PCMAC Workshop
Sacramento, California
November, 2011

Disclaimer: The opinions presented here are those of the presenter and do not necessarily reflect Caltrans' official policy.

PCMAC Workshop
Sacramento, California
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Caltrans Research
Seismic Connections in Prefabricated Substructures

Presented By: Ron Bromenschenkel, PE

NGB	**Next Generation Bridge**	**UNR**
CFT	**Concrete Filled Tube**	**UW**
ISO	**Isolated PC bridge**	**UCB**

Caltrans Research
Seismic Connections in Prefabricated Substructures

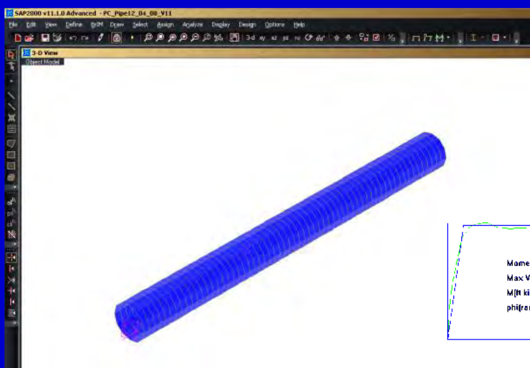
NGB	Next Generation Bridge	UNR

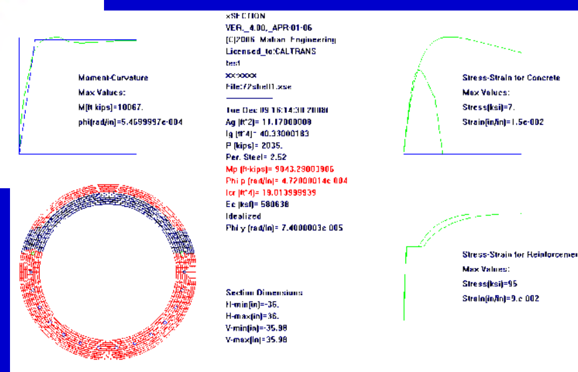
Caltrans Research

Seismic Connections in Prefabricated Substructures

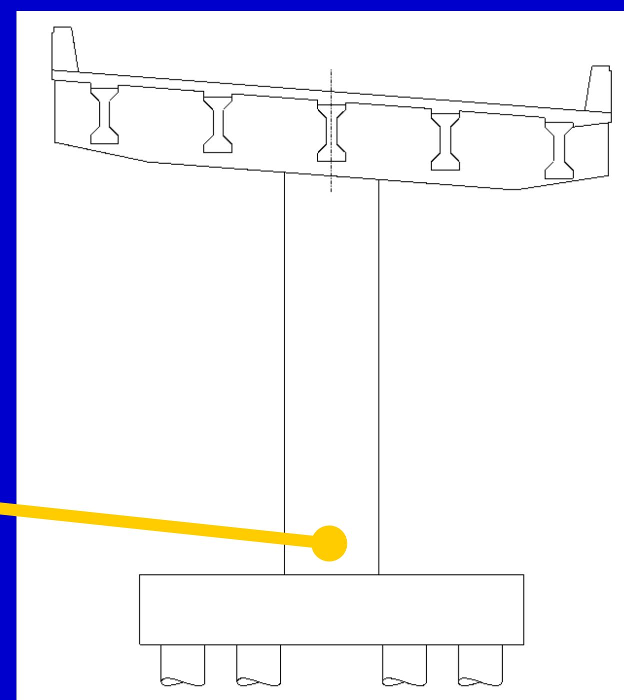
Next Generation Bridges

Initial Focus: Precast elements - *columns*



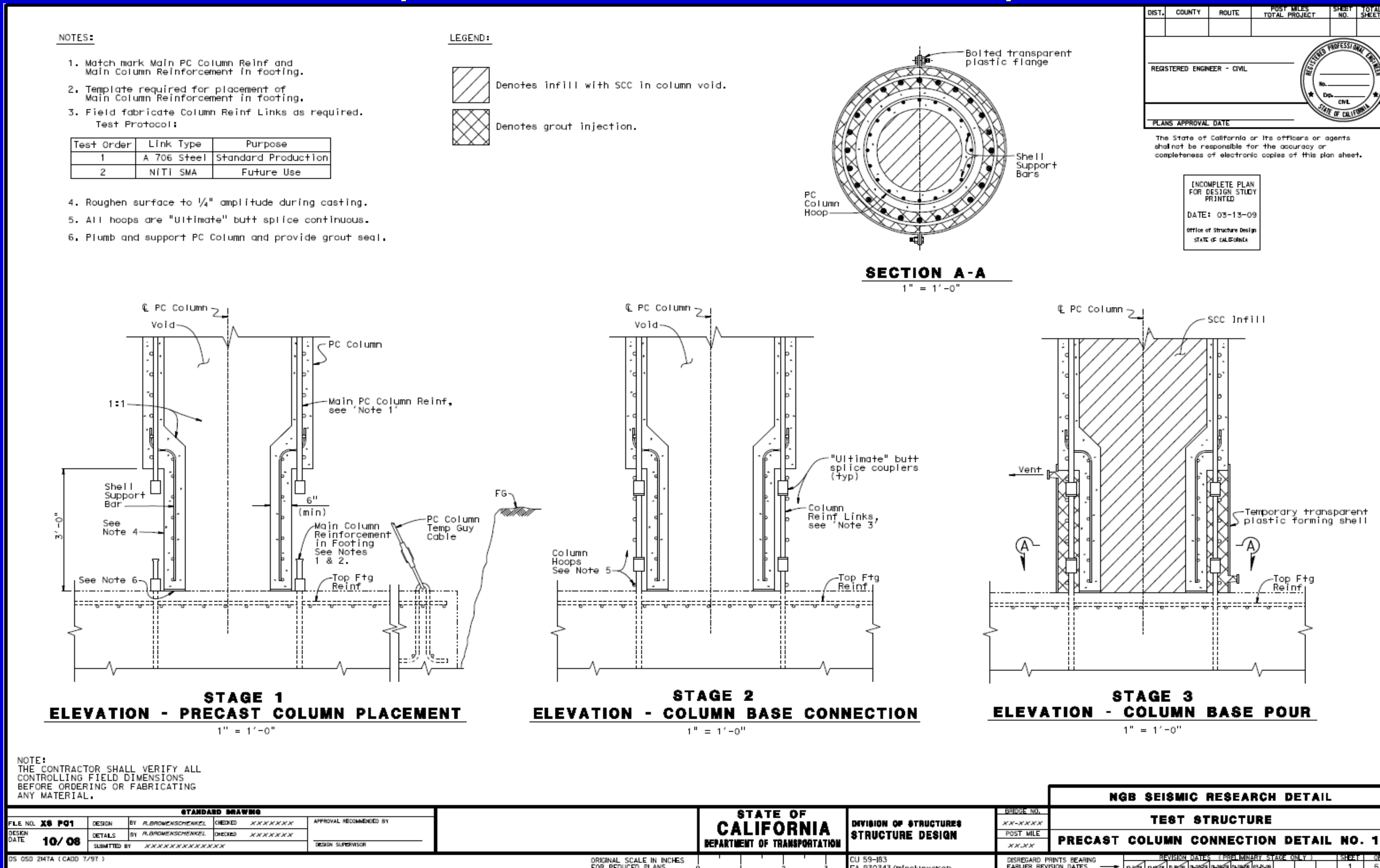


Plastic Hinge Zone



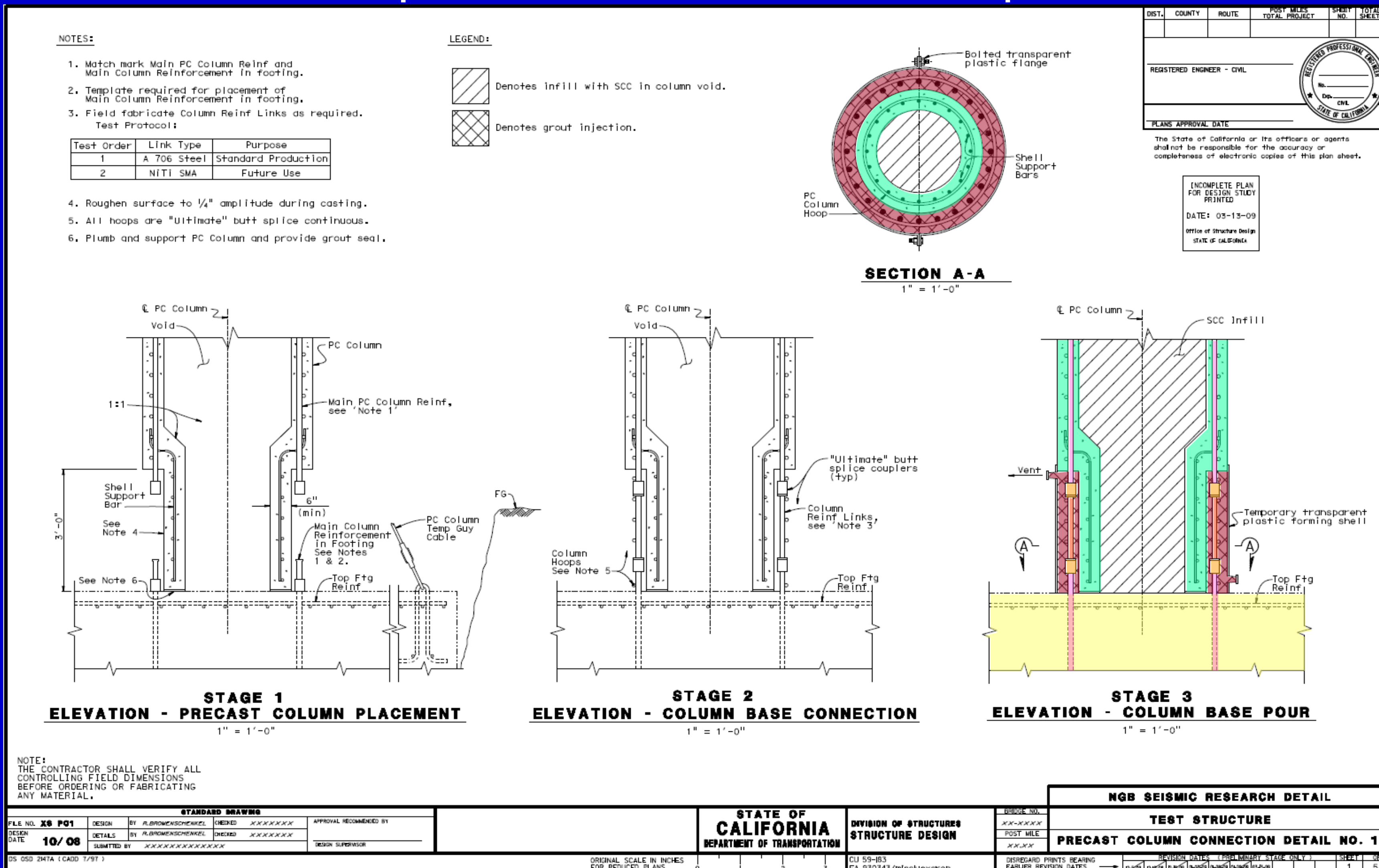
Next Generation Bridges

Proposed Construction Concepts

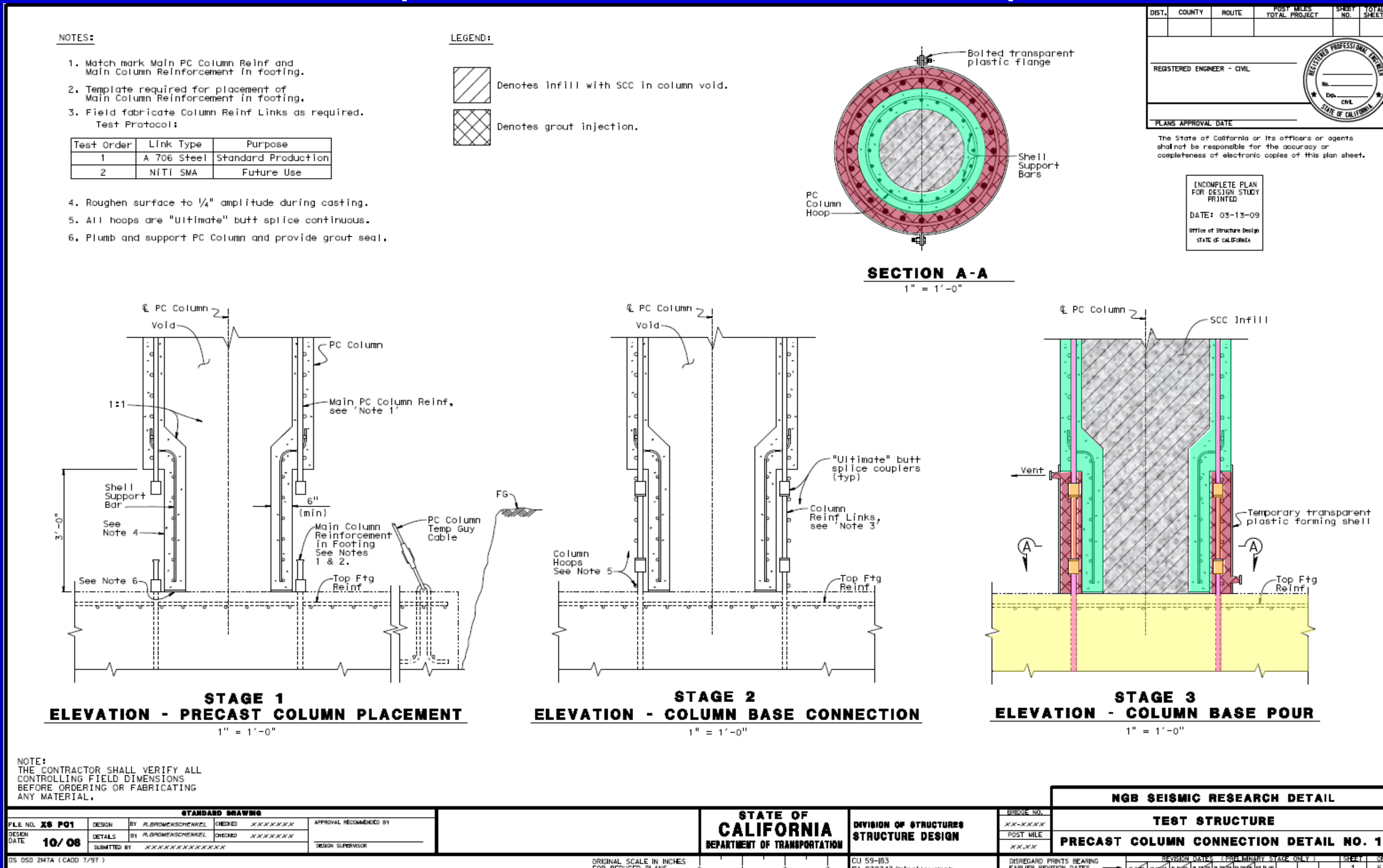


Next Generation Bridges

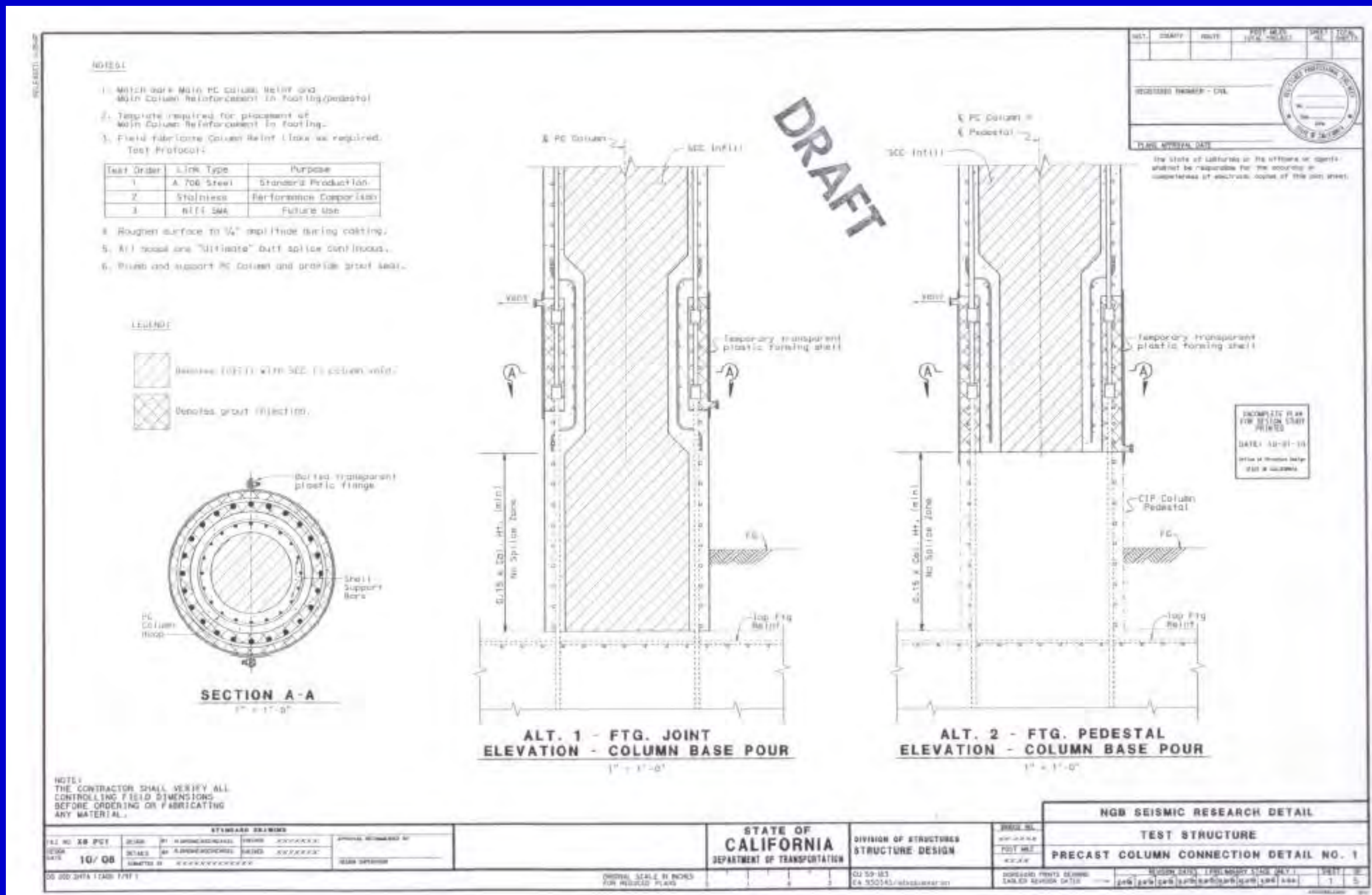
Proposed Construction Concepts



Next Generation Bridges
Proposed Construction Concepts

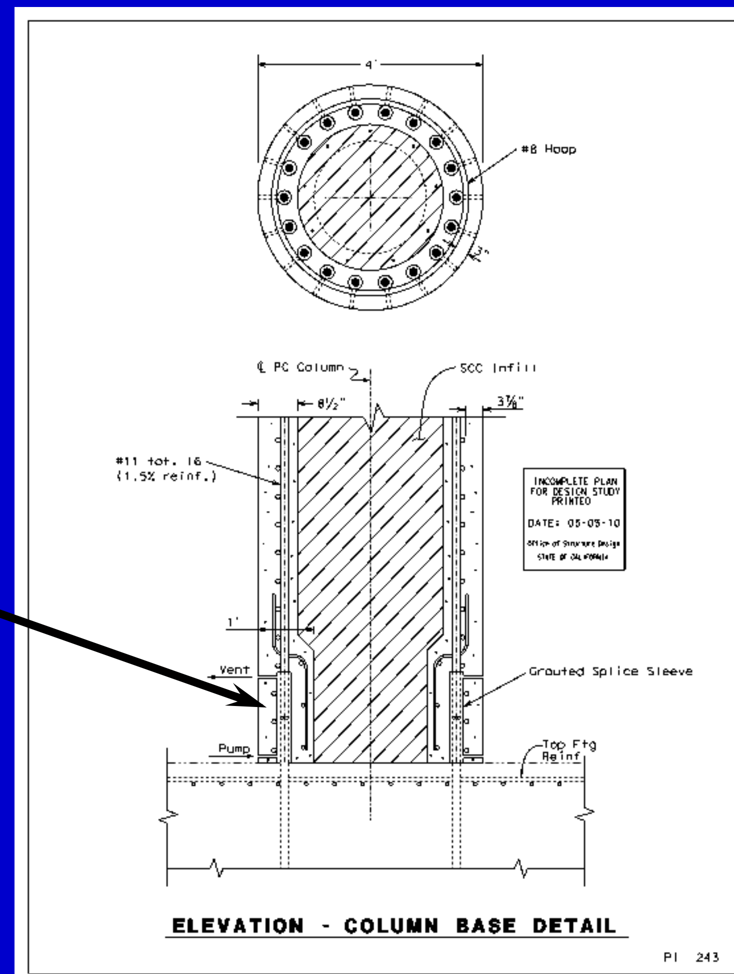


Next Generation Bridges
Alternative Configurations



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 17th 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

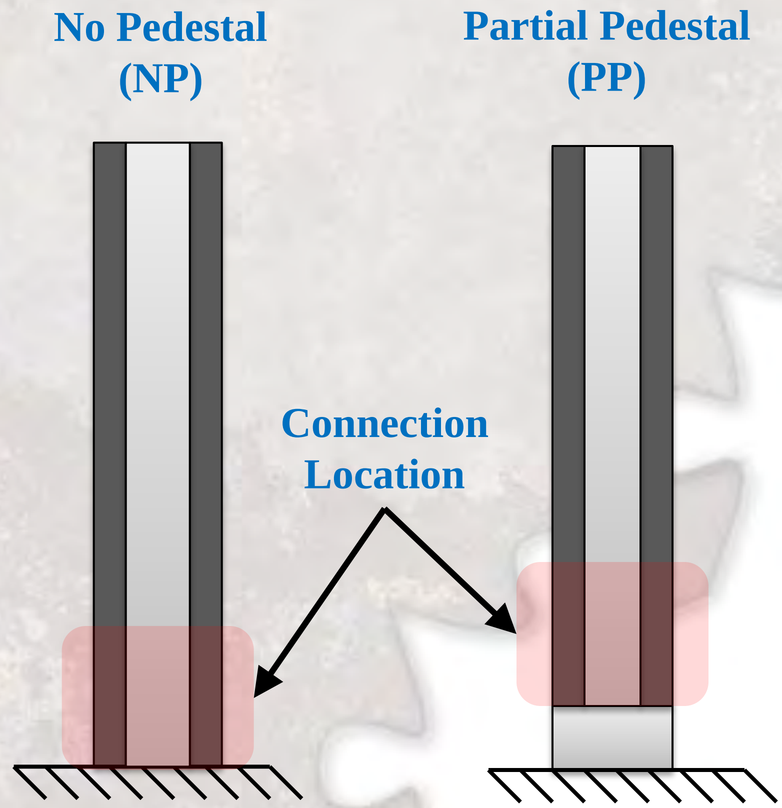
Grouted Sleeve Coupler (GC)

SERVICE COUPLER

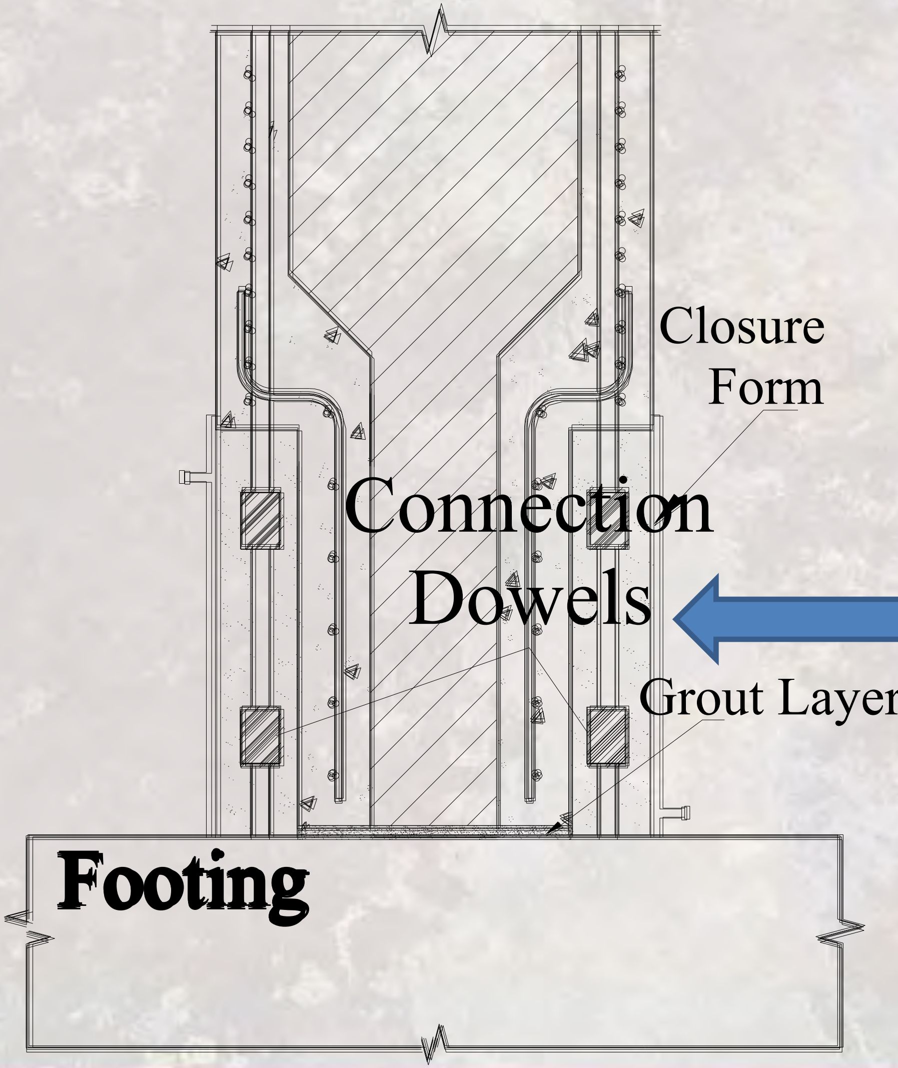
Bridging Theory & Practice

Half-scale Column Models

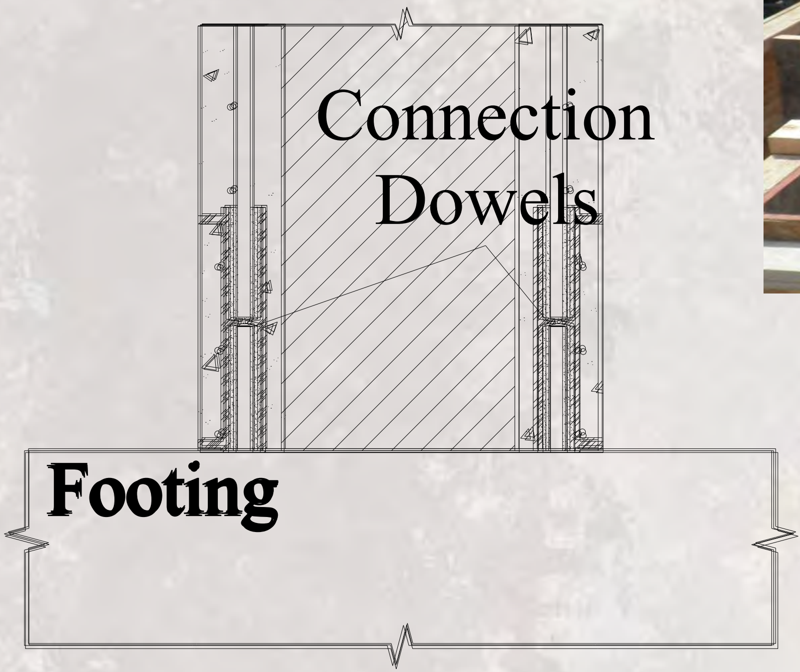
- Caltrans Seismic Design Criteria (Disp. Ductility ≥ 5)
- Design Details
  - 9ft Tall & 2ft Diameter
  - 11 #8 Longitudinal Steel (1.9%)
  - #3 Spiral @ 2in Pitch
  - Axial Load = 226kip ($0.1f'_c A_g$)
- Precast Hollow Shell Deign
- Use of Partial Pedestal



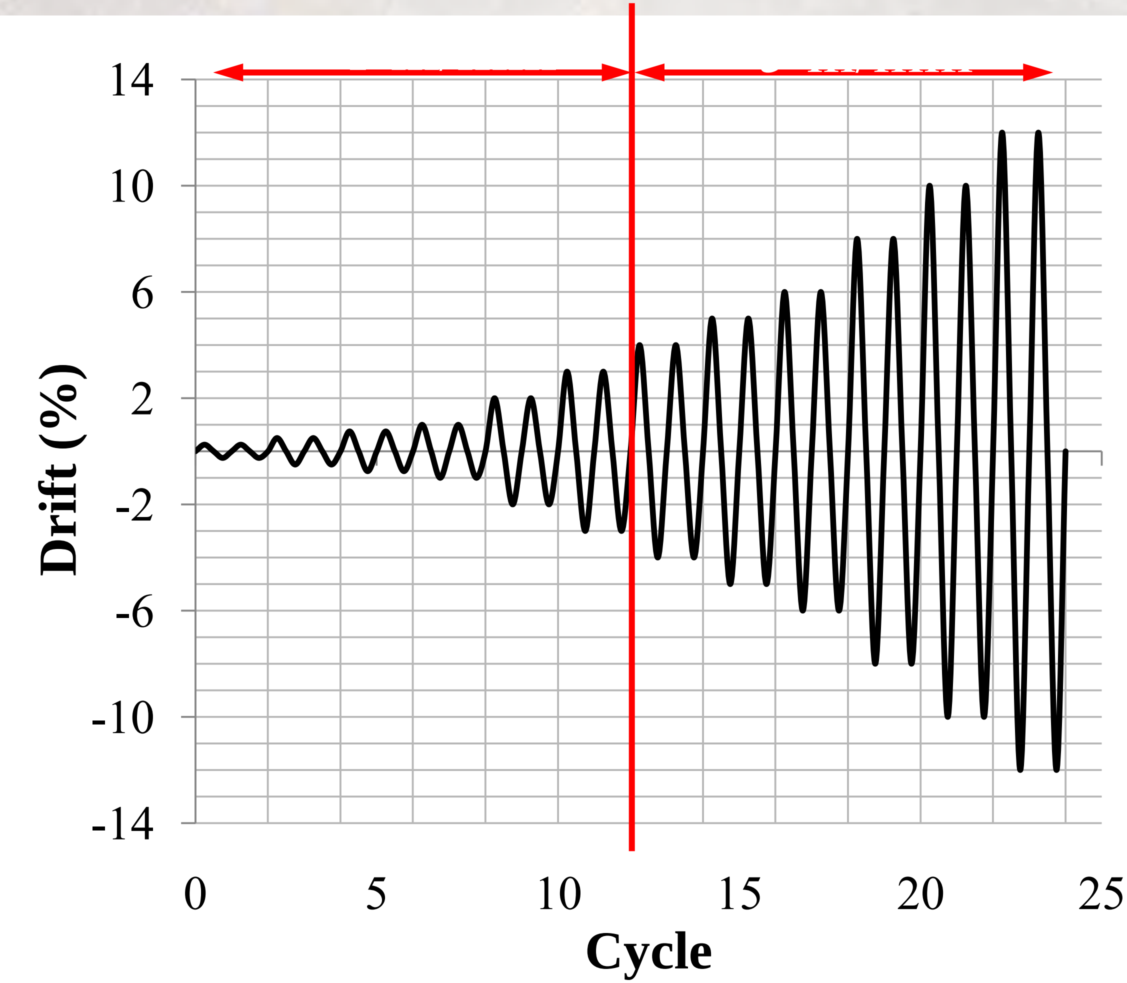
Connection Details – HC Models



Connection Details – GC Models



Experimental Testing



Observations – Accumulated Damage at Failure

CIP
(2nd Cycle -10% Drift)

HCNP
(2nd Cycle -10% Drift)

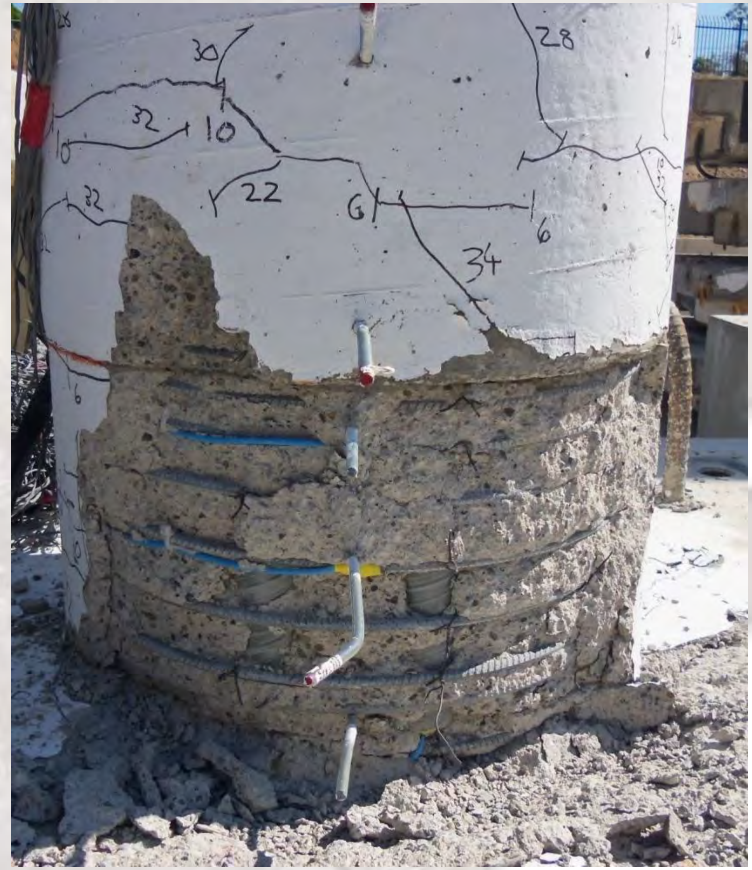
HCPP
(1nd Cycle -10% Drift)

Bridging Theory & Practice

Observations – Accumulated Damage at Failure

GCNP

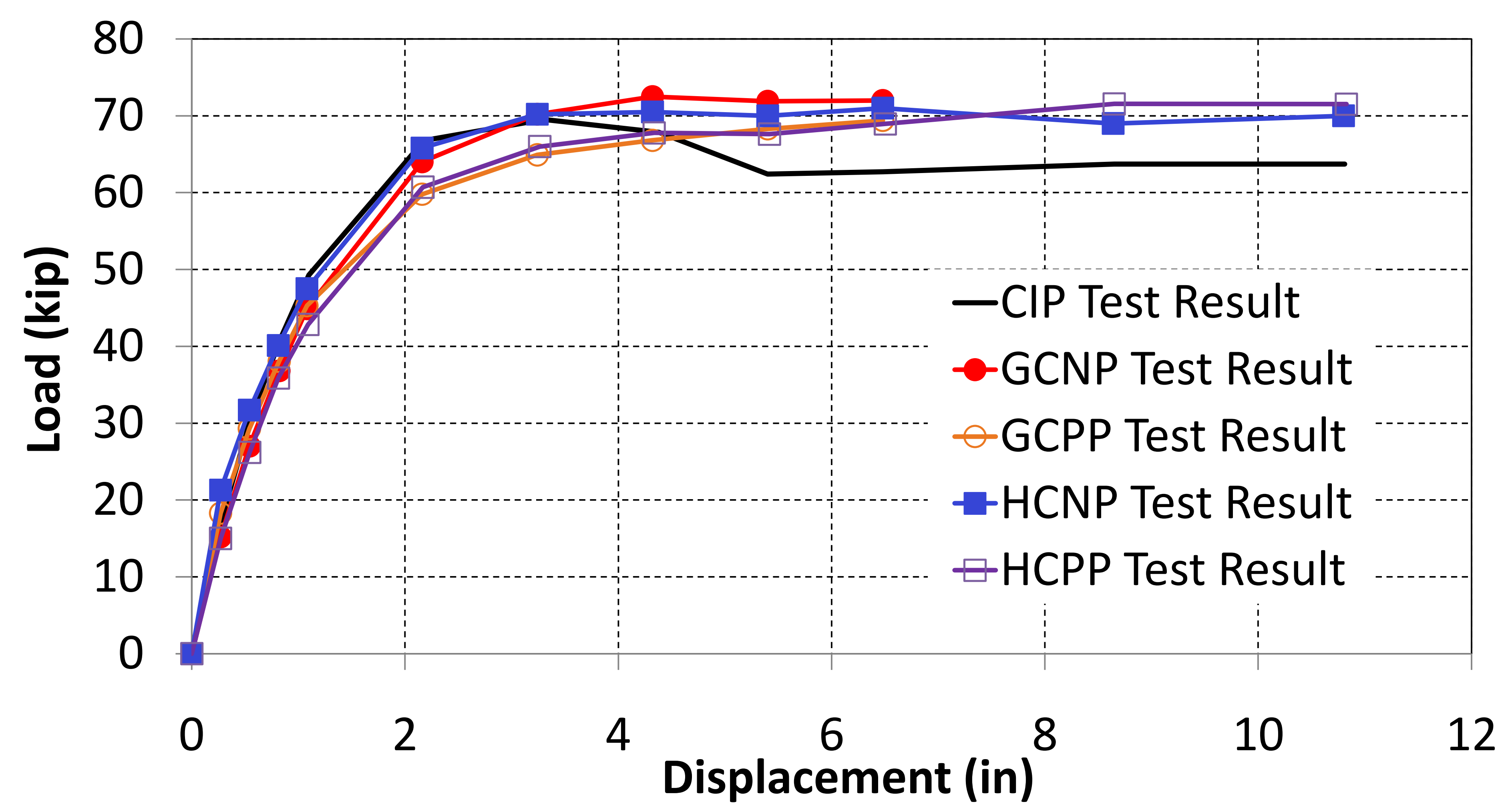
(2nd Cycle -6% Drift)



GCPP

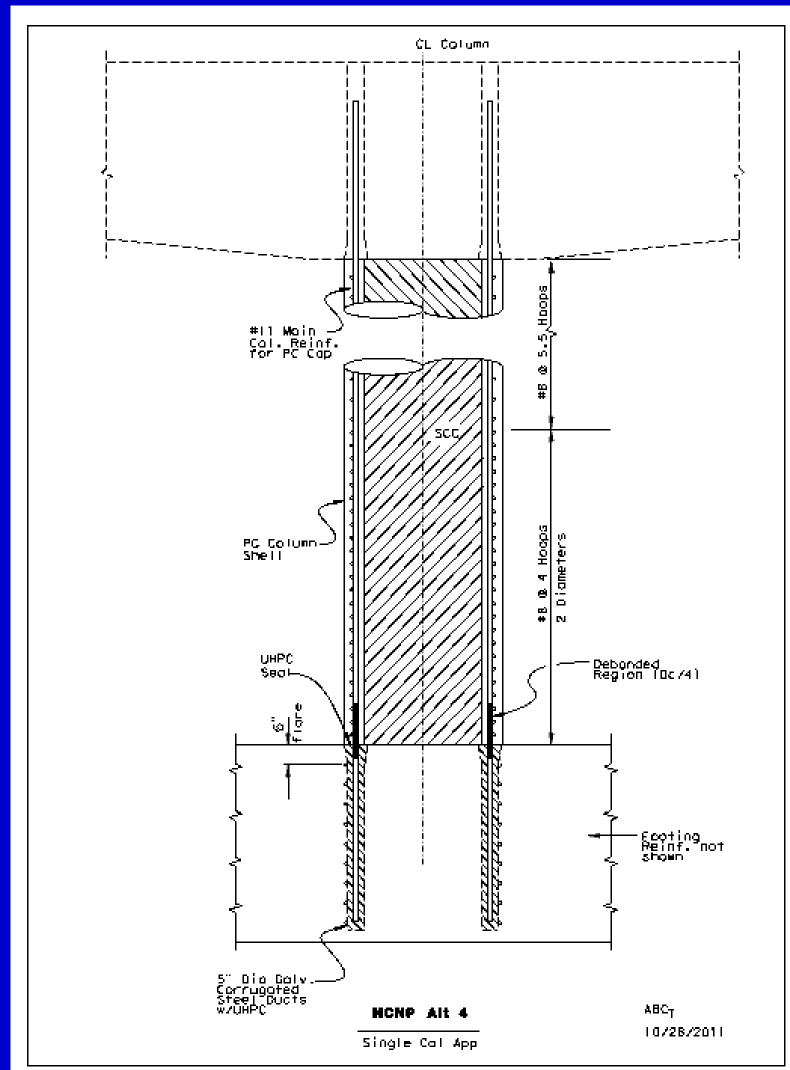
(1nd Cycle -6% Drift)

Results - Pushover Curves



Next Generation Bridges

Alternative Configurations



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Caltrans Research
Seismic Connections in Prefabricated Substructures

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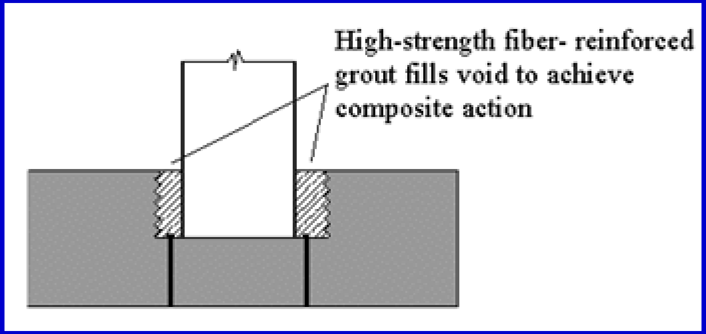
Caltrans Research

Seismic Connections in Prefabricated Substructures

Concurrent Research

University of Washington

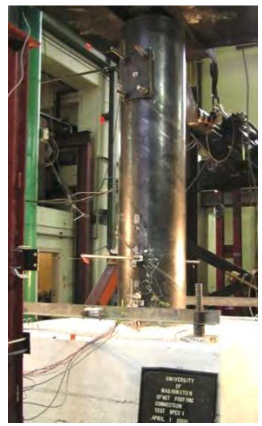
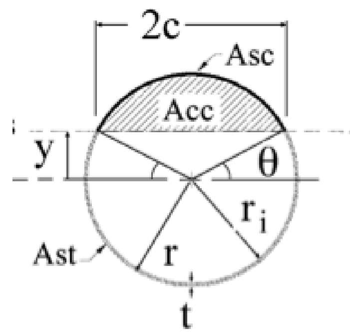
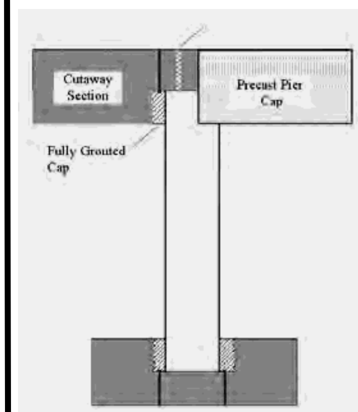
CFT connection tests



Rapid Construction of Bridge Piers with Concrete Filled Tubes

Dawn Lehman and Charles Roeder
University of Washington

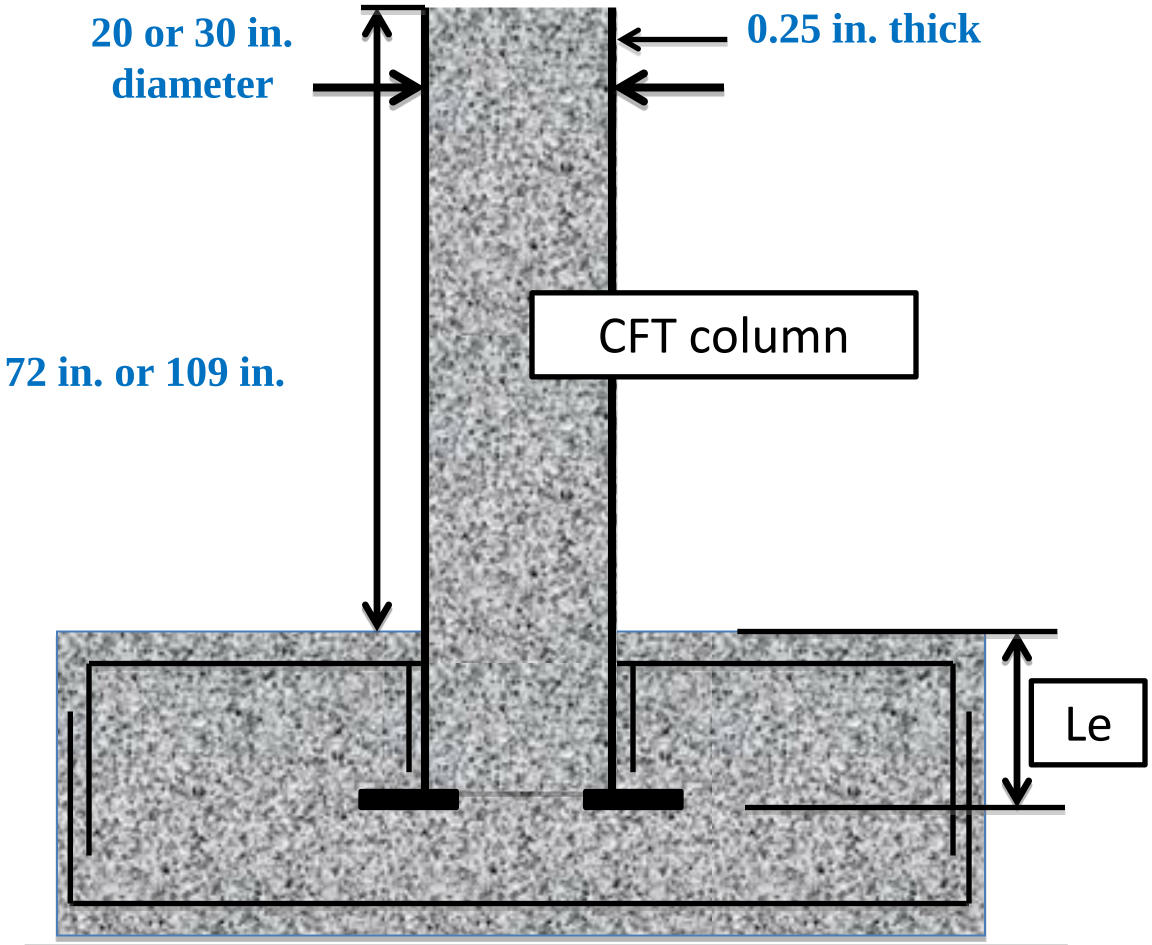
Collaborative Research Program

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



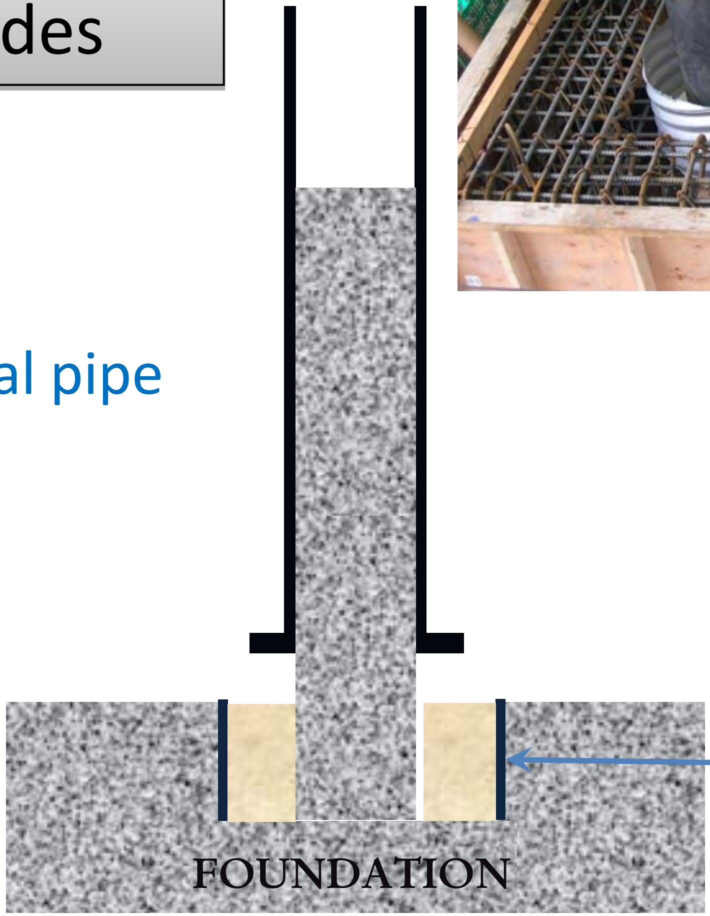
Note: Vertical Reinforcement not shown

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

Design of Isolated Connection

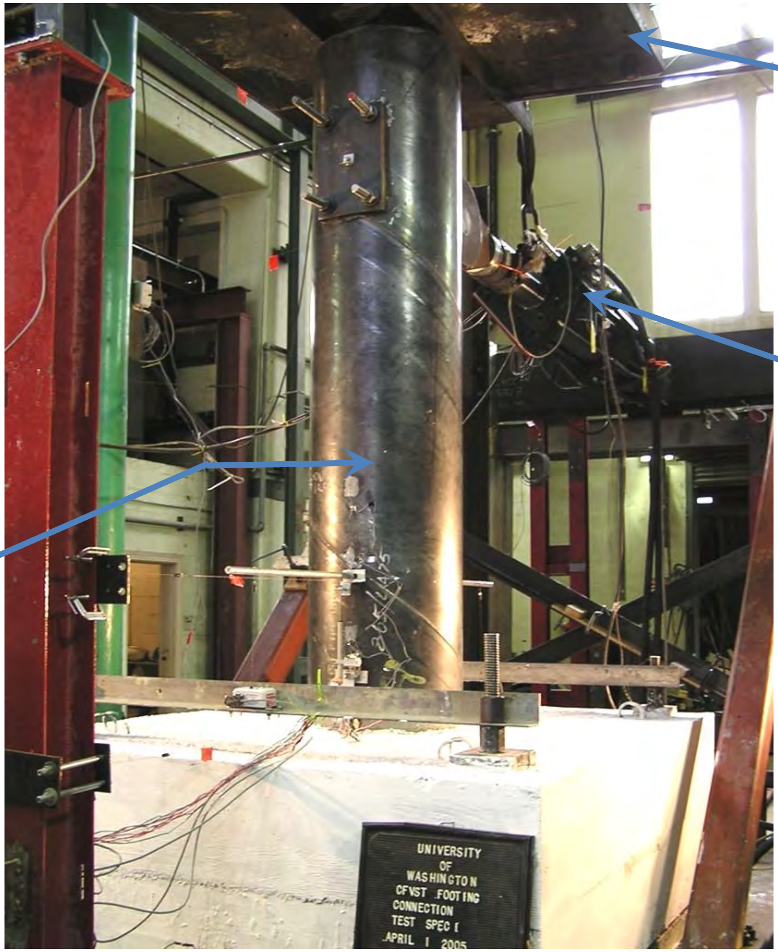
Isolation of Structural and Reinforcing Steel Trades

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



Test Configuration

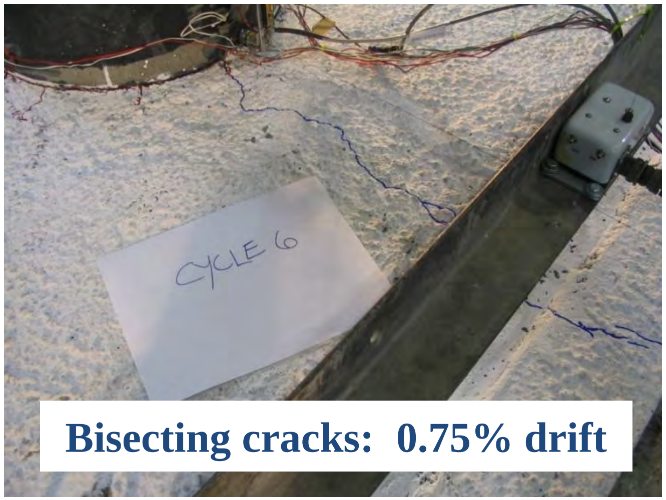
Test Specimen



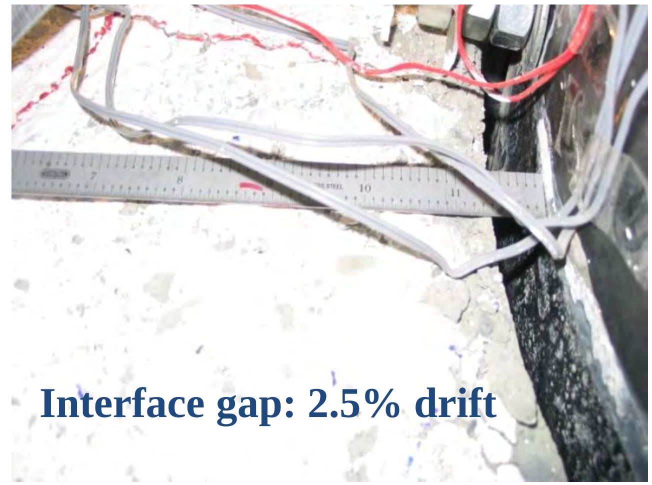
Constant axial load
($10\%P_0$)

Cyclic Lateral Load

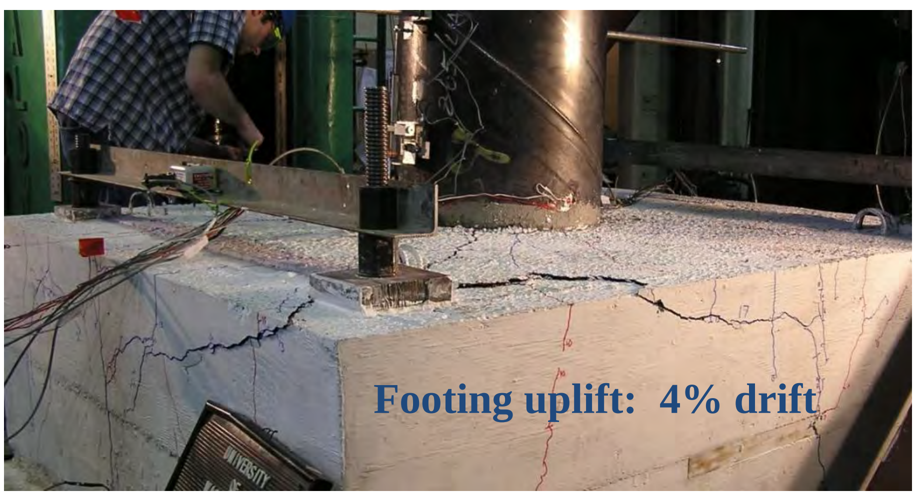
Behavior if Embedment is Too Small



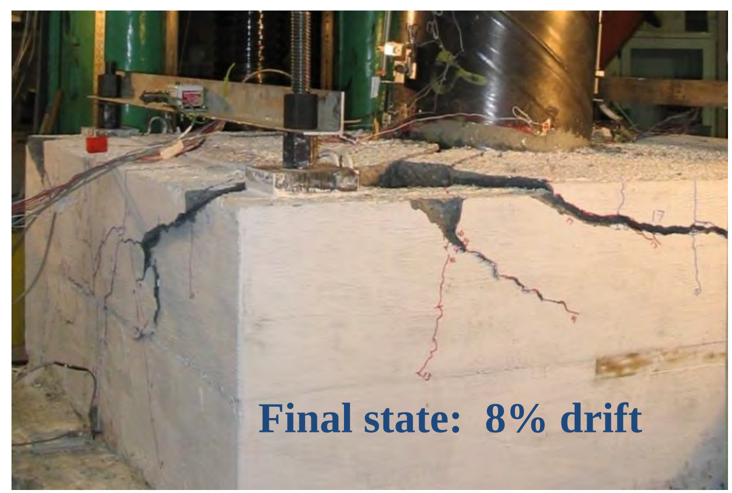
Bisecting cracks: 0.75% drift



Interface gap: 2.5% drift



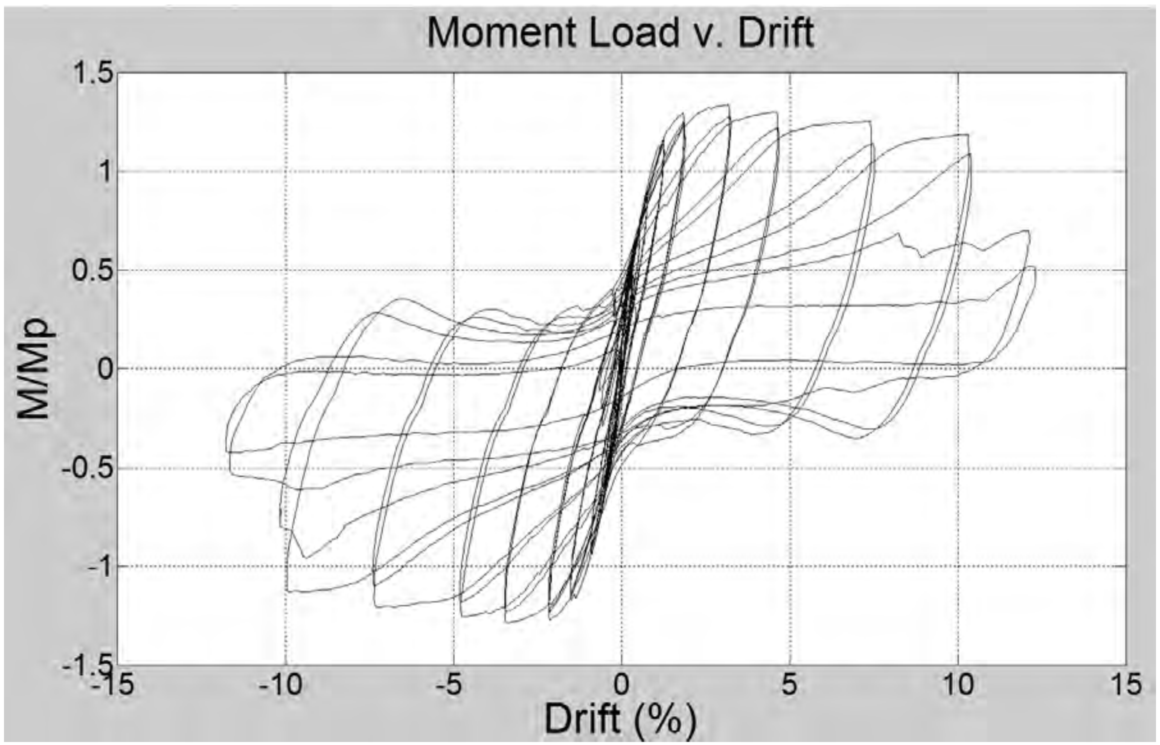
Footing uplift: 4% drift



Final state: 8% drift

CIVIL & ENVIRONMENTAL ENGINEERING
UNIVERSITY of WASHINGTON

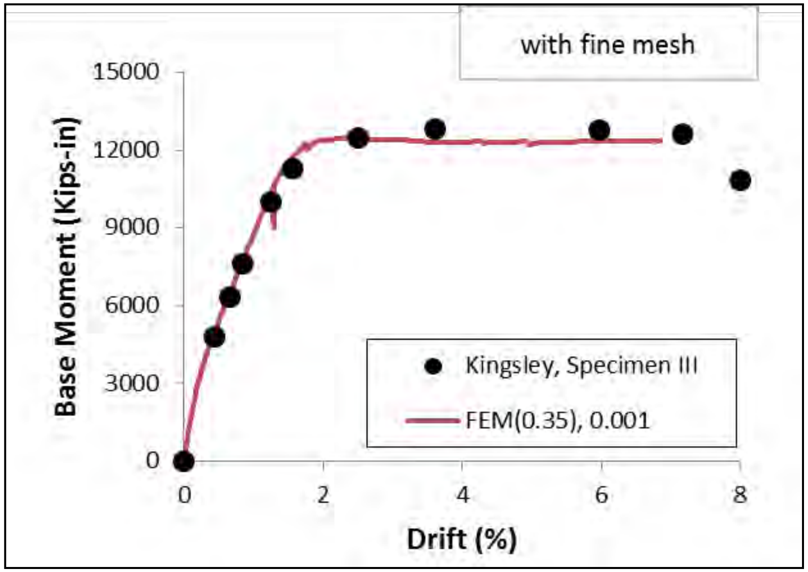
Behavior of Specimen with Sufficient Embedment

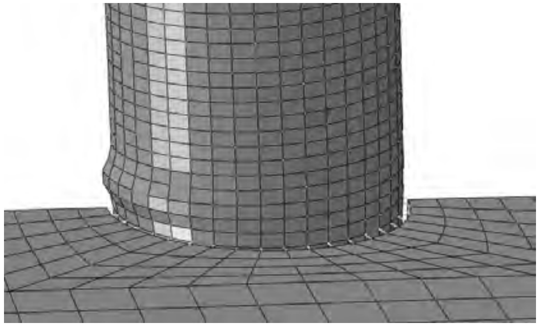


Finite Element Study

Nonlinear FE Analysis Study to Extend Testing.

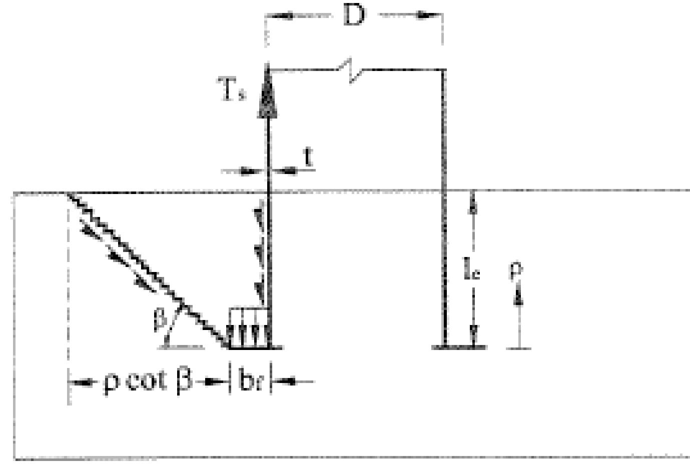
- Capable of simulating global response and local deformations.
- Gap elements to model interface and confinement.
- Solid elements for concrete fill. Shell element used to simulate tube.
- Validated using Caltrans and other large-scale test results.



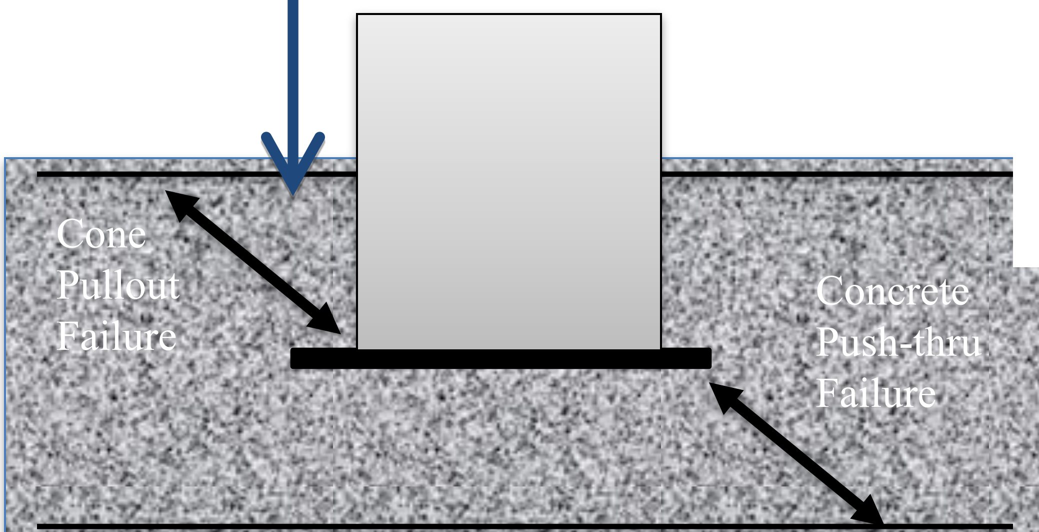


Design Methods

Required Embedment Depth



$$\tau := \frac{r \cdot Fu \cdot t}{\frac{Le^2}{2} + ro \cdot Le} = \frac{D \cdot Fu \cdot t}{Le^2 + Do \cdot Le}$$



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

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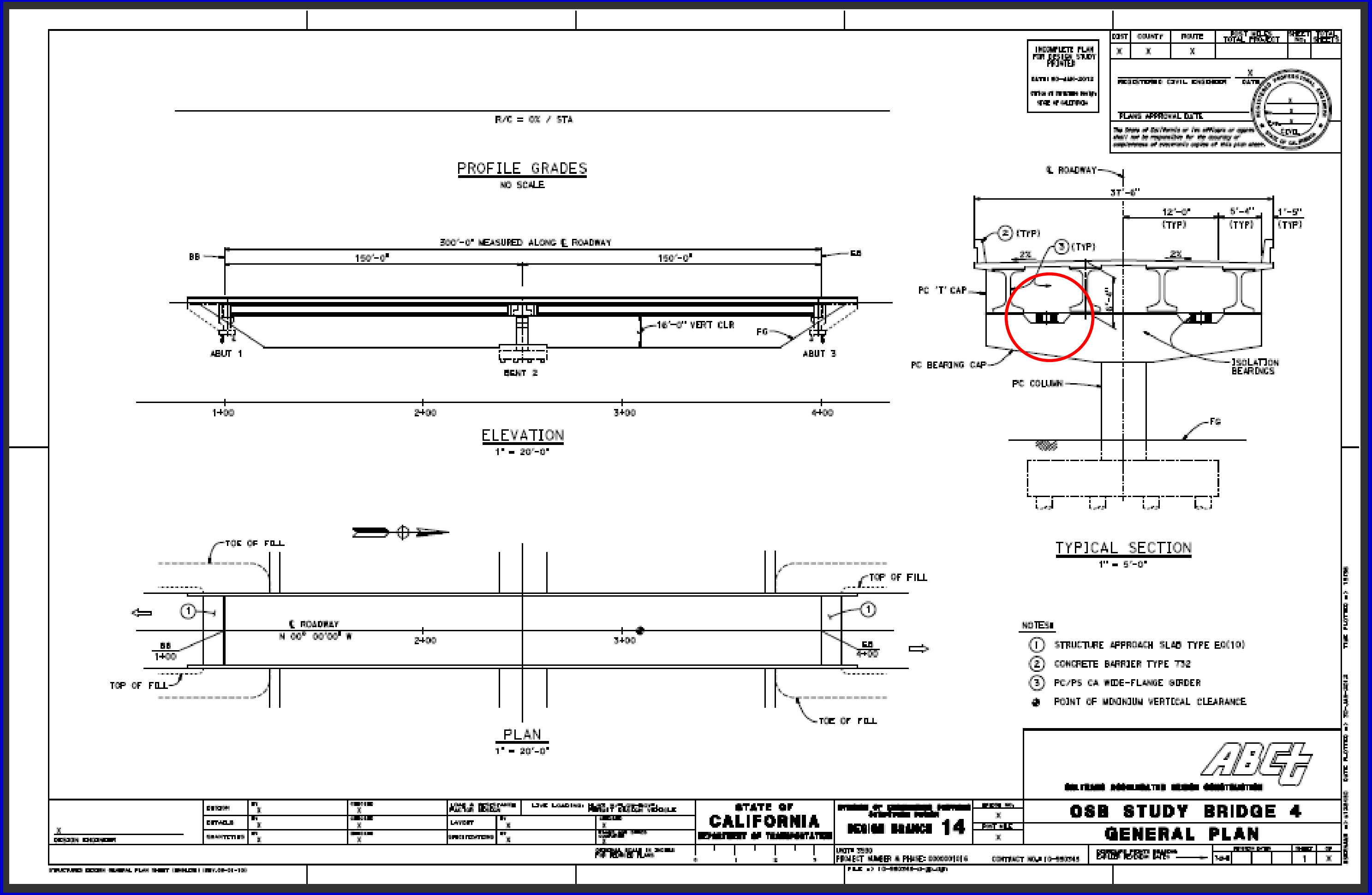
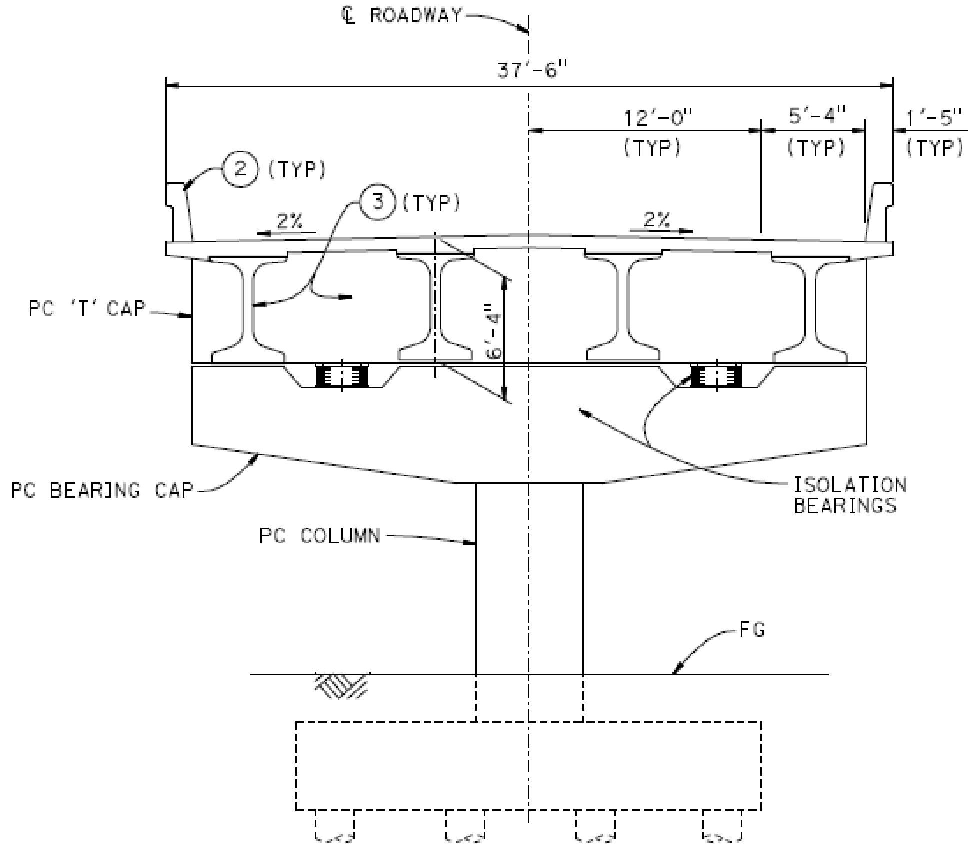
Isolated Precast
Ordinary Standard Bridge Study

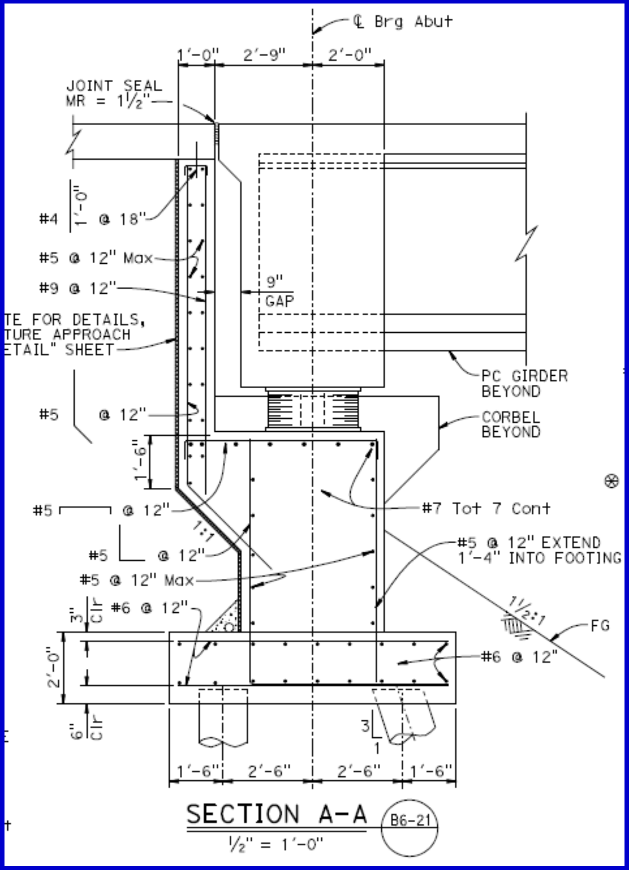


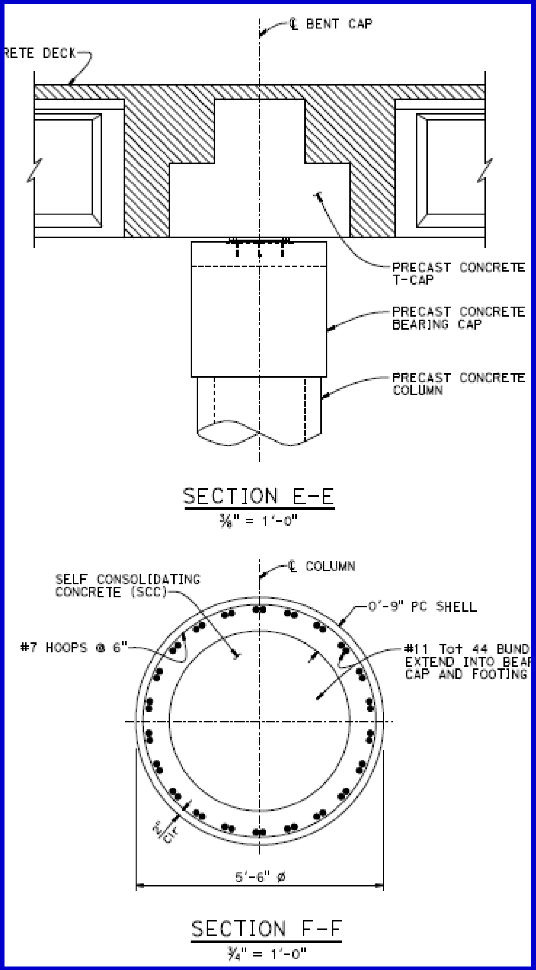
Isolated Precast
Ordinary Standard Bridge Study



TYPICAL SECTION

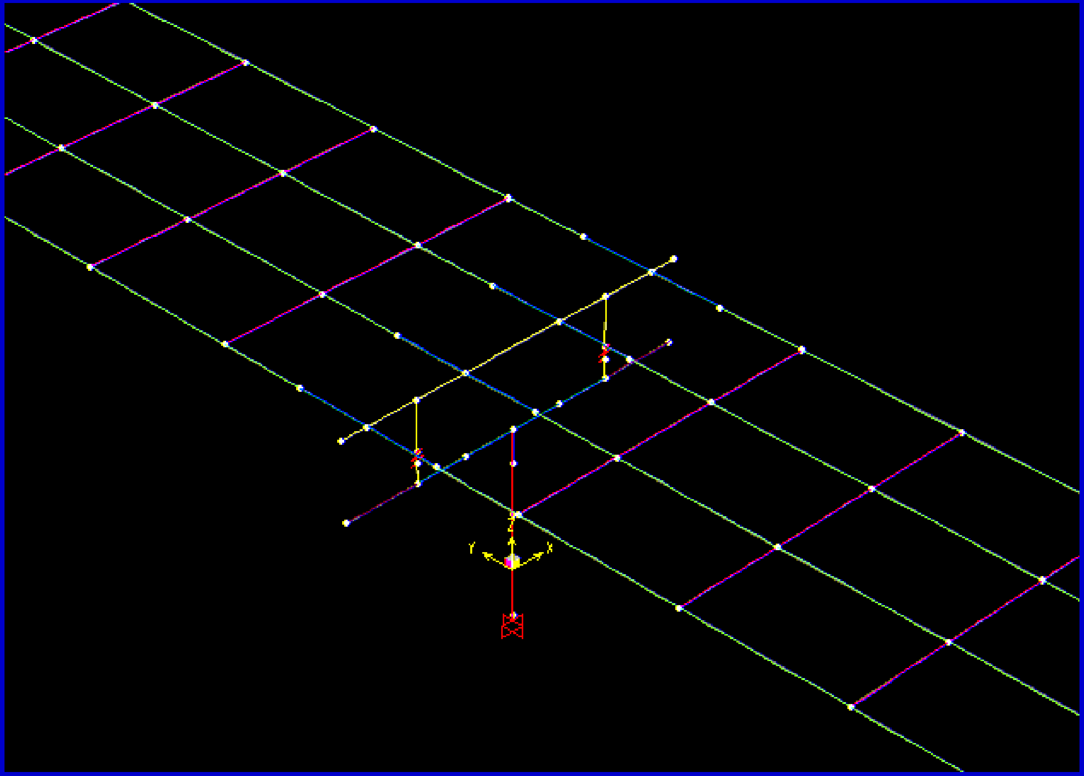
Isolated Precast
Ordinary Standard Bridge Study





Isolated Precast
Ordinary Standard Bridge Study

UC Berkely
Professor Marios Panagiotou

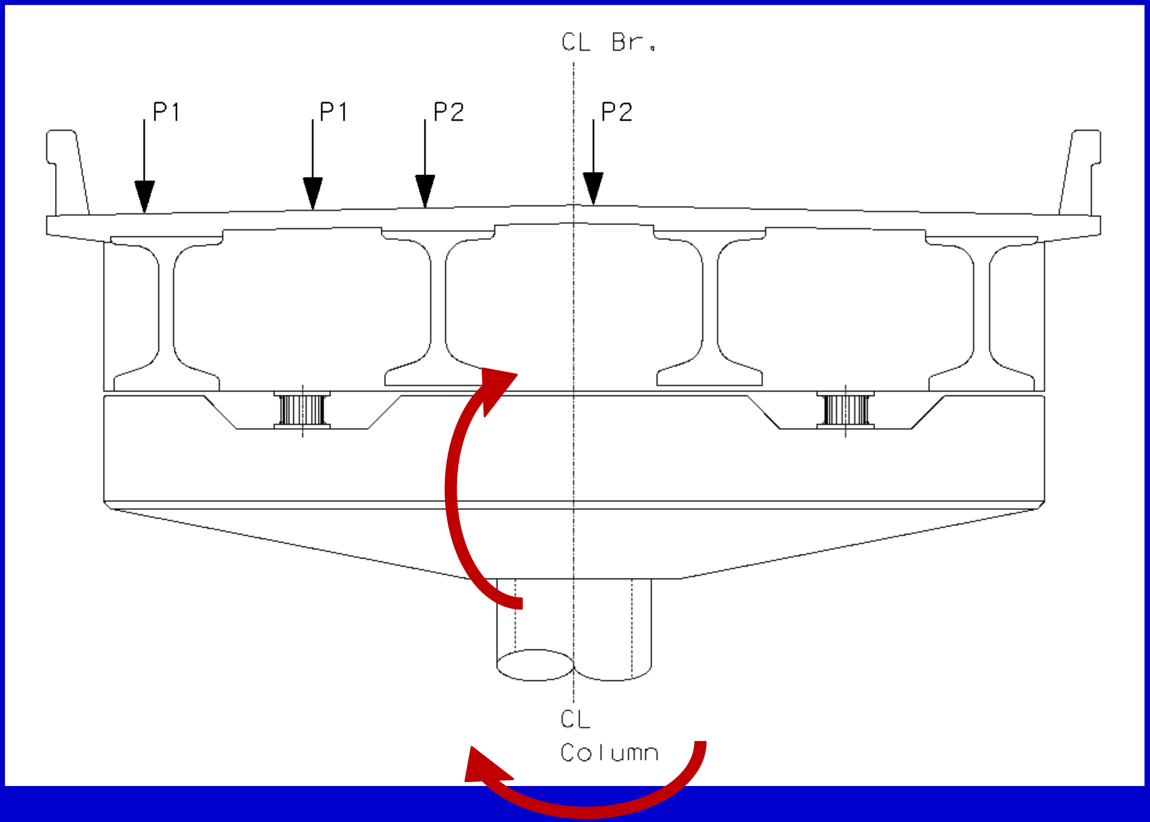


UNR Isolated Bridge
Video Clip – October 2011

Isolated Precast
Ordinary Standard Bridge Study

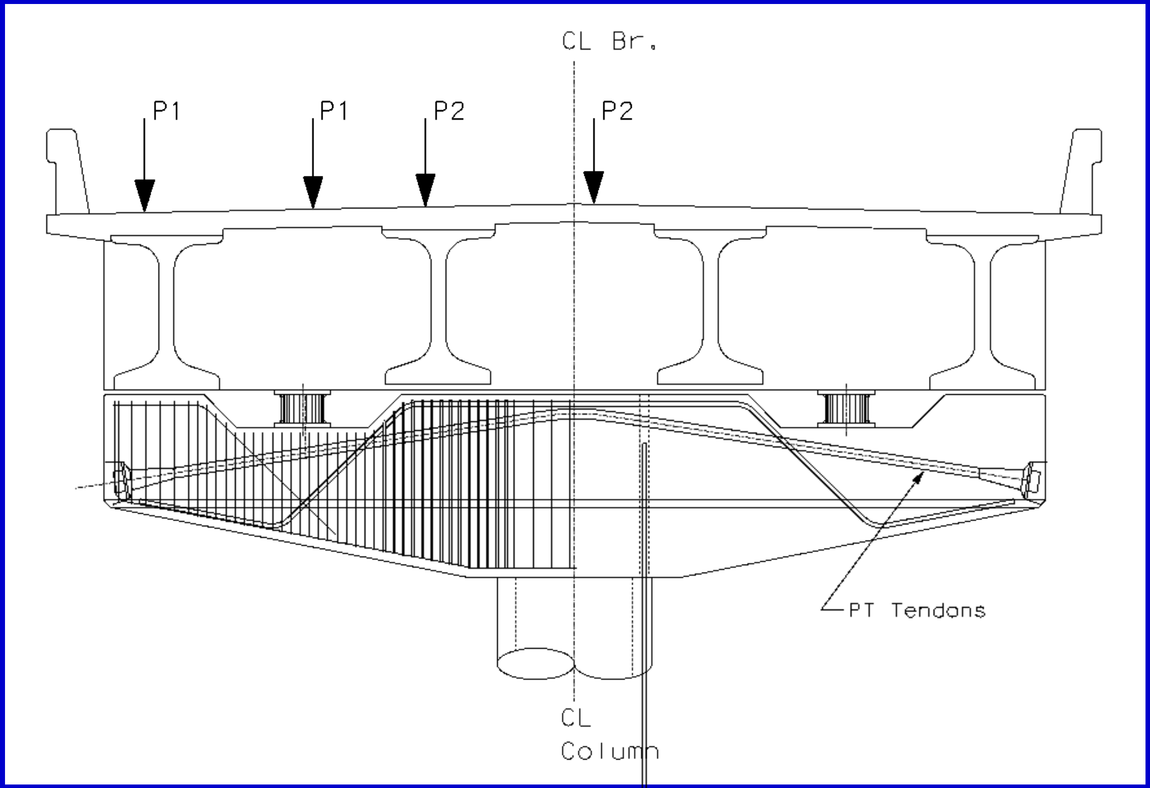
Isolated Precast Ordinary Standard Bridge Study

LRFD Service Load Considerations

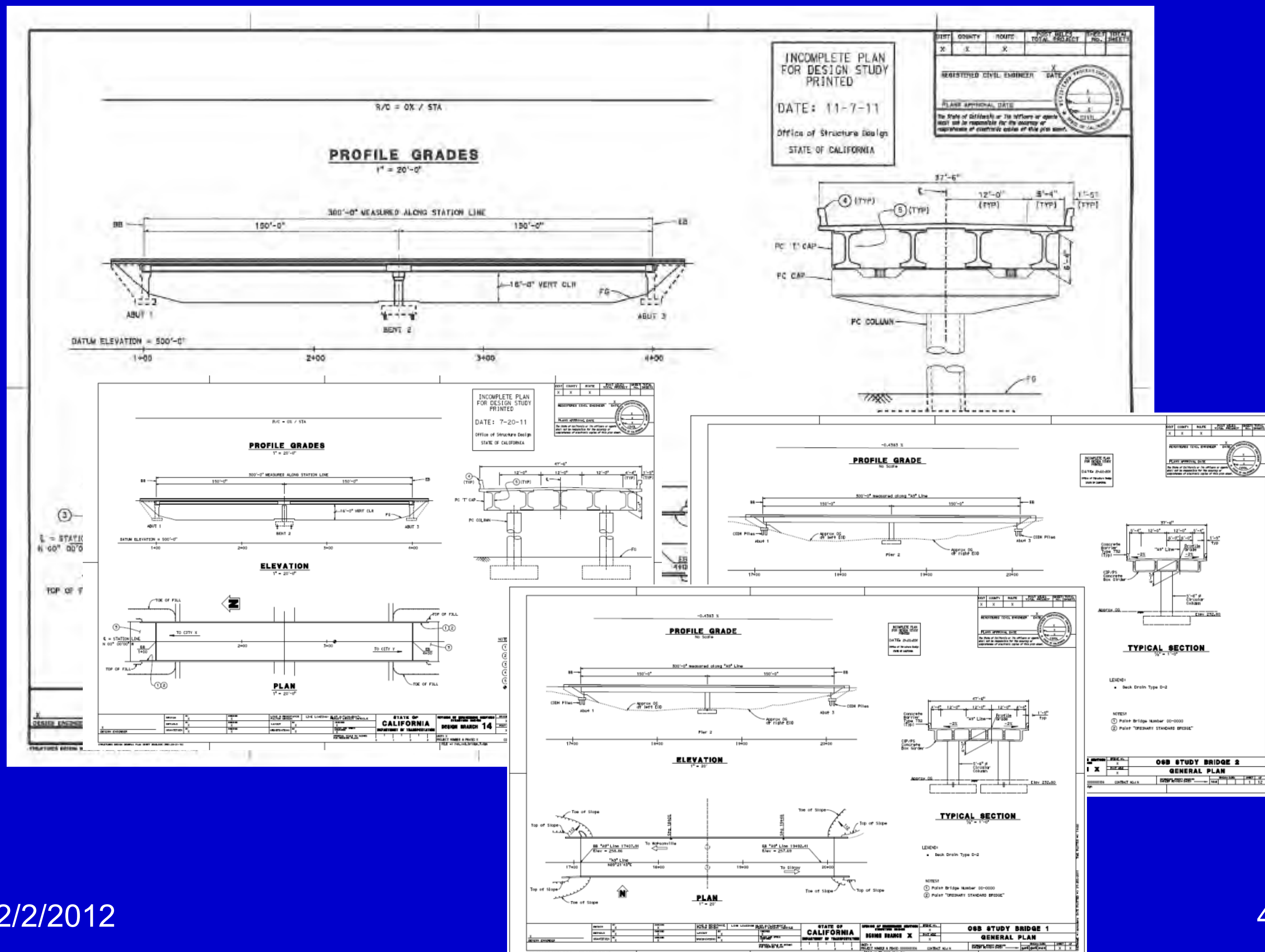


Isolated Precast
Ordinary Standard Bridge Study

LRFD Service Load Considerations



Isolated Precast
Ordinary Standard Bridge Study



"A scientific theory should be as simple as possible, but no simpler."

A. Einstein

Caltrans Research