Retrofit Measures for Substructure Components

Presented by Richard V. Nutt

Components to be Retrofitted

- Piers and Columns
- Cap Beams and Column to Cap Beam Joints
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Pier and Column Retrofitting

- Reinforced Concrete Columns
- Steel Columns, Frames and Compression Members
- Concrete Pier Walls
Pier and Column Retrofitting

- Reinforced Concrete Columns
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Reinforced Concrete Columns

- Column Replacement
- Flexural Strengthening
- Ductility Improvement and Shear Strengthening
- Supplemental Shear Walls
- Preservation of Vertical Load Capacity
- Limitation of Column Forces
Column Replacement

LEGEND

A Lower bent (pier) cap retrofit
   - New prestressed concrete beam

B Column replacement
   - Remove existing columns and construct new reinforced concrete column

C New "super" girder (see Fig. 9-37)

D Footing retrofit or replacement

E Barrier replacement

F Upper bent cap retrofit
   - New prestressed concrete beam

G New concrete diaphragm overlays

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
**Column Replacement**

- New Vertical Reinforcement
- Column
- Bent
- Spiral Reinforcement

Section A-A

- Existing Reinforcement to Remain
- Spiral Reinforcement

Section B-B

**Column Anchorage**

- Remove and Replace Superstructure Concrete
- Core or Drill Holes for Column Reinforcement
- New Reinforced Concrete Column
- Headed Column Reinforcement
Replaceable Plastic Hinge

Section A-A
- Starter Bar
- Main Bar
- Hexagonal Coupler
- Pedestal (Reinf. Not Shown)

North-South Elevation
- Original Rebars
- Cut at Midlength

East-West Elevation
- 19 mm Dia. Original Rebar
- 11 mm Weld (TYP.)
- 216x114x13 Steel Plate (TYP.)
- Hexagonal Couplers (TYP.)
- Lock Nut (TYP.)

Detail A
- Original Rebars Cut at Midlength

Fuse Bar Details
- 29 mm Threaded Stud
- Hexagonal Couplers
- Lock Nut
Supplemental Column

Reinforced Concrete Columns

- Column Replacement
- Flexural Strengthening
- Ductility Improvement and Shear Strengthening
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- Preservation of Vertical Load Capacity
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Concrete Overlay

Existing Concrete Column

Epoxy Bonding

New Reinforcing

New Concrete

Drilled and Grouted Dowels

Section A - A

Column Strengthening

Existing Superstructure

Temporary Lifting Bars (optional) to be Removed and Ground Smooth After Installation

Steel Casing

Existing Column

Finish Grade

Limits of Waterproofing

Top of Footing Retrofit

Existing Pile

Bent Elevation

Increased Casing Thickness

Nominal Casing Thickness

Increased Casing Thickness

Drill & Bond Bars or Bar Cast in New Footing Concrete

New Pile
Column Strengthening

- Oval Shaped Steel Casing
- Existing Column
- Existing Footing
- Anchor New Column Reinforcement in New Footing Concrete
- New Limits of Concrete Footing
- Drill & Bond Bars Into Existing Footing

Section A-A
Reinforced Concrete Columns

- Column Replacement
- Flexural Strengthening
- Ductility Improvement and Shear Strengthening
- Supplemental Shear Walls
- Preservation of Vertical Load Capacity
- Limitation of Column Forces

Typical Steel Shell

- 12 mm Steel Shell
- Surface of Existing Column
- Backing Bar
- 19 mm Grouted Gap
- CJP Weld
Composit Fiber Properties

<table>
<thead>
<tr>
<th>Type of Fiber</th>
<th>Ultimate Strength, MPa (ksi)</th>
<th>Ultimate Strain</th>
<th>Modulus of Elasticity, GPa (ksi)</th>
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<tr>
<td>E-Glass</td>
<td>2410 (350)</td>
<td>0.020</td>
<td>41 (6,000)</td>
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<tr>
<td>S-Glass</td>
<td>3450 (500)</td>
<td>0.030</td>
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<td>CF-Pan</td>
<td>4140 (600)</td>
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<td>228 – 345 (33,000 – 50,000)</td>
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<td>C-Pitch-GP</td>
<td>1380 (200)</td>
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<td>Pitch UHM</td>
<td>2760 (400)</td>
<td>0.005</td>
<td>483 – 827 (70,000 – 120,000)</td>
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<td>Aramid</td>
<td>3450 (500)</td>
<td>0.020</td>
<td>69 – 138 (10,000 – 20,000)</td>
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<tr>
<td>Ceramic</td>
<td>690 (100)</td>
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<td>69 – 276 (10,000 – 40,000)</td>
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<tr>
<td>Nylon</td>
<td>345 (50)</td>
<td>0.050 – 0.500</td>
<td>3.5 (500)</td>
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Anchorage for Prestress Strand

1/4" Concrete Screw
2-3/4" to 3-1/2" Long
(69.9 mm to 88.9 mm Long)
If Required

Prestress Wrap Using Wedges
Semi-circular Reinforcing Bars

- Shotcrete Cover
- Existing Concrete Column
- Chip Concrete for Turnbuckle
- Reinforcing Hoops Tensioned with Special Turnbuckle

Cross Section

Semi-circular Reinforcing Bars

- Special Turnbuckle
- Shotcrete

Elevation
Semi-circular Reinforcing Bars

Threaded Reinforcing Bar

Turnbuckle Detail

Reinforced Concrete Columns

- Column Replacement
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- Limitation of Column Forces
**Infill Shear Wall**

- New Infill Wall - Tie to Existing Cap Beam, Columns and New Footing with Drilled and Grouted Dowels
- Existing Columns

**Reinforced Concrete Columns**

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Verticle Capacity Preservation

Reinforced Concrete Columns

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Sierra Point Overhead

Flexural Strength Reduction

- Existing Column
- Concrete Collar
- Column Base Cut
- Soffit Buffer
- Steel on Steel Plate
- Displacement Restrainer

Existing Foundation
Pier and Column Retrofitting

- Reinforced Concrete Columns
- Steel Columns, Frames and Compression Members
- Concrete Pier Walls

Steel Columns, Frames and Compression Members

- Braced Frames
- Built-up Compression Members
Steel Columns, Frames and Compression Members

- Braced Frames
- Built-up Compression Members

Steel Column Retrofit

(a) As-built Section
Steel Column Retrofit

(b) Retrofitted Section

Steel Column Retrofit

12 mm Steel Shell

Fill with Concrete

Existing Built-up Steel Section
(See Fig. 9-24)
Pier and Column Retrofitting

- Reinforced Concrete Columns
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Pier Wall Retrofit

- Use increased number of bolts and supplemental plate washers in plastic hinge zone when startet bars have been used.
Components to be Retrofitted

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Bent Cap Configurations

(a) Drop (Separate) Cap
(b) Integral Cap
Bent Cap Configurations

(c) Outrigger Cap with Integral Columns
(d) Outrigger Cap with "Pinned" Columns

Cap Beams and Column to Cap Beam Joints

- Pier Cap Replacement
- Pier Cap Strengthening
- Reduction in Pier Cap Forces
- Strengthening of Column and Beam Joints
- Supergirders
Pier Cap Replacement

LEGEND

A. Lower bent (pier) cap retrofit
   - New prestressed concrete beam
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Pier Cap Strengthening

Plan

- Bent Cap Reinforcement is Symmetrical About Bent
- Concrete Overlay on Either Side of Existing Bent Cap

Elevation

- New Knee Joint
- Bent Cap Prestressing Tendons
Bent Cap Strengthening

Pier Cap Retrofit Test

F = 56 kN / Tendon
Total PS Force = 560 kN
Bent Cap Strengthening

- Replace, Add Rebar
- Dowels
- External Prestressing Tendon
- Overlay.

Cap Beams and Column to Cap Beam Joints

- Pier Cap Replacement
- Pier Cap Strengthening
- Reduction in Pier Cap Forces
- Strengthening of Column and Beam Joints
- Supergirders
Link Beam Retrofit

Cap Beams and Column to Cap Beam Joints

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Integral Bent Cap Retrofit

Existing Cap Beam

New Concrete Bolster

Prestress Rod

Hole Cored Through Cap Beam

Knee Joint Retrofit

Steel Confinement Plate

Vertical Stiffener

Existing Bent (Per) Cap

Longitudinal Stiffener

Existing Column

Elevation

Section A-A

Steel Plate

Steel Washer

Bolt Through Drilled Hole

Inject Epoxy in Space Under Plate
Cap Beams and Column to Cap Beam Joints

- Pier Cap Replacement
- Pier Cap Strengthening
- Reduction in Pier Cap Forces
- Strengthening of Column and Beam Joints
- Supergirders

Supergirders

[Diagram of Supergirders]