Precast Bent System for Use in High Seismic Regions

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Presentation Overview

- Introduction and Concept
- Connection Validation Testing
  - Column-to-Cap Beam
  - Column-to-Spread Footing
  - Column-to-Drilled Shaft
- Demonstration Project
  - Design, Construction and Lessons Learned
- Deployment Aids

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Highways for LIFE Project

- Funded by FHWA's Highways for LIFE Technology Partnerships Program
- Project Team:
  - BergerABAM – Grant Awardee
  - University of Washington
  - Washington State Department of Transportation
  - Concrete Technology Corporation
  - TriState Construction
- More Information @ www.fhwa.dot.gov/hfl

Bent System: For Prestressed Girder Bridges Integral at Piers In Higher Seismic Regions

Example Bents Used with Prestressed Concrete Girders

Background

- Need to Accelerate On-Site Bridge Construction
- Use Precast Concrete Components
  - Precast Superstructures Used Routinely
  - Precast Pier System Is Goal
- Connections are Critical
- Must Be:
  - Constructible
  - Seismically Resistant

Precast Bent System for High Seismic Regions

- Two-stage cap
- Upper stage CIP
- Girders integral with combined lower and upper stages of cap
- Few, but large bars at precast cap connection
- Member socket connection at base

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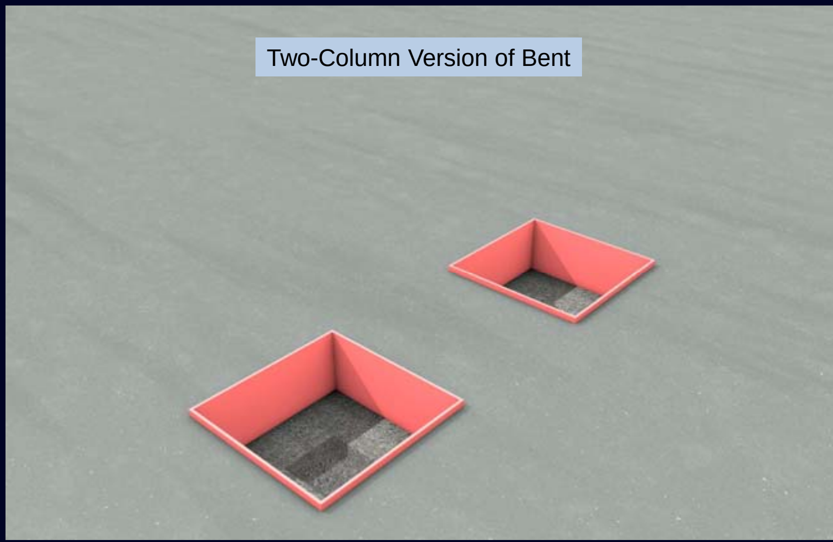
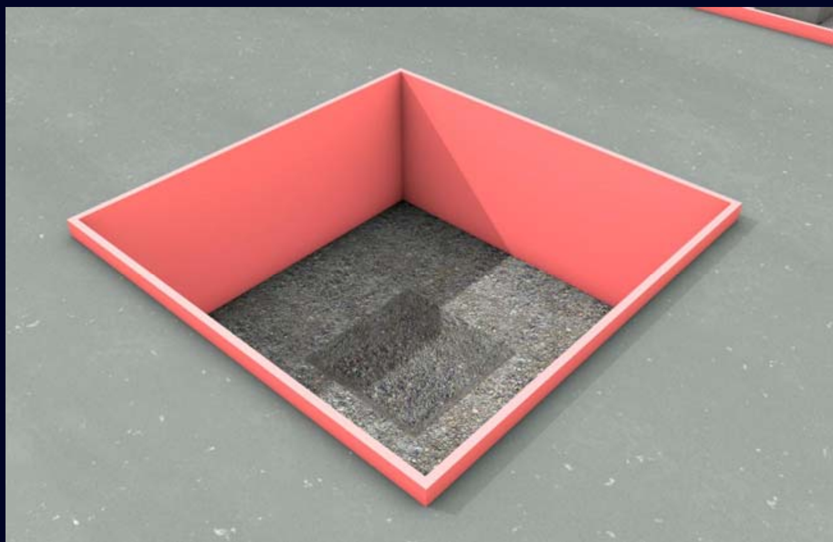
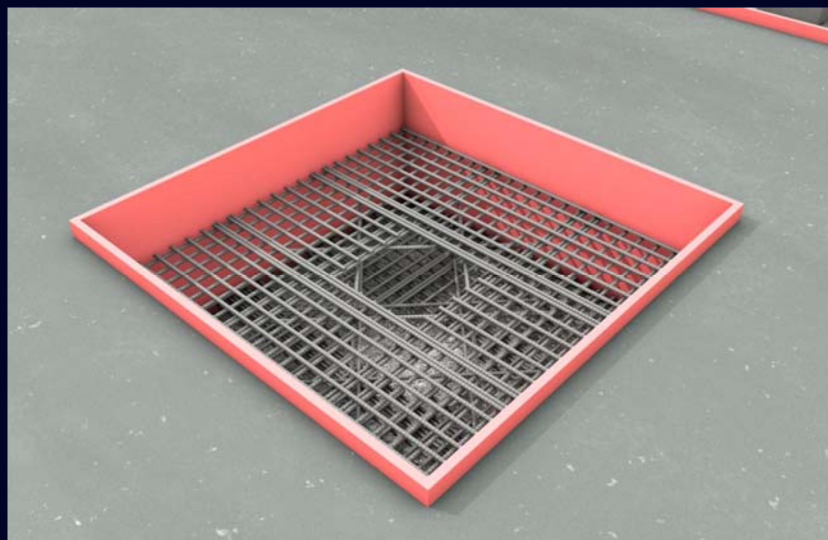
Construction Sequence



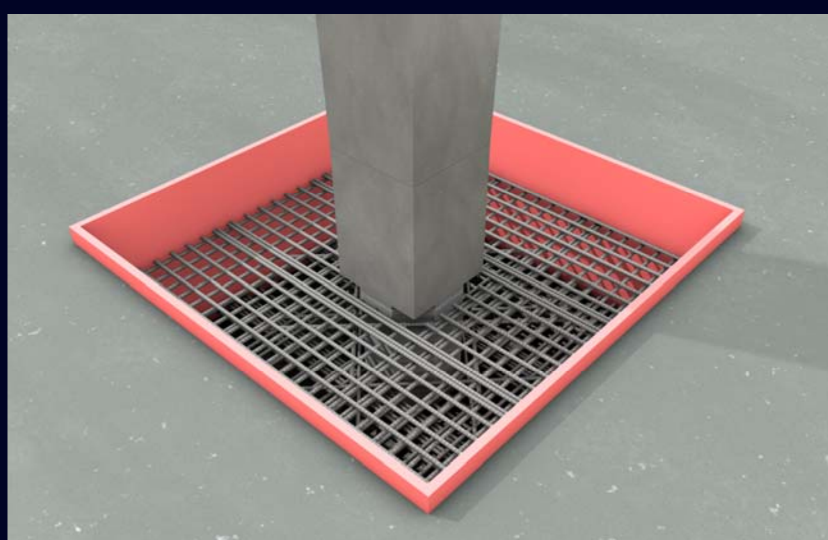
Excavate Footing and Erect Formwork



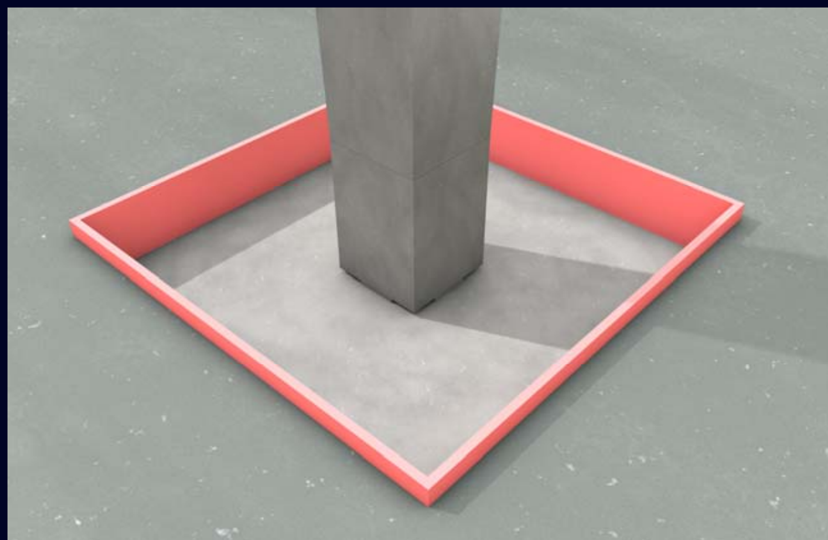
Place Footing Reinforcement



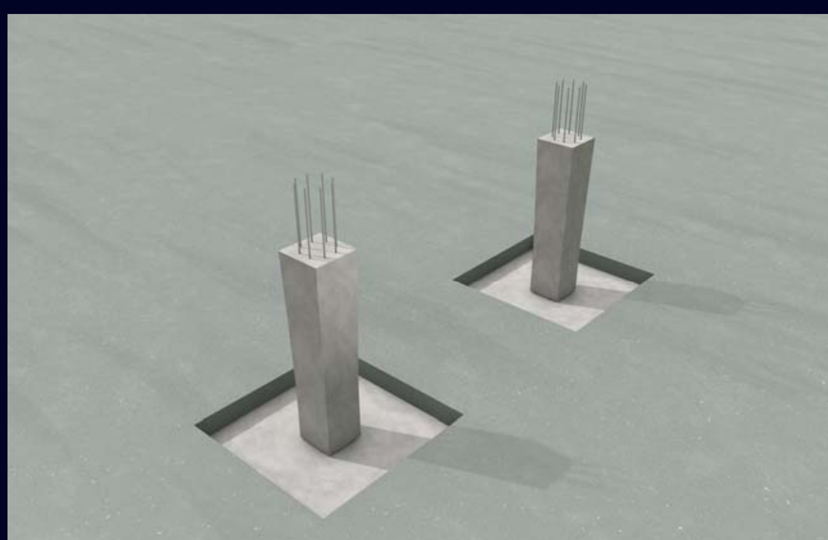
Set Column



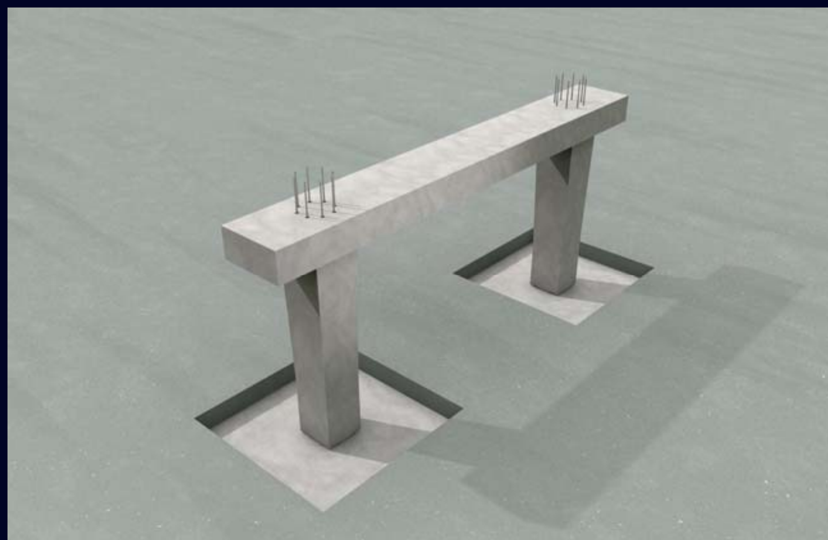
Place Footing Concrete



Columns In Position

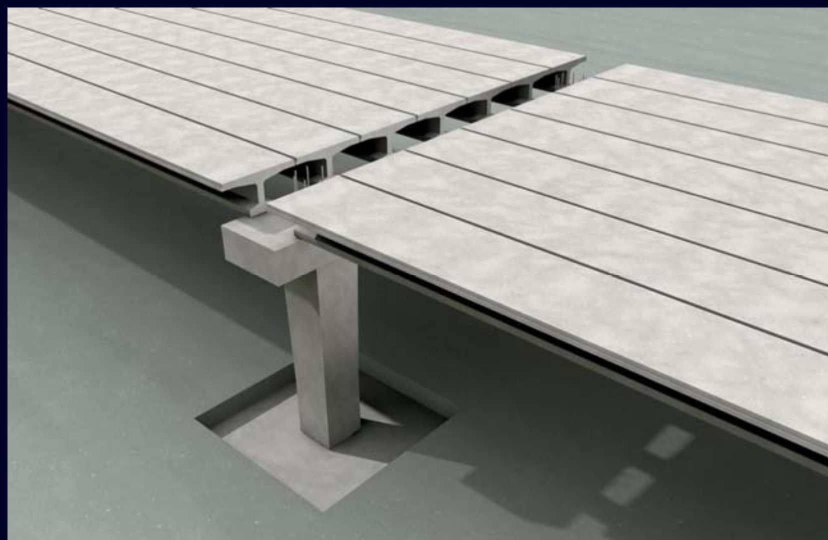


Set Lower-stage Cap Beam



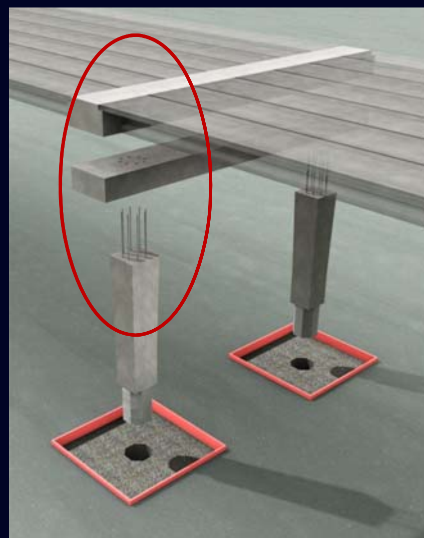
Place Girders on One Side

Place Remaining Girders

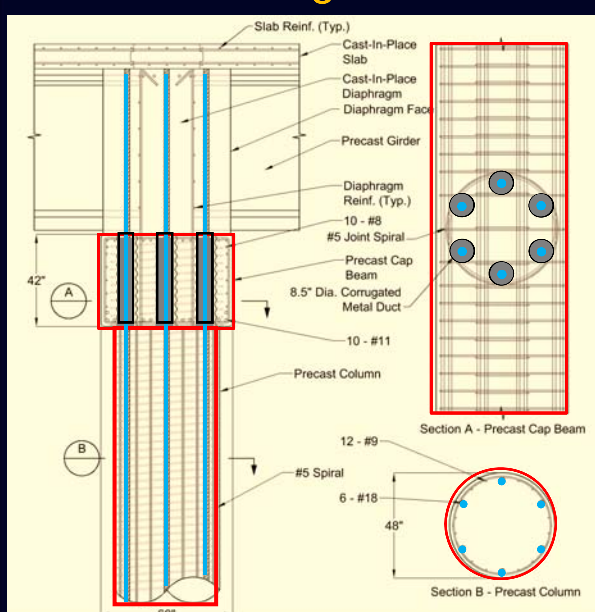


Place Upper-Stage Cap Beam Concrete

Column-to-Cap Connection



Large-Bar Connection



- 4ft Diameter Column
- 5ft x 3.5ft Cap Beam
- 6 # 18 rebar
- 8.5" Corrugated Metal Ducts
- High Strength Grout

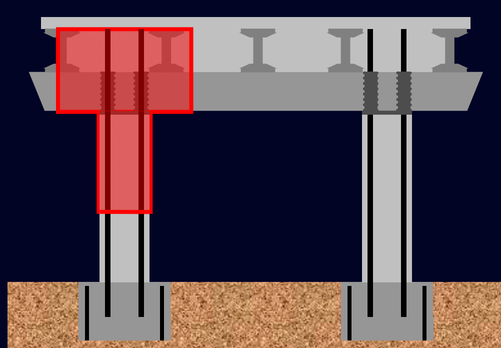
Anchorage of large bars?

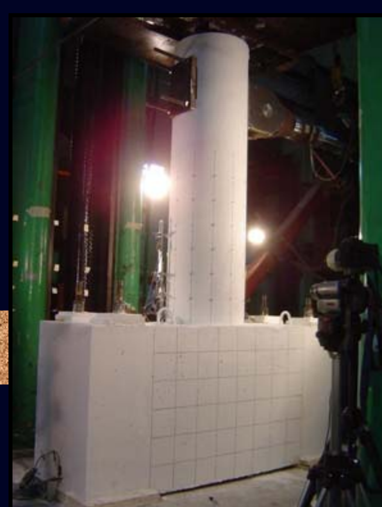
Full-Scale #18 (57mm) Bar Anchorage Tests

Short l_e: pullout failure

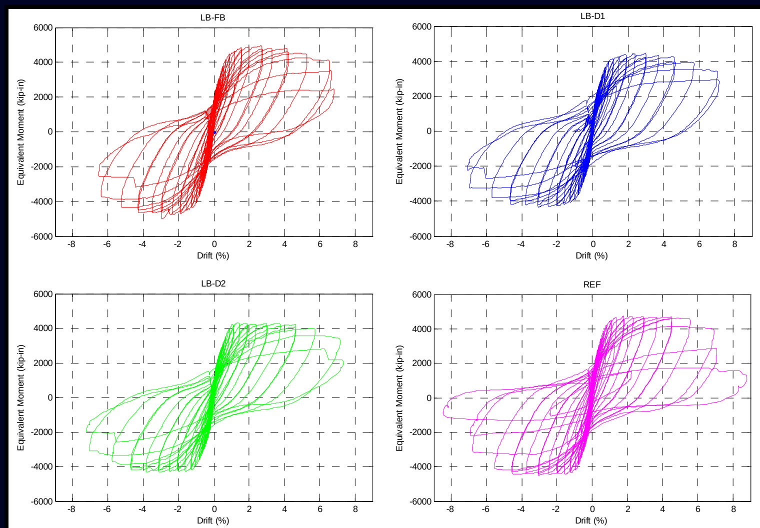
Long l_e: bar fracture, embedment of 16 d_b

Connection Tests (42% Scale)





Moment vs. Drift

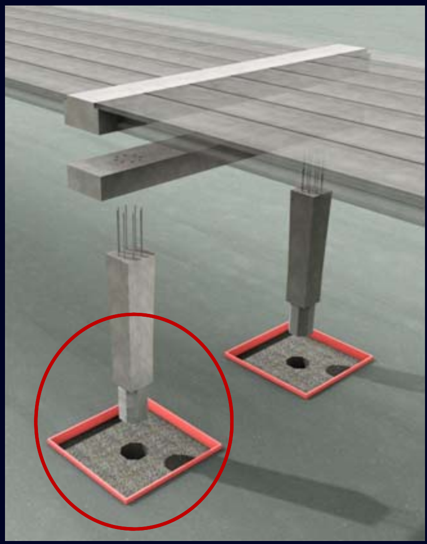


Same response for precast and CIP

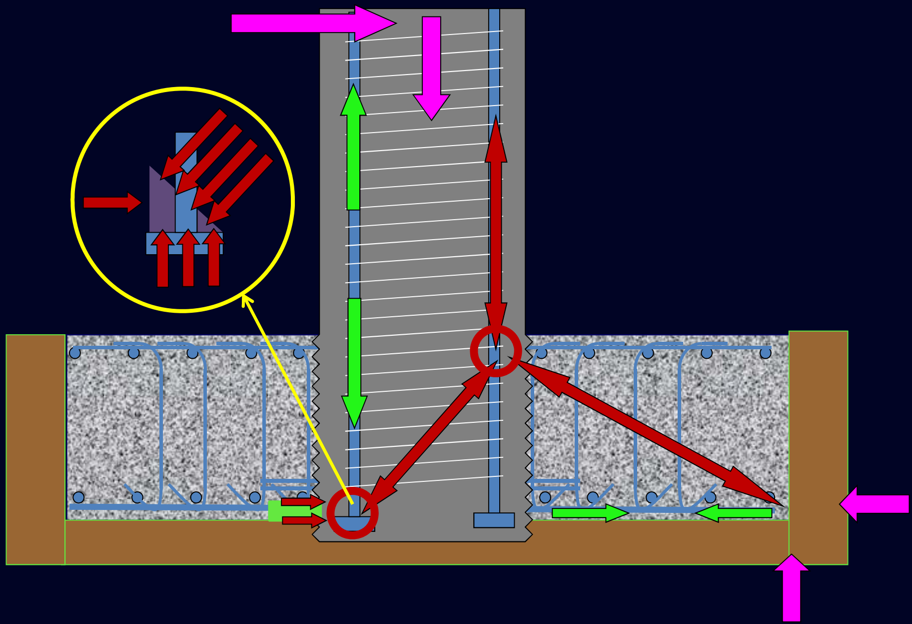
Large Bar Connection - Conclusions

- PC cap beam saves significant time on site.
- Generous tolerances make erection easy.
- Large bars can easily be developed.
- Seismic performance like cast-in-place.

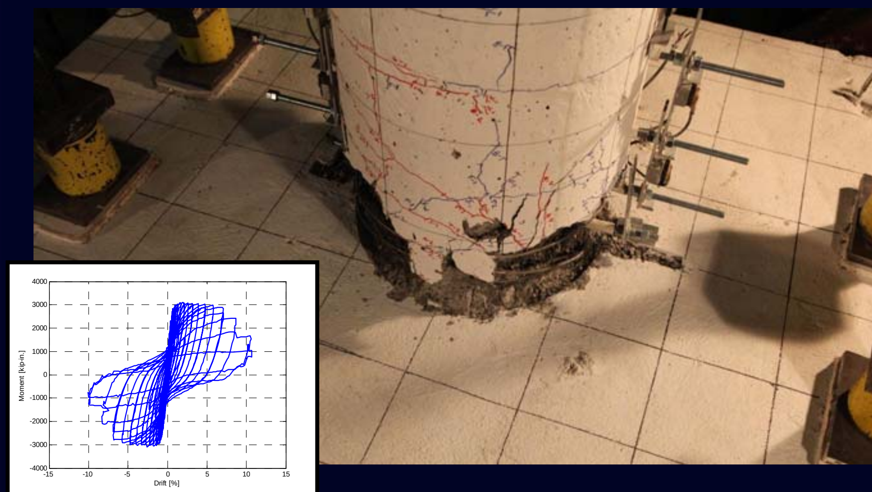
Column-to-Spread Footing Connection



Socket Connection – Internal Forces



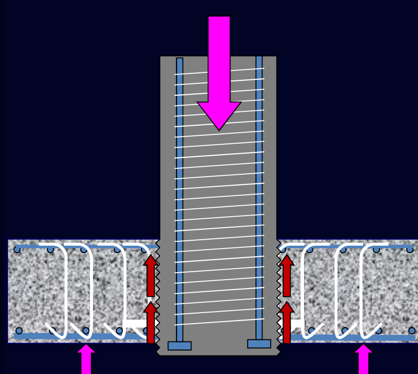
Specimen SF-2 after Lateral Load Test



Footing undamaged

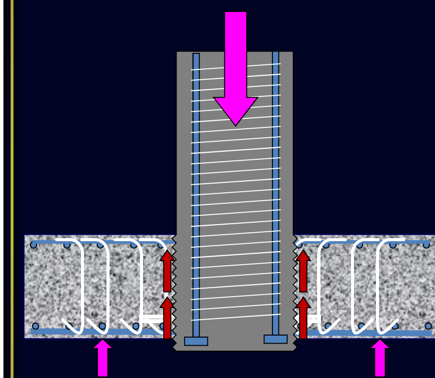
Spread Footing Connection

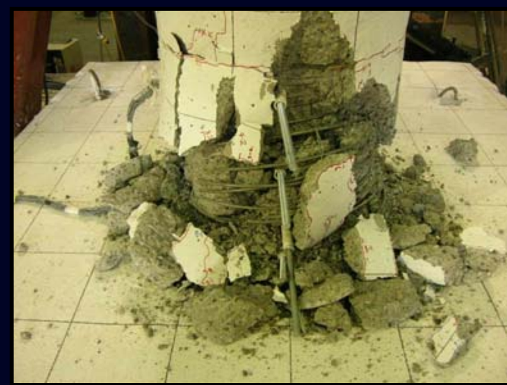
Gravity Load Test



Spread Footing Connection

Gravity Load Test





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

No damage to footing.

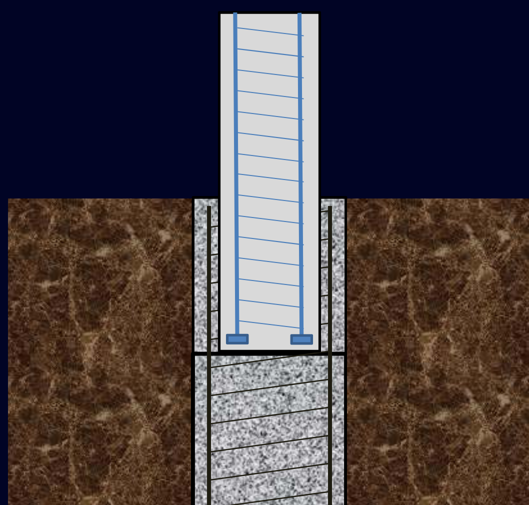
No sign of punching failure

Spread Footing - Conclusions

- Easy to build
- Vertical strength easily sufficient
- For h_f / D_{col} = 1.1, seismic performance like CIP (failure in column)
- Superior force flow in connection

Column-to-Drilled Shaft Connection

Drilled-Shaft Connection Concept

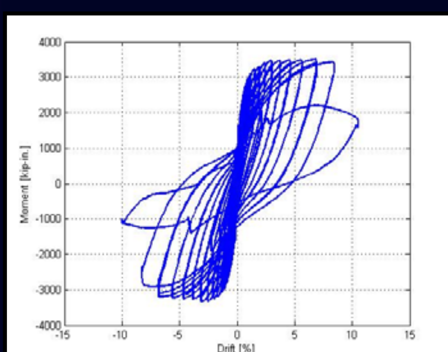


Drilled-Shaft Connection

Test specimen fabrication

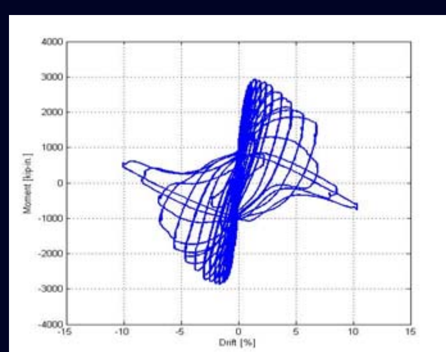
DS-1

• 100% transverse reinforcement in transition region

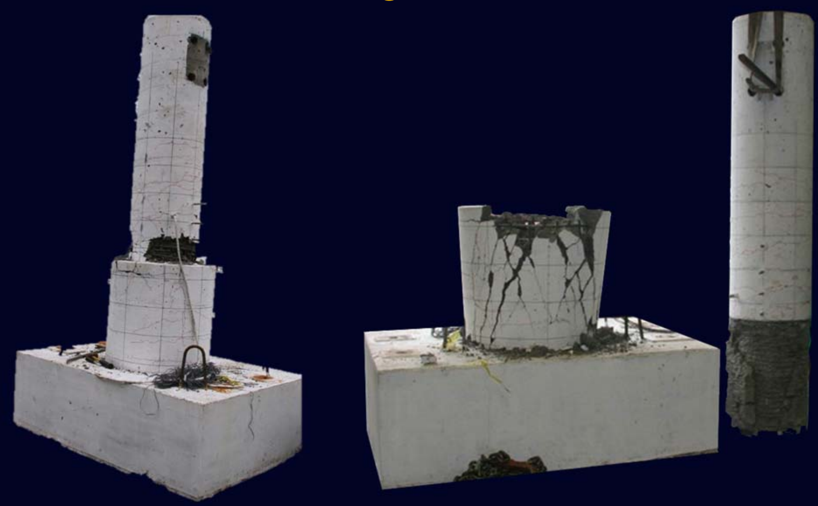


DS-2

• 50% transverse reinforcement in transition region



Post-Test Damage State – Drill Shafts

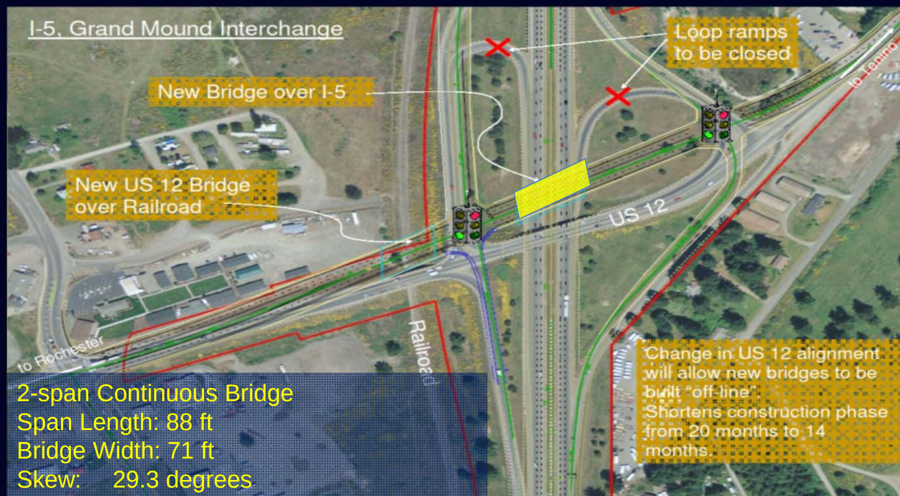


DS-1 DS-2

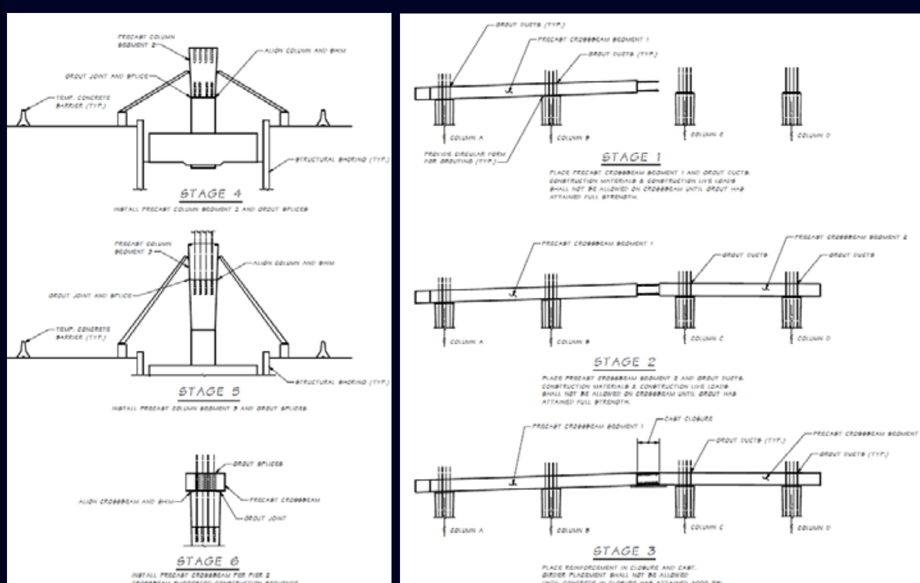
Drilled Shaft - Conclusions

- Easy to build
- For “100%” shaft spiral, seismic failure in column, performance as cip.
- For “50%” shaft spiral, failure in transition.

WSDOT Highways For LIFE Project:
I-5 Grand Mound to Maytown I/C
2-span Precast Prestressed Girder Bridge



Construction Sequences: Footing, Column and Crossbeam Placement



Footing and Precast Column Placement

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

Precast Column Placement

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

Precast Bent Cap Placement

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

Grouting the Joints

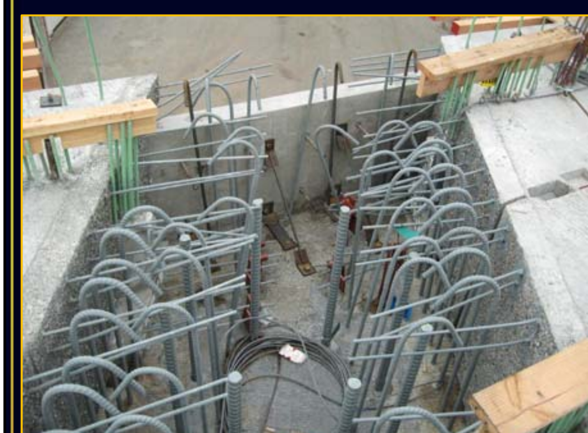
- Inspect Grout in Joint and Grout Tubes
- Patch Back Grout Tubes
- Investigate Unfilled Grout Tubes
- Repair Unfilled Grout Tubes

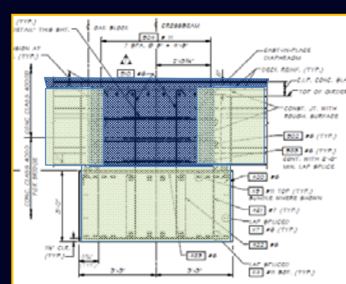
Superstructure Girder Erection

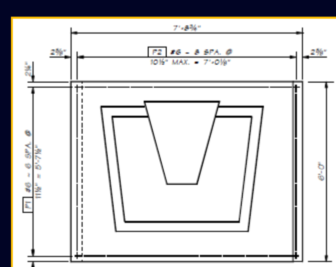
Completion of Precast Girder Erection
Precasting Included End and Intermediate Diaphragms

CIP Pier Diaphragm

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







Precast End Panel

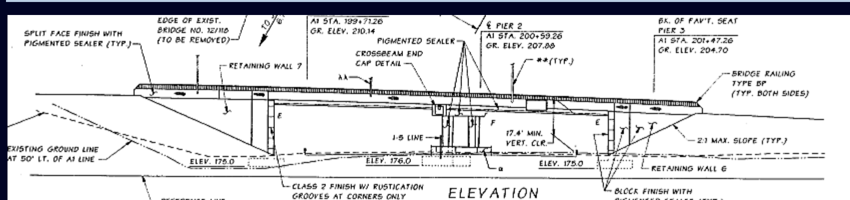
Completed Bent

Side View

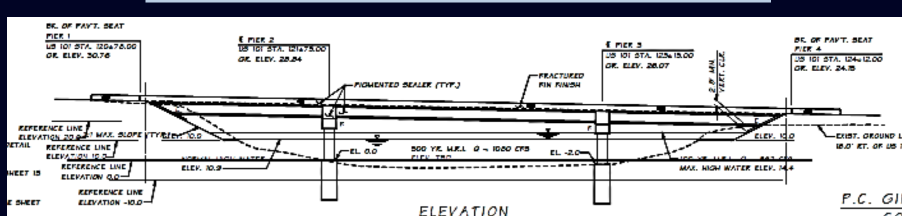
End View

Design Aids - Examples

Grand Mound Bridge (Demo Project) 2-span, 4-column bents, spread footings



Bone River Bridge 3-span, 2-column bents, drilled shafts



Design Aids - Specifications

- Design Specifications
  - Formatted in AASHTO Guide Spec Language
    - Appendix format with all details in one place
  - Address design with HfL bent details
    - ERS & ERE, displacement capacity, development, joint design, unique load paths, etc
- Construction Specifications
  - Material controls
  - Tolerance control
  - Recommendations for contract control

Schedule

- Demonstration project complete fall 2011
- Laboratory work completed fall 2011
- Design Examples and Aids summer 2012
- Final reports summer 2012

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Thank You!

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