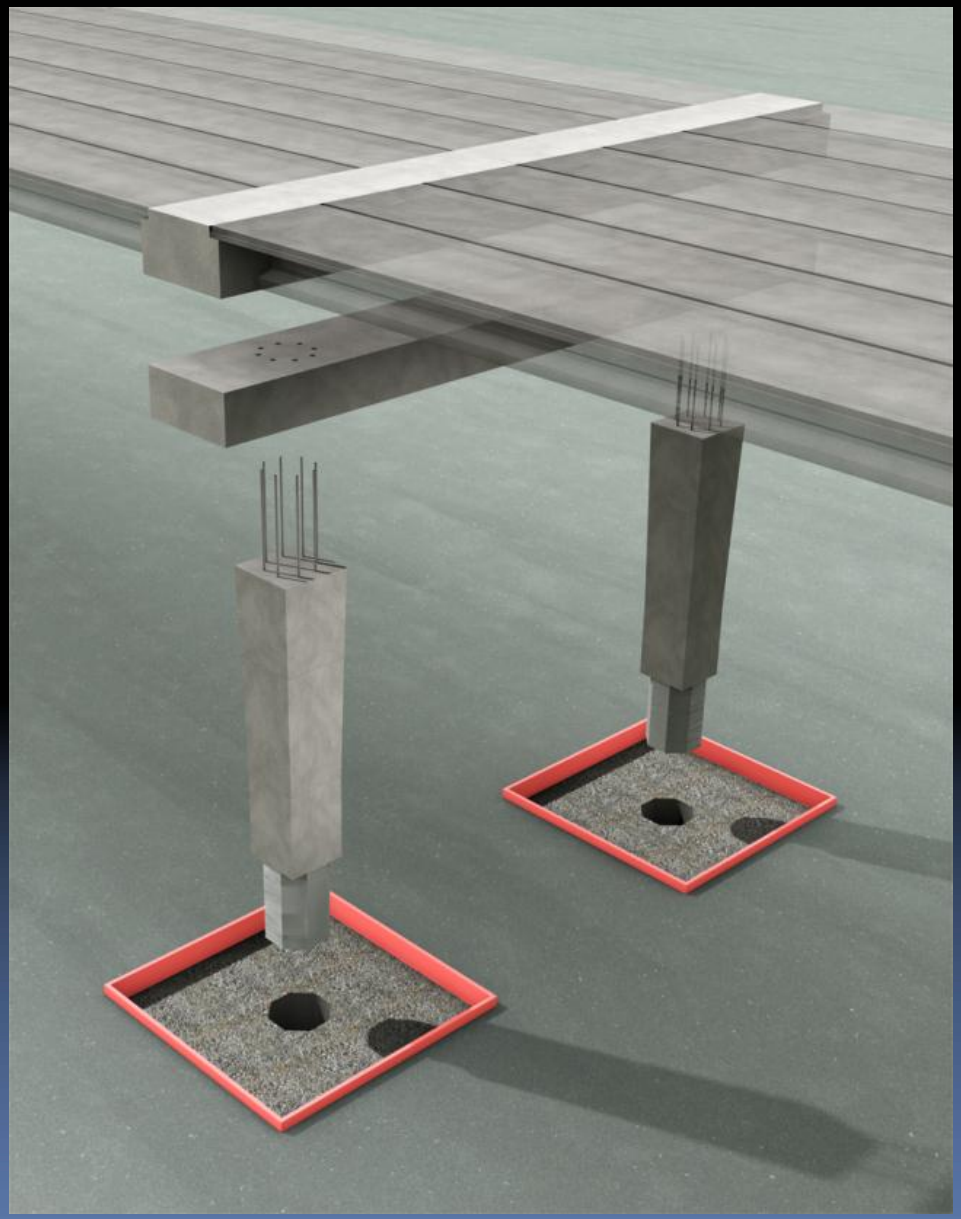
I-5 Grand Mount to Maytown I/

2-span Precast Girder Bridge

Span Length: 88 ft
Bridge Width: 71 ft
Skew:29.3 degrees



Precast Bent System for High Seismic Region

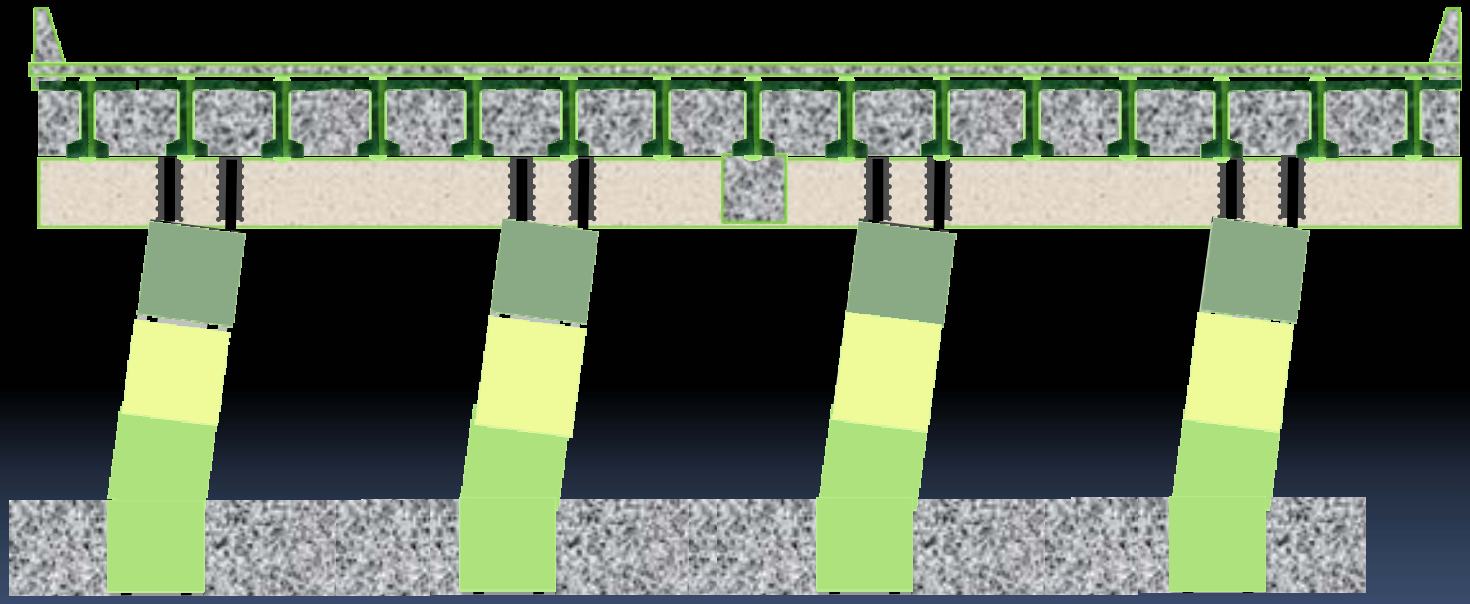


- Two-stage cap
- Precast Lower and CIP Upper
- Girders integral with combined lower Cap and upper Diaph
- Column Grouted Duct Connection
- Large bars at precast cap connection
- Socket connection at Footing

Fully Precast Bent with Dropped Bent Cap

- Superstructure – Precast Girder And Diaphragms
- Substructure – Precast Columns And Bent Cap

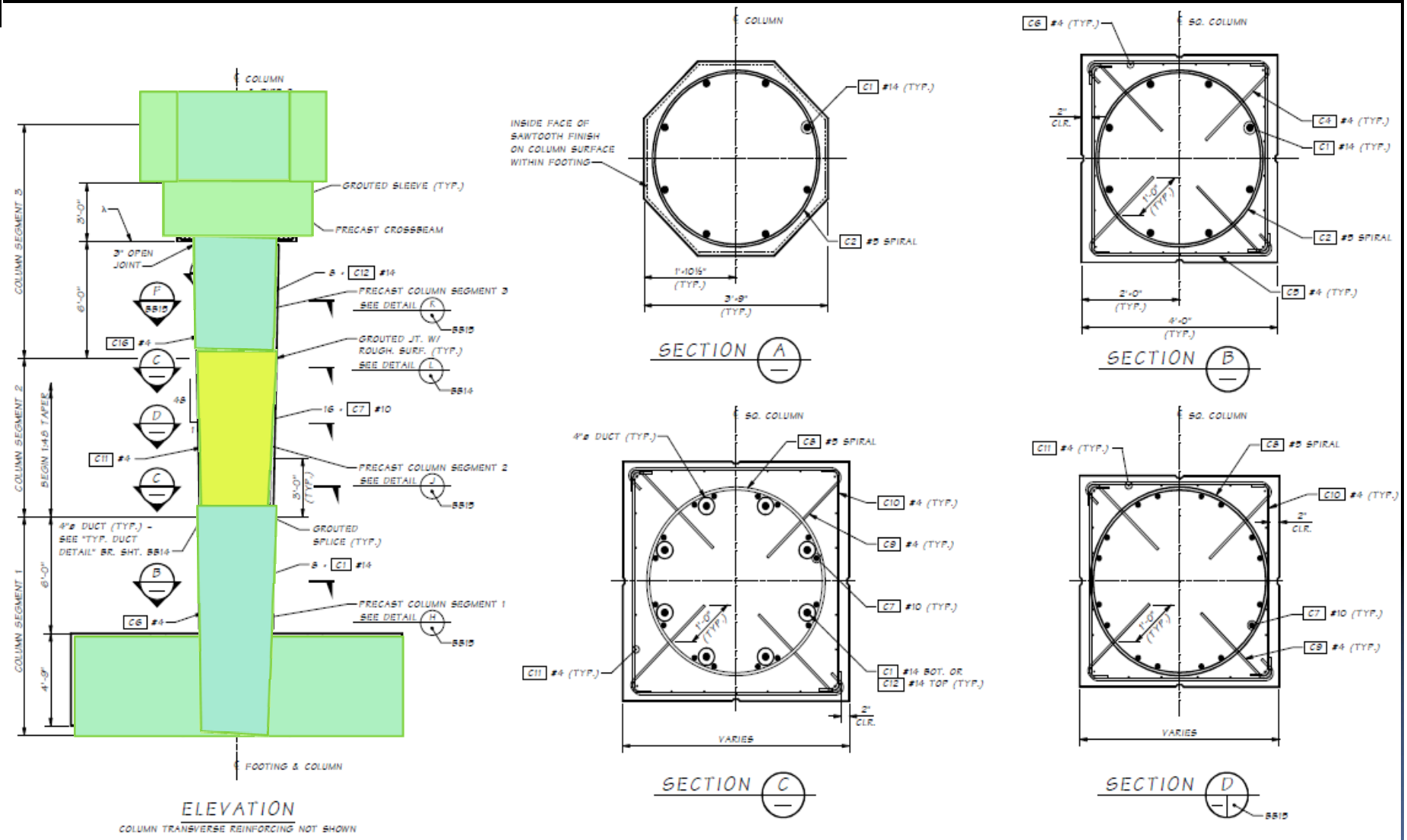
Objective: CIP Emulative Behavior



HFL Bridge Feature:

- 12 Precast Column Segments
- 2 Precast Pretensioned Bent Cap Segments
- 30 Precast Pretensioned Deck Bulb Tee Girders
- 96 Grouted Duct Connections

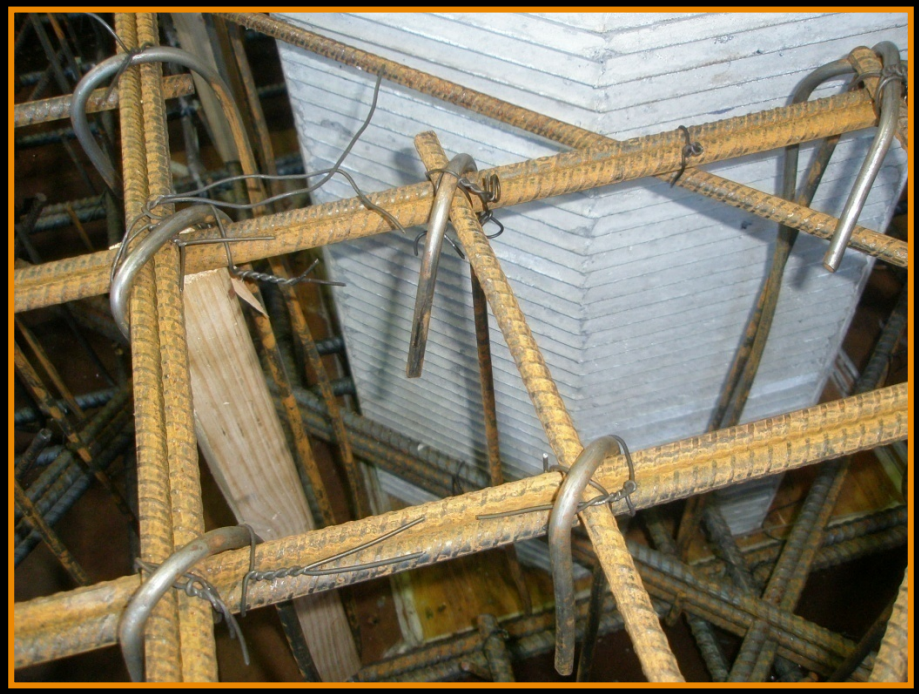
Fully Precast Bridge For Seismic Regions



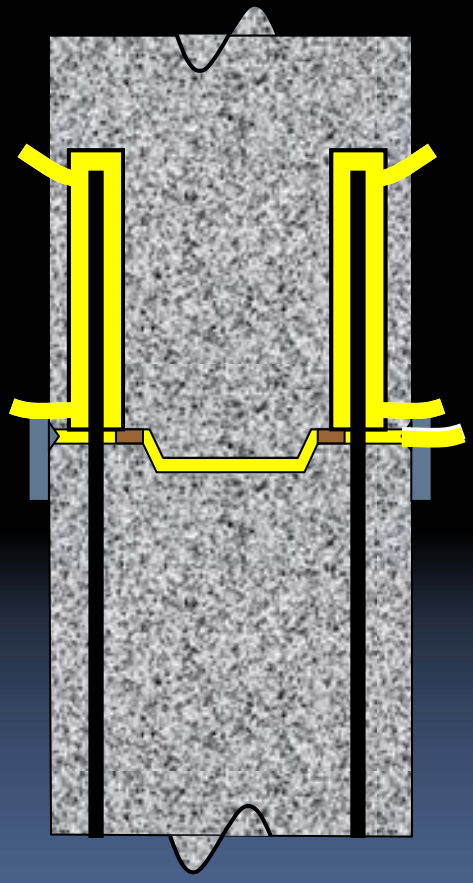
Pier Elevation - Segmental Columns and Precast Bent Cap

WSDOT - FHWA - Highways for LIFE UW Test

TEST SPECIMEN



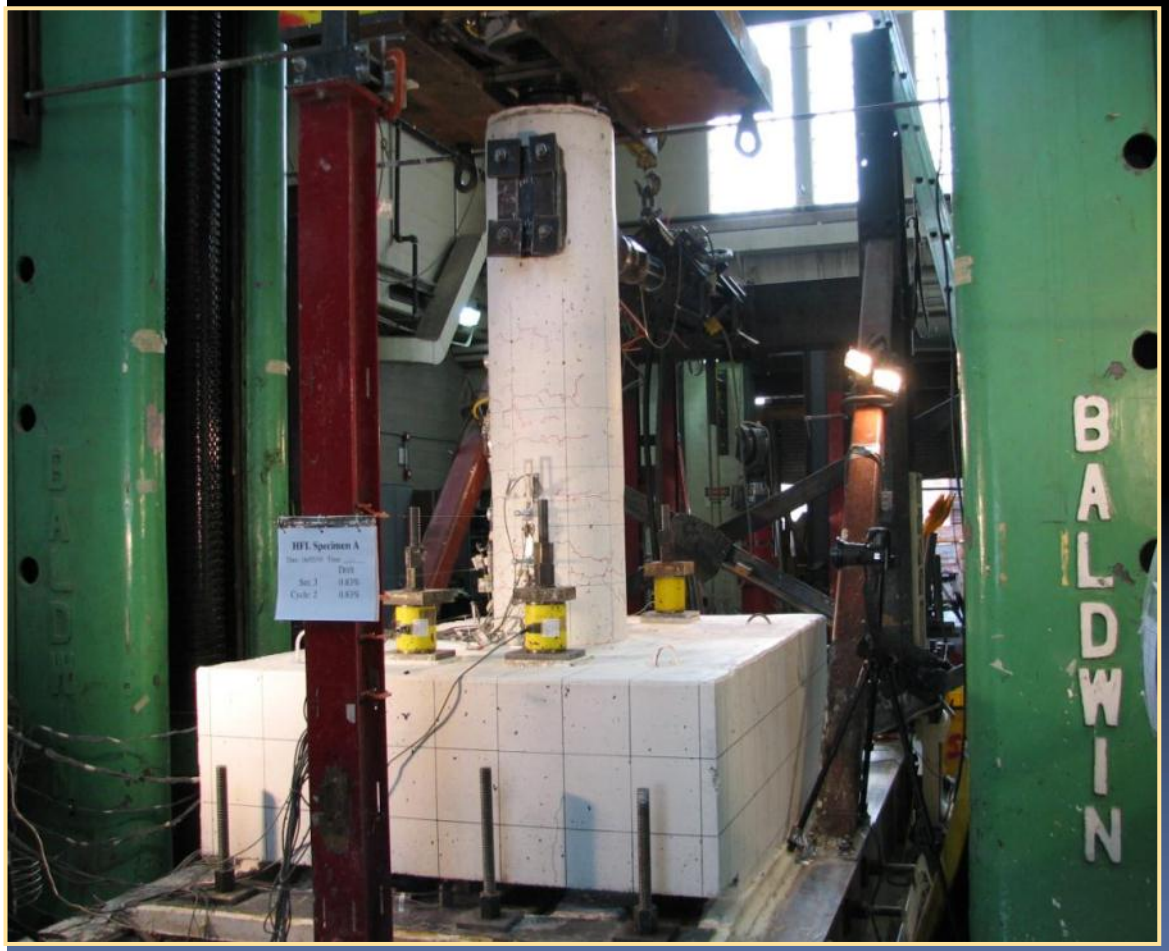
WSDOT - FHWA - Highways for LIFE (HFL)
UW Test

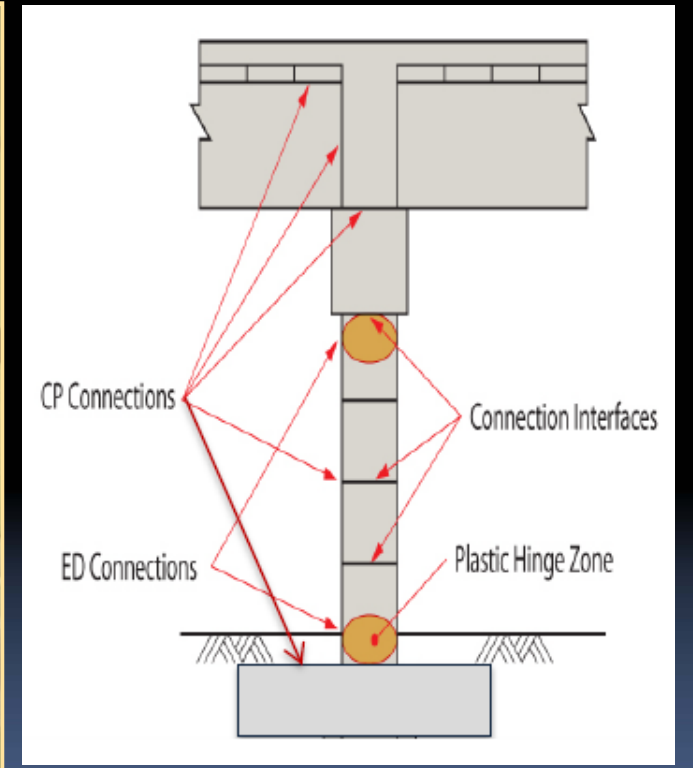


Grouting the interface. (Silica fume grout. 12,500 psi.)

WSDOT Highways For Life Project

UW Test: Precast Segmental Column Embedded in CIP Concrete Footing





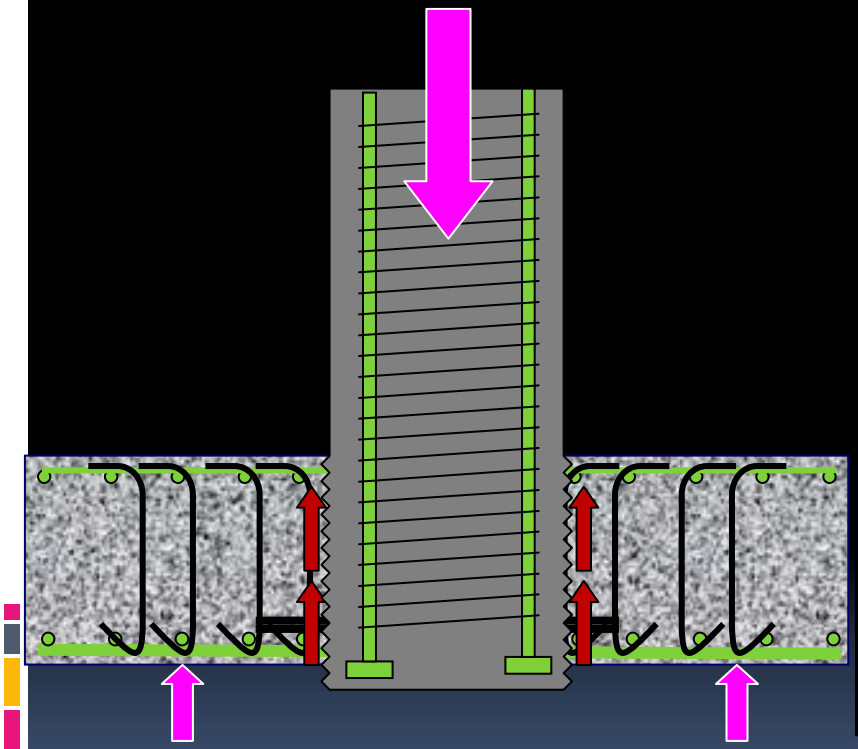
CP – Capacity Protected
ED – Energy Dissipating

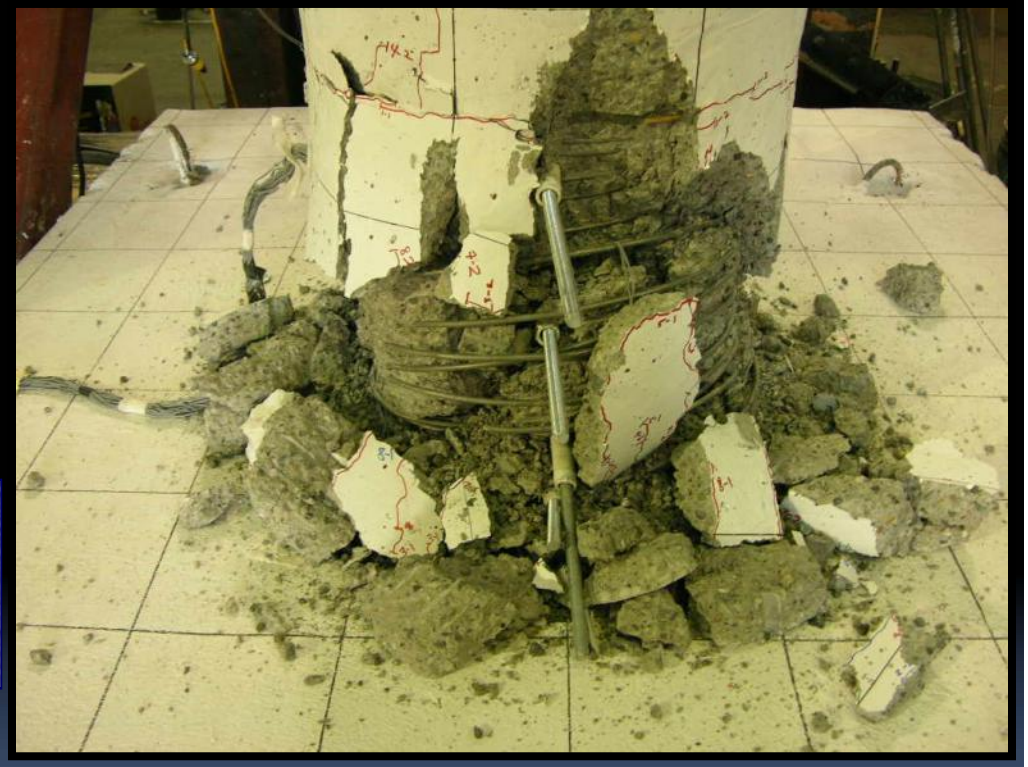
Specimen SF-2 after Lateral Load Test

Footing undamaged

Spread Footing Connection

Gravity Load Test





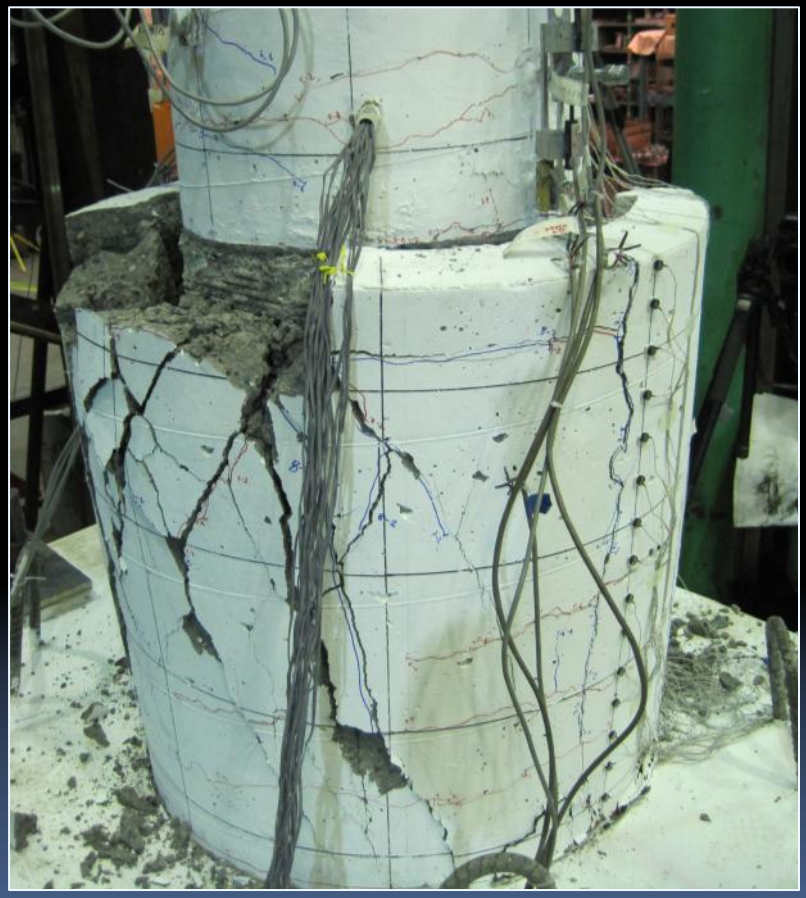
Column crushed at: 3.5 * (1.25DL + 1.75LL)

No damage to footing.

No sign of punching failure

UW Drilled Shaft Tests

DS-1



DS-2

Precast Column Erection: Bridge Project in WA

HFL Precast Column Concept For City of Redmond 36th Street Bridge Project

Footing: Excavation, Shoring and Reinforcement

Work Zone: 44’-0”
CIP Footing: 18’ x 18’ x 4’

Leveling Pad and Shims for Column Erection

Precast Column Segments

Column Dimensions	4’ x 4’ with circular core reinf.
Segment length	7’-10”, 10’-0”, 4’-10”
Segment weight	25 kips max
Reinforcement	8 #14 at ducts, (1% Ag)
Reinforcement At Splice	8 #14 at ducts and 16 #10 on either side of duct
Transverse Reinforcement	# 5 spirals at 4”
Duct Dimension	4” diameter galvanized metal
Bar-Duct Splice - Column	3’-0” (2’-6” required, 3’ used for splice)
Duct Splice - Bent Cap	3’-0” (2’-6” required, 3’ used for depth)
Concrete Strength	4.0 ksi
Ducts	Semi-rigid, corrugated, galvanized - 31-gauge

Precast Column 1st Segment Placement

- Shipment of Column Segments To the Jobsite
- Steel Frame Template for Column Erection

Footing and Precast Column Placement

- Square-to-Octagonal Transition
- Top Layer Reinforcement
- Isolation Gap at Column Base

Precast Column Segments Erection

- Roughened Concrete Surface at Joints
- Color Coded Shims for Column Segment Erection
- 1” Gap for Grouting
- Grout Vents Vertically Aligned

Precast Column Placement

- Completion of Segmental Column
- Erection Braces are Removed
- All Columns to be Erected Prior to Bent Cap Erection

Precast Pretensioned Bent Cap

Fabricated In 2 Segments for Ease of Shipping and Handling
Assembled at the Jobsite with Cast-in-place Concrete Closure

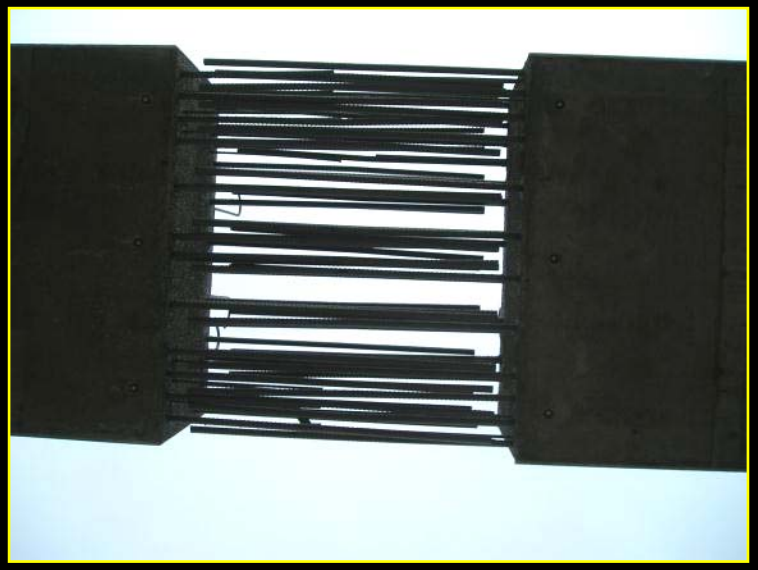
Crossbeam Length	96’-0”
Crossbeam Dimensions	3’-0” x 6’-6”
Segment Lengths	53’ and 37’-6”
CIP Closure Dimension	5’-6” x 3’-0”
Segment Weight	165 kips, 120 kips
Concrete Strength	4.0 ksi
Reinforcing Steel	32 #11
Prestressing Strands	36 – 0.6” dia. Low Relax
CIP Closure Strength	4.0 ksi

Precast Bent Cap Placement

Two Erection Cranes
Segment Weight :(120 &165 kips)
16 Duct Connection per Segment
CIP Closure

Precast Bent Cap - Closure

- Precast Bent Cap Erection
- Bar And Strand Clearance
- Cast Concrete Closures



Column and Bent Cap Joint Grouting

- Install Grout Forms and Seal
- Pump Grout
- Close Grout Tubes

Grout strength, ksi : 2.5(1d), 4.0 (3d), 5.0(7d), 6.0(28d)

Grouting the Joints

- Inspect Grout in Joint and Grout Tubes
- Patch Back Grout Tubes
- Investigate Unfilled Grout Tubes
- Repair Unfilled Grout Tubes

Superstructure Precast DBT Girders

Girder Type	W35DG DBT - 5” CIP Slab
Precast Girder Length	84’-3”
Girder Weight	80 Kips – Including Precast Diaphragms
Concrete Strengths: Transfer Final CIP Slab	 7.9 Ksi 8.9 Ksi 4.0 Ksi – Class 4000P
Prestressing Strands	20–0.6” Dia. Straight 11–0.6: Dia. Harped
Girders Connection	Welded Ties at 5’-0”
End Supports	Integral & Elastomeric Pad

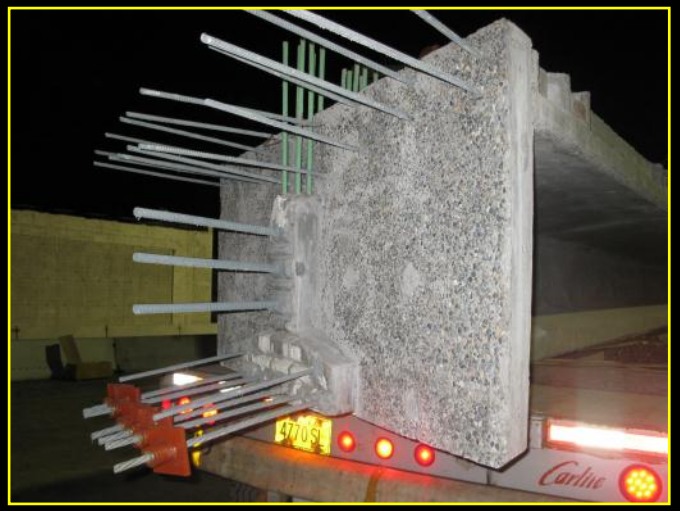
Precast Girder Erection

Girder Total Weight Including Diaphragms: 80 Kips

Single Crane for Girder Erection

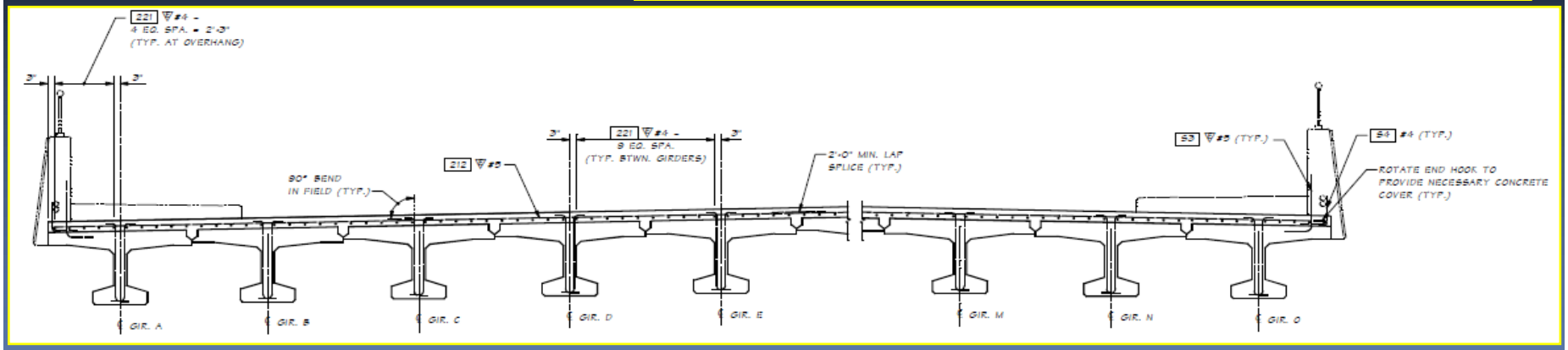
Superstructure Girder Erection

- Completion of Precast Girder Erection
- Precast girders Included End and Intermediate Diaphragms



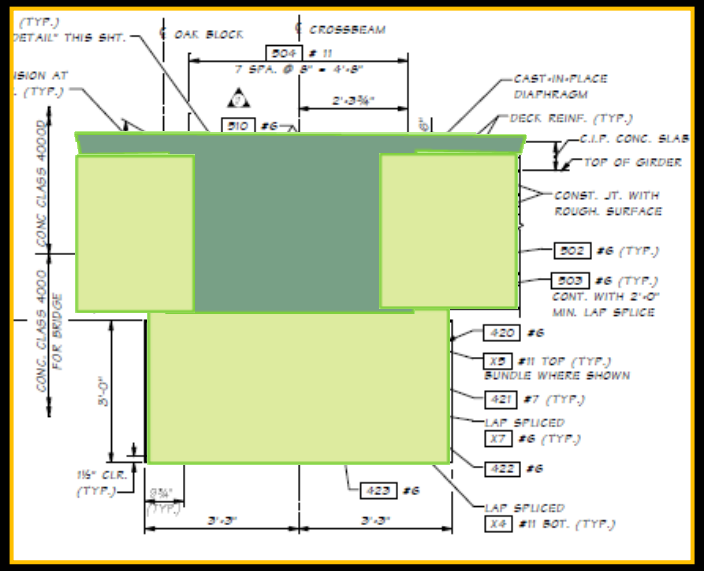
Precast Girder Connections

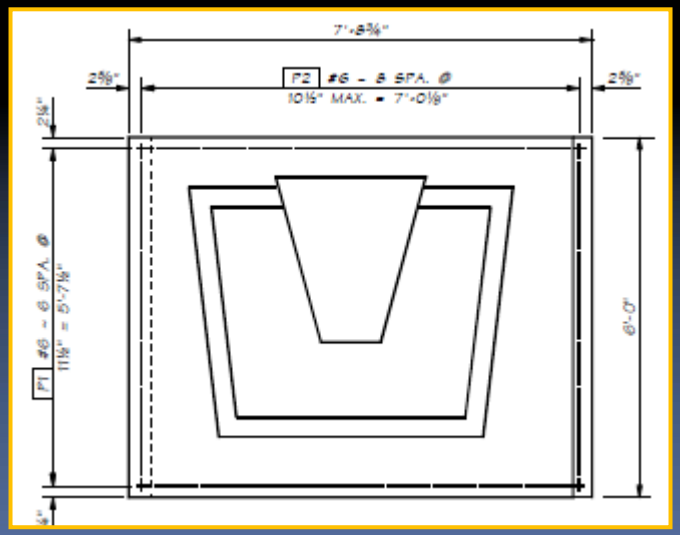
Typical Section
Welded Tie Connections
CIP Concrete Slab



CIP Pier Diaphragm

- Integral Joint
- CIP Concrete Diaphragms
- Extended Strands and Stirrups





Precast End Panel

Precast Intermediate Diaphragms

- Precast Intermediate Diaphragms
- Headed Bars and Anchor Assembly
- Precast End Diaphragms

Tolerances – Precast Bent System

WSDOT STD Specifications
- Fabrication Tolerances
- Construction Tolerances

Lessons Learned
Precast Bent System

- Tolerance of Precast Pieces Not Consistent With Survey Tolerances
- The Contractor Would Have Preferred The Columns to be Cast in One Segment Instead Of Three
- Transverse Bars in the Closure Should Be Made From Single-Bend Bars Instead of “U” Shaped Stirrups
- Use CIP instead of Precast End Diaphragms

Lessons Learned Related to Precast Segmental Columns

- The Contractor Preferred Ducts in the Lower Section
- Erection Plans to Include Shim Locations and Grout Lifting Pressures
- Pressure From Grouting May Lift Segments
- Grout Form Quality and Sealing is Key to Successful Grouting
- Would Be Helpful if Grout Tubes Were Mapped As Part of the Precast Operation

HFL Completion Schedule

- Laboratory Work Completed Spring 2011
- Bridge Project Complete Summer 2011

Hfl Project Deliverable:

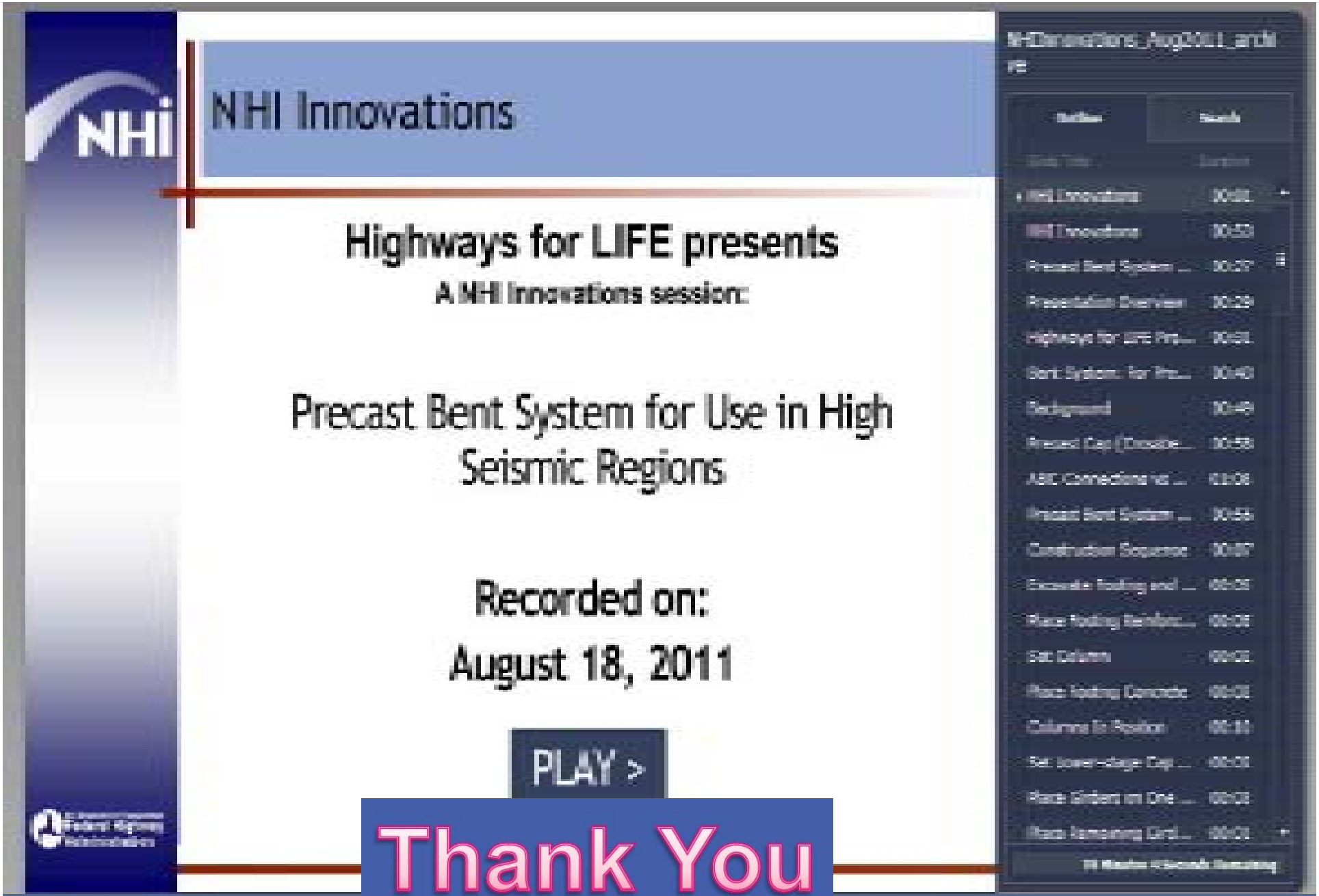
Final Reports Fall 2011 Including:

- Design Specifications Formatted In SGS
- Construction Specifications - Tolerances
- Materials Specifications
- Design Examples And Aids

WSDOT Highways For Life Project:

Fully Precast Bridge Bents for Use in Seismic Regions

Last stages of Bridge Construction, Sept 2011


NHI Innovations
Highways for LIFE presents
A NHI Innovations session:
Precast Bent System for Use in High Seismic Regions
Recorded on:
August 18, 2011
PLAY >
Thank You
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