

# PCMAC Workshop Sacramento, California November, 2011

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and do not necessarily reflect Caltrans' official policy.



# PCMAC Workshop Sacramento, California November, 2011

Caltrans Research  
Seismic Connections in Prefabricated Substructures

Presented By: Ron Bromenschenkel, PE



<b>NGB</b>	<b>Next Generation Bridge</b>	<b>UNR</b>
<b>CFT</b>	<b>Concrete Filled Tube</b>	<b>UW</b>
<b>ISO</b>	<b>Isolated PC bridge</b>	<b>UCB</b>



## Caltrans Research Seismic Connections in Prefabricated Substructures

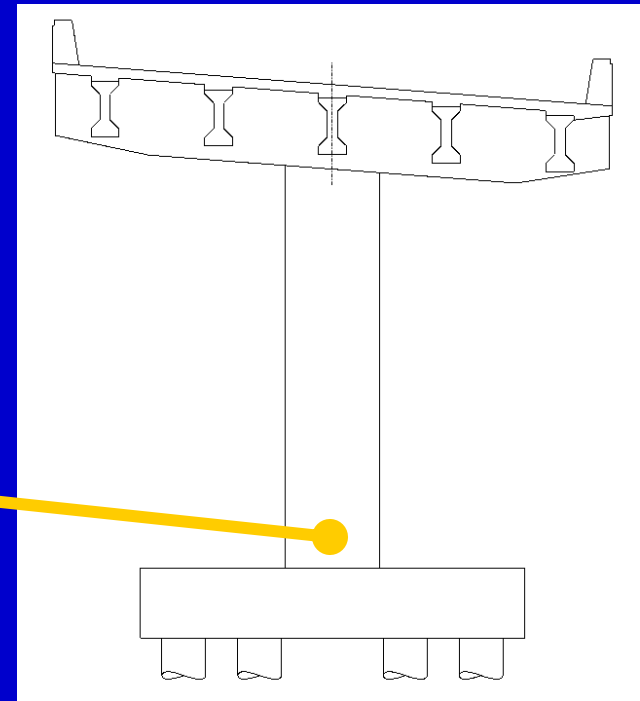
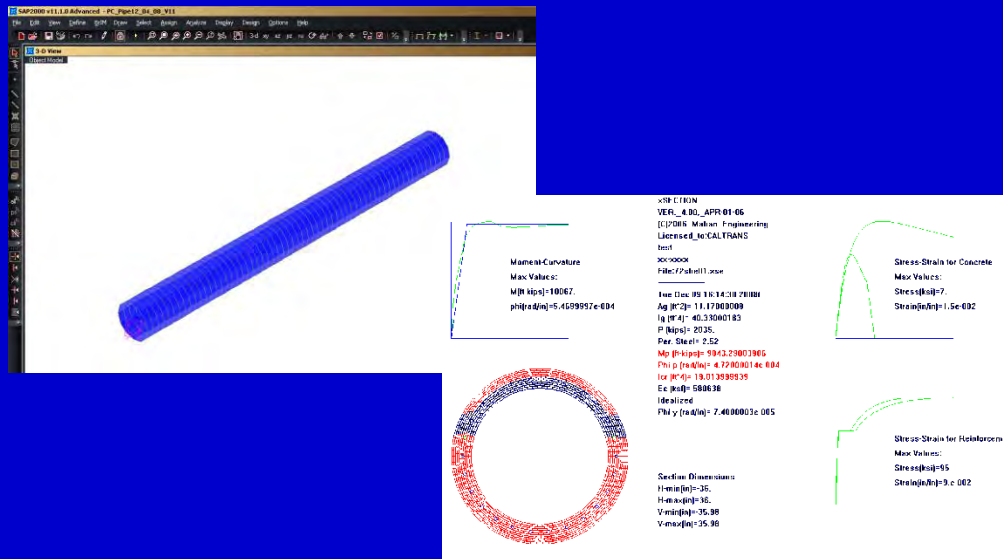
NGB	Next Generation Bridge	UNR



## Caltrans Research Seismic Connections in Prefabricated Substructures

# Next Generation Bridges

## Initial Focus: Precast elements - *columns*



# Next Generation Bridges

## Proposed Construction Concepts



### NOTES:

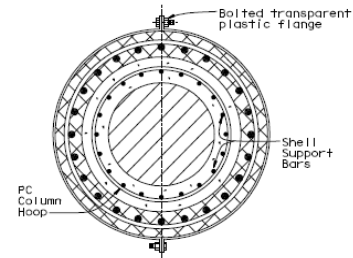
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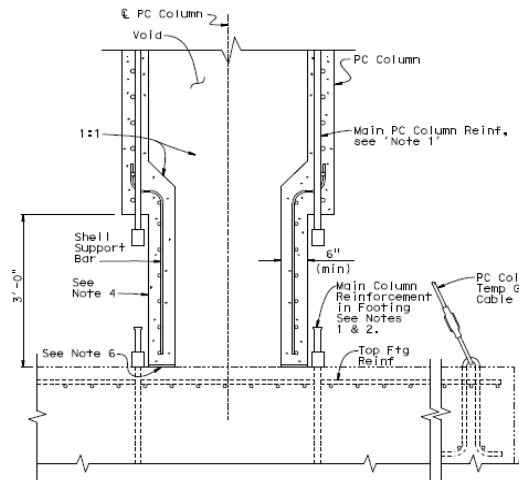


**SECTION A-A**  
1" = 1'-0"

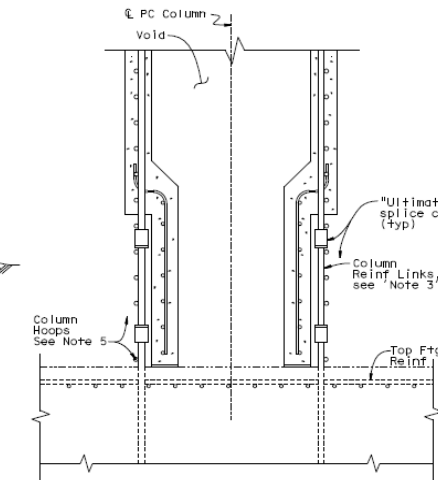
DIST.	COUNTY	ROUTE	POST MILES	SHEET NO.	TOTAL SHEETS
REGISTERED ENGINEER - CIVIL					
					
PLANS APPROVAL DATE					

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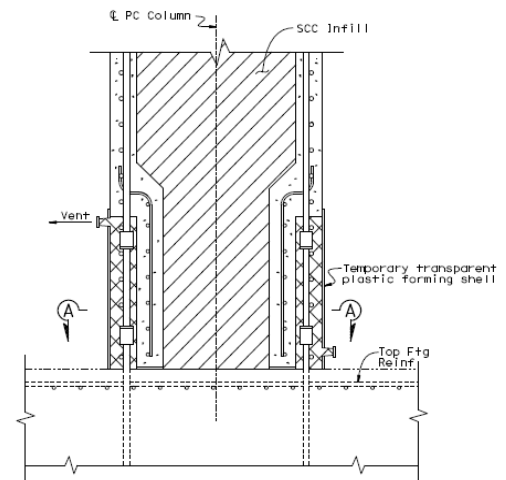
INCOMPLETE PLAN  
FOR DESIGN STUDY  
PRINTED  
DATE: 03-13-09  
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**STAGE 1**  
**ELEVATION - PRECAST COLUMN PLACEMENT**  
1" = 1'-0"



**STAGE 2**  
**ELEVATION - COLUMN BASE CONNECTION**  
1" = 1'-0"



**STAGE 3**  
**ELEVATION - COLUMN BASE POUR**  
1" = 1'-0"

NOTE:  
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STANDARD DRAWING			
FILE NO. <b>X8 P01</b>	DESIGN BY <b>ALBROMSCHENKEL</b>	DRAWN BY <b>XXXXXXXXXX</b>	APPROVAL RECOMMENDED BY
DATE <b>10/08</b>	DETAILS BY <b>ALBROMSCHENKEL</b>	CHECKED BY <b>XXXXXXXXXX</b>	DESIGN SUPERVISOR
SUBMITTED BY <b>XXXXXXXXXXXXXXXXXXXX</b>			

**STATE OF CALIFORNIA**  
DEPARTMENT OF TRANSPORTATION

DIVISION OF STRUCTURES  
STRUCTURE DESIGN

PROJECT NO.  
XX-XXXX  
POST MILE  
XXXX

### NGB SEISMIC RESEARCH DETAIL

**TEST STRUCTURE**  
**PRECAST COLUMN CONNECTION DETAIL NO. 1**

DESIGNED BY: [blank] DRAWN BY: [blank] CHECKED BY: [blank] DATE: [blank] SHEET 1 OF 5

ORIGINAL SCALE IN INCHES  
FOR REDUCED PLANS

CU 59-B3  
EA 930343/melchiorson



2/2/2012

# Next Generation Bridges

## Proposed Construction Concepts



### NOTES:

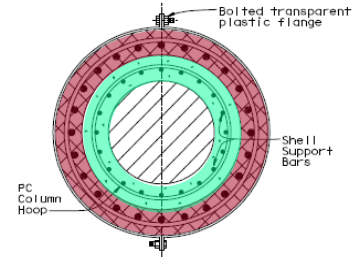
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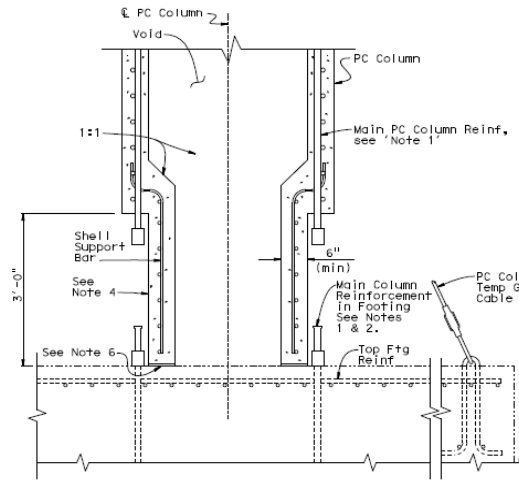
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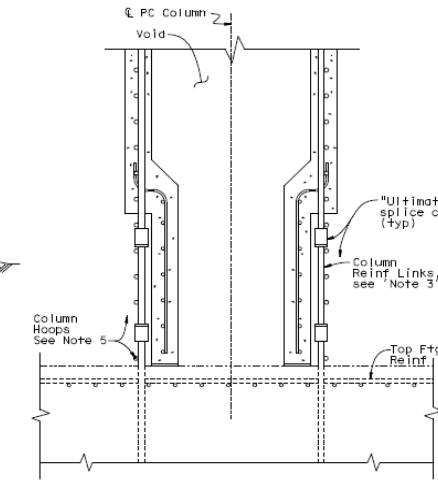
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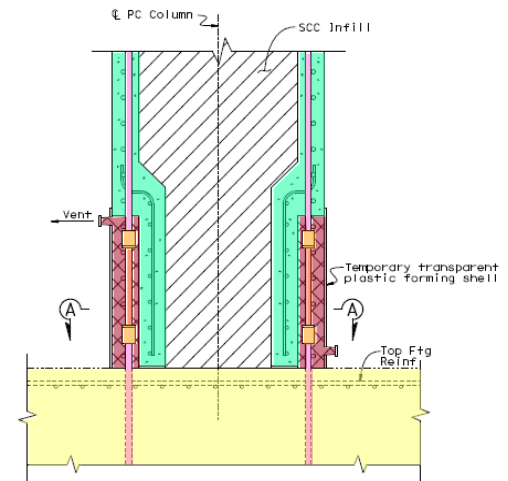
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2/2/2012

# Next Generation Bridges

## Proposed Construction Concepts



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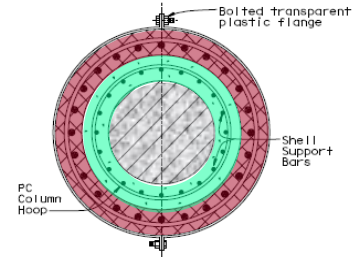
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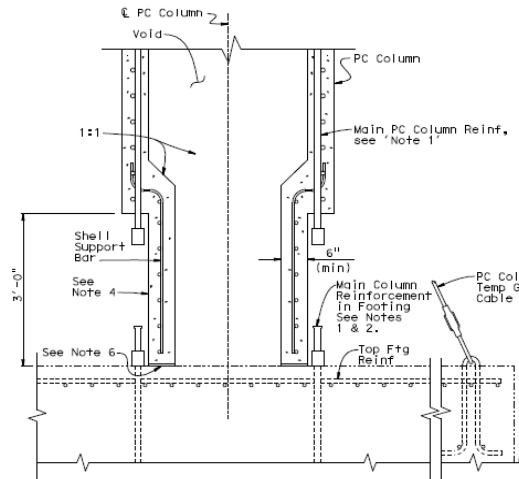


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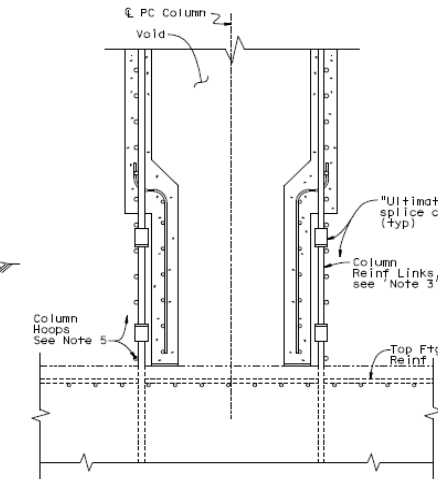
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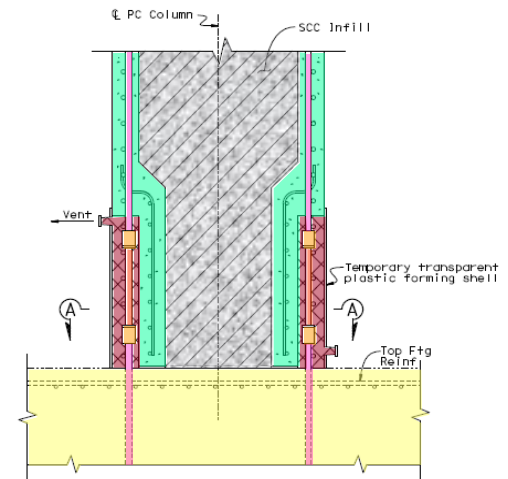
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XX-XXXX	XX-XXXX	XX-XX-XX	1	5

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DESIGNED BY  
EARLIER REVISION DATES

REVISION DATES (PRELIMINARY SCALE ONLY)

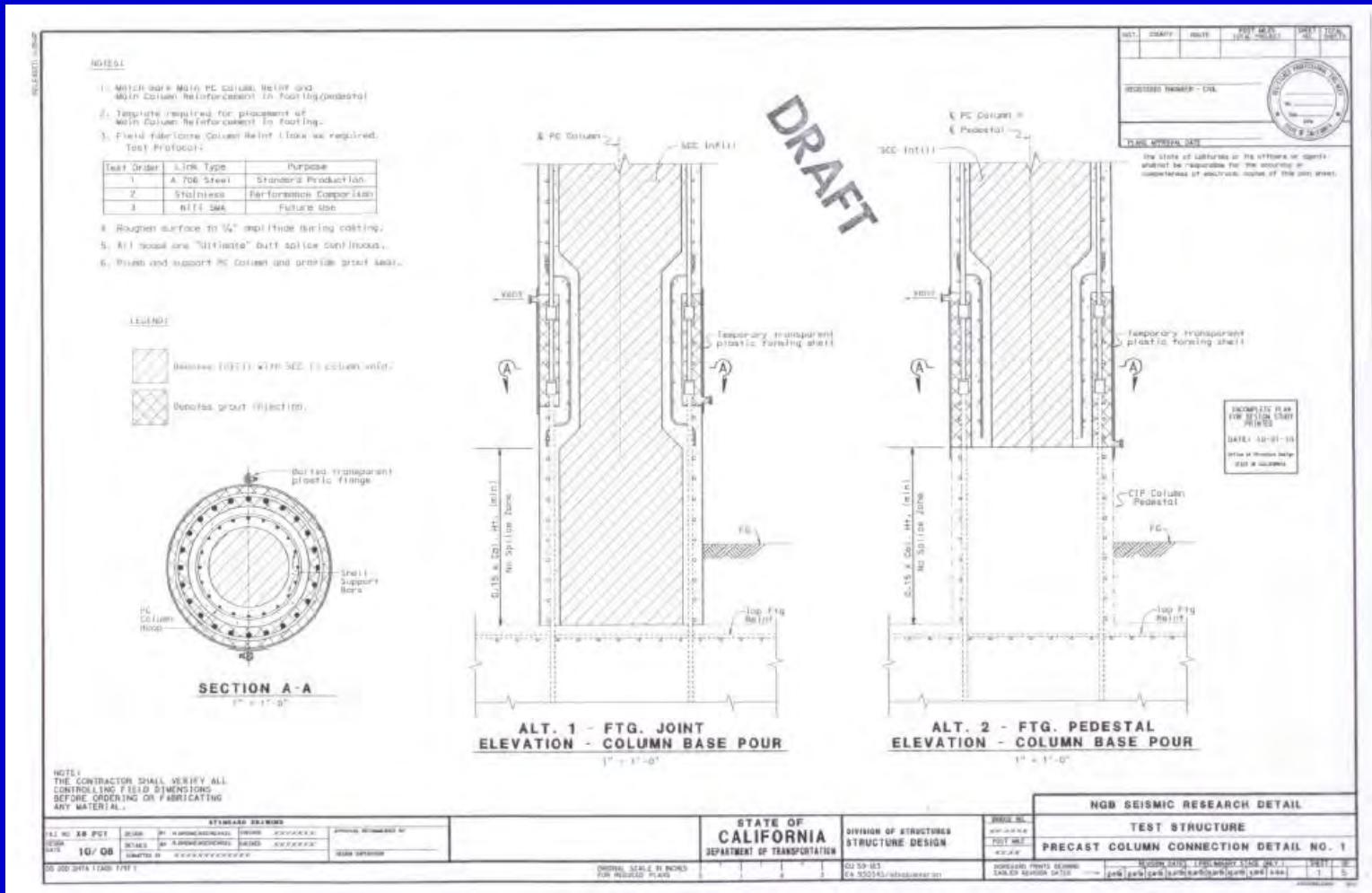


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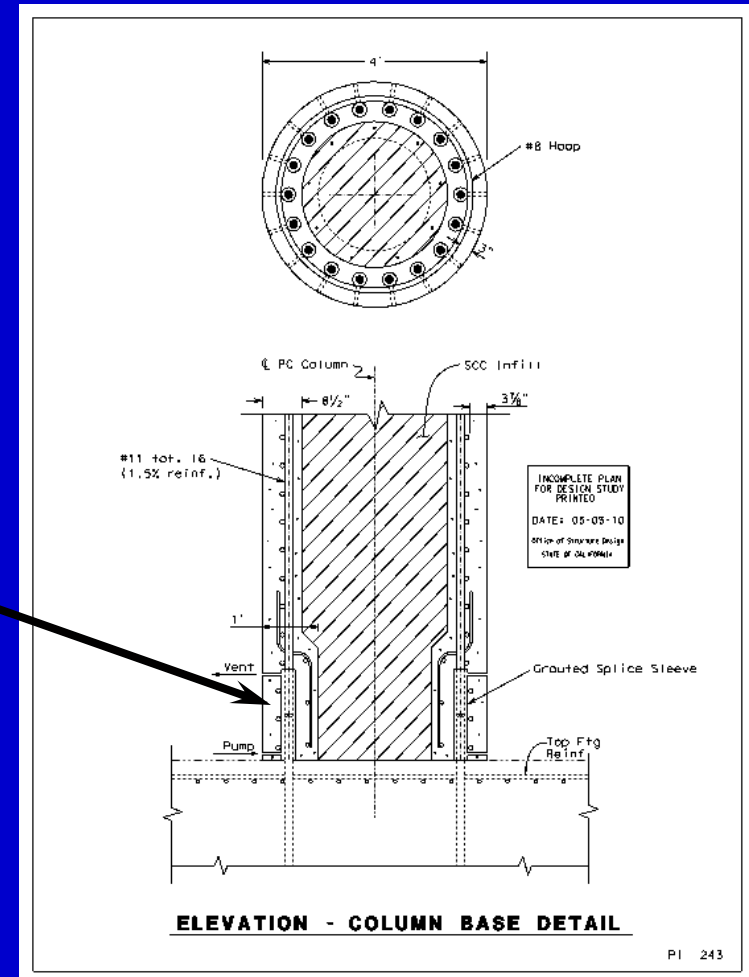
# Next Generation Bridges

## *Alternative Configurations*



# Next Generation Bridges

## *Alternative Configurations*



# **Seismic Performance of Precast Column to Foundation Connections for Accelerated Bridge Construction**

Zachary B. Haber – PhD Student

M. Saiid Saiidi, PhD, P.E. – Professor

David Sanders, PhD – Professor

**Department of Civil and Environmental Engineering**

**University of Nevada, Reno**

**Research Sponsor: California Department of Transportation**

ACI Fall 2011 Meeting – Research in Progress – October 17<sup>th</sup> 2011



# Objective & Scope

- Develop an Innovative Precast Column Element
  - Emulative Design, Light weight, Moment connections using mechanical bar couplers
- 5 Half-scale Column Models Designed/Constructed
  - 1 Conventional Column Model
  - 4 Precast Models

**Up-set Headed Coupler (HC)**



**ULTIMATE COUPLER**

**Grouted Sleeve Coupler (GC)**

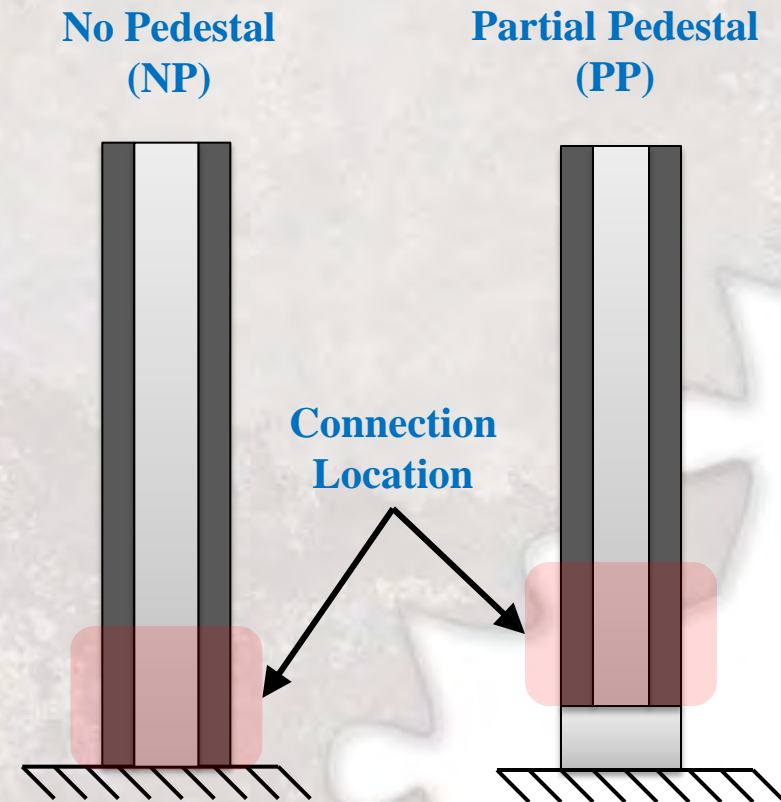


**SERVICE COUPLER**

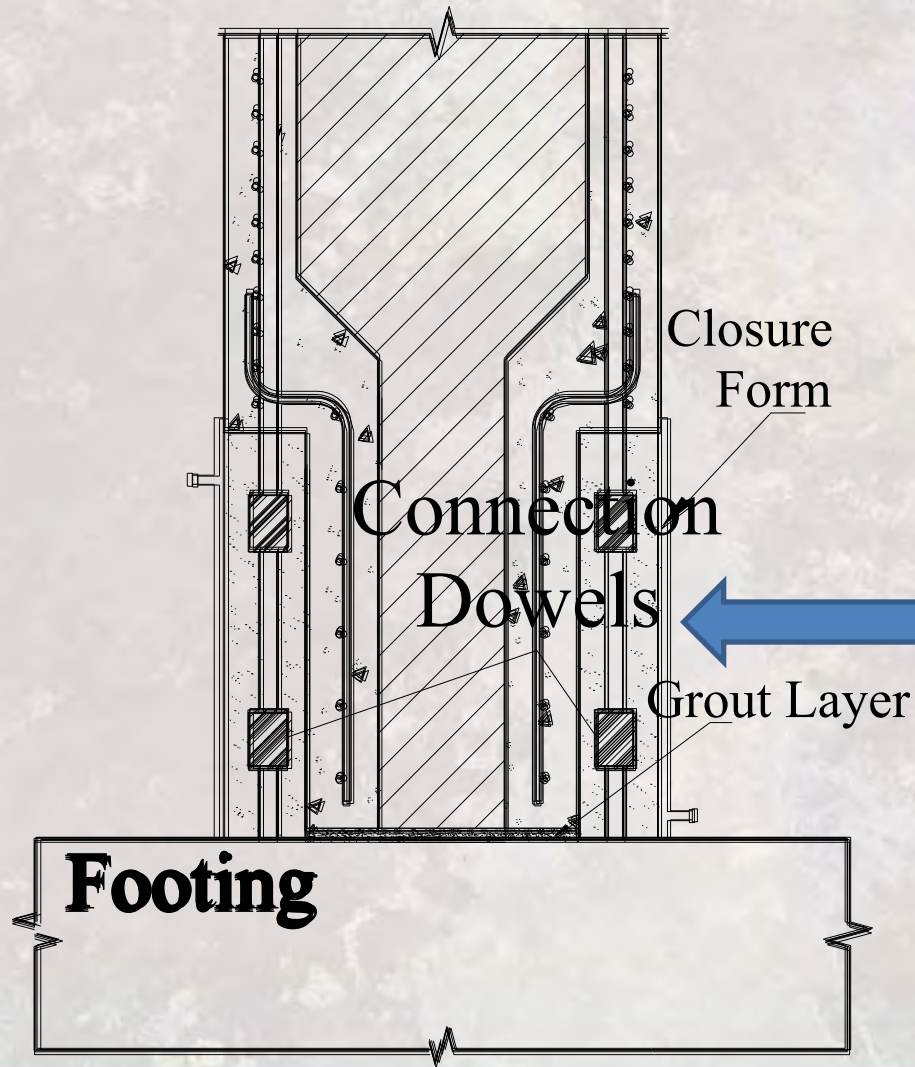


# Half-scale Column Models

- Caltrans Seismic Design Criteria (Disp. Ductility  $\geq 5$ )
- Design Details
  - 9ft Tall & 2ft Diameter
  - 11 #8 Longitudinal Steel (1.9%)
  - #3 Spiral @ 2in Pitch
  - Axial Load = 226kip ( $0.1f'_c A_g$ )
- Precast Hollow Shell Design
- Use of Partial Pedestal

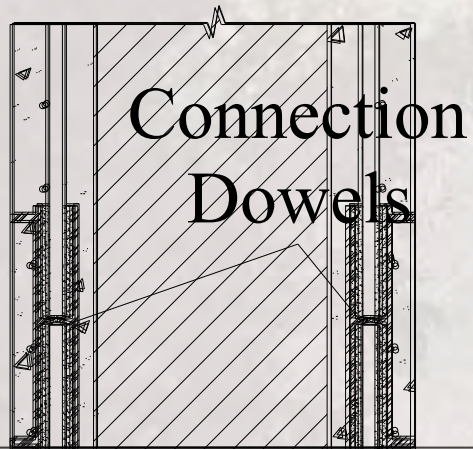


# Connection Details – HC Models





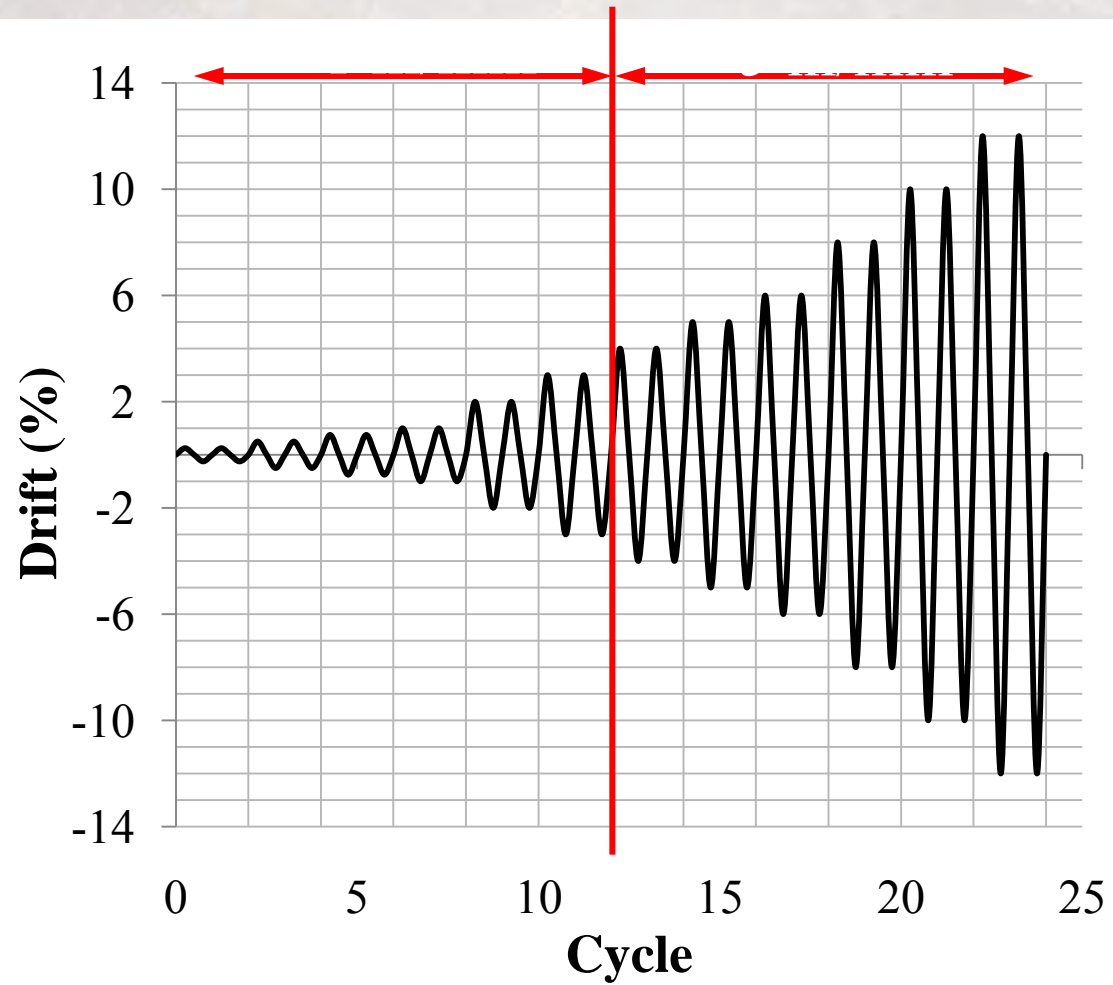
# Connection Details – GC Models



**Footing**



# Experimental Testing





# Observations – Accumulated Damage at Failure



**CIP**

**(2<sup>nd</sup> Cycle -10% Drift)**



**HCNP**

**(2<sup>nd</sup> Cycle -10% Drift)**



**HCPP**

**(1<sup>st</sup> Cycle -10% Drift)**



# Observations – Accumulated Damage at Failure

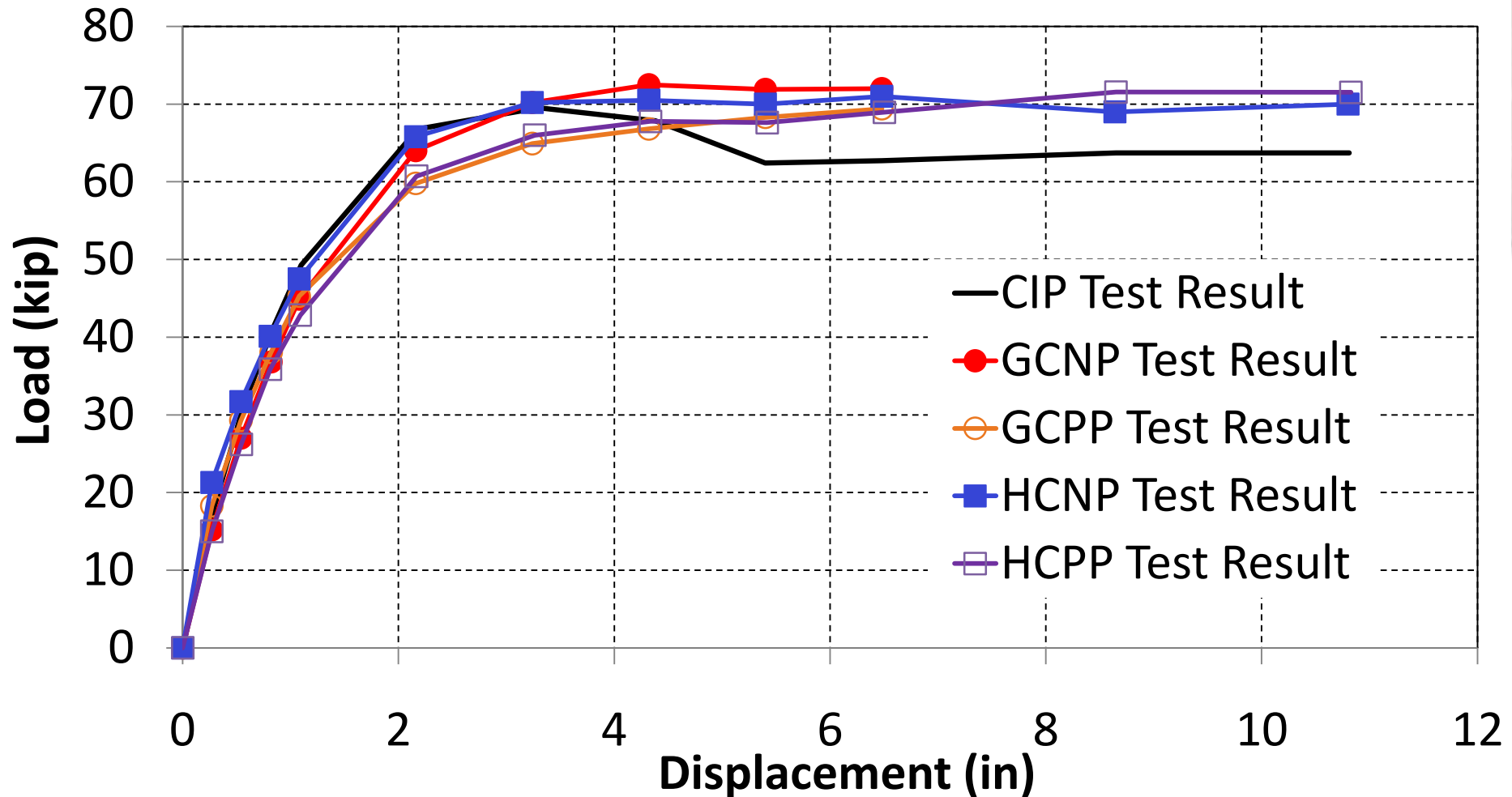


**GCNP**  
**(2<sup>nd</sup> Cycle -6% Drift)**



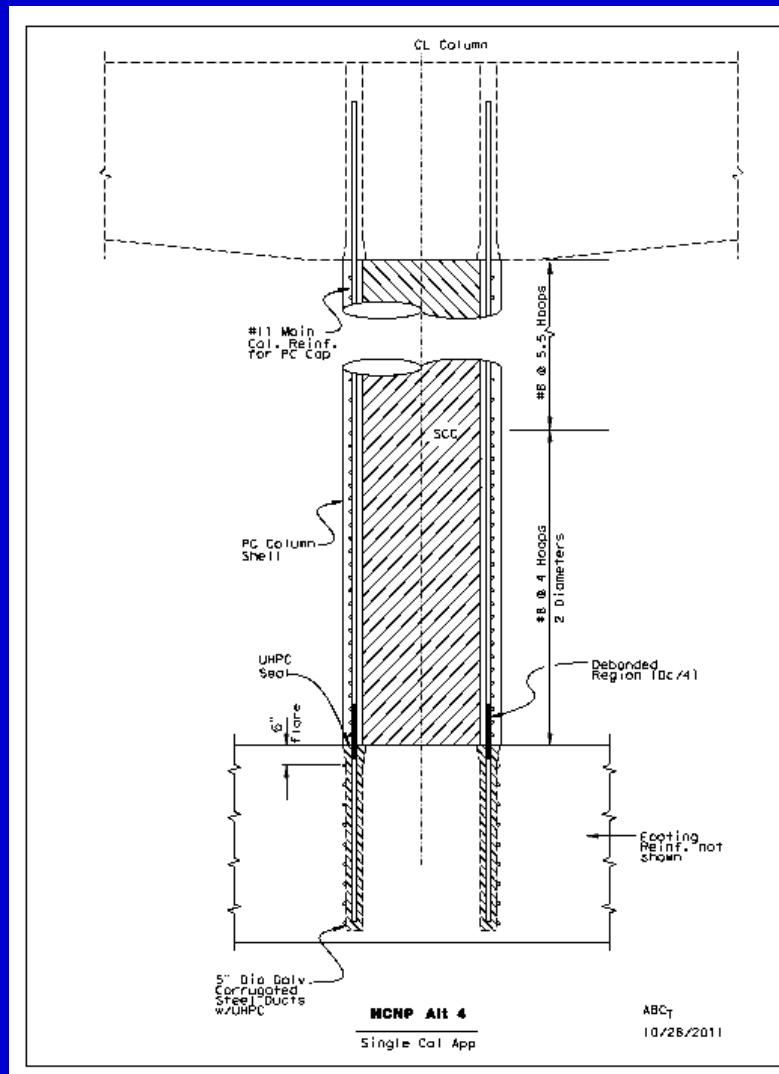
**GCPP**  
**(1<sup>st</sup> Cycle -6% Drift)**

# Results - Pushover Curves



# Next Generation Bridges

## *Alternative Configurations*



NGB	Next Generation Bridge	UNR



# Caltrans Research

## Seismic Connections in Prefabricated Substructures

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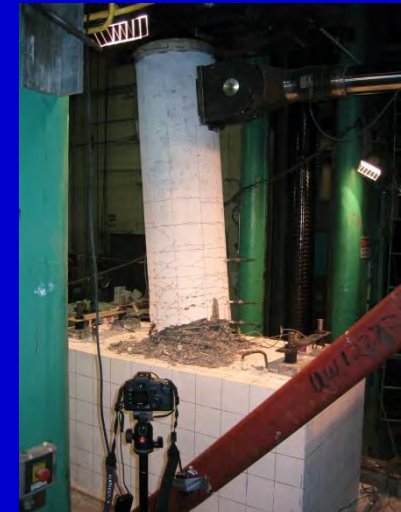
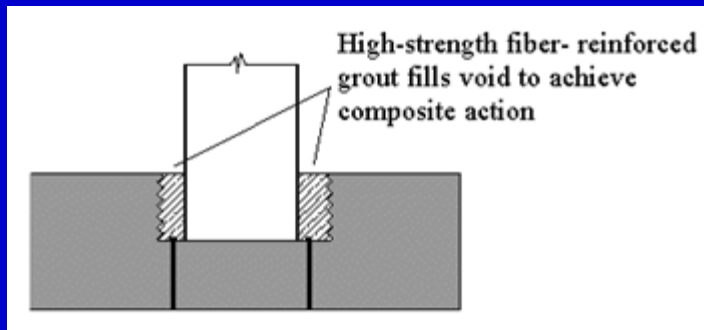
## Caltrans Research Seismic Connections in Prefabricated Substructures



# Concurrent Research

University of Washington

CFT connection tests



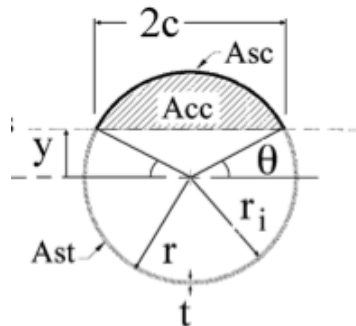
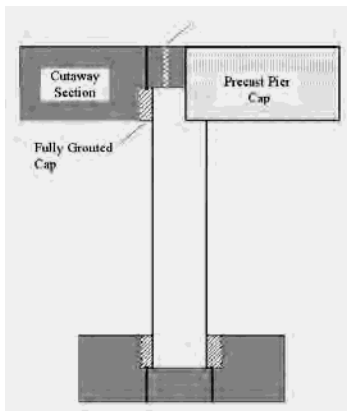


# Rapid Construction of Bridge Piers with Concrete Filled Tubes

Dawn Lehman and Charles Roeder  
University of Washington



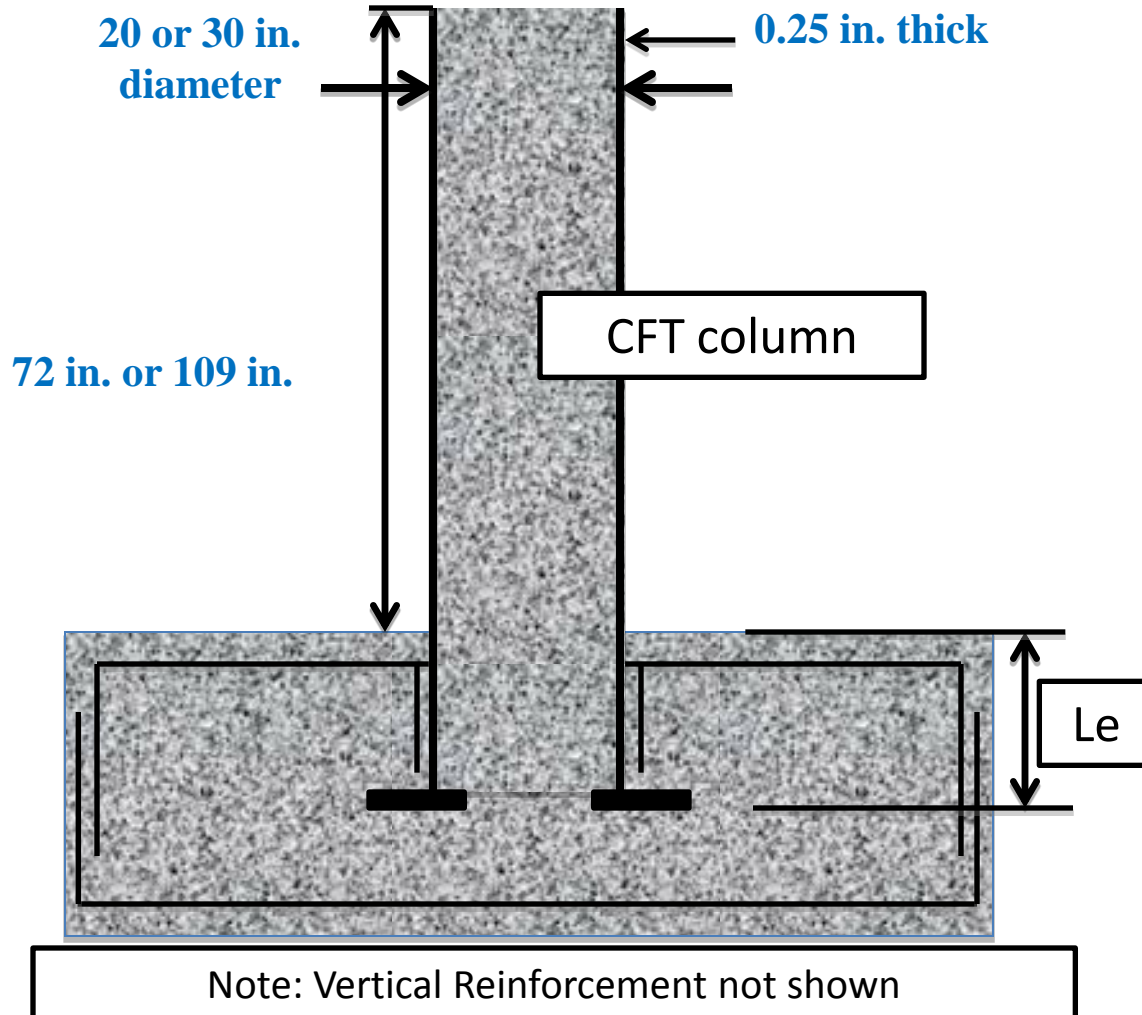
# Collaborative Research Program

COMPONENT TESTS	COLUMN FOUNDATION	DESIGN MODELS	COLUMN CAP BEAM
			
Engineering Properties Influence of Bond Impact of Weld Properties	Embedment Connection Type Material Strengths Axial Load	Flexural Strength Slenderness Stiffness	Future Work: Connection Type Geometry Embedment
ARMY/Caltrans	ARMY Caltrans	Caltrans WashDOT	Proposed Caltrans

# Test Matrix

Specimen	Diameter/Thickness	Type of Connection	Type of Tube Seam	Embedment/Diameter
1	20/0.25	Monolithic	Straight	0.8
2	20/0.25	Isolated	Straight	0.78
3	20/0.25	Isolated	Spiral	0.78
4	20/0.25	Monolithic	Spiral	0.8
5	20/0.25	Isolated	Spiral	0.7
6	20/0.25	Isolated	Spiral	0.6
7	30/0.375	Isolated	Spiral	0.62

# Large-Scale Specimens: Monolithic Connection



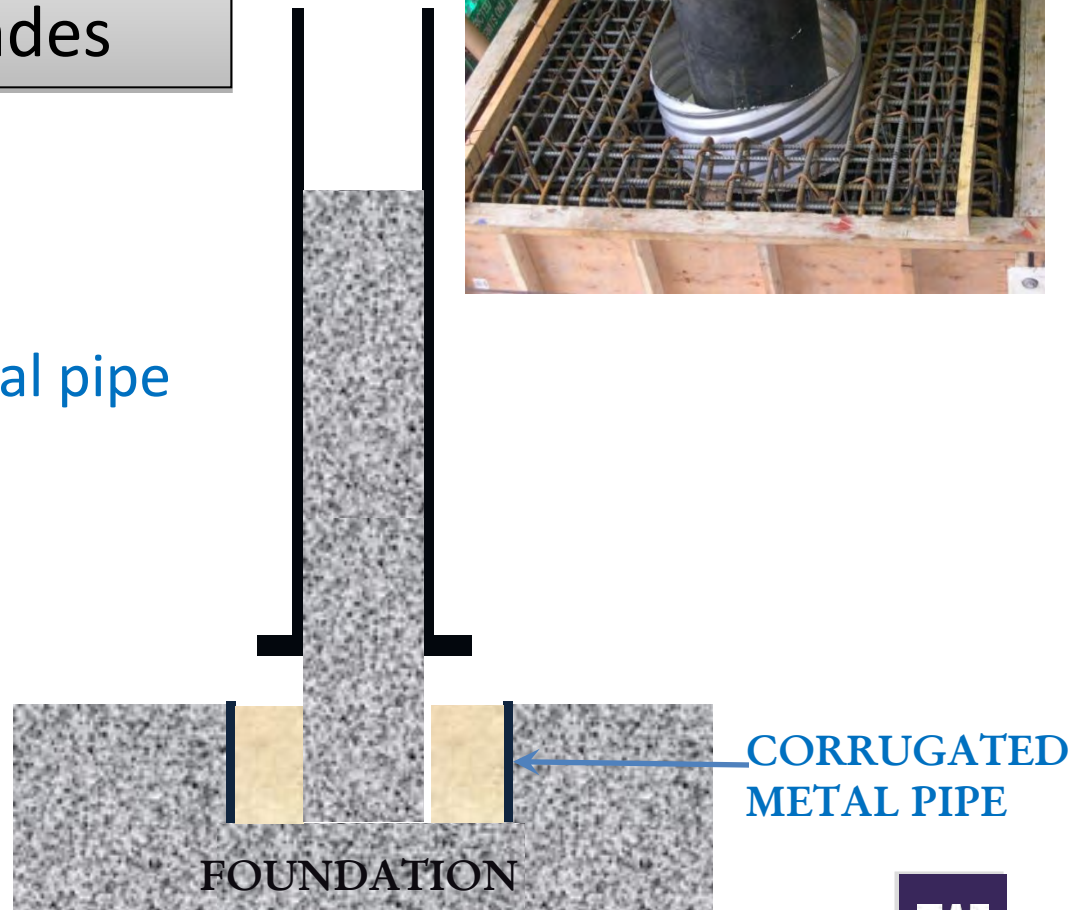
Annular ring  
at base of tube.  
Embedded in  
foundation  
for anchorage.



# Design of Isolated Connection

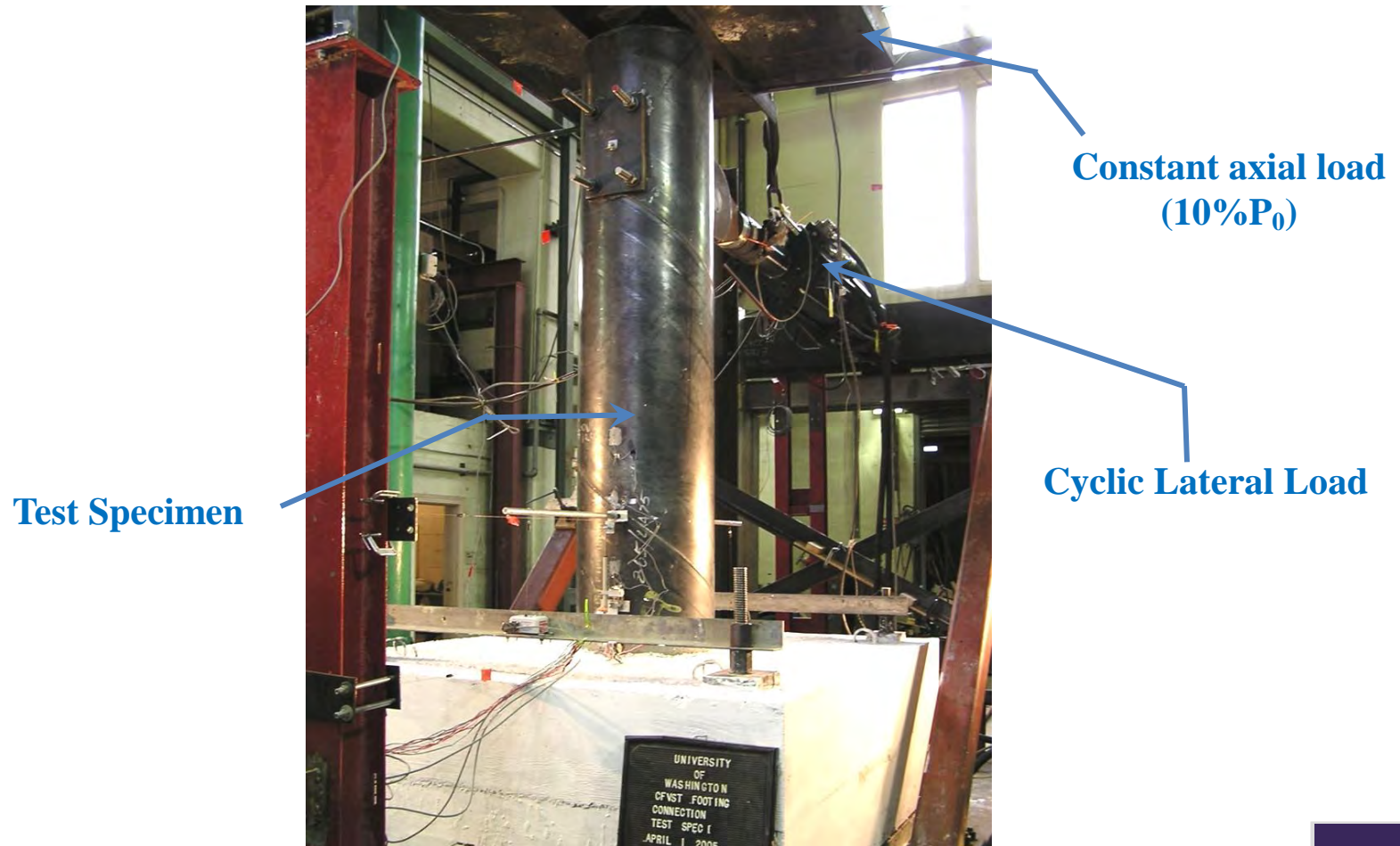
## Isolation of Structural and Reinforcing Steel Trades

- 1 Build foundation cage
- 2 Install corrugated metal pipe
- 3 Cast foundation
- 4 Install and grout tube
- 5 Cast column

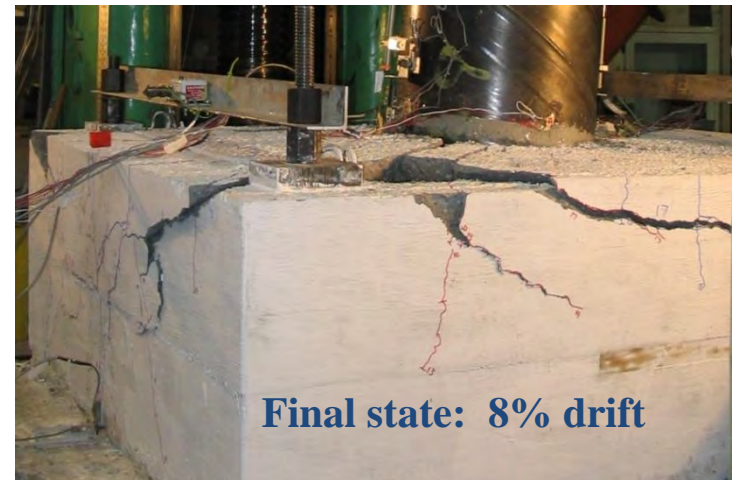
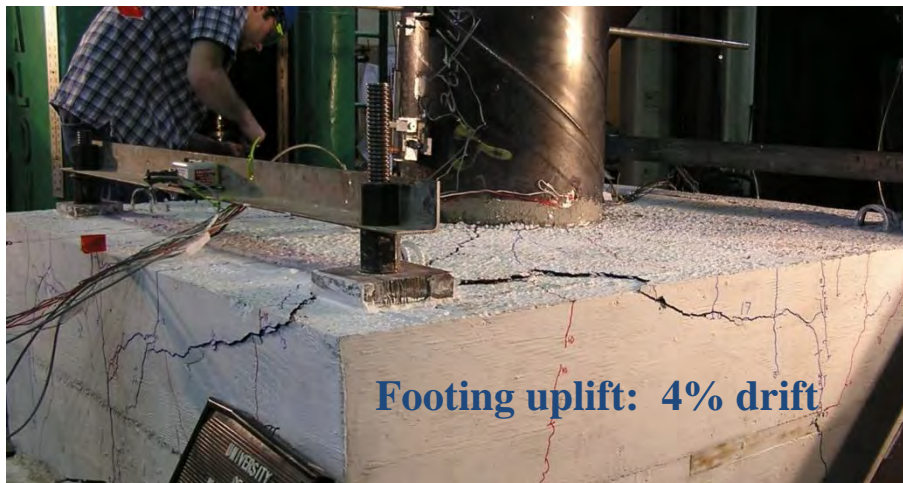
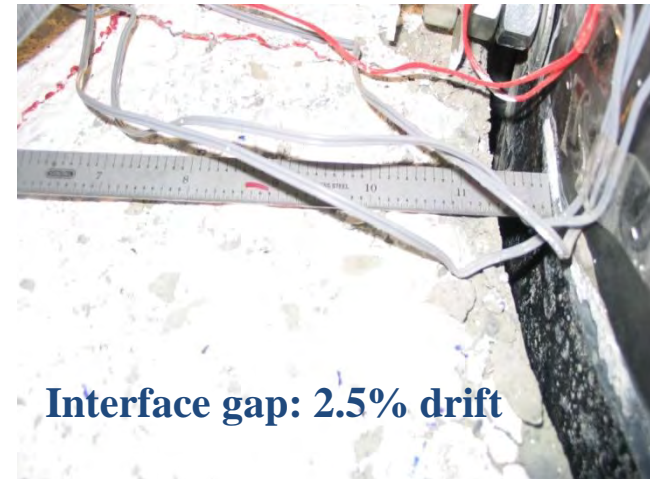
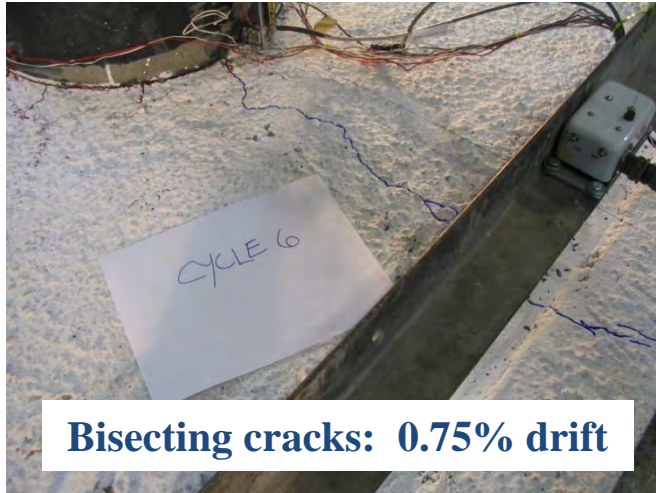




# Test Configuration

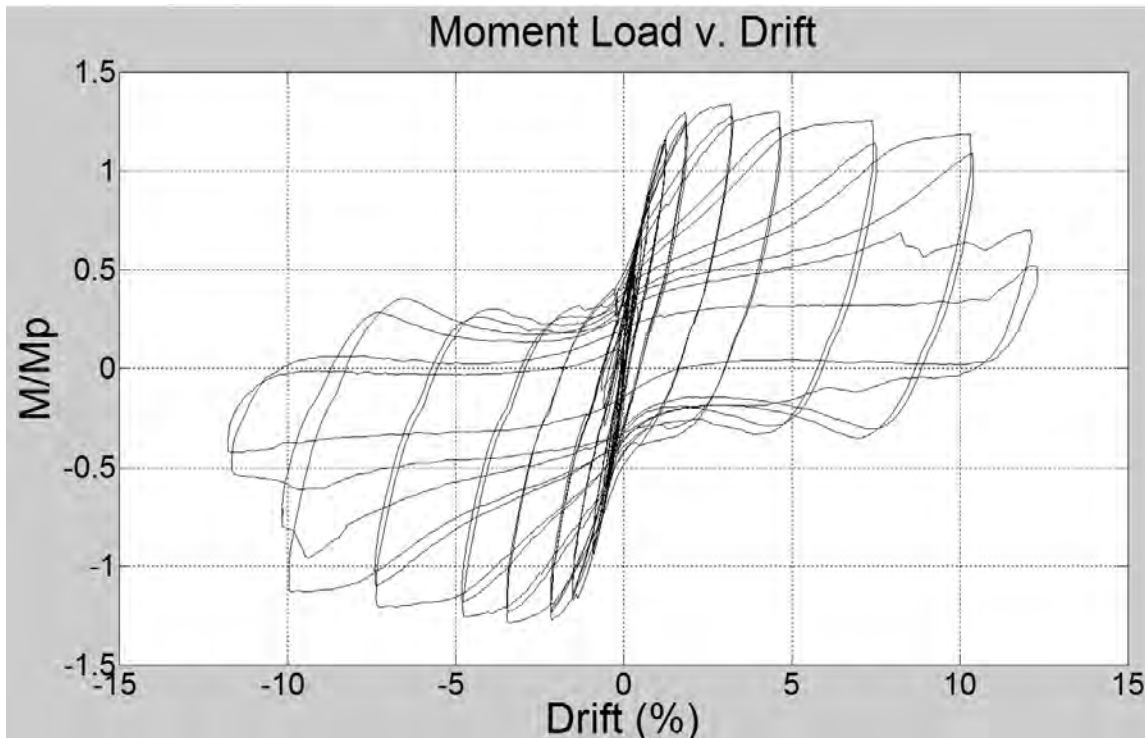


# Behavior if Embedment is Too Small





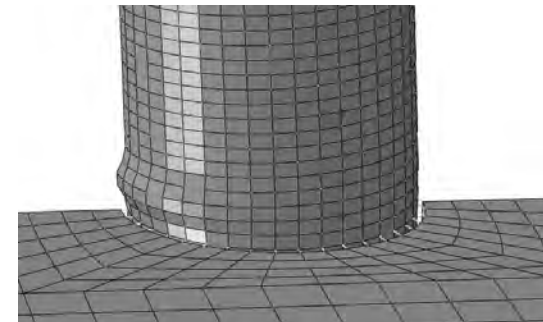
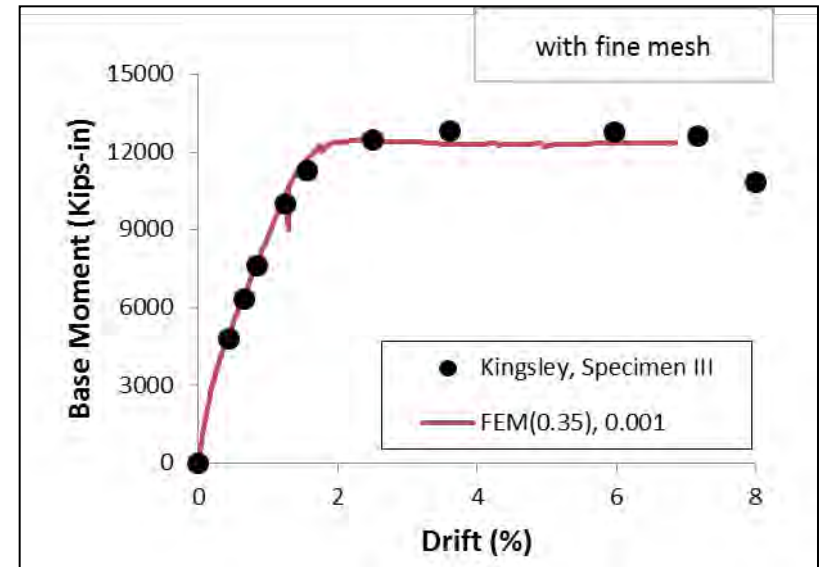
# Behavior of Specimen with Sufficient Embedment



# Finite Element Study

## Nonlinear FE Analysis Study to Extend Testing.

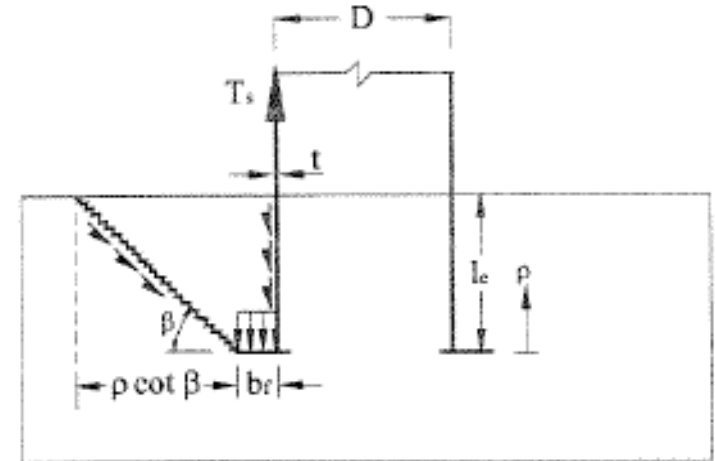
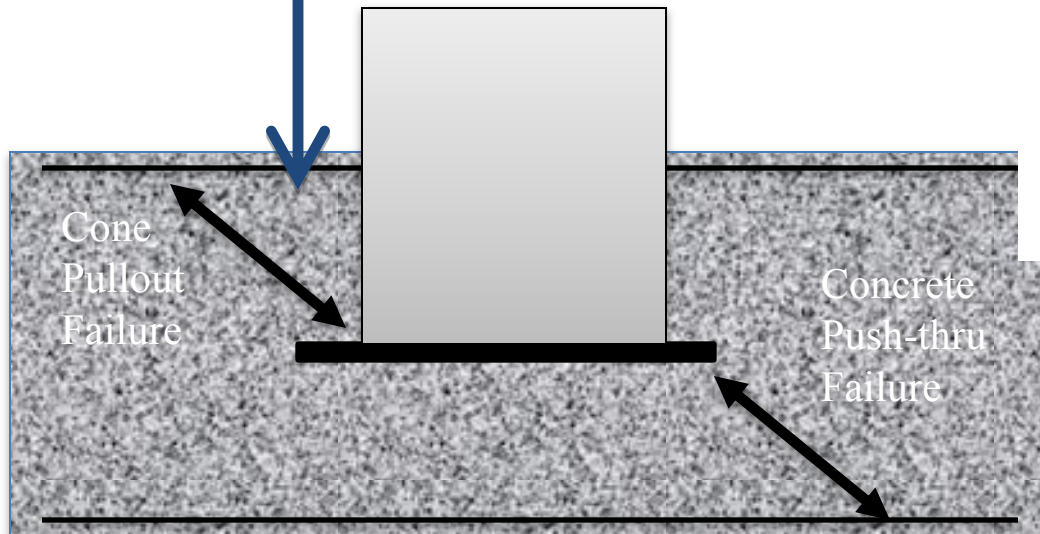
- Capable of simulating global response and local deformations.
- Gap elements to model interface and confinement.
- Solid elements for concrete fill. Shell element used to simulate tube.
- Validated using Caltrans and other large-scale test results.





# Design Methods

# Required Embedment Depth



$$\tau := \frac{r \cdot F_u \cdot t}{\frac{Le^2}{2} + r_o \cdot Le} = \frac{D \cdot F_u \cdot t}{Le^2 + D_o \cdot Le}$$

Footing Damage for  
 $\tau > 7 \text{ to } 8 \sqrt{f'_c}$

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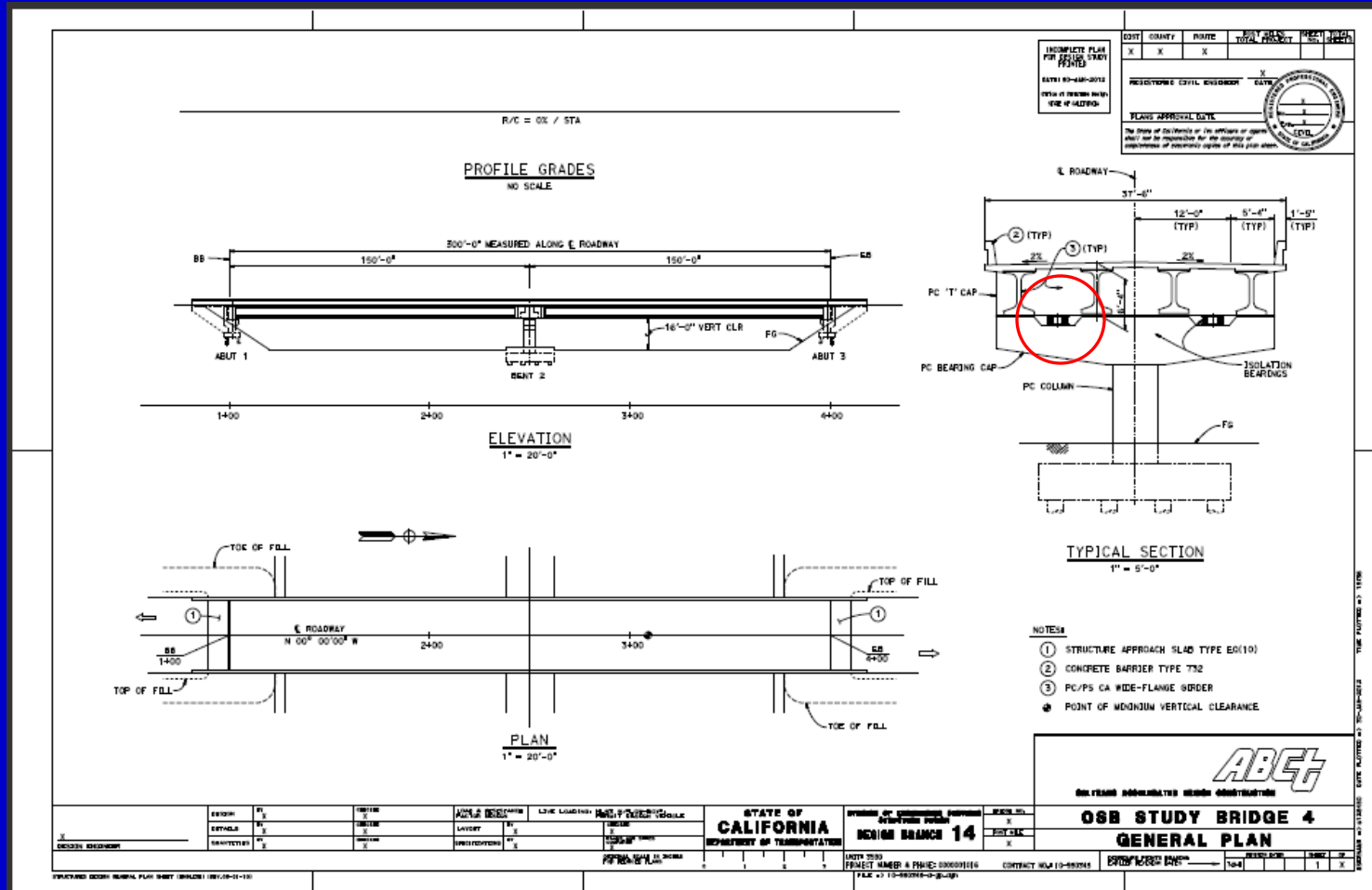
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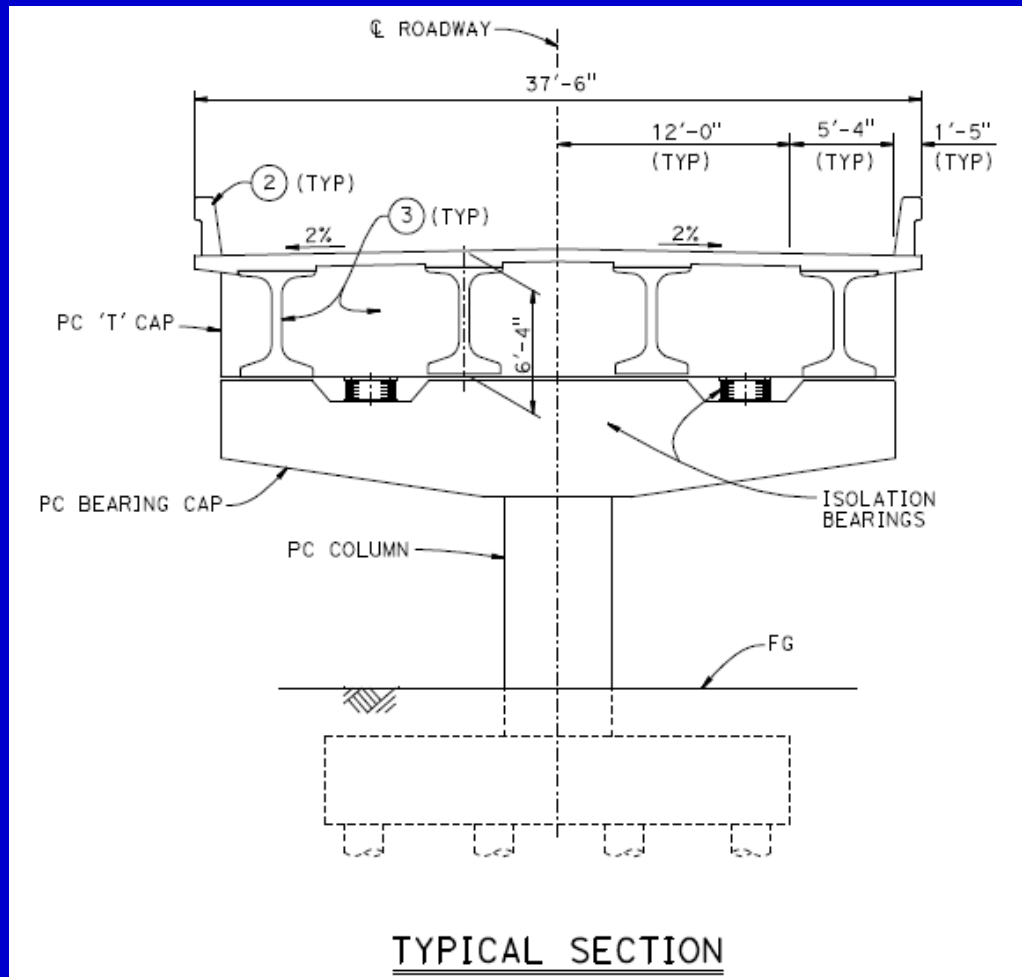


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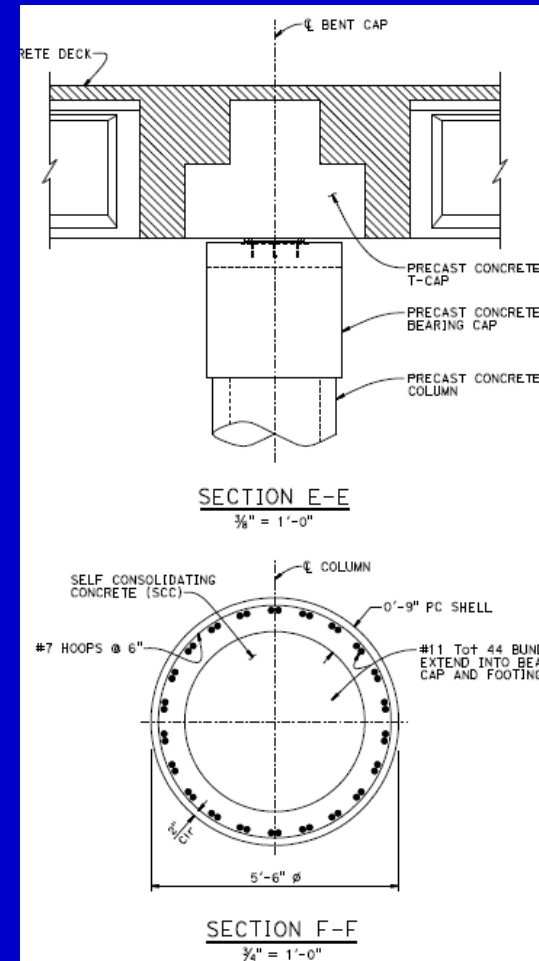
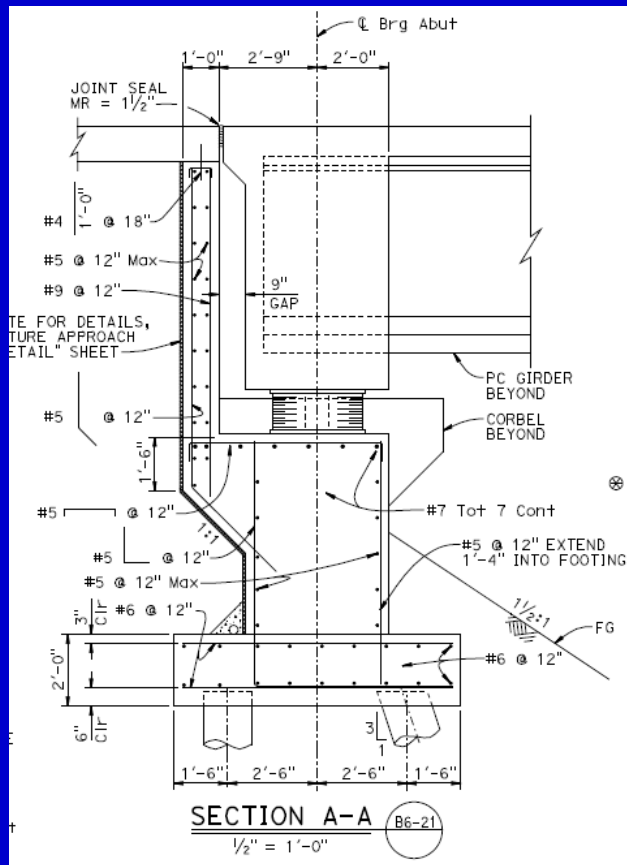
# Isolated Precast Ordinary Standard Bridge Study



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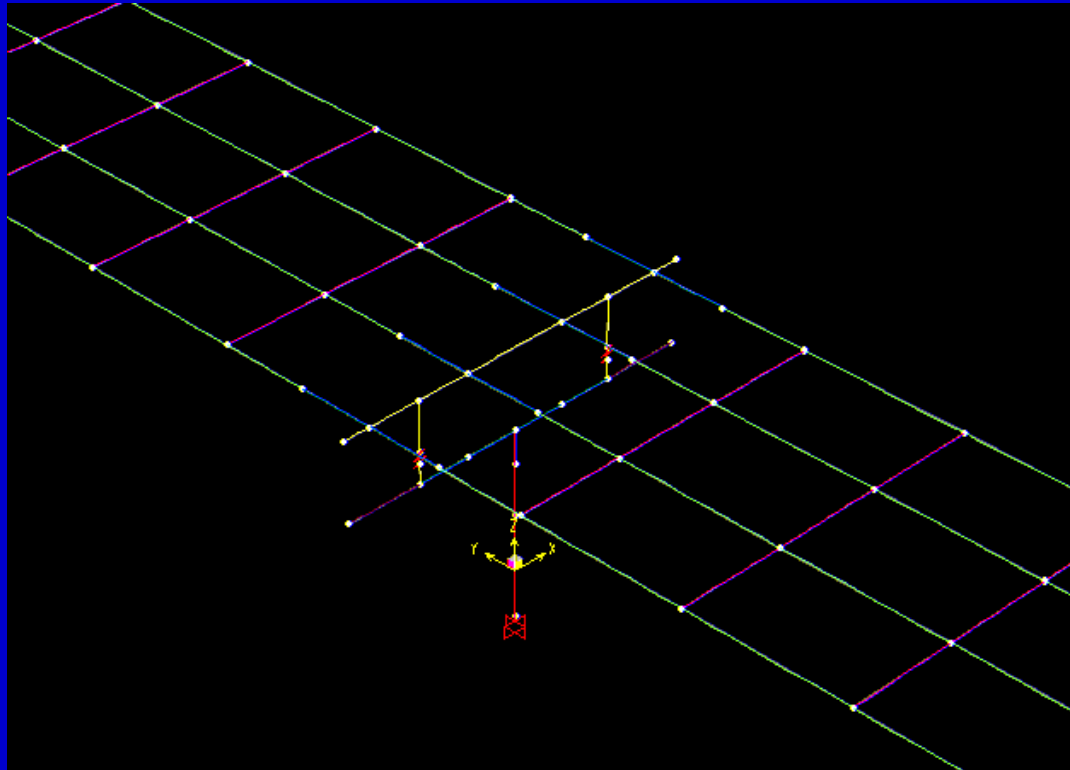


# Isolated Precast Ordinary Standard Bridge Study



# Isolated Precast Ordinary Standard Bridge Study

UC Berkely  
Professor Marios Panagiotou





# *UNR Isolated Bridge Video Clip – October 2011*

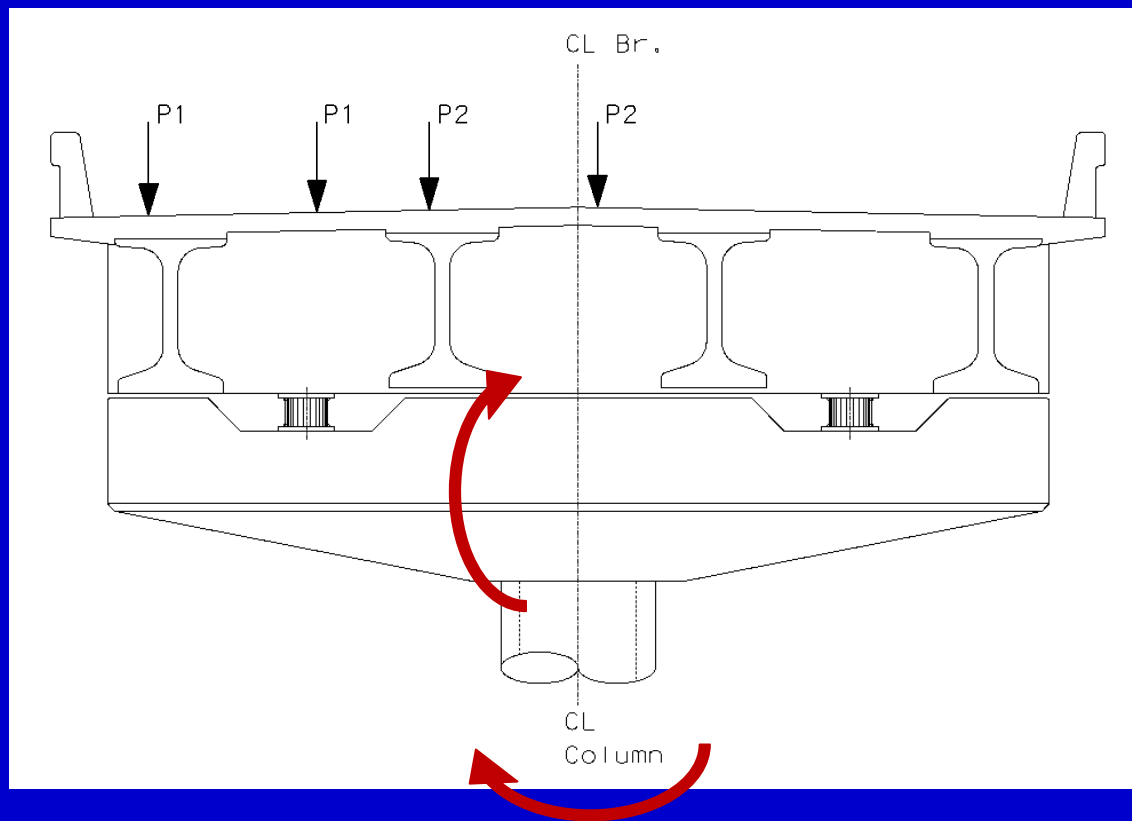


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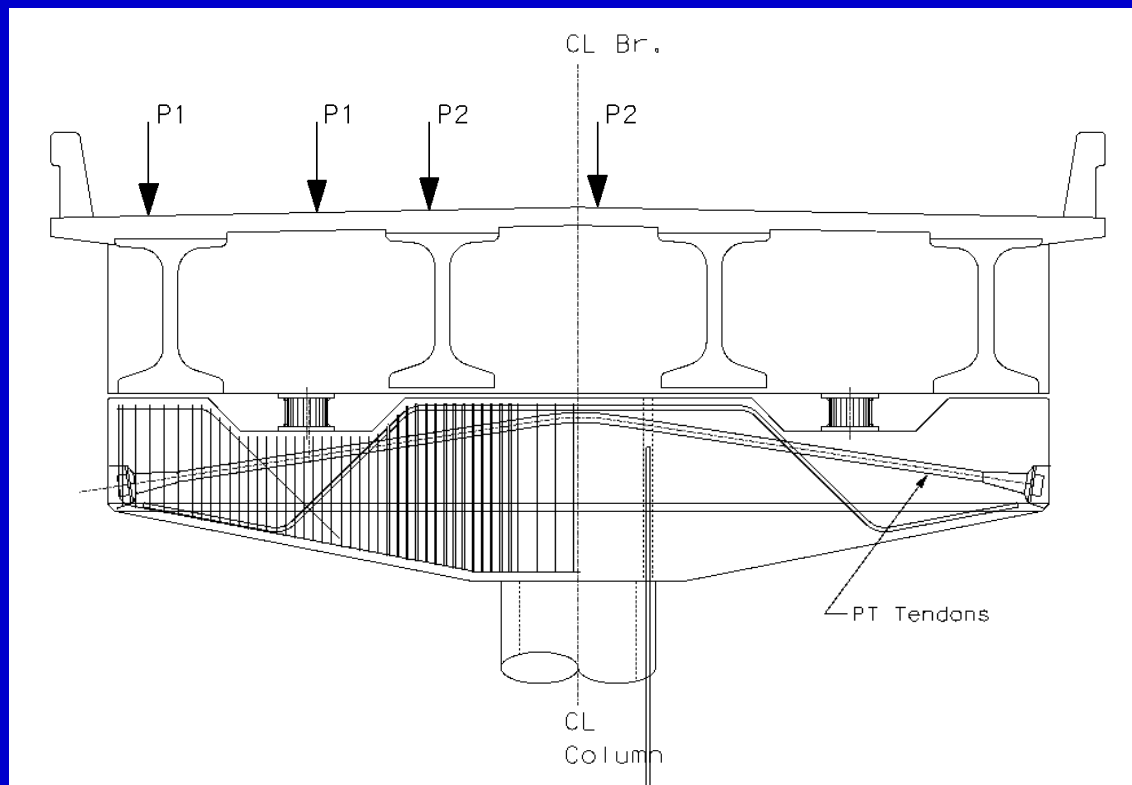
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## *LRFD Service Load Considerations*

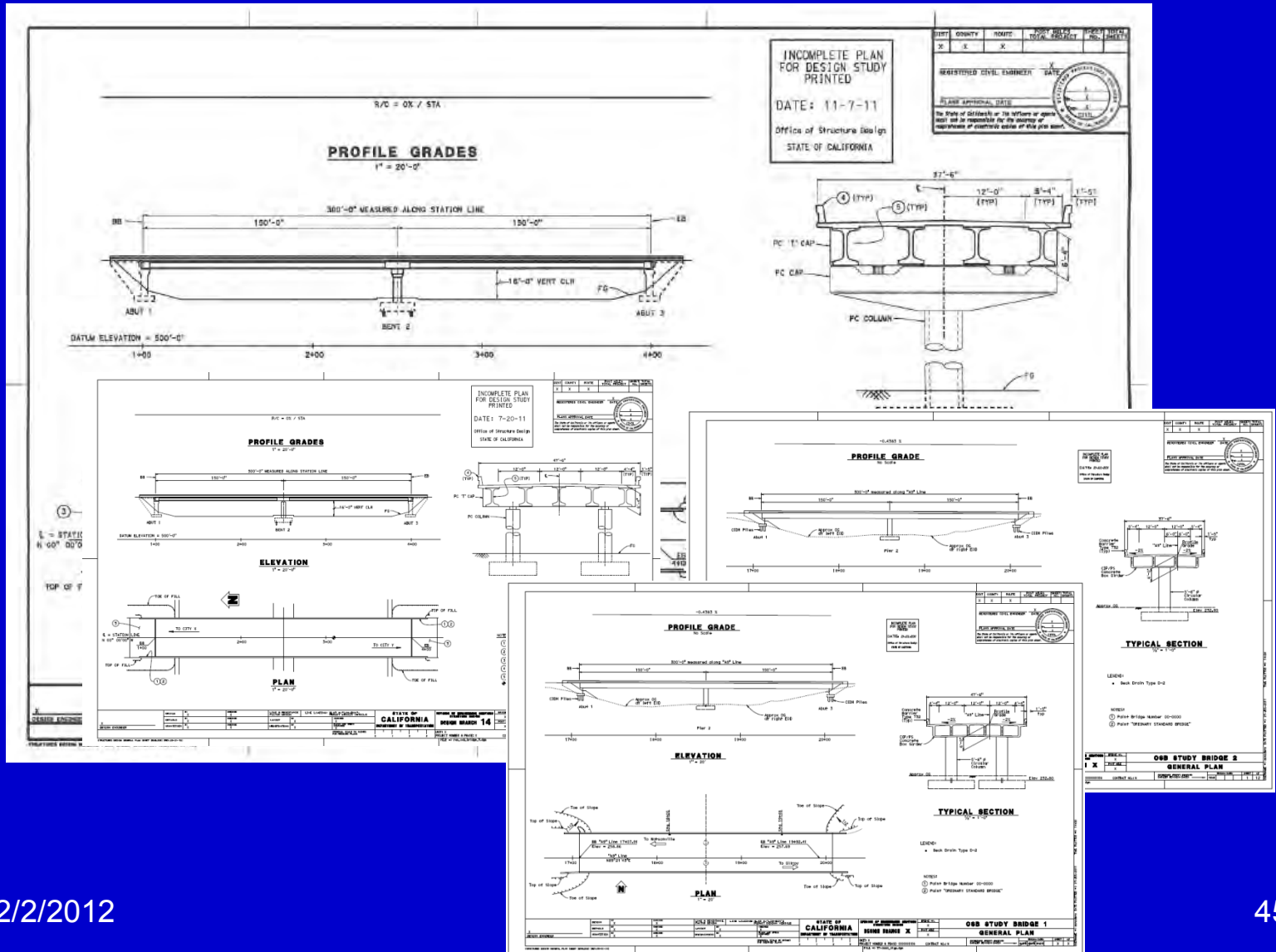


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## *LRFD Service Load Considerations*



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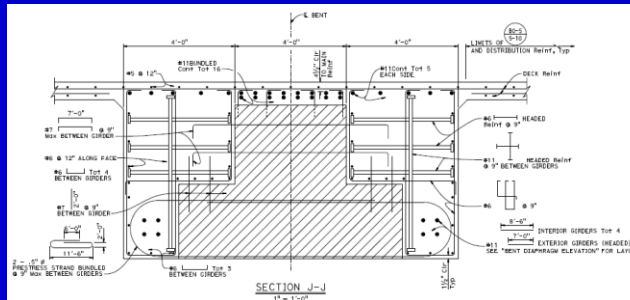
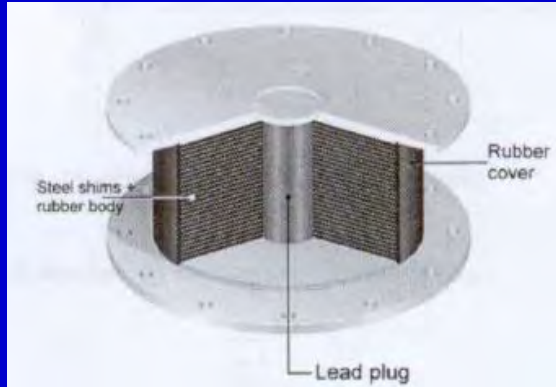


*“A scientific theory should be as simple  
as possible, but no simpler.”*

*A. Einstein*



# Caltrans Research



## RESEARCH NOTES

THE EARTHQUAKE ENGINEERING GROUP

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