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
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
Construction Sequence

Two-Column Version of Bent

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 $l_s$: pullout failure

Long $l_s$: bar fracture, embedment of 16 $d_b$

Connection Tests (42% Scale)
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
Gravity Load Test

Column crushed at: 3.5 * (1.25DL + 1.75LL)
No damage to footing.
No sign of punching failure

Spread Footing Connection

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
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

2-span Continuous Bridge
Span Length: 88 ft
Bridge Width: 71 ft
Skew: 29.3 degrees

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

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

CIP Pier Diaphragm

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

Precast End Panel
Completed Bent

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!