# PCMAC Workshop
# Sacramento, California
# November, 2010

## Caltrans' *N*ext *G*eneration *B*ridge

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

# Caltrans NGB Effort

Development Team:

Tom Shantz
Angel Perez-Cobo
Mark Mahan
Ron Bromenschenkel
Gudmund Setberg
Joey Aquino
Talal Sadek
John Lammers
Mike Keever

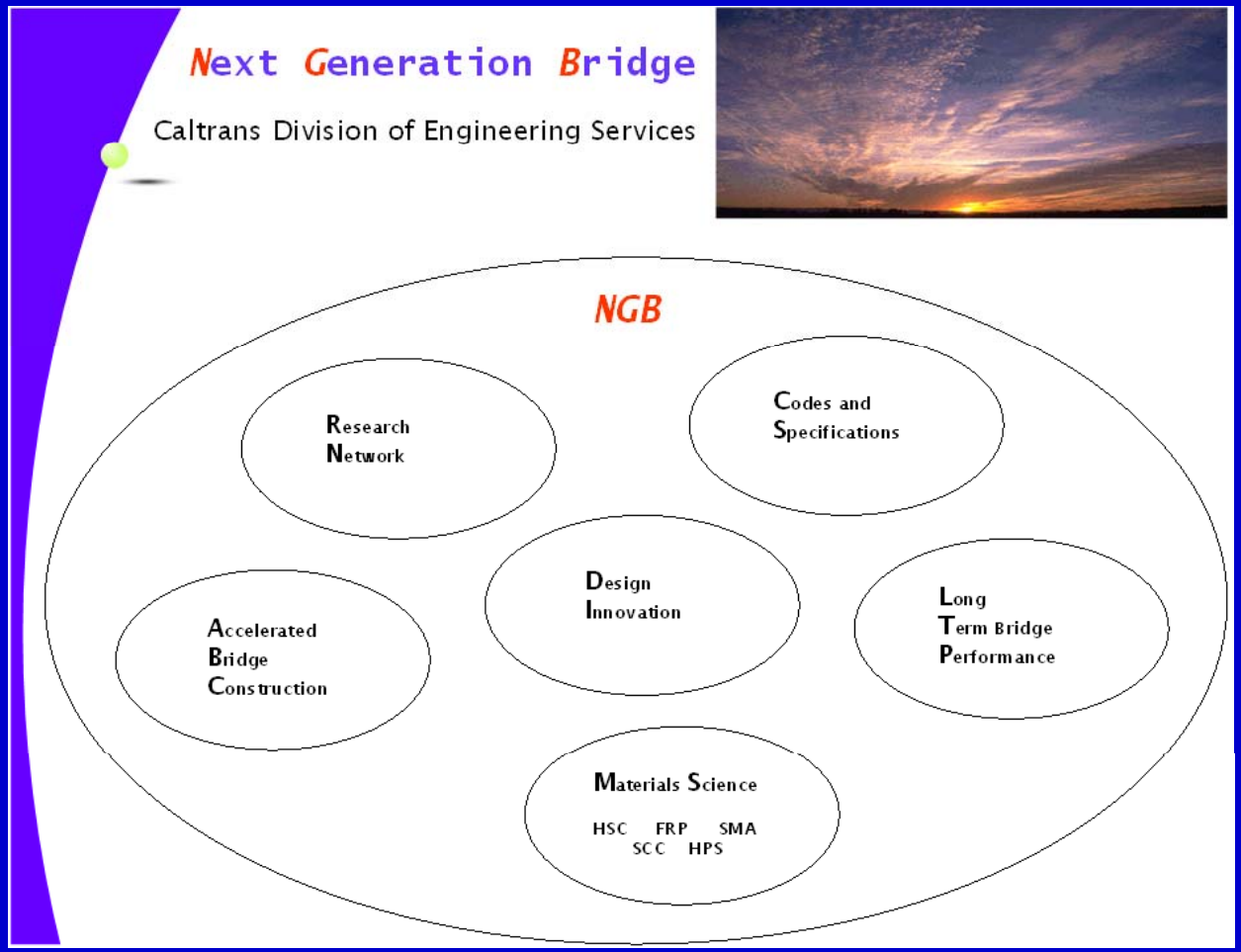
Review Team:

Mike Keever
Joe Downing
Steve Wiman
Paul Chung

# NGB Systems

- Consider all bridge types
- Consider speed of construction
- Consider variety of materials
- Test to validate ideas; service/seismic
- Develop codes/specs
- Consider maintenance

# Caltrans NGB Effort

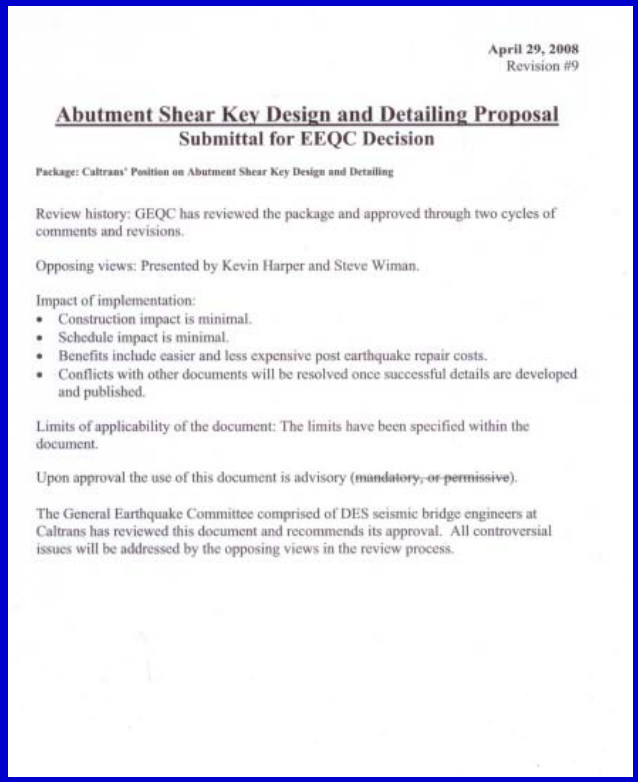


# Component Level Example

- **Abutment Shear Keys**

First tested 2002


Category ‘A’ Decision Document 2008



April 29, 2008
Revision #9

**Abutment Shear Key Design and Detailing Proposal**
**Submittal for EEQC Decision**

**Package: Caltrans' Position on Abutment Shear Key Design and Detailing**

Review history: GEQC has reviewed the package and approved through two cycles of comments and revisions.

Opposing views: Presented by Kevin Harper and Steve Wiman.

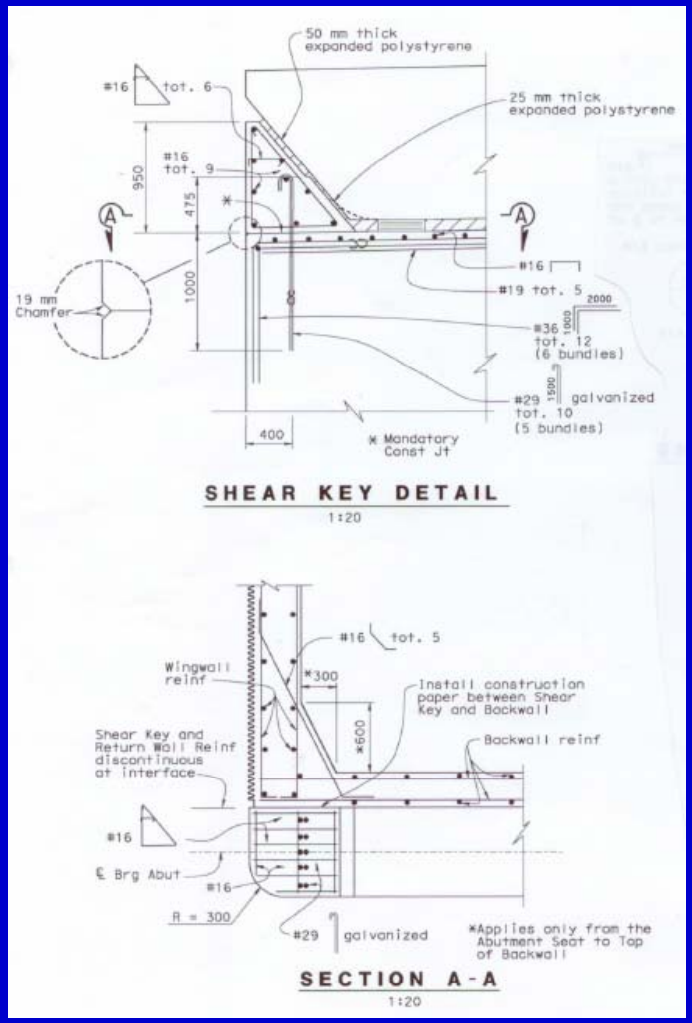
Impact of implementation:
- Construction impact is minimal.
- Schedule impact is minimal.
- Benefits include easier and less expensive post earthquake repair costs.
- Conflicts with other documents will be resolved once successful details are developed and published.

Limits of applicability of the document: The limits have been specified within the document.

Upon approval the use of this document is advisory (~~mandatory, or permissive~~).

The General Earthquake Committee comprised of DES seismic bridge engineers at Caltrans has reviewed this document and recommends its approval. All controversial issues will be addressed by the opposing views in the review process.

# Sacrificial Shear Key Design




## Construction of New Keys

## Completed Seismic Shear Keys

## Isolated Key for 68.6m (226 ft) span

# Next Generation Bridges

Initial Focus:

# Next Generation Bridges

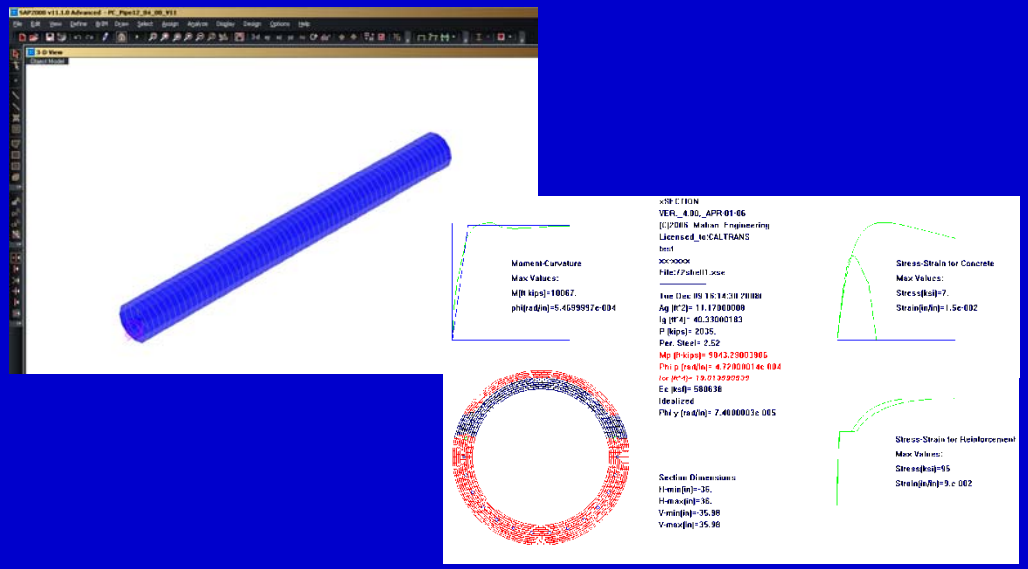
Initial Focus: Precast elements

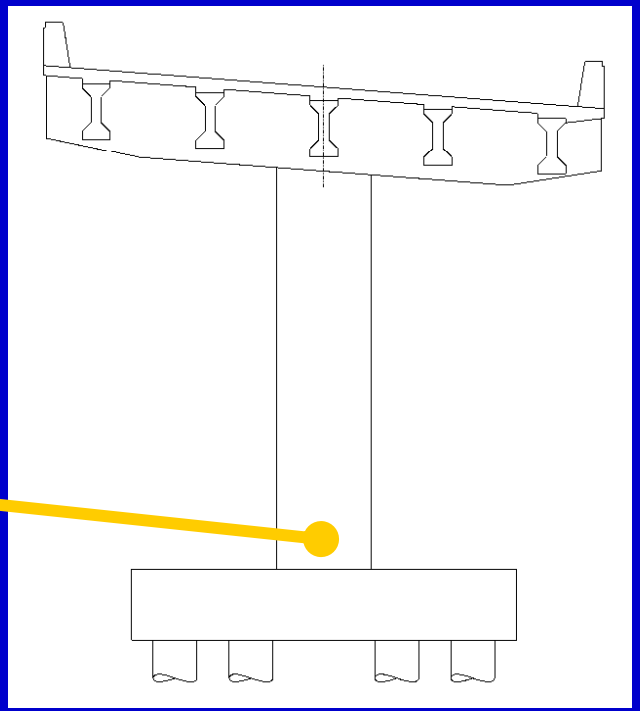
# Next Generation Bridges

Initial Focus: Precast elements - *columns*

# Next Generation Bridges

Initial Focus: Precast elements - *columns*



Plastic Hinge Zone

# Next Generation Bridges
## -Current Caltrans Policy-



### 8. SEISMIC DETAILING

#### 8.1 Splices in Reinforcing Steel

##### 8.1.1 No Splice Regions in Ductile Components

Splicing of flexural reinforcement is not permitted in critical locations of ductile elements. The "no splice" region shall be the greater of: The length of the plastic hinge region as defined in Section 7.6.3 or the portion of the column where the moment demand exceeds $M_y$. A "no splice" region shall be clearly identified on the plans for both hinge locations of fixed-fixed columns.

##### 8.1.2 Reinforcement Spliced in Ductile Components & Components Expected to Accept Damage

Reinforcing steel splices in ductile components outside of the "no splice" region shall meet the "ultimate splice" performance requirements identified in Memo to Designers 20-9.

# Next Generation Bridges

*We can see by comparing CA to Japan, that varying seismic hazard maps and detailing practices exists between countries.*

# Comparisons – Japan / Caltrans

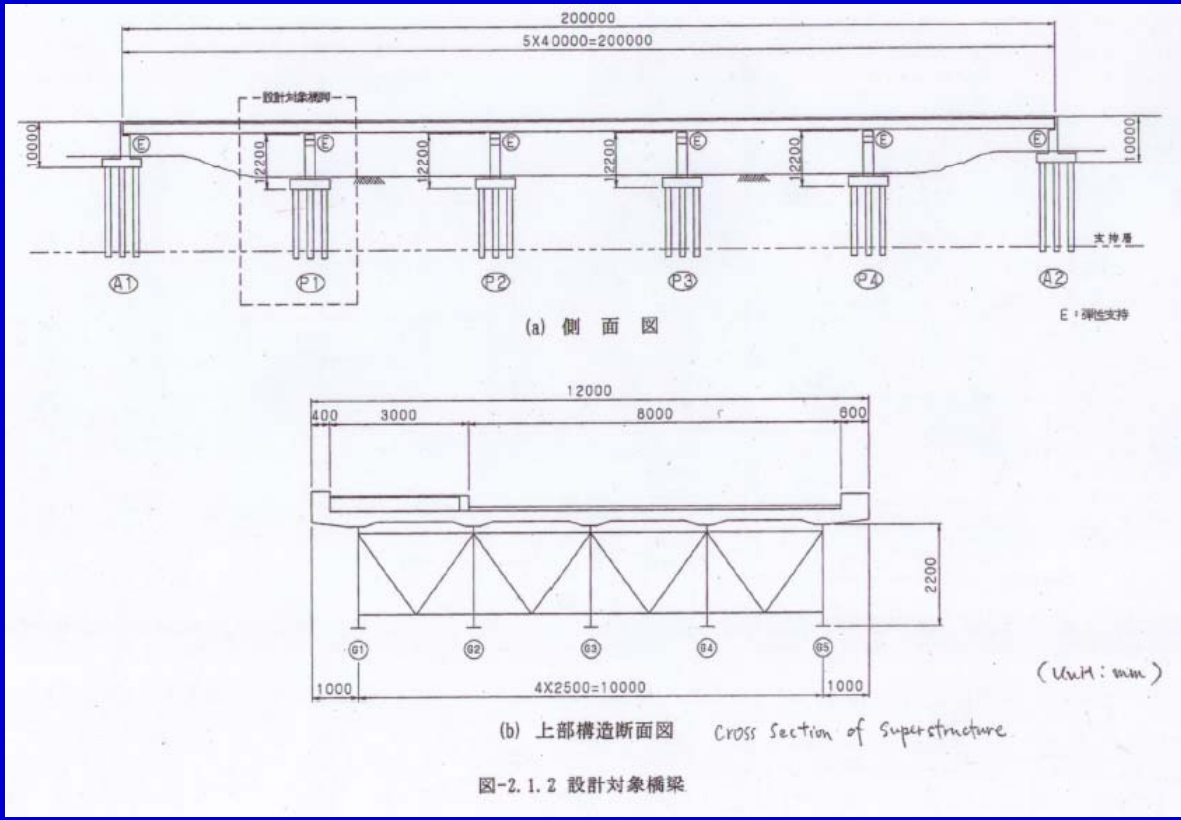



図-2. 1. 2 設計対象橋梁

# Comparisons – Japan / Caltrans

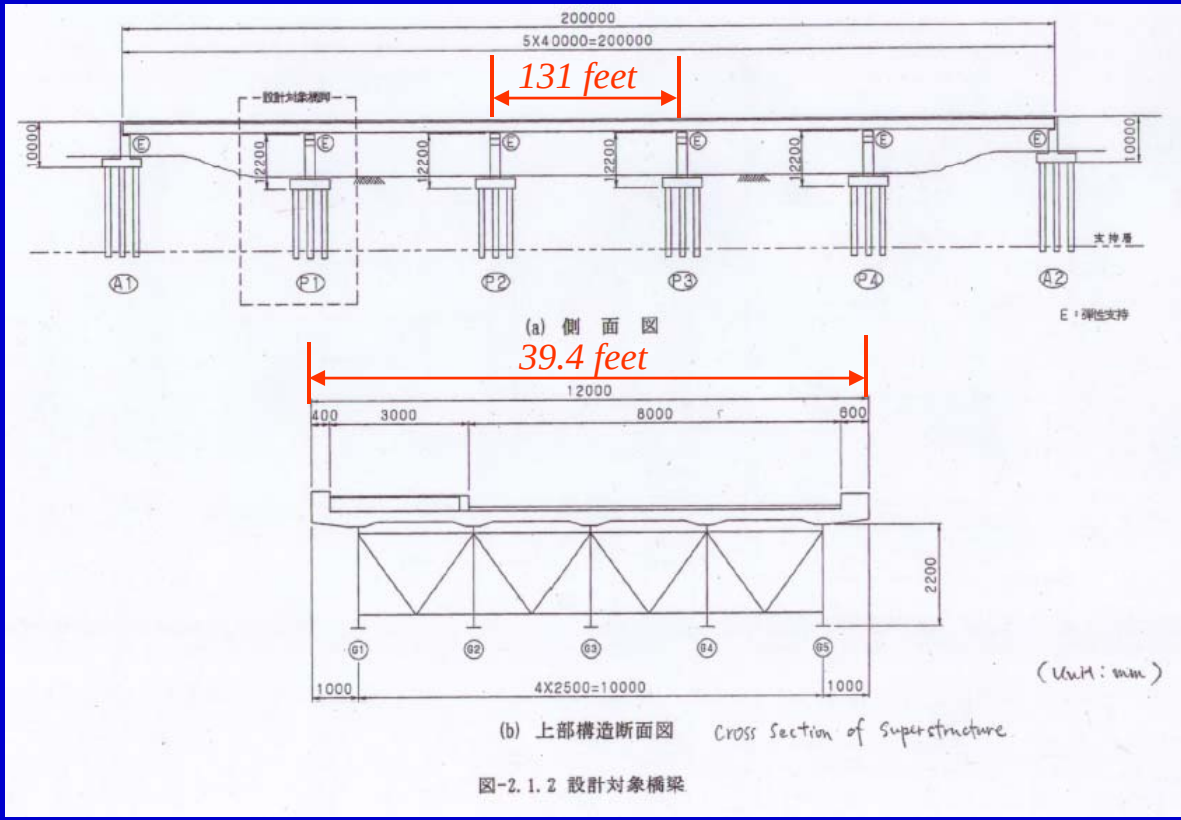
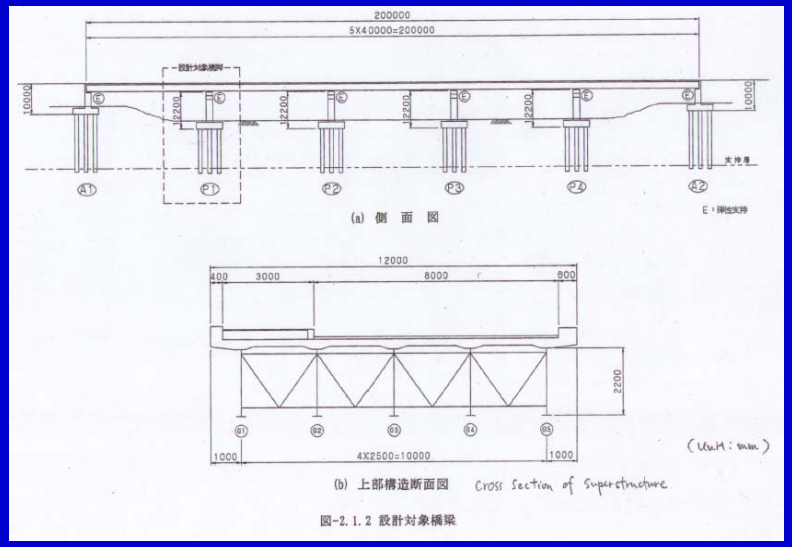
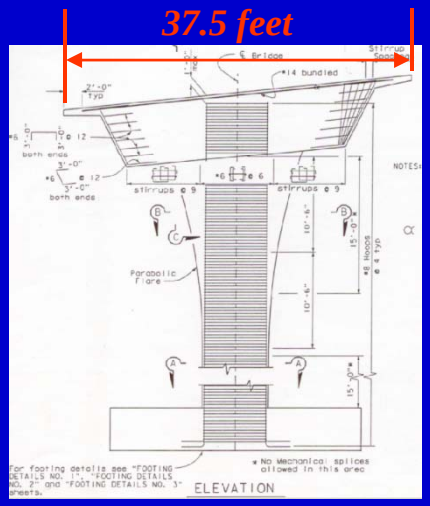



図-2. 1. 2 設計対象橋梁

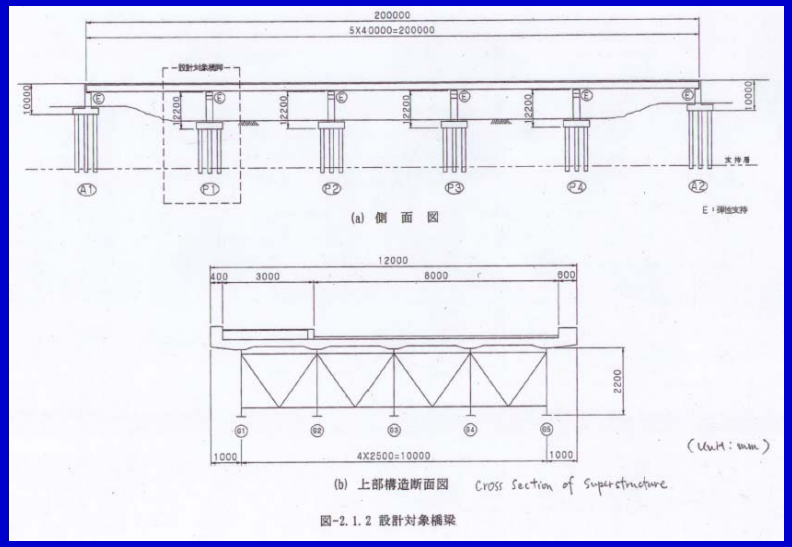
# Comparisons – Japan / Caltrans

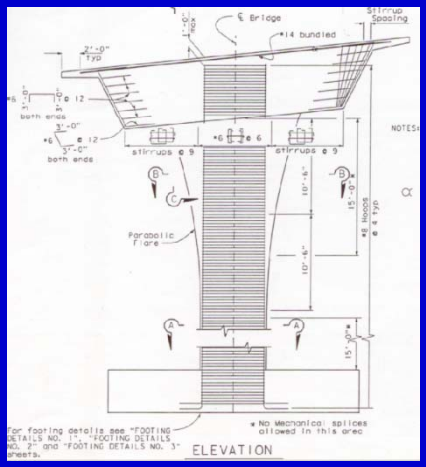


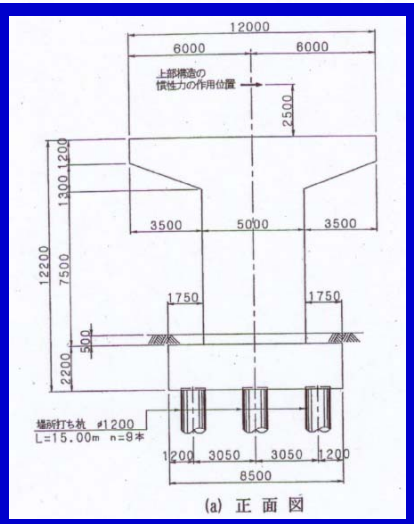




***144 to 170 ft spans***

# Comparisons – Japan / Caltrans



# Comparisons – Japan / Caltrans

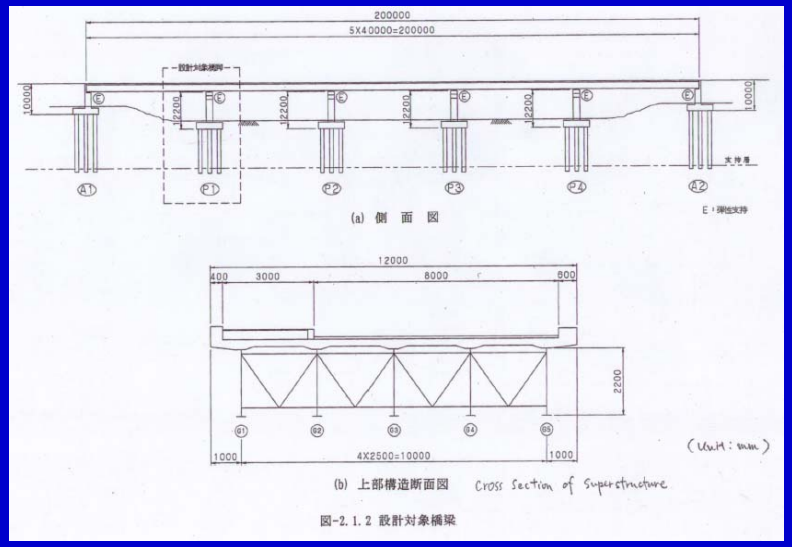
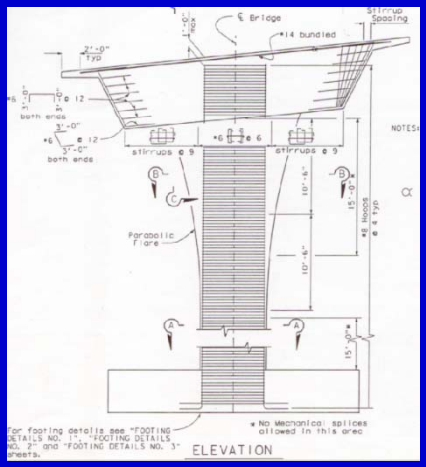
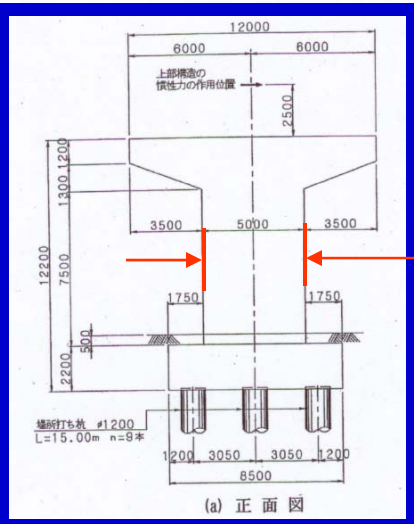


図-2.1.2 設計対象橋梁




***16.4 feet***

# Comparisons – Japan / Caltrans

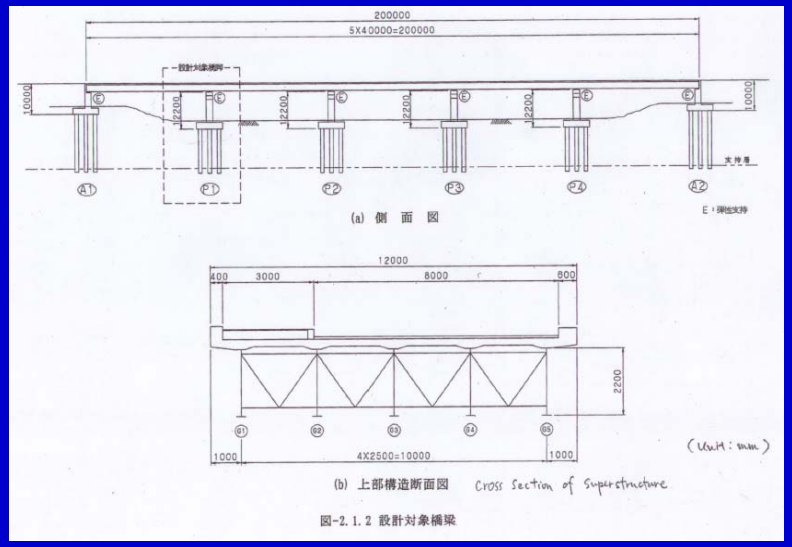
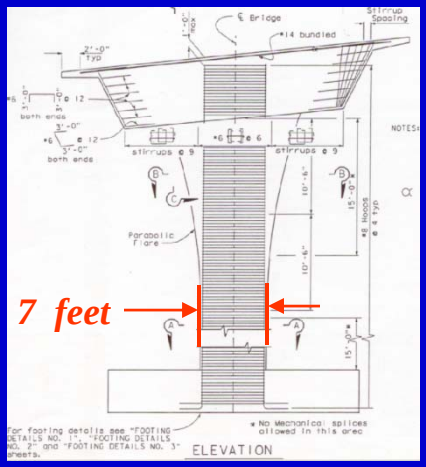
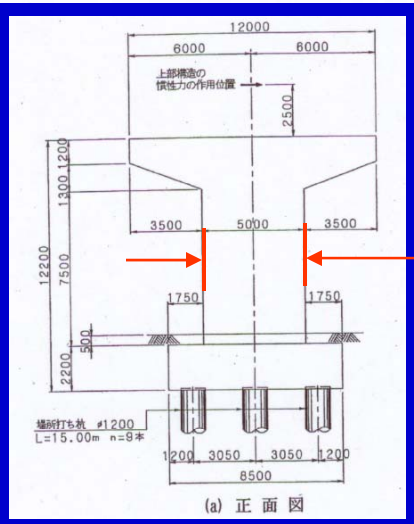
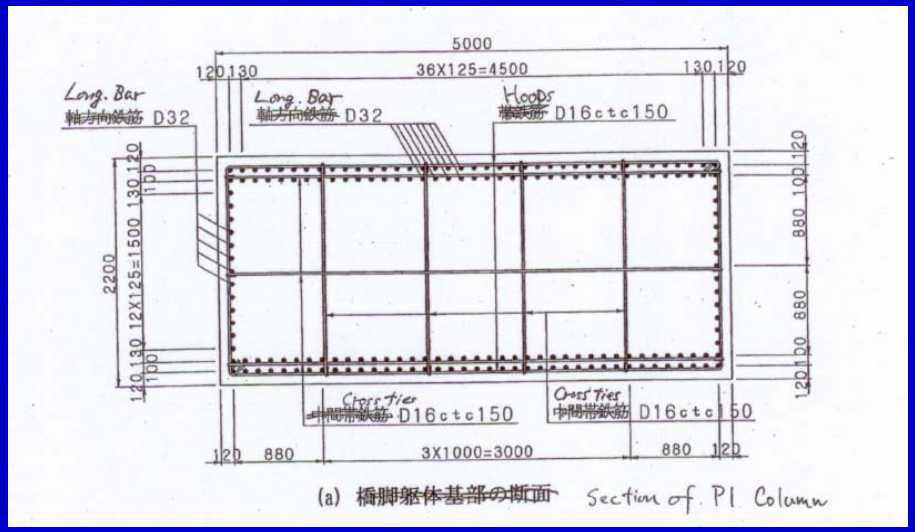


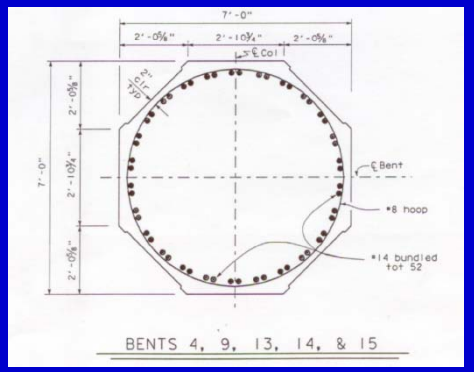
図-2.1.2 設計対象橋梁



# Comparisons – Japan / Caltrans



# Next Generation Bridges

*We can see by comparing CA to Japan, that varying seismic hazard maps and detailing practices exists between countries.*

*Furthermore, given the same 1000 year event uniform hazard map used within the US, various DOT's are addressing seismic capacity in detailing differently.*

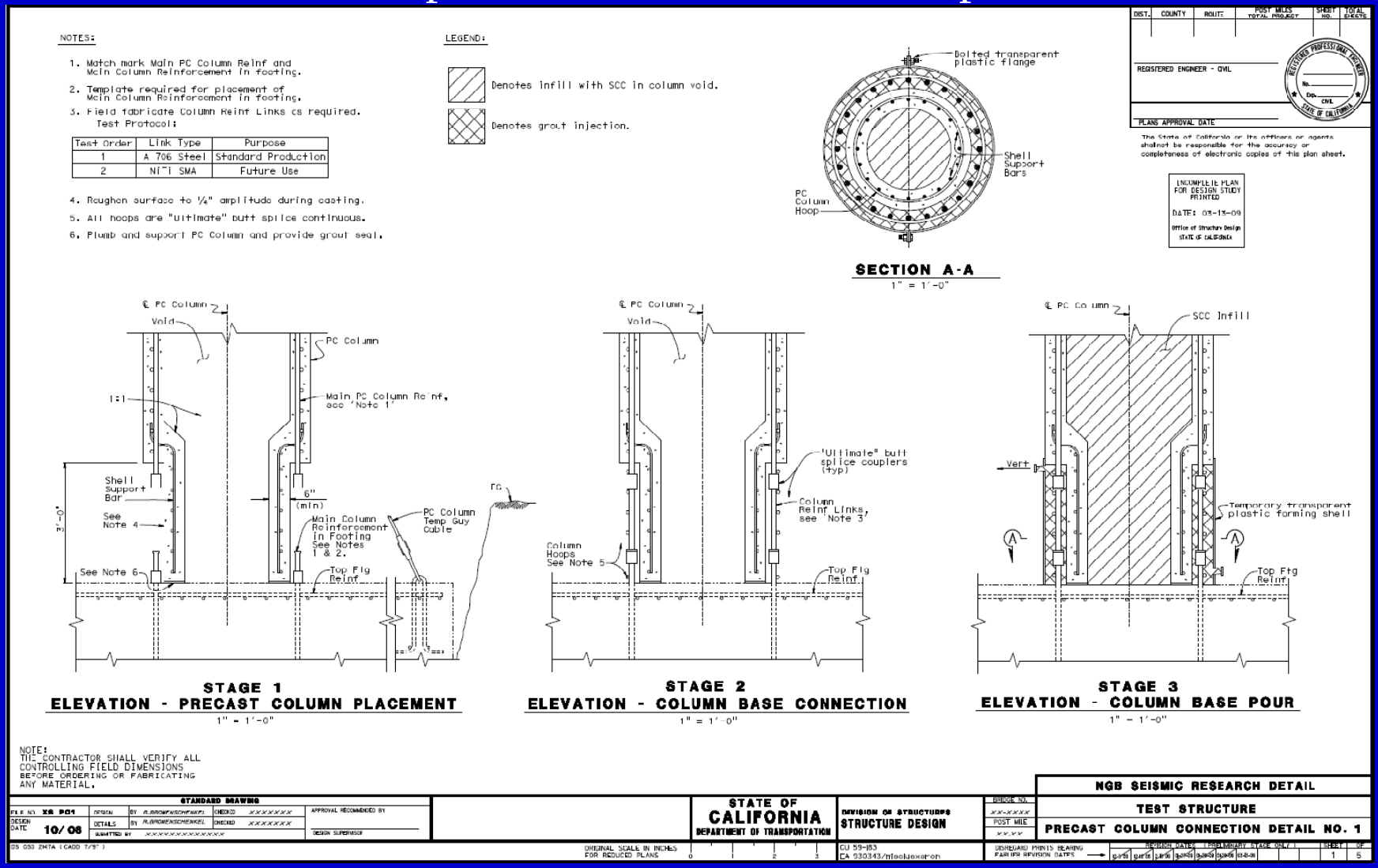
# Next Generation Bridges
## Proposed Construction Concepts

Precast elements are to emulate Cast-in-Place performance.

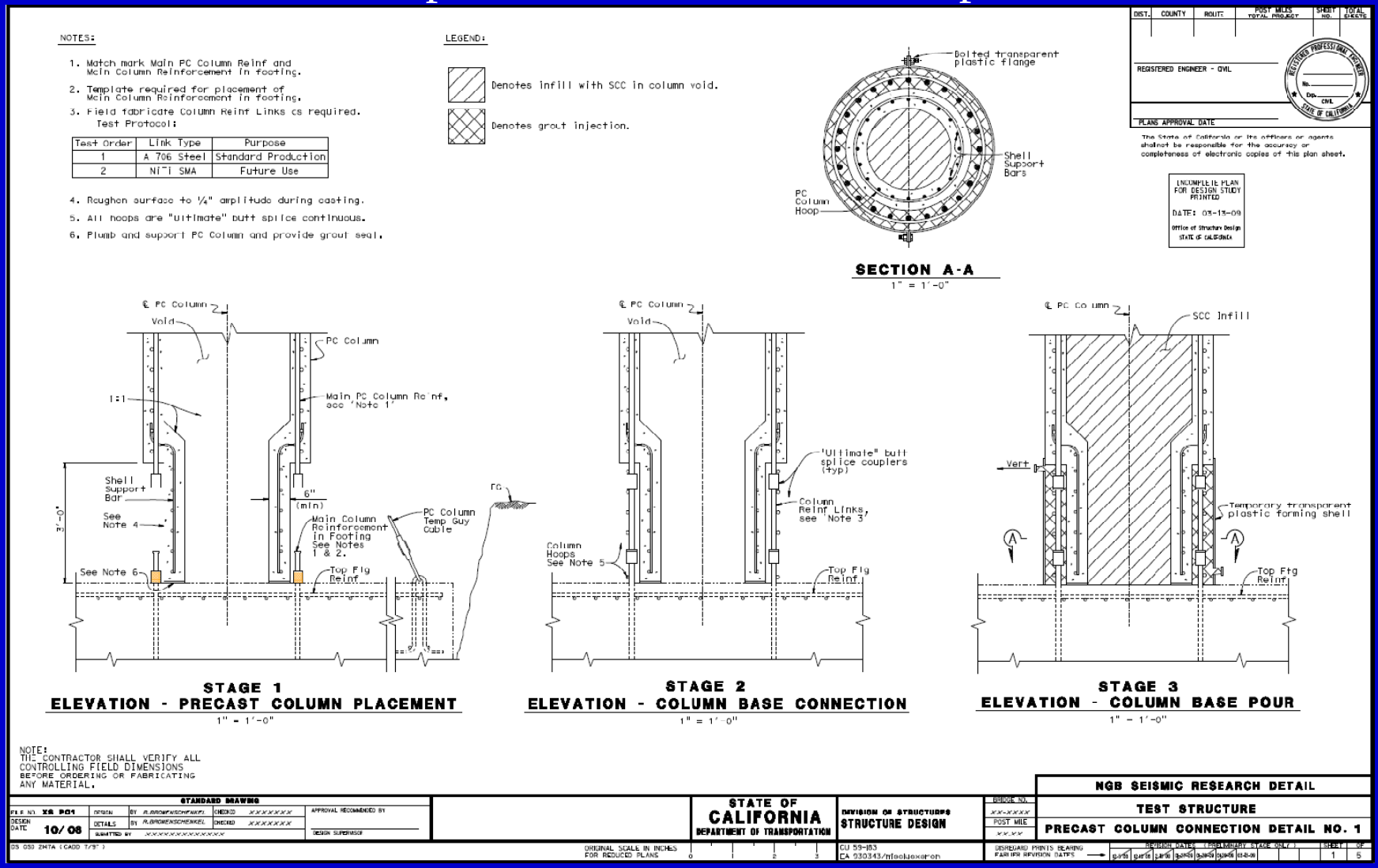
Precast element tests are required to validate expected performance.

# Next Generation Bridges

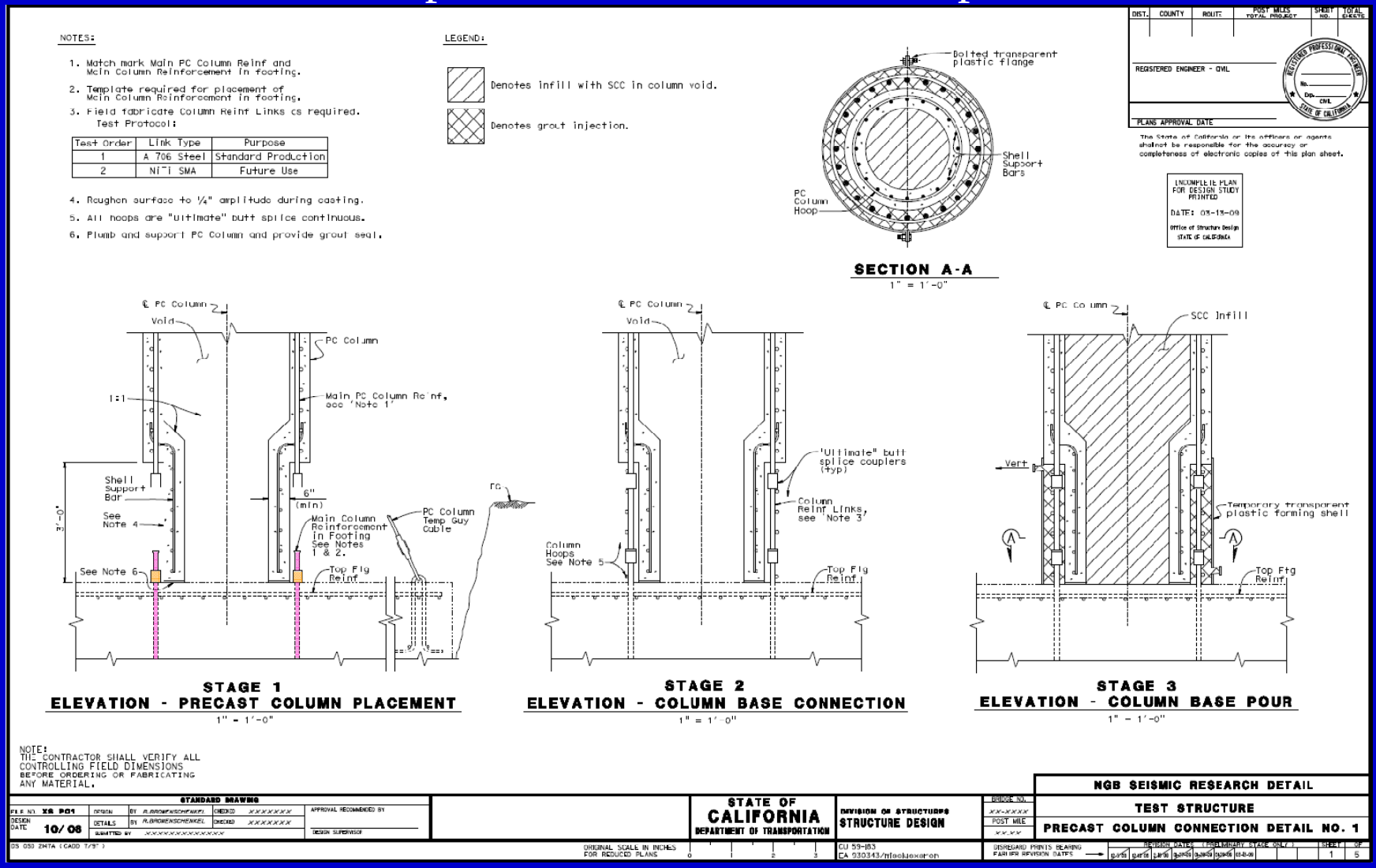
## Proposed Construction Concepts



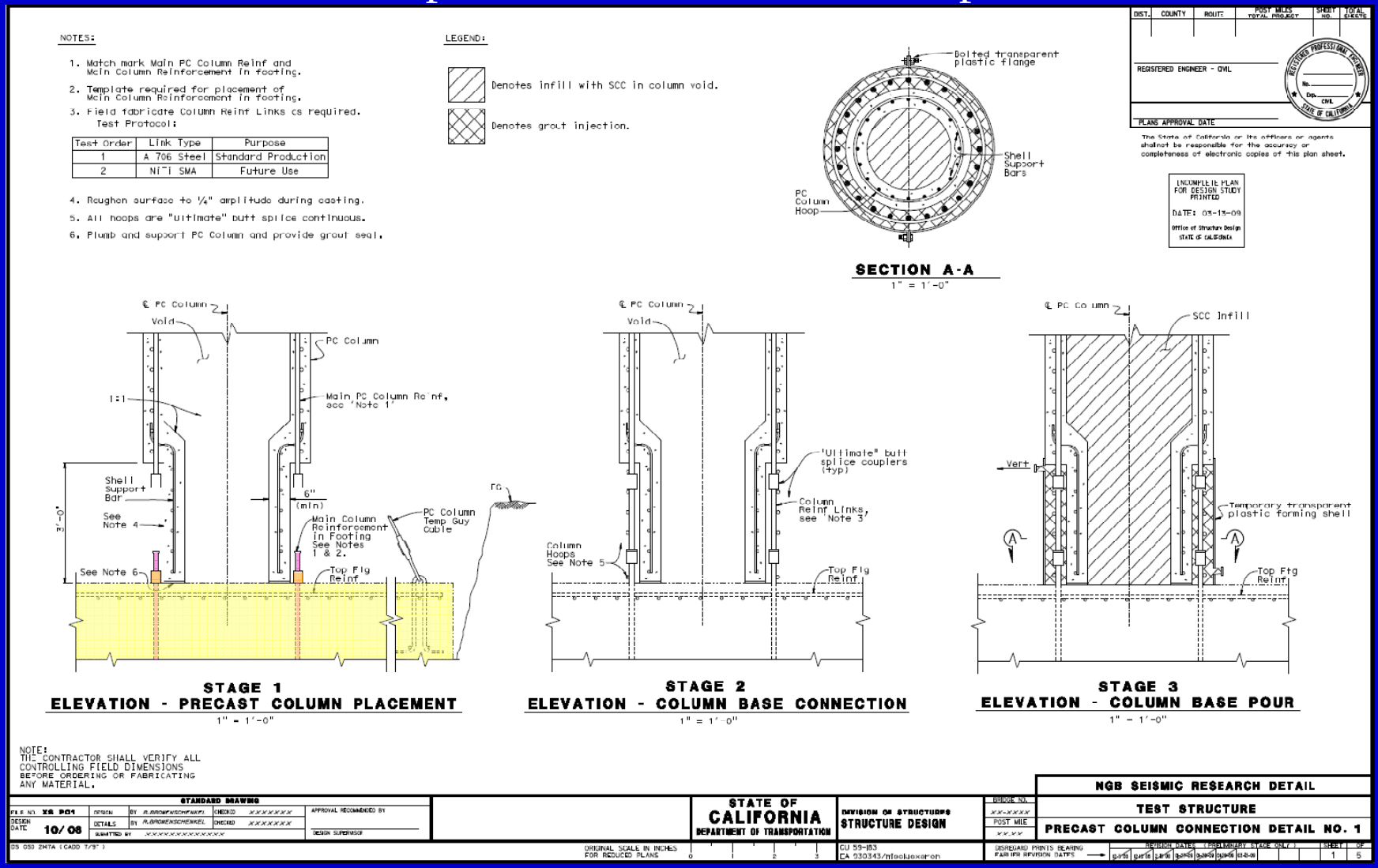
# Next Generation Bridges
## Proposed Construction Concepts



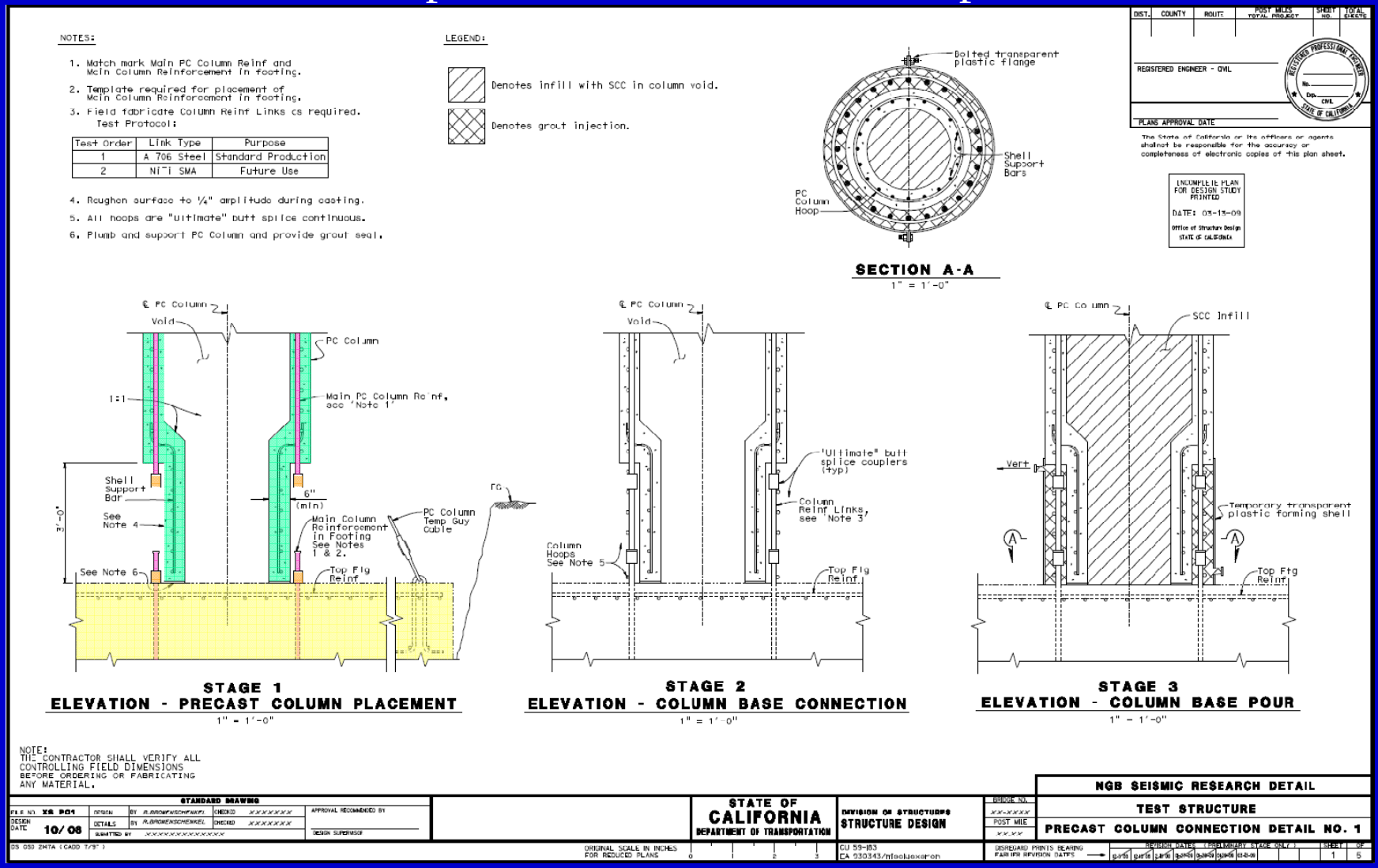
# Next Generation Bridges
## Proposed Construction Concepts



# Next Generation Bridges
## Proposed Construction Concepts

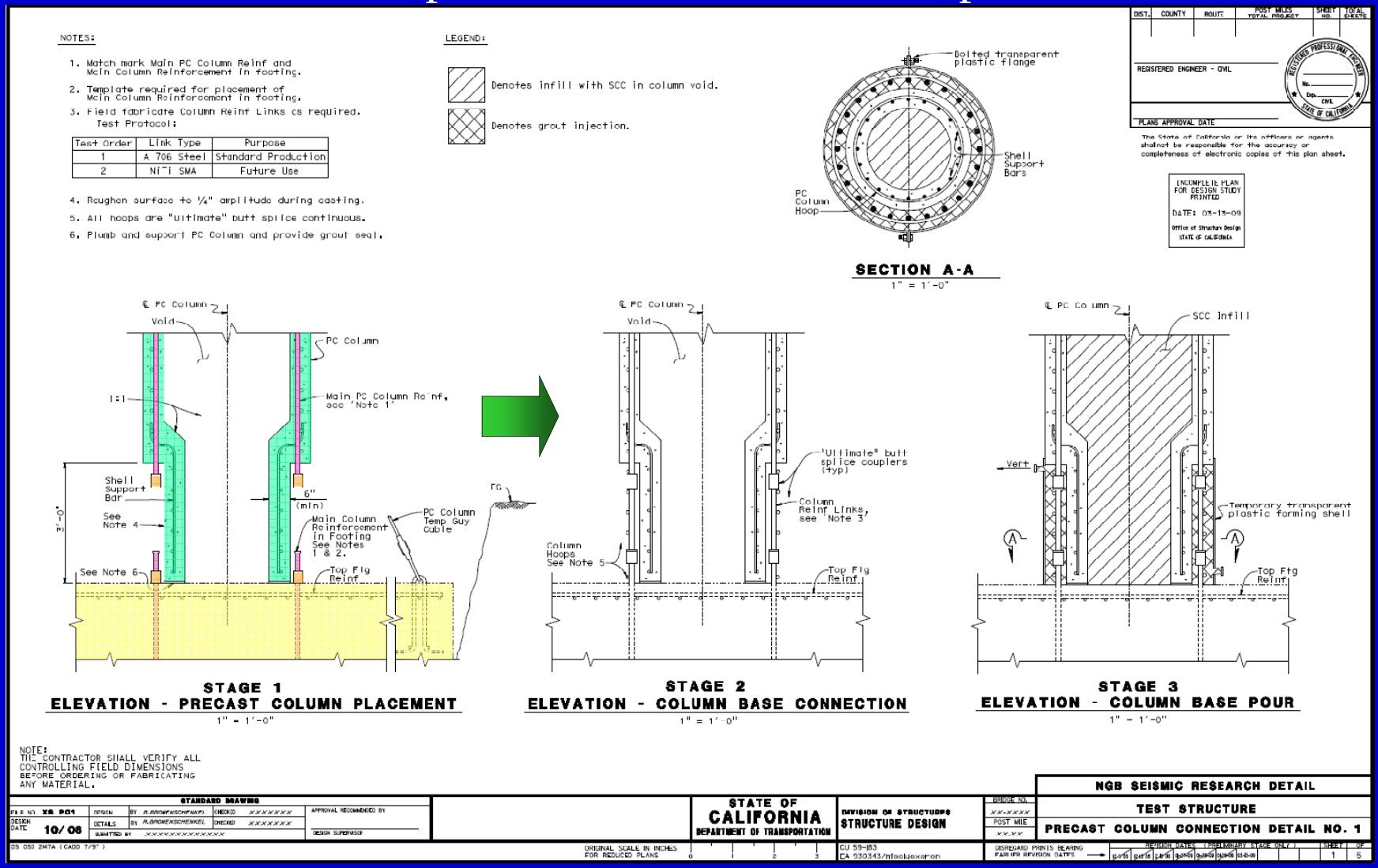


# Next Generation Bridges
## Proposed Construction Concepts



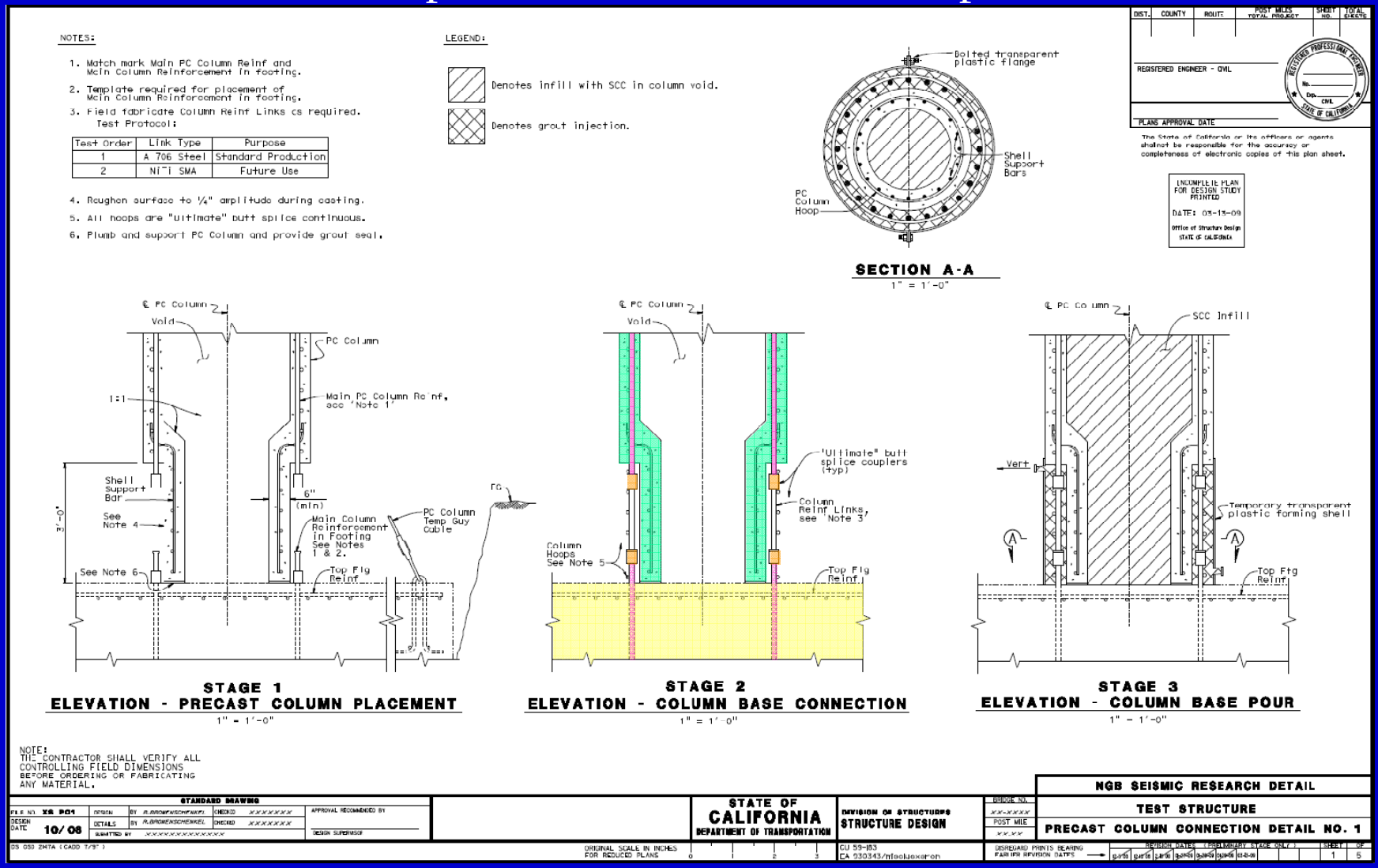
# Next Generation Bridges

## Proposed Construction Concepts

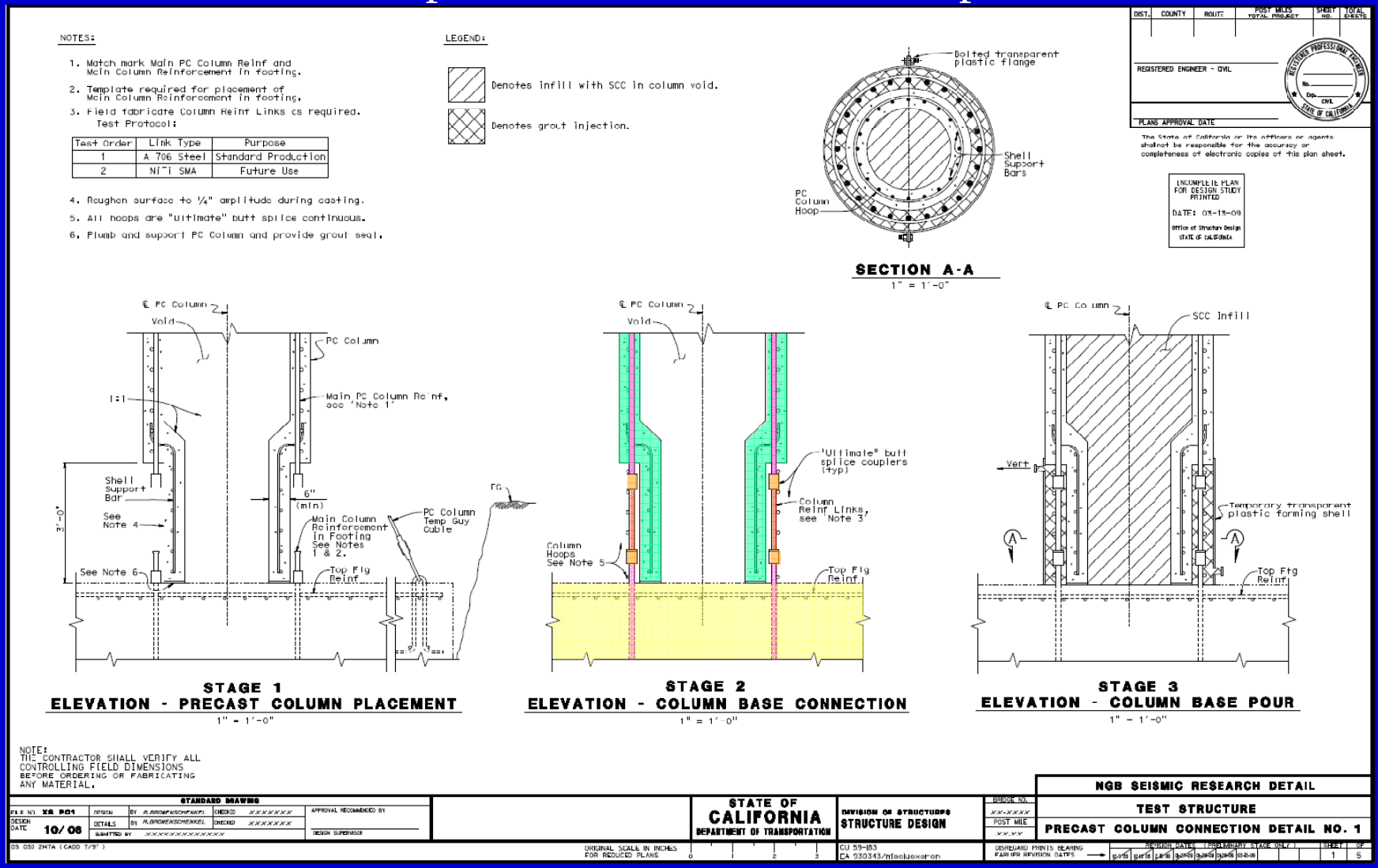


# Next Generation Bridges

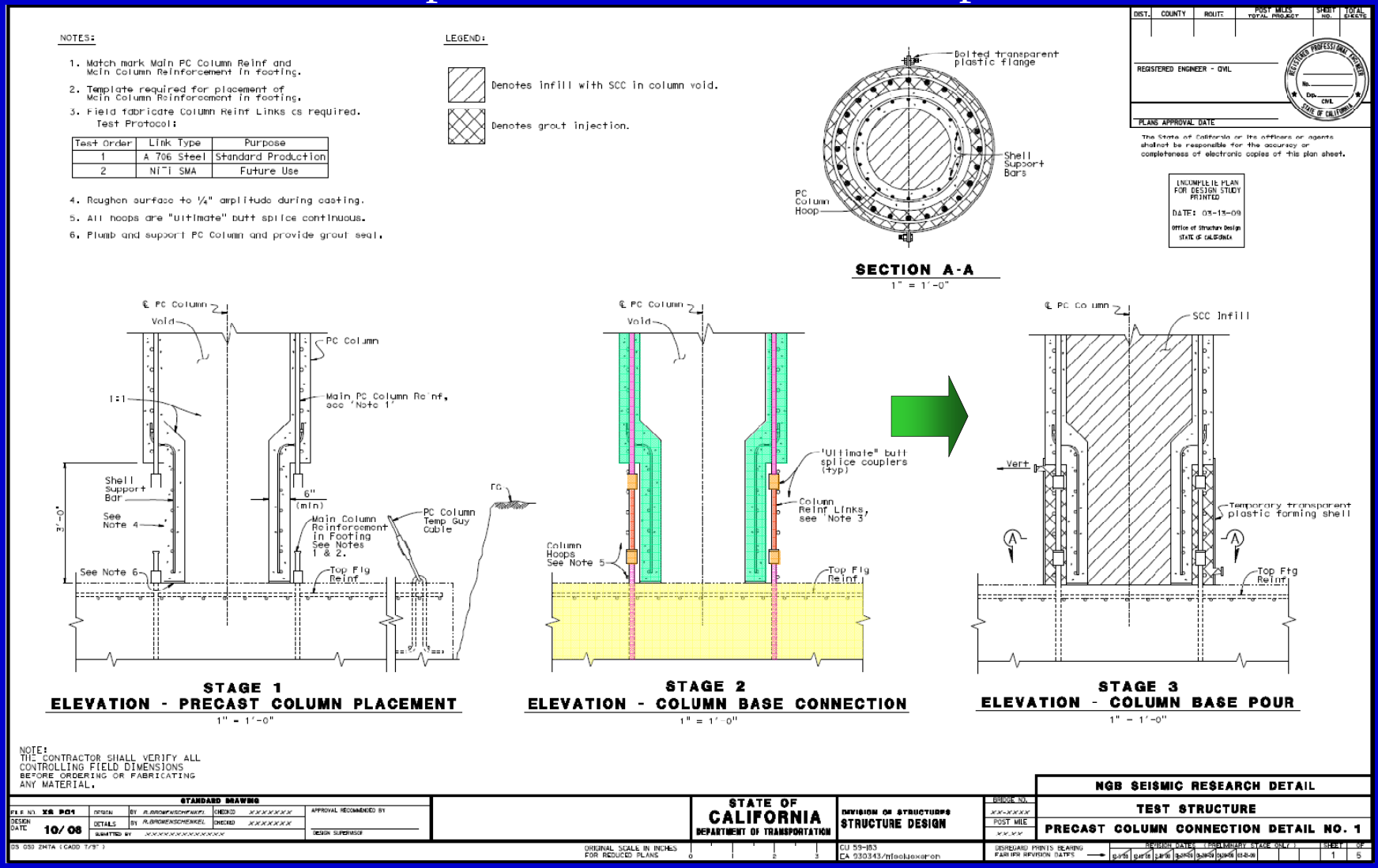
## Proposed Construction Concepts



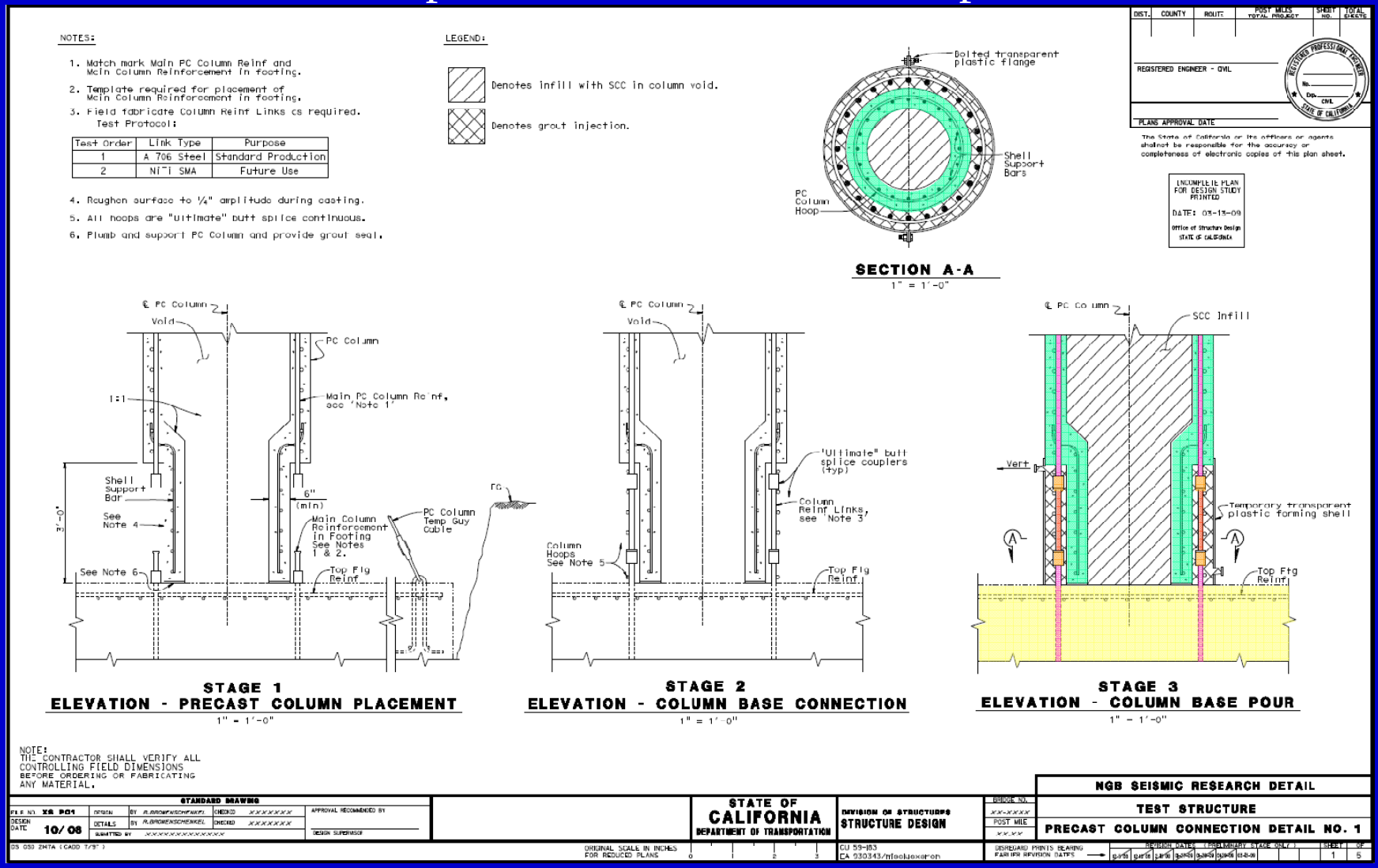
# Next Generation Bridges
## Proposed Construction Concepts



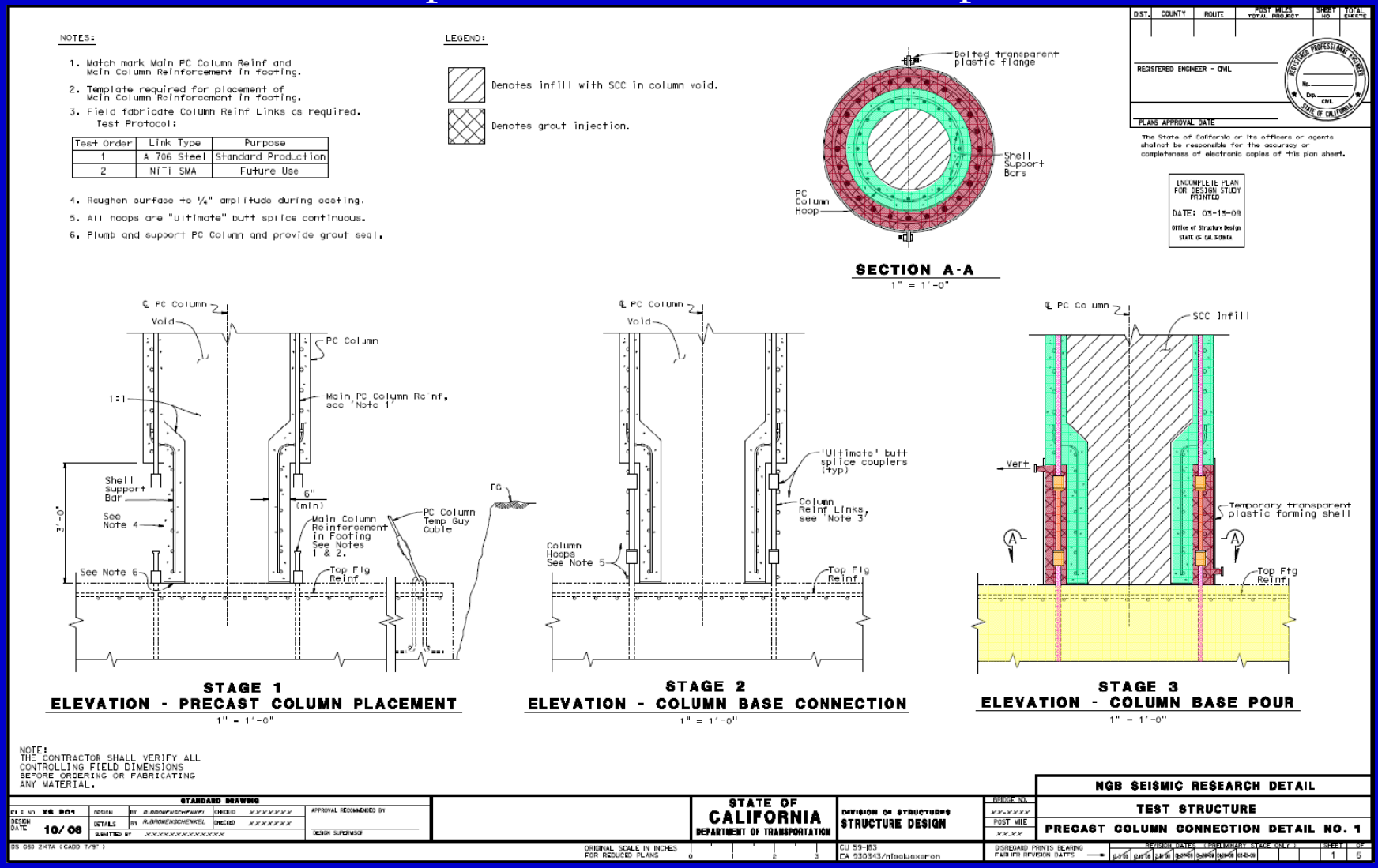
# Next Generation Bridges
## Proposed Construction Concepts



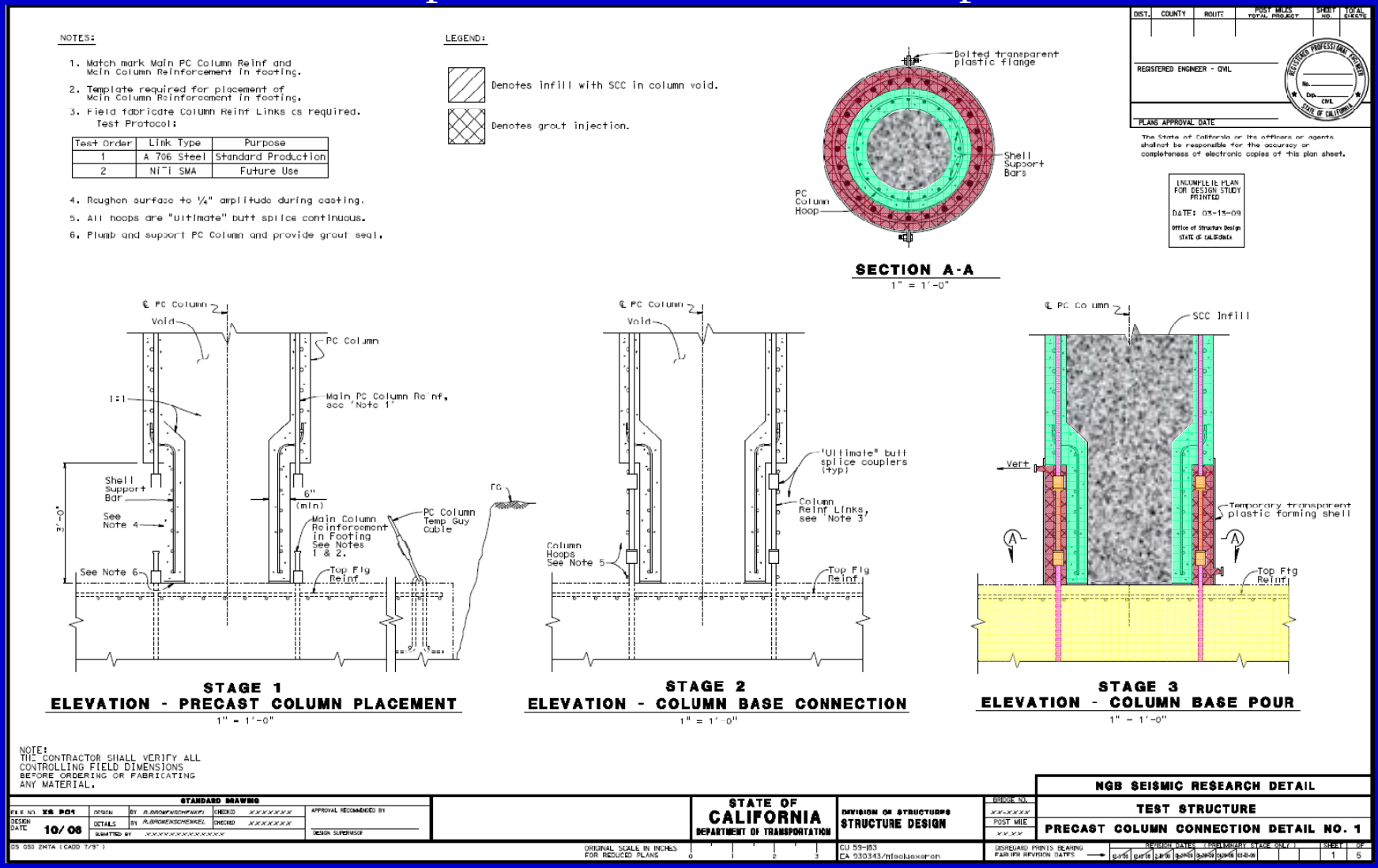
# Next Generation Bridges
## Proposed Construction Concepts



# Next Generation Bridges
## Proposed Construction Concepts



# Next Generation Bridges
## Proposed Construction Concepts



NOTES:

1. Match mark Main PC Column Reinf and Main Column Reinforcement in footing.
2. Template required for placement of Main Column Reinforcement in footing.
3. Field fabricate Column Reinf Links as required.
   Test Protocol:

| Test Order | Link Type | Purpose |
|---|---|---|
| 1 | A 706 Steel | Standard Production |
| 2 | Ni-Ti SMA | Future Use |

4. Roughen surface to ¼" amplitude during casting.
5. All hoops are "ultimate" butt splice continuous.
6. Plumb and support PC Column and provide grout seal.

LEGEND:

Denotes infill with SCC in column void.

Denotes grout injection.

Bolted transparent plastic flange
Shell Support Bars
PC Column Hoop

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

DIST. | COUNTY | ROUTE | POST MILES TOTAL PROJECT | SHEET NO. | TOTAL SHEETS

REGISTERED ENGINEER - CIVIL

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

INCOMPLETE PLAN FOR DESIGN STUDY PRINTED
DATE: 03-13-09
Office of Structure Design
STATE OF CALIFORNIA

℄ PC Column
Void
PC Column
Main PC Column Reinf, see 'Note 1'
1:1
Shell Support Bar
See Note 4
3'-0"
6" (min)
Main Column Reinforcement in Footing See Notes 1 & 2.
PC Column Temp Guy Cable
See Note 6
Top Ftg Reinf

STAGE 1
ELEVATION - PRECAST COLUMN PLACEMENT
1" = 1'-0"

℄ PC Column
Void
"Ultimate" butt splice couplers (typ)
Column Reinf Links, see 'Note 3'
Column Hoops See Note 5
Top Ftg Reinf

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

℄ PC Column
SCC Infill
Vert
Temporary transparent plastic forming shell
Top Ftg Reinf

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

NOTE:
THE CONTRACTOR SHALL VERIFY ALL CONTROLLING FIELD DIMENSIONS BEFORE ORDERING OR FABRICATING ANY MATERIAL.

STANDARD DRAWING
FILE NO. XS P01
DESIGN DATE 10/08
DESIGN BY R.BROWENSCHENKEL CHECKED xxxxxxx
DETAILS BY R.BROWENSCHENKEL CHECKED xxxxxxx
SUBMITTED BY xxxxxxxxxxxxx
APPROVAL RECOMMENDED BY
DESIGN SUPERVISOR

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES
STRUCTURE DESIGN

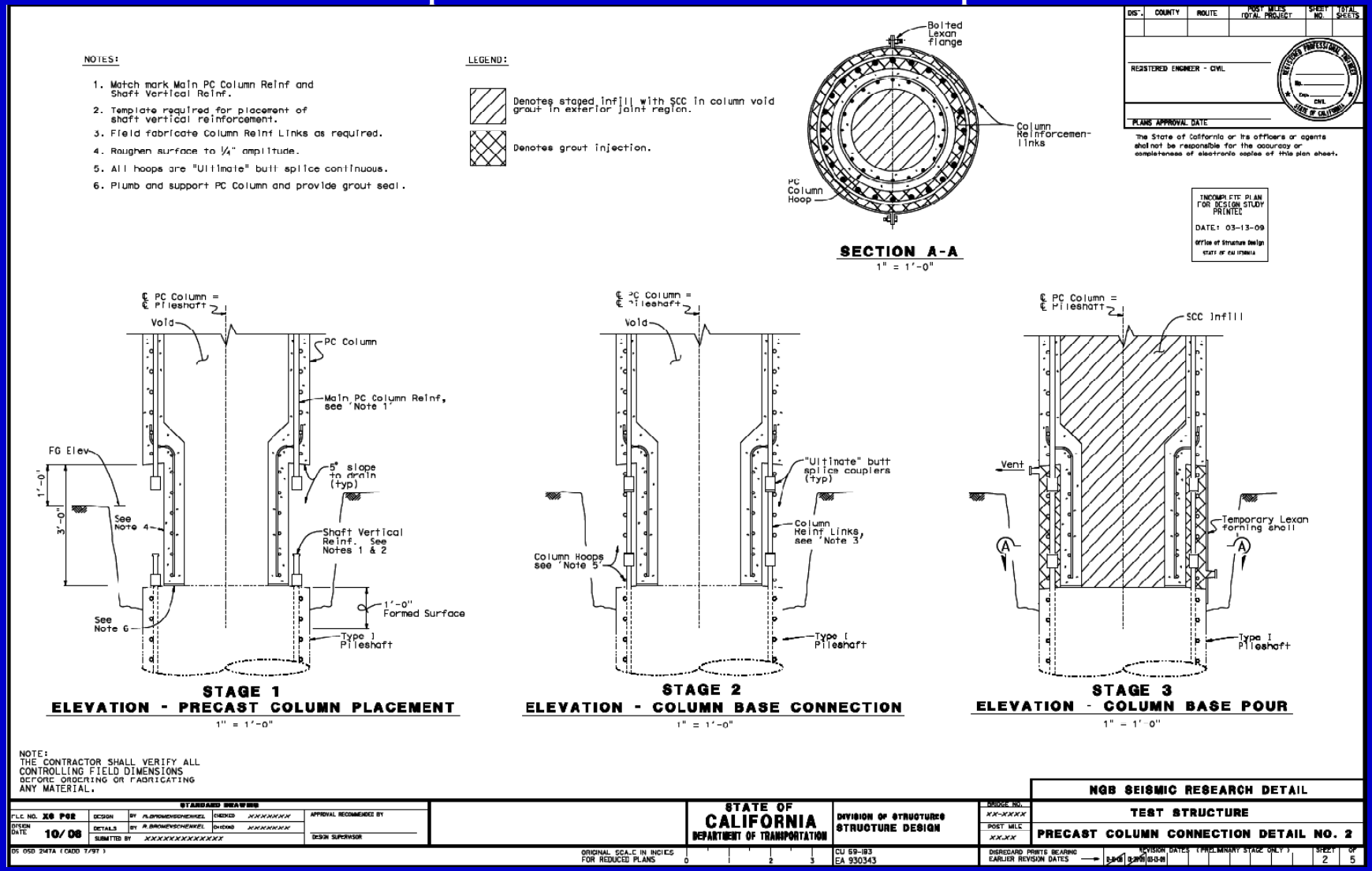
BRIDGE NO. xx-xxxx
POST MILE xx.xx

NGB SEISMIC RESEARCH DETAIL
TEST STRUCTURE
PRECAST COLUMN CONNECTION DETAIL NO. 1

DS 050 ZHTA (CADD 7/97)
ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3
CU 59-183
EA 930343/miscellaneous
DISREGARD PRINTS BEARING EARLIER REVISION DATES →
REVISION DATES (PRELIMINARY STAGE ONLY)
SHEET 1 OF 5

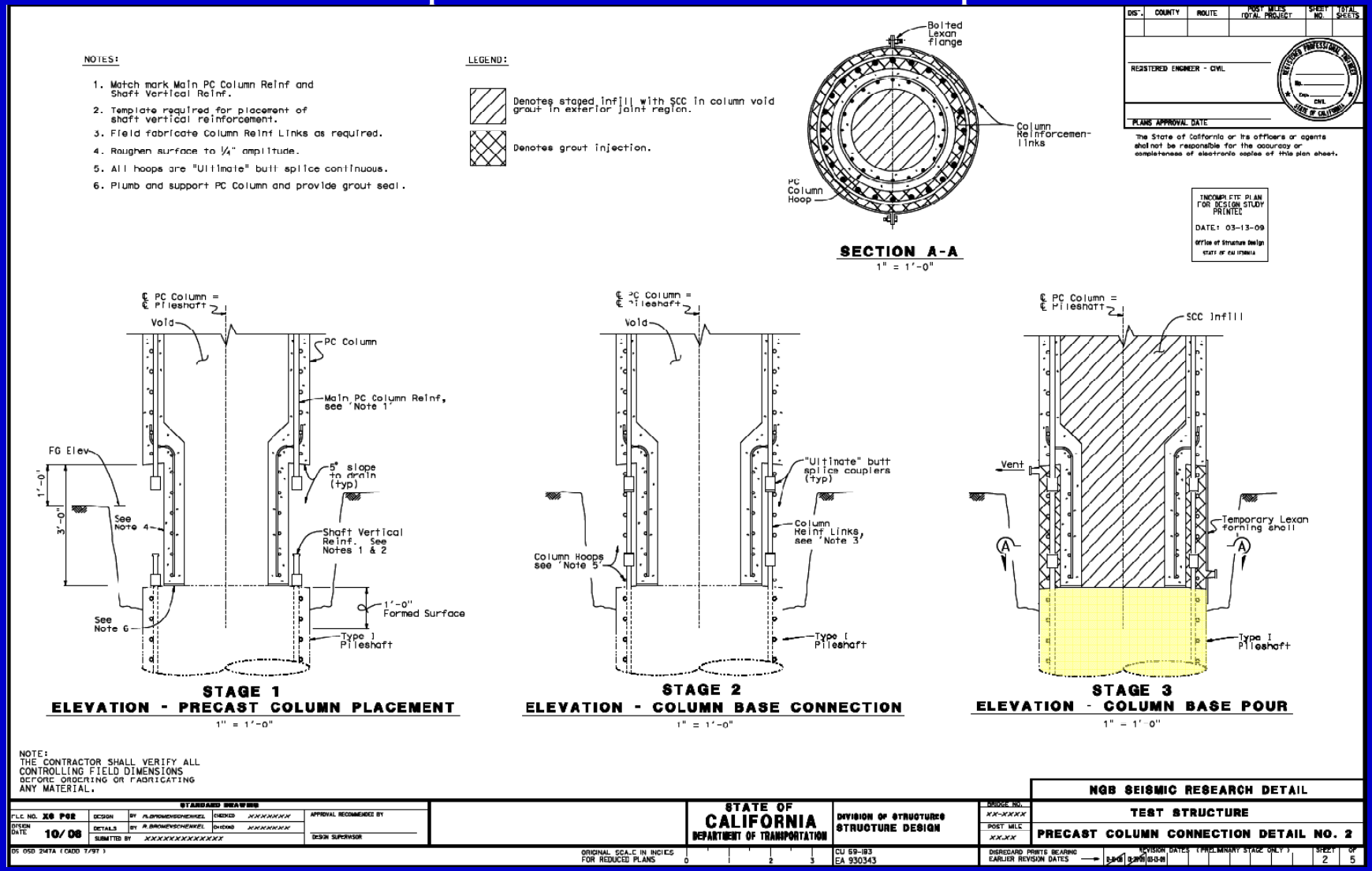
# Next Generation Bridges

## Proposed Construction Concepts



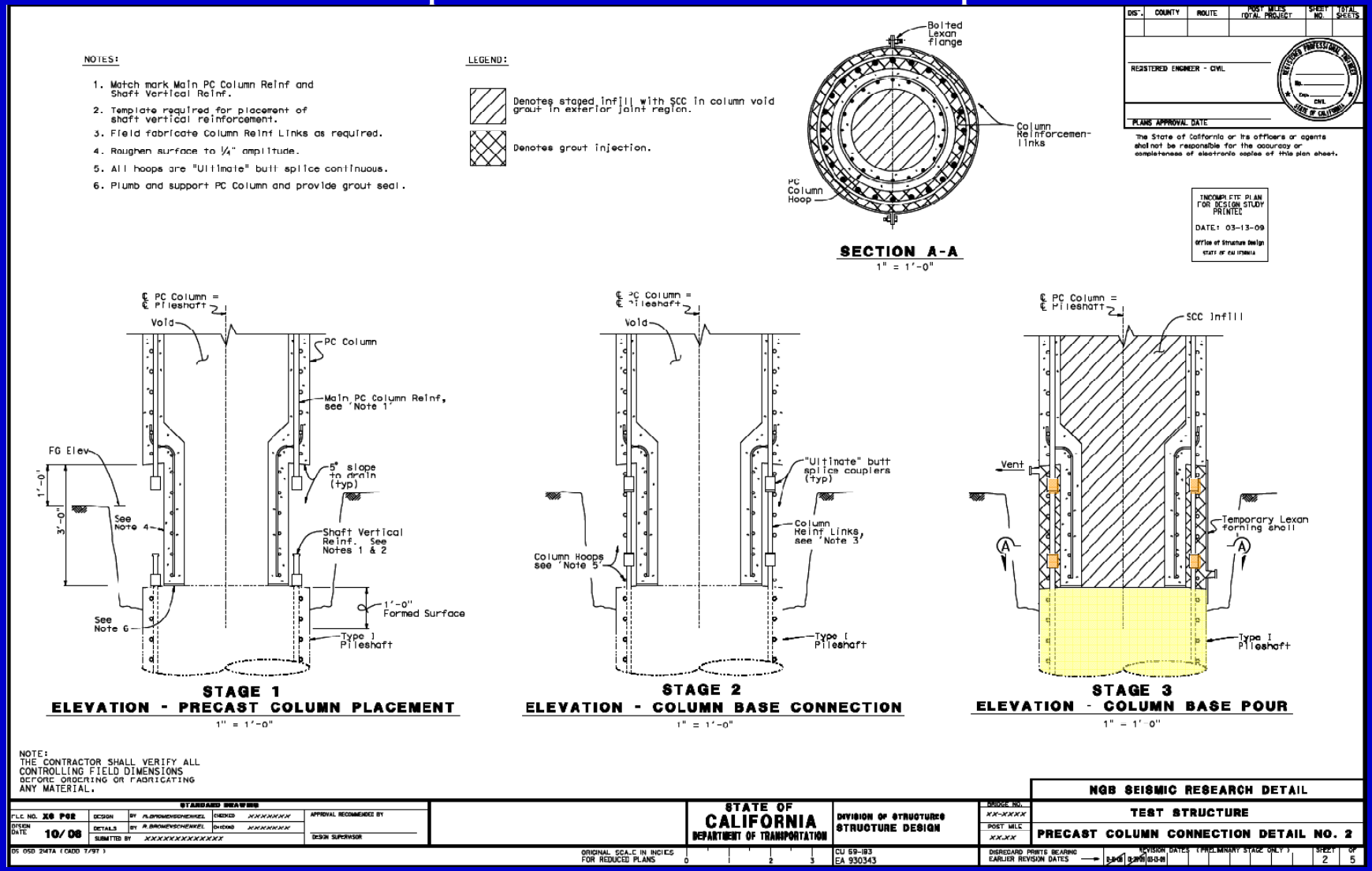
# Next Generation Bridges

## Proposed Construction Concepts



# Next Generation Bridges

## Proposed Construction Concepts



# Next Generation Bridges
## Proposed Construction Concepts

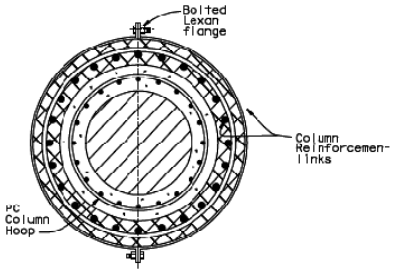
NOTES:

1. Match mark Main PC Column Reinf and Shaft Vertical Reinf.
2. Template required for placement of shaft vertical reinforcement.
3. Field fabricate Column Reinf Links as required.
4. Roughen surface to ¼" amplitude.
5. All hoops are "Ultimate" butt splice continuous.
6. Plumb and support PC Column and provide grout seal.

LEGEND:

Denotes staged infill with SCC in column void grout in exterior joint region.

Denotes grout injection.




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

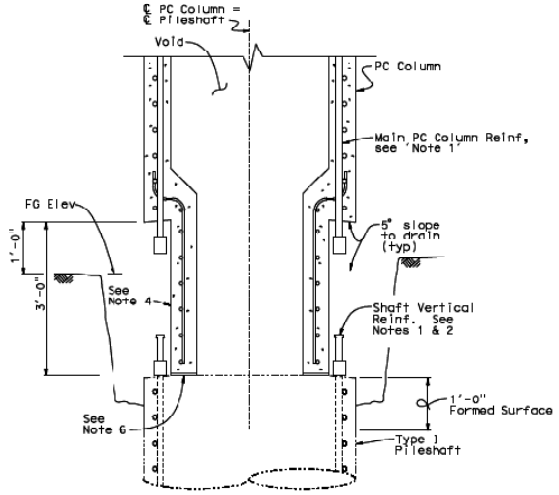
| DIST. | COUNTY | ROUTE | POST MILES TOTAL PROJECT | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|---|---|
| | | | | | |

REGISTERED ENGINEER - CIVIL

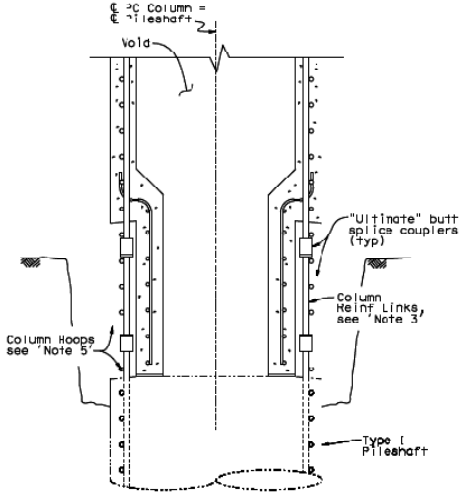
PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

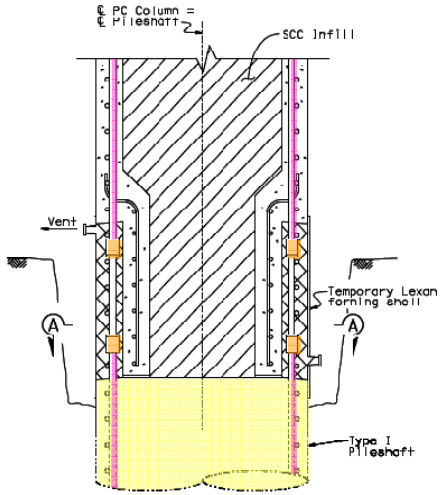
INCOMPLETE PLAN FOR DESIGN STUDY PRINTED
DATE: 03-13-09
Office of Structure Design




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:
THE CONTRACTOR SHALL VERIFY ALL CONTROLLING FIELD DIMENSIONS BEFORE ORDERING OR FABRICATING ANY MATERIAL.

STANDARD DRAWING

| FILE NO. | DESIGN | BY | CHECKED | APPROVAL RECOMMENDED BY |
|---|---|---|---|---|
| XS P02 | DETAILS | BY | CHECKED | |
| DESIGN DATE 10/08 | SUBMITTED BY | | | DESIGN SUPERVISOR |

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES
STRUCTURE DESIGN

BRIDGE NO. XX-XXXX
POST MILE XX.XX

CU 59-183
EA 930343

NGB SEISMIC RESEARCH DETAIL
TEST STRUCTURE
PRECAST COLUMN CONNECTION DETAIL NO. 2

DS 05D 214TA (CADD 7/97)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

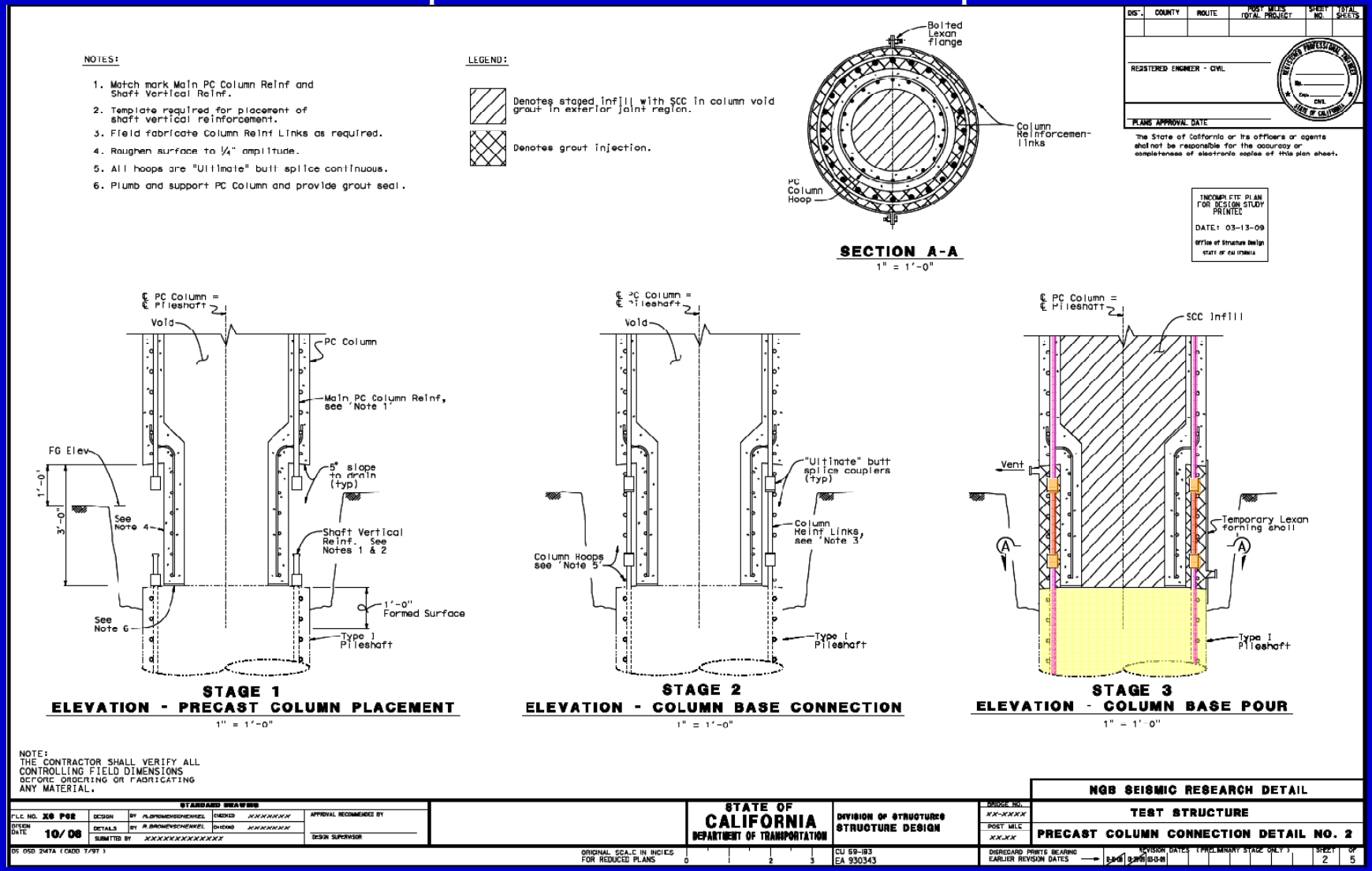
DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)

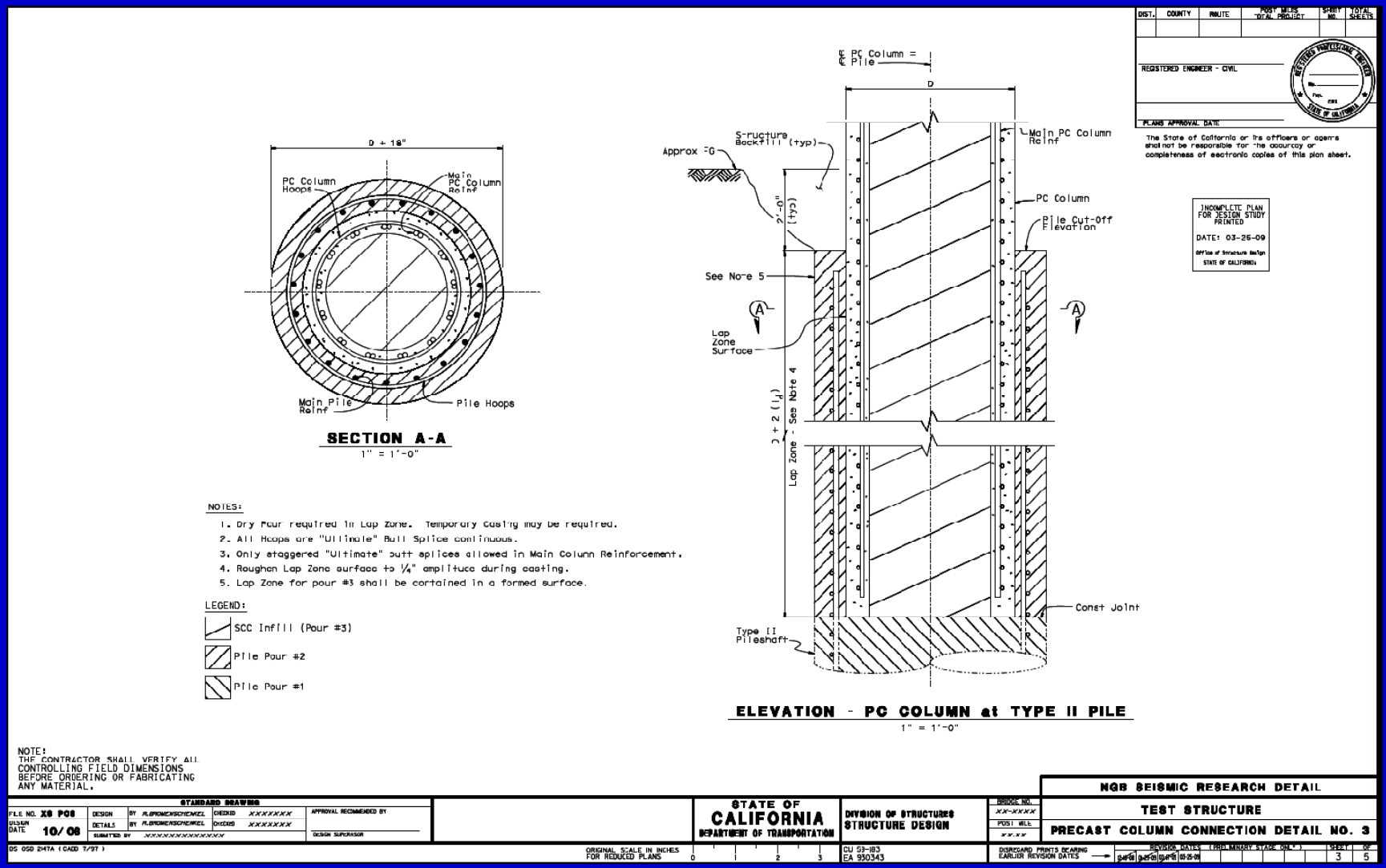
SHEET 2 OF 5

# Next Generation Bridges

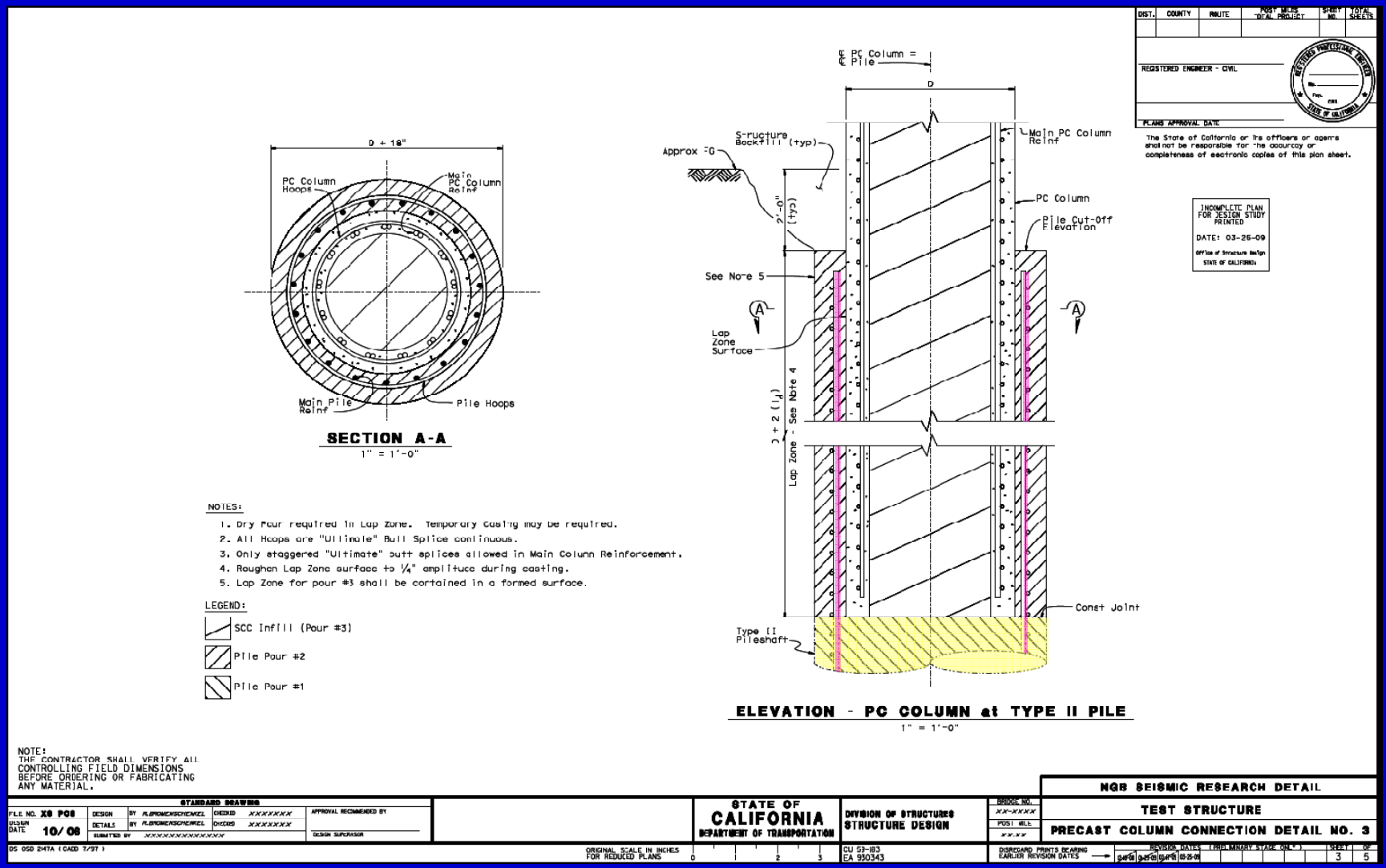
## Proposed Construction Concepts



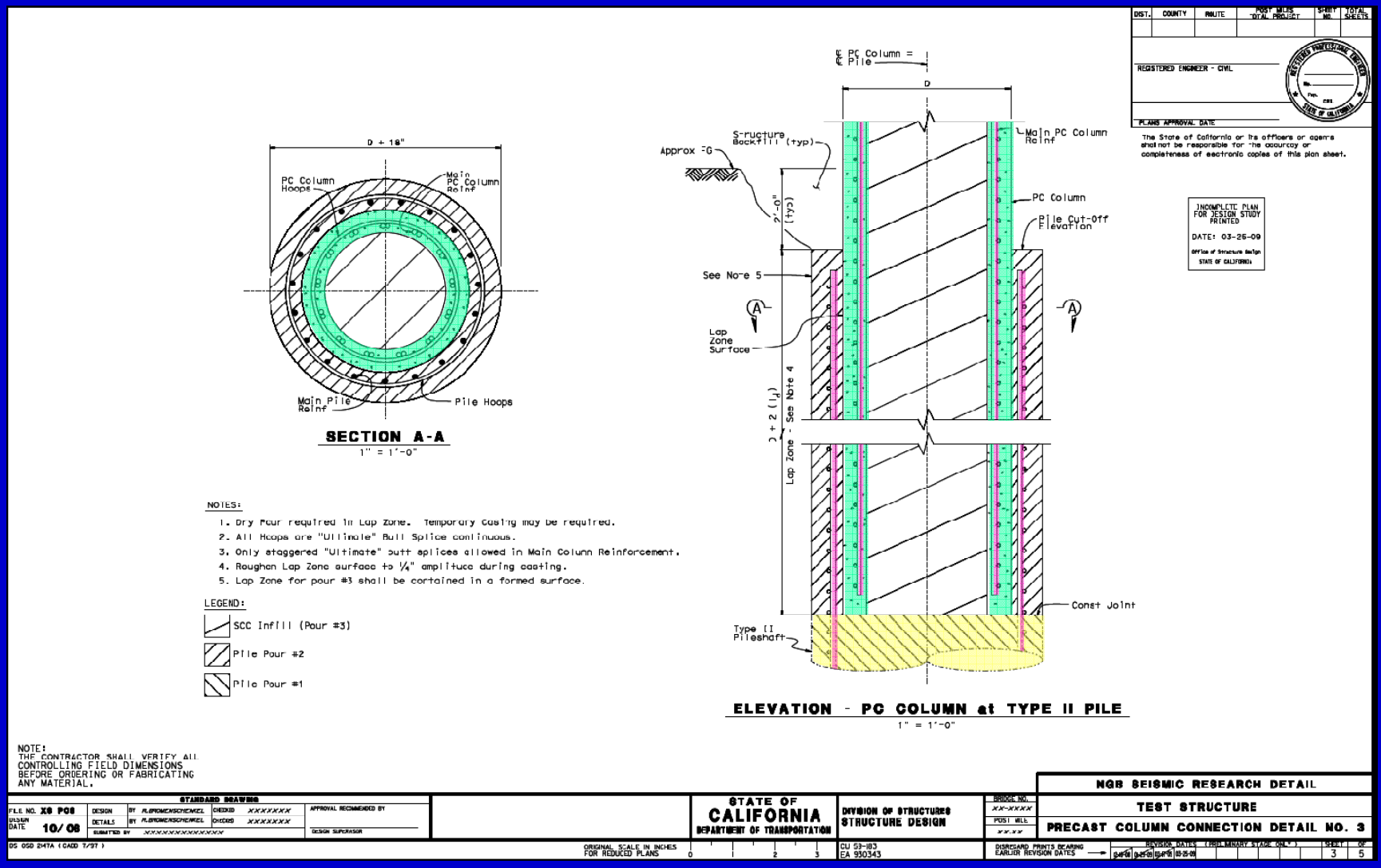
# Next Generation Bridges
## Proposed Construction Concepts



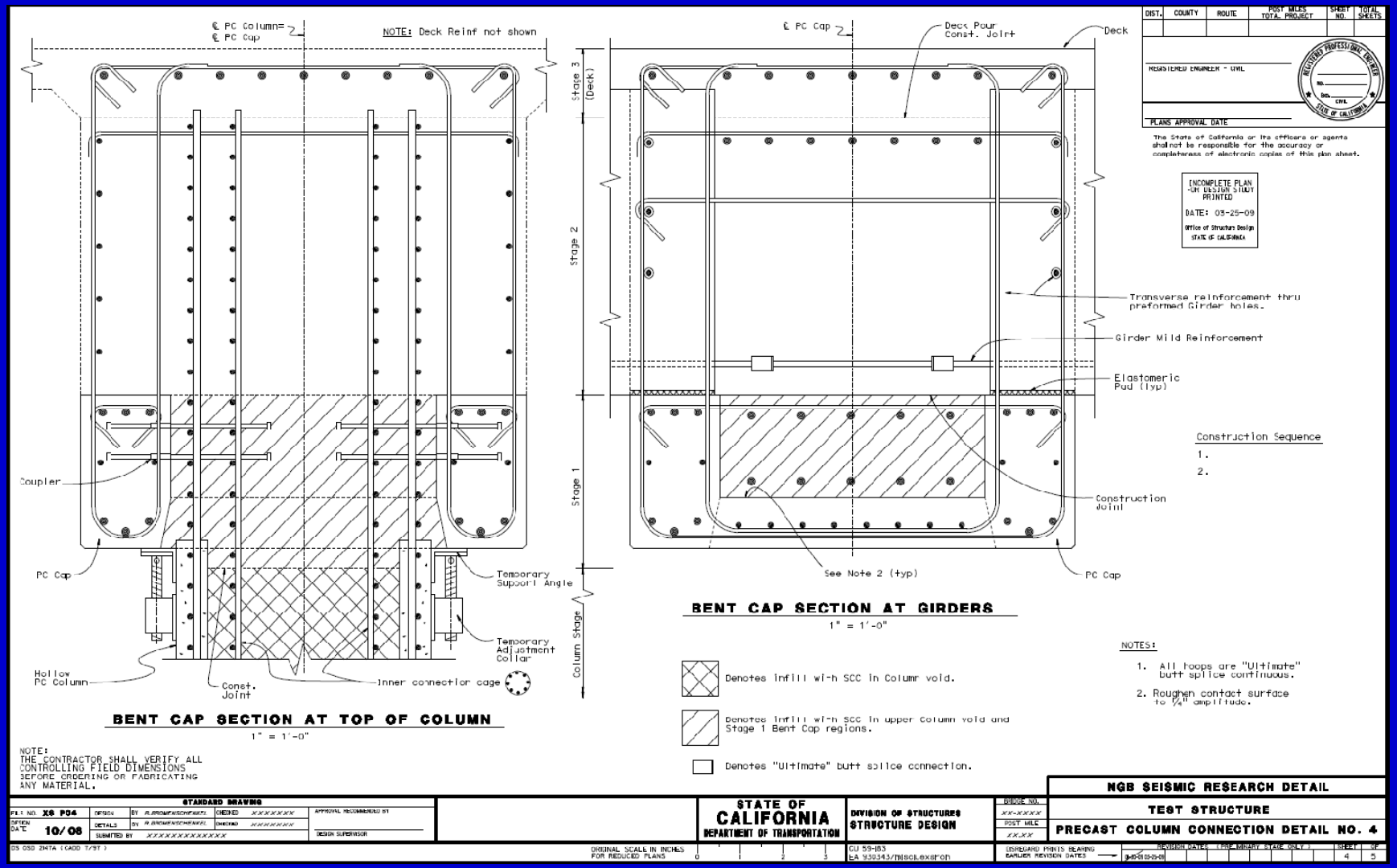
# Next Generation Bridges
## Proposed Construction Concepts



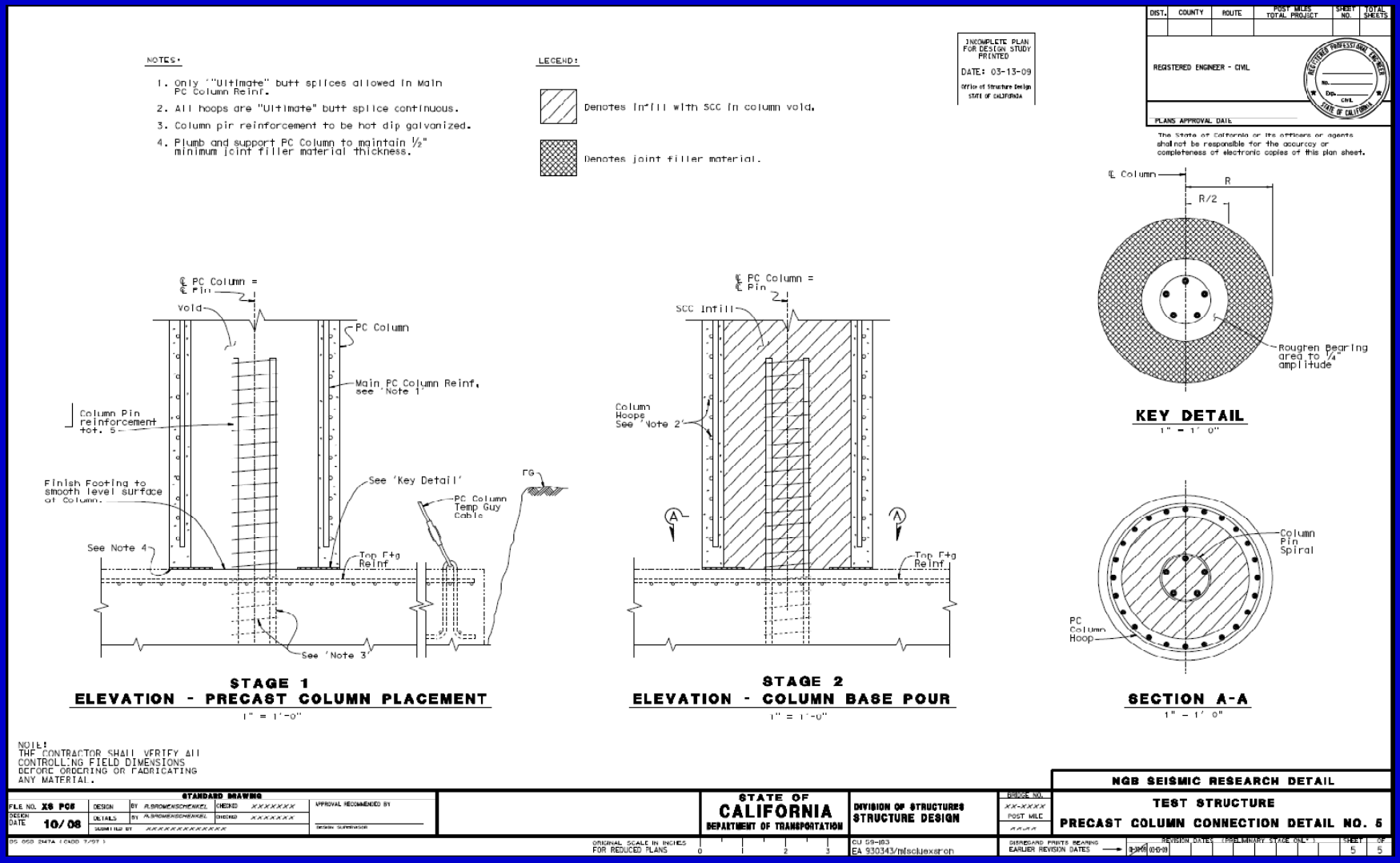
# Next Generation Bridges
## Proposed Construction Concepts



# Next Generation Bridges
## Proposed Construction Concepts



# Next Generation Bridges
## Proposed Construction Concepts



CA.GOV CALIFORNIA DEPARTMENT OF TRANSPORTATION

Structure, Geotechnical, & Seismic Research

CALIFORNIA DEPARTMENT OF TRANSPORTATION

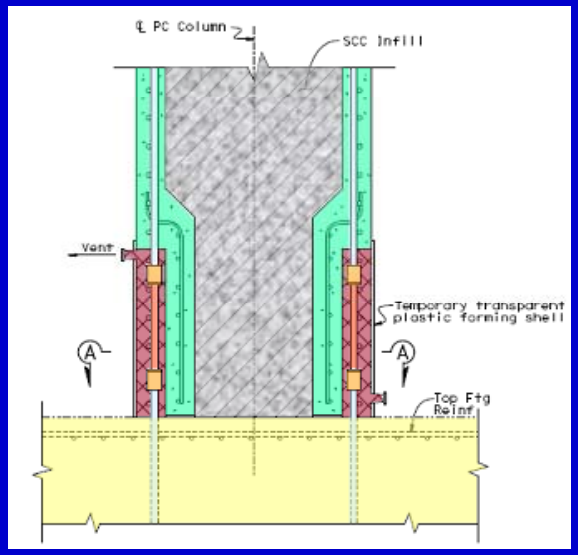
Structure, Geotechnical, & Seismic Research

UNR Research Contract, July 2010

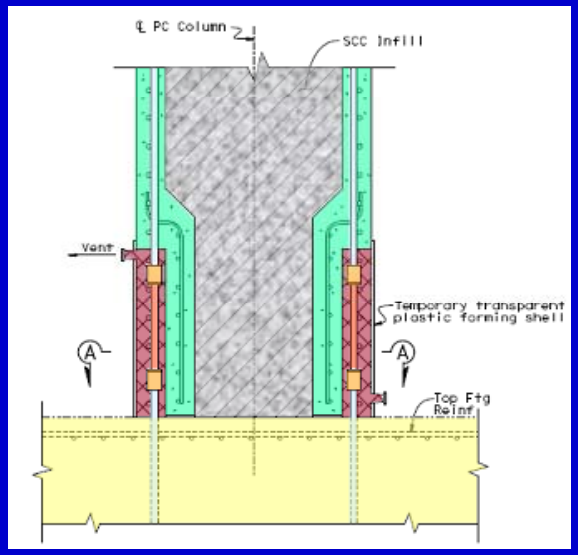
Principal Investigator: Dr. Saiid Saiidi

Professor of Civil & Environmental Engineering

# Connection Detail #1:



## Connection Detail #1:




## Proposed Test Protocol

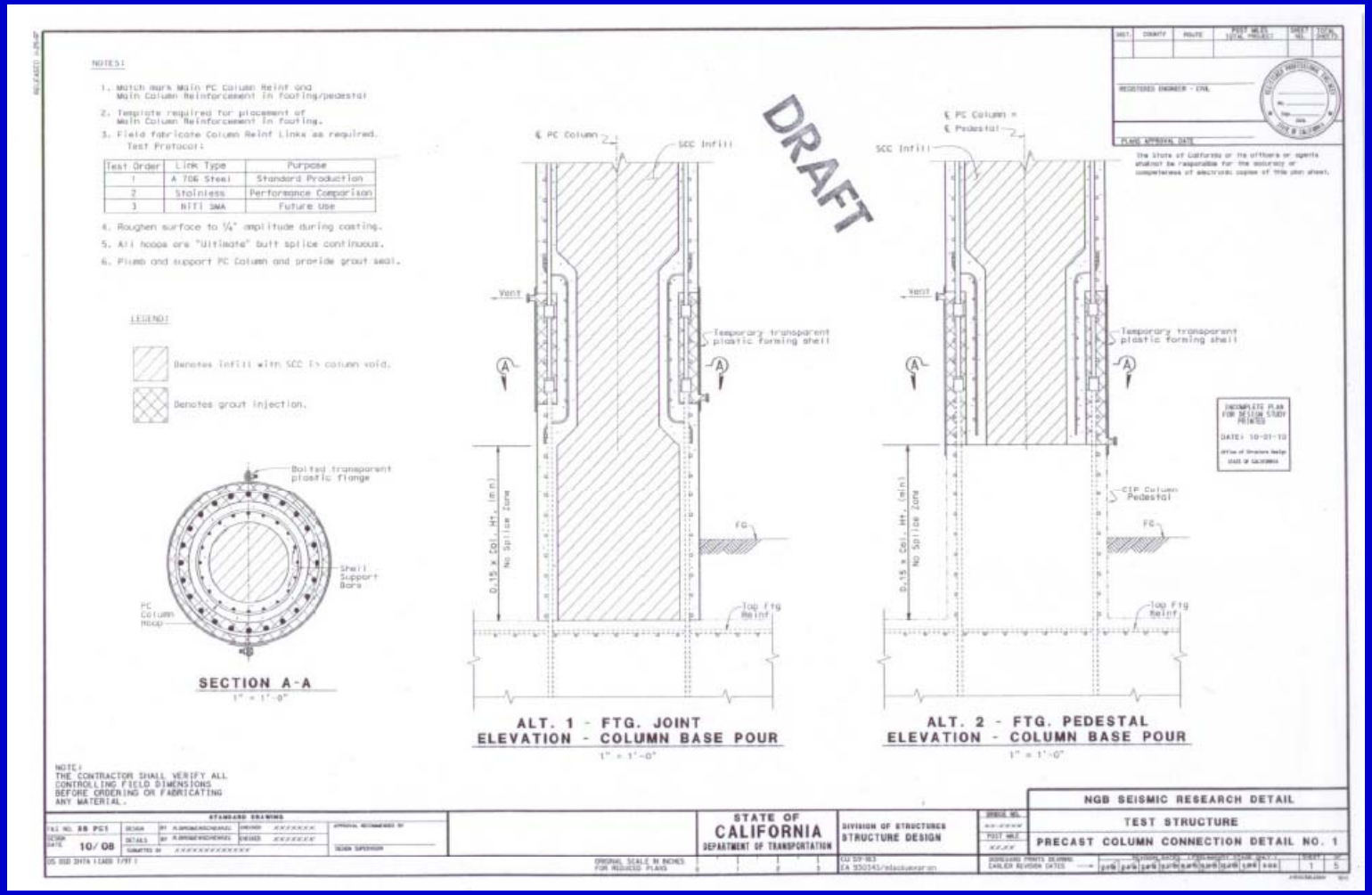
| Phase | Test Unit | Diameter [in] | Reinf. [%] | Confinement |
|---|---|---|---|---|
| A | 1 | 36 | 1.5 | #8 @ 8" |
| | 2 | 36 | 1.5 | #8 @ 6" |
| | 3 | 36 | 1.5 | Bund. #8 @ 8" |
| | 4 | 36 | 1.5 | Bund. #8 @ 6" |
| B | 1 | 48 | 1.5 | #8 @ 8" |
| | 2 | 48 | 1.5 | #8 @ 6" |
| | 3 | 48 | 1.5 | Bund. #8 @ 8" |
| | 4 | 48 | 1.5 | Bund. #8 @ 6" |
| C | 1 | 60 | 1.5 | #8 @ 8" |
| | 2 | 60 | 1.5 | #8 @ 6" |
| | 3 | 60 | 1.5 | Bund. #8 @ 8" |
| | 4 | 60 | 1.5 | Bund. #8 @ 6" |

# Next Generation Bridges

*Alternative Configurations*

# Next Generation Bridges

*Alternative Configurations*



# Concurrent Research

# Concurrent Research

University of Washington

CFT connection tests

# Concurrent Research

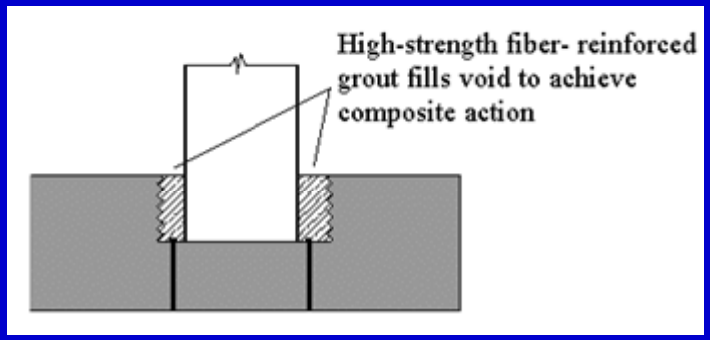
University of Washington

CFT connection tests

# Concurrent Research

University of Washington

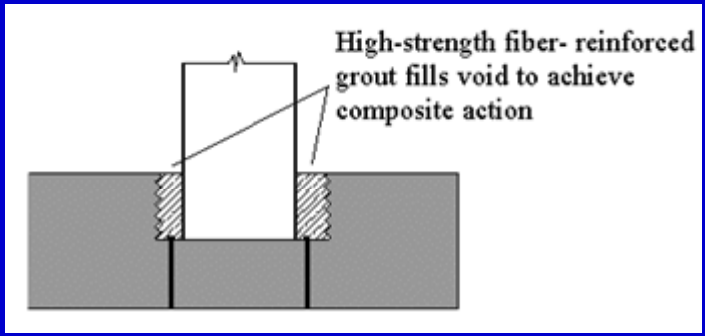
CFT connection tests




# Concurrent Research

University of Washington

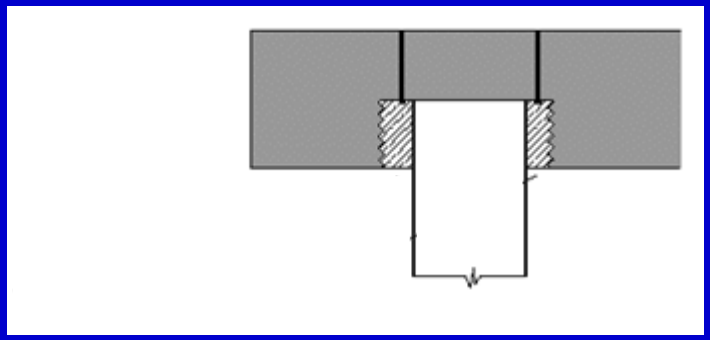
CFT connection tests



# Concurrent Research

University of Washington

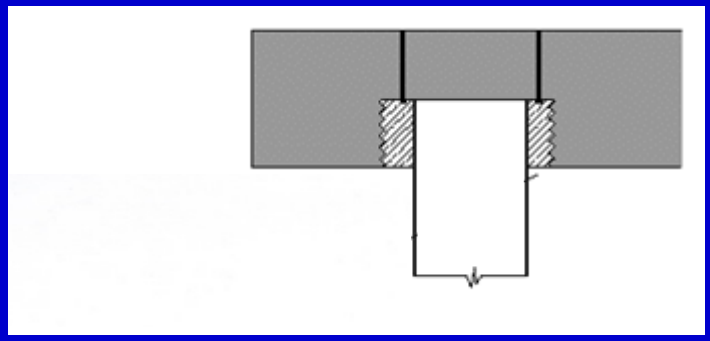
CFT connection tests



# Concurrent Research

University of Washington

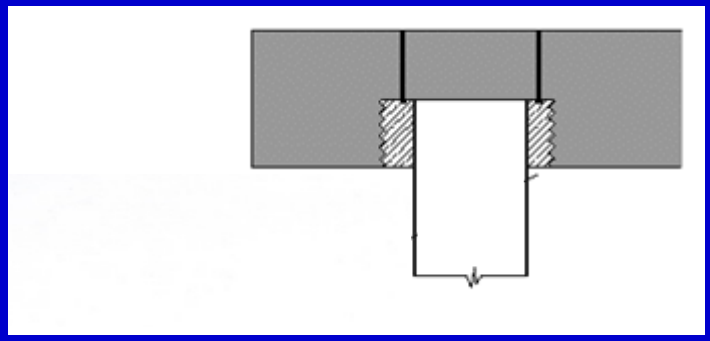
CFT connection tests

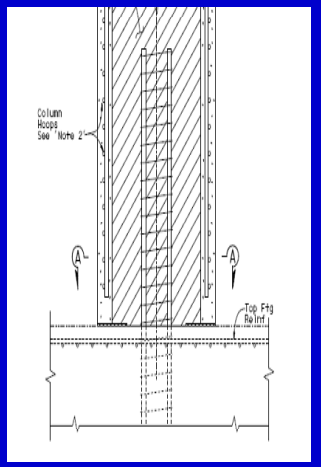


# Concurrent Research

University of Washington

CFT connection tests

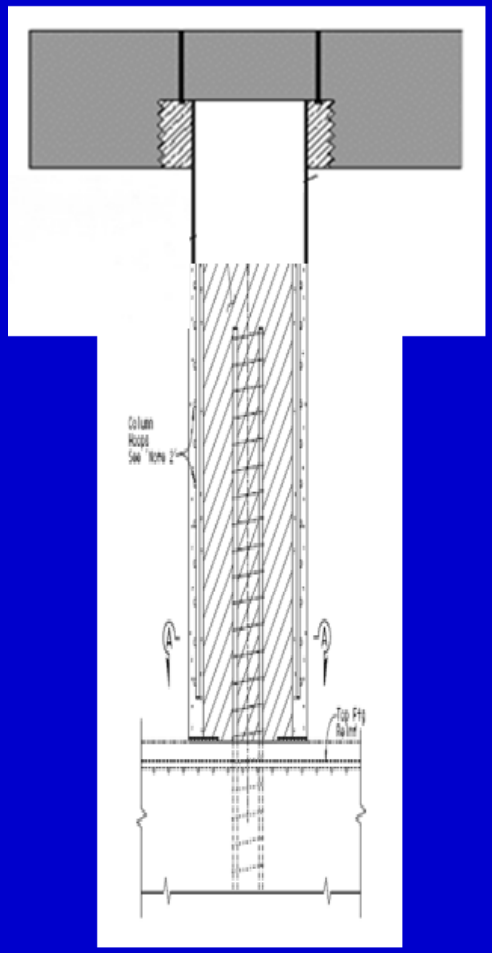




# Concurrent Research

University of Washington

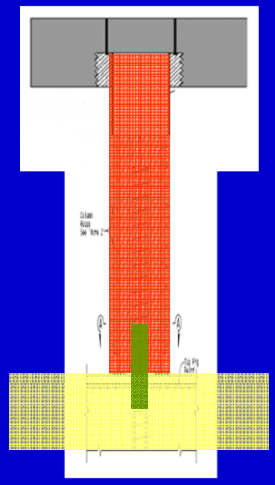
CFT connection tests



# Concurrent Research

University of Washington

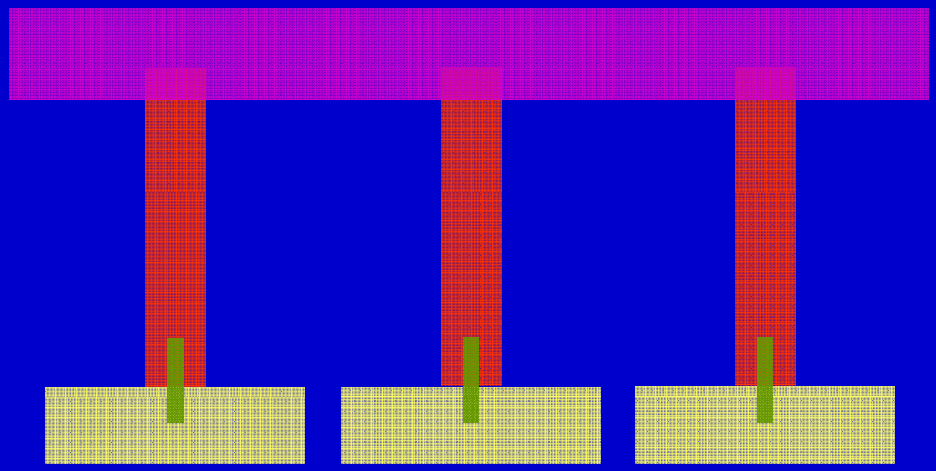
CFT connection tests



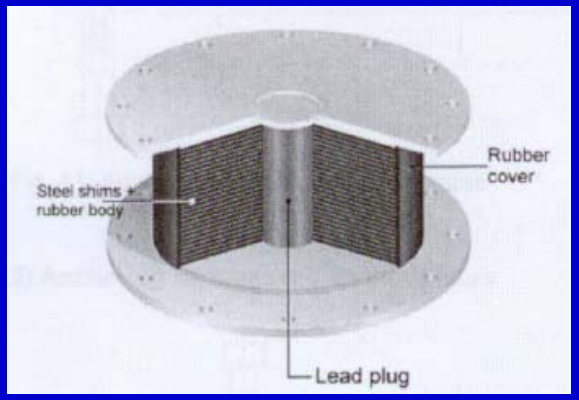
# Concurrent Research

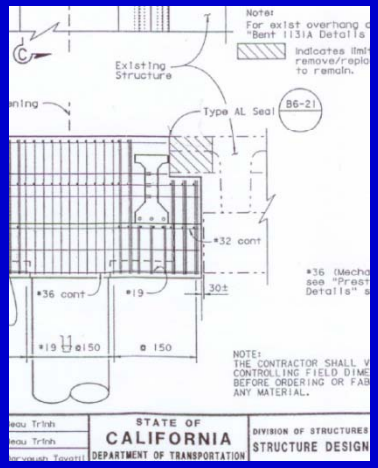
University of Washington

CFT connection tests



# Caltrans NGB Effort




R. JON GRAFTON
PRESIDENT
e-mail: jgrafton@us-concrete.com

US CONCRETE
PRECAST GROUP

POMEROY CORPORATION
A U.S. CONCRETE COMPANY

P.O. Box 2020, Perris, CA 92572
2020 Goetz Rd., Perris, CA 92570
Telephone: (951) 657-6093
Facsimile: (951) 657-5293

•PRECAST CONCRETE
•CONSTRUCTION
•ENGINEERING
LICENSE NO. 929340

**RESEARCH NOTES**
THE EARTHQUAKE ENGINEERING GROUP

September 2006
GRG Vol.4, No.4

Caltrans