Post-Earthquake Bridge Inspection

Cypress Viaduct on Route 880 after the 6.9 Loma Prieta EQ, 1989

Ching Chao, PE, MS; Vinh Dang, PE

Office of Structure Maintenance & Investigations, Caltrans

Caltrans District Map

Provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability

EOC Emergency Operation Centers

LA Regional Transportation Management Center

SM&I Emergency Response Plan

California Department of Transportation

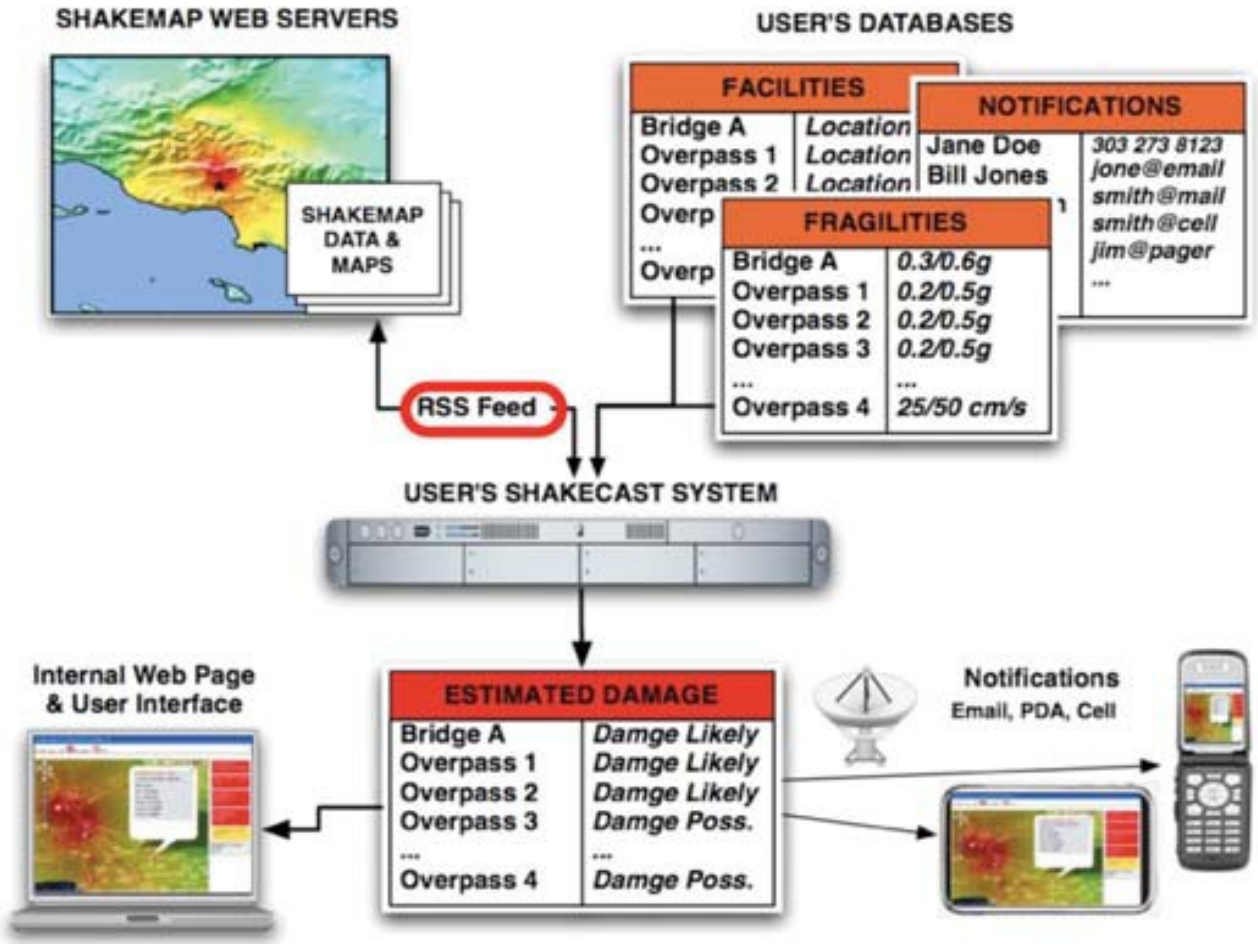
Structure Maintenance and Investigation

Emergency Response Plan

2014

ShakeCast

A post-earthquake decision-making and rapid-response tool



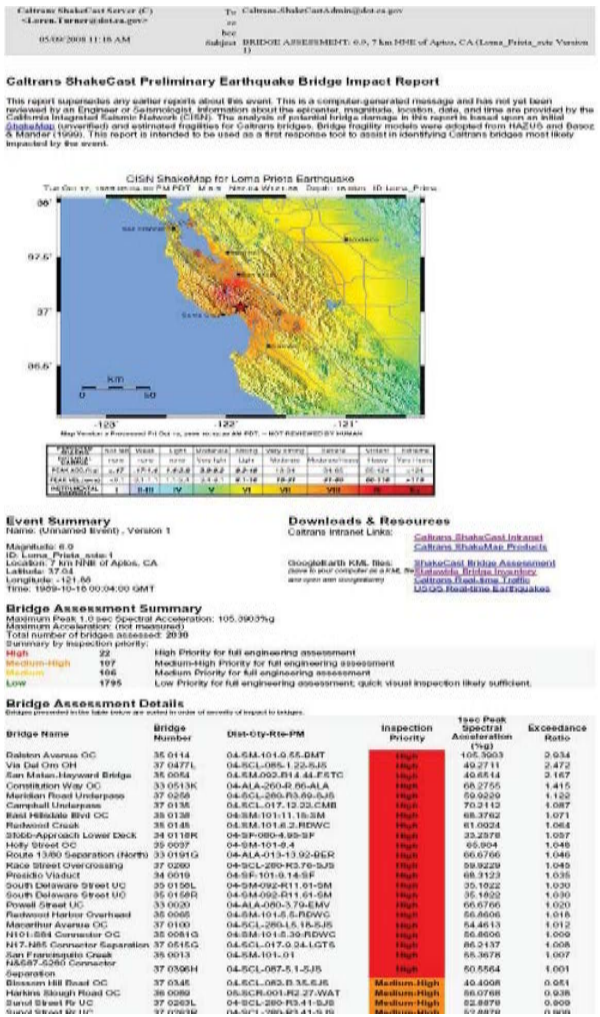
ShakeCast

- *Retrieves measured shaking data within minutes after an earthquake.*
- *Compares shaking distribution with unique bridge vulnerabilities.*
- *Provides hierarchical lists and maps of bridges most likely impacted.*
- *Emails bridge and facility location and inspection priority information to responders within 15 minutes following events with a magnitude greater than 4.0.*
- *Automatically generates products for direct use in Google Earth, ArcGIS, and Excel*
- *Provides a suite of tools on ShakeCast website*

USGS ShakeCast website:

http://earthquake.usgs.gov/research/software/shakecast/

ShakeCast



Caltrans ShakeCast Preliminary Earthquake Bridge Impact Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by an Engineer or Seismologist. Information about the epicenter, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an initial ShakeMap (unverified) and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from HAZUS and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.

CISN ShakeMap for Loma Prieta Earthquake

Event Summary
Name: (Unnamed Event) , Version 1

Magnitude: 6.9
ID: Loma_Prieta_scsn:1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
Longitude: -121.88
Time: 1989-10-18 00:04:00 GMT

Downloads & Resources
Caltrans Intranet Links:
Caltrans ShakeCast Intranet
Caltrans ShakeMap Products

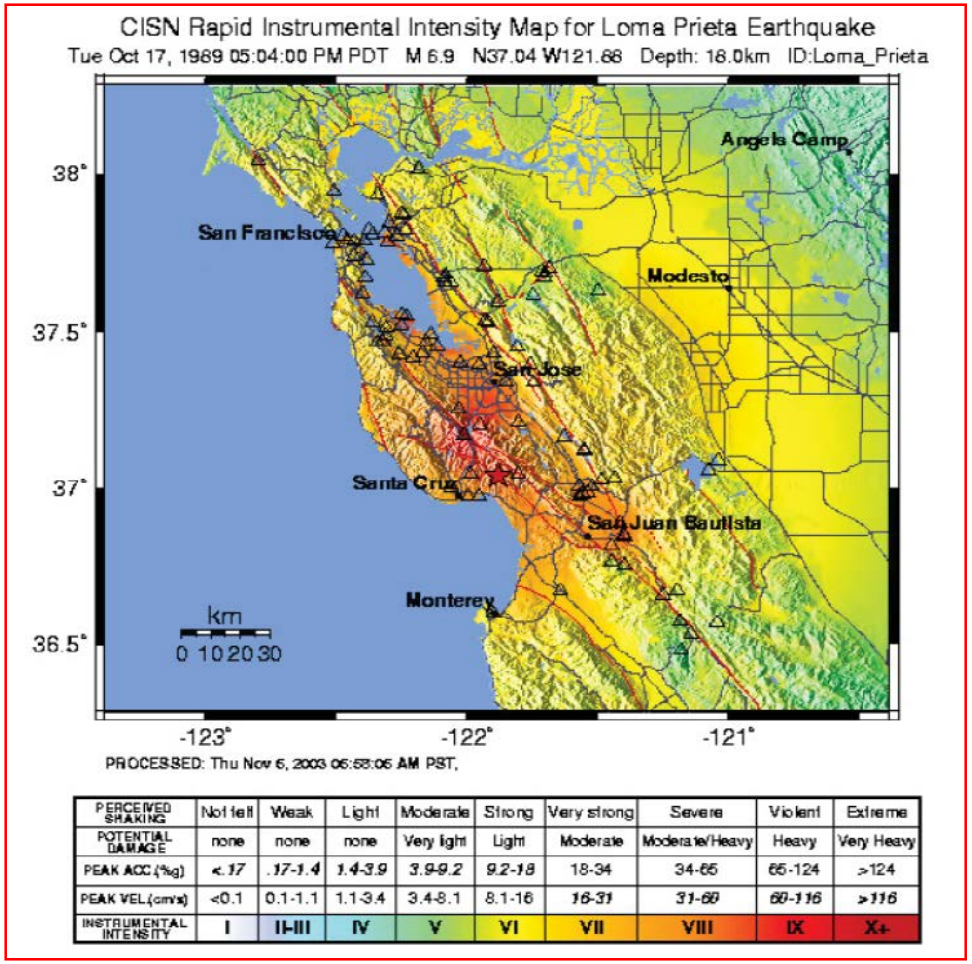
Google Earth KML files:
ShakeCast Bridge Assessment
Statewide Bridge Inventory
Caltrans Real-time Traffic
USGS Real-time Earthquakes

Bridge Assessment Summary
Maximum Peak 1.0 sec Spectral Acceleration: 105.3903%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: 2030
Summary by inspection priority:

High	22	High Priority for full engineering assessment
Medium-High	107	Medium-High Priority for full engineering assessment
Medium	106	Medium Priority for full engineering assessment
Low	1795	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details
Bridges presented in the table below are sorted in order of severity of impact to bridges.

Bridge Name	Bridge Number	Dist-Qty-Rte-PM	Inspection Priority	1sec Peak Spectral Acceleration (%g)	Exceedance Ratio
Dakota Avenue OC	35 0114	04-SM-101-0.55-SMT	High	105.3903	2.034
Via Del Oro OH	37 0477L	04-SCL-085-1.22-SJS	High	49.2711	2.472
San Mateo-Hayward Bridge	35 0054	04-SM-092-R14.44-EBTC	High	49.6514	3.167
Constitution Way OC	33 0513K	04-ALA-260-R.86-ALA	High	68.2755	1.415
Meridian Road Underpass	37 0258	04-SCL-280-R3.66-SJS	High	59.9229	1.122
Campbell Underpass	37 0135	04-SCL-017-12.22-CMB	High	70.2113	1.087
East Hillsdale Blvd OC	35 0138	04-SM-101-11.18-SM	High	68.3762	1.071
Redwood Creek	35 0118	04-SM-101-8.2-REDWC	High	61.0024	1.064
35bb-Approach Lower Deck	34 0118R	04-SF-080-4.99-SF	High	33.2578	1.057
Holly Street OC	35 0097	04-SM-101-9.4	High	65.904	1.046
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
Rice Street Overcrossing	37 0260	04-SCL-280-R3.76-SJS	High	59.9229	1.045
Presidio Viaduct	34 0019	04-SF-101-9.14-SF	High	68.3123	1.035
South Delaware Street UC	35 0156L	04-SM-092-R11.01-SM	High	35.1622	1.030
South Delaware Street UC	35 0156R	04-SM-092-R11.01-SM	High	35.1622	1.030
Powell Street UC	33 0020	04-ALA-080-3.79-EMV	High	66.6766	1.020
Redwood Harbor Overhead	35 0065	04-SM-101-8.5-REDWC	High	56.8606	1.016
Macarthur Avenue OC	37 0150	04-SCL-280-L5.16-SJS	High	54.4613	1.012
N101-584 Connector OC	35 0061G	04-SM-101-8.39-REDWC	High	56.8606	1.009
N17-N85 Connector Separation	37 0515G	04-SCL-017-0.24-LGTS	High	86.2137	1.008
San Francisquito Creek N8587-5260 Connector Separation	35 0013	04-SM-101-.01	High	55.3678	1.007
	37 0306H	04-SCL-087-5.1-SJS	High	50.5564	1.001
Blossom Hill Road OC	37 0345	04-SCL-082-B 35.6JS	Medium-High	49.4008	0.951
Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	66.0768	0.938
Sunol Street Rt UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8879	0.909
Sunol Street Rt UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8879	0.909



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

ShakeCast

Caltrans ShakeCast Server (C) <Loren.Turner@dot.ca.gov>
05/09/2008 11:18 AM

To Caltrans-ShakeCastAdmin@dot.ca.gov
cc
bcc
Subject BRIDGE ASSESSMENT: 6.9, 7 km NNE of Aptos, CA (Loma_Prieta_scte Version 1)

Caltrans ShakeCast Preliminary Earthquake Bridge Impact Report

This report supersedes any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by an Engineer or Seismologist. Information about the epicenter, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an initial ShakeMap (unverified) and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from HAZUS and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.

Map Version: a Processed Fri Oct 13, 2006 10:12:35 AM PDT -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Event Summary
Name: (Unnamed Event) , Version 1

Magnitude: 6.9
ID: Loma_Prieta_scte-1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
Longitude: -121.88
Time: 1989-10-18 00:04:00 GMT

Downloads & Resources
Caltrans Intranet Links: Caltrans ShakeCast Intranet; Caltrans ShakeMap Products

GoogleEarth KML files: (save to your computer as a KML file and open with GoogleEarth): ShakeCast Bridge Assessment; Statewide Bridge Inventory; Caltrans Real-time Traffic; USGS Real-time Earthquakes

Bridge Assessment Summary
Maximum Peak 1.0 sec Spectral Acceleration: 105.3903%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: 2030
Summary by inspection priority:

High	22	High Priority for full engineering assessment
Medium-High	107	Medium-High Priority for full engineering assessment
Medium	106	Medium Priority for full engineering assessment
Low	1795	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details
Bridges presented in the table below are sorted in order of severity of impact to bridges.

Bridge Name	Bridge Number	Dist-Cty-Rte-PM	Inspection Priority	1sec Peak Spectral Acceleration (%g)	Exceedance Ratio
Ralston Avenue OC	35 0114	04-SM-101-9.55-BMT	High	105.3903	2.934
Via Del Oro OH	37 0477L	04-SCL-085-1.22-SJS	High	49.2711	2.472
San Mateo-Hayward Bridge	35 0054	04-SM-092-R14.44-FSTC	High	49.6514	2.167
Constitution Way OC	33 0513K	04-ALA-260-R.86-ALA	High	68.2755	1.415
Meridian Road Underpass	37 0258	04-SCL-280-R3.89-SJS	High	59.9229	1.122
Campbell Underpass	37 0135	04-SCL-017-12.22-CMB	High	70.2112	1.087
East Hillsdale Blvd OC	35 0138	04-SM-101-11.15-SM	High	68.3762	1.071
Redwood Creek	35 0145	04-SM-101-6.2-RDWC	High	61.0924	1.064
Sfobb-Approach Lower Deck	34 0118R	04-SF-080-4.95-SF	High	33.2578	1.057
Holly Street OC	35 0037	04-SM-101-8.4	High	65.904	1.048
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
Race Street Overcrossing	37 0260	04-SCL-280-R3.76-SJS	High	59.9229	1.045
Presidio Viaduct	34 0019	04-SF-101-9.14-SF	High	68.3123	1.035
South Delaware Street UC	35 0158L	04-SM-092-R11.61-SM	High	35.1822	1.030
South Delaware Street UC	35 0158R	04-SM-092-R11.61-SM	High	35.1822	1.030
Powell Street UC	33 0020	04-ALA-080-3.79-EMV	High	66.6766	1.020
Redwood Harbor Overhead	35 0065	04-SM-101-5.5-RDWC	High	56.8606	1.018
Macarthur Avenue OC	37 0100	04-SCL-280-L5.18-SJS	High	54.4613	1.012
N101-S84 Connector OC	35 0081G	04-SM-101-5.39-RDWC	High	56.8606	1.009
N17-N85 Connector Separation	37 0515G	04-SCL-017-9.24-LGTS	High	86.2137	1.008
San Francisquito Creek	35 0013	04-SM-101-.01	High	55.3678	1.007
N85/87-S280 Connector Separation	37 0396H	04-SCL-087-5.1-SJS	High	50.5564	1.001
Blossom Hill Road OC	37 0345	04-SCL-082-R.35-SJS	Medium-High	49.4998	0.951
Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909

Event Summary

Name: (Unnamed Event) , Version 1
Magnitude: 6.9
ID: Loma_Prieta_scte-1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
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Map Version: 3 Processed Fri Oct 13, 2006 10:32:35 AM PDT -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.27	.27-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Event Summary

Name: (Unnamed Event) , Version 1

Magnitude: 6.9
ID: Loma_Prieta_scte-1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
Longitude: -121.88
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Low	1795	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details

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Bridge Name	Bridge Number	Dist-Cty-Rte-PM	Inspection Priority	1sec Peak Spectral Acceleration (%g)	Exceedance Ratio
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Holly Street OC	35 0037	04-SM-101-8.4	High	65.904	1.048
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
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South Delaware Street UC	35 0158L	04-SM-092-R11.61-SM	High	35.1822	1.030
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Medium-High	136	Medium-High Priority for full engineering assessment
Medium	152	Medium Priority for full engineering assessment
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Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Winchester Boulevard OC	37 0195	04-SCL-280-4.57-SJS	Medium-High	55.327	0.898
Lincoln Avenue UC	37 0262L	04-SCL-280-R3.51-SJS	Medium-High	52.8878	0.896
South Gilroy OH	37 0305L	04-SCL-101-R5.1	Medium-High	43.2728	0.896

Field Inspection

SM&I Earthquake Field Damage Report 9/22/14

SM&I Disaster Command Center - Email: smidcc@dot.ca.gov Phone: (888) 893-9974

Bridge Number: _____ **Date:** _____ **Time (24hr):** _____

Bridge Name: _____

Inspector 1: _____ **Inspector 2:** _____

Unit: _____ Phone No: _____ Unit: _____ Phone No: _____

Current Status:

1 ☐ Open 2 ☐ Open with Shoring 3 ☐ Closed / Can Be Open 4 ☐ Closed

Restrictions: (Select all that apply)

5 ☐ No Restrictions
6 ☐ Operational
7 ☐ Structural
8 ☐ Investigate / Repair Prior to Open
9 ☐ No Permit Loads
10 ☐ Traffic Control Required for Repair
11 ☐ Lane Usage Restrictions

Damage:

12 ☐ Damage
13 ☐ No Damage
14 ☐ No Additional Damage

15 Damage Summary:

Repair Cost Estimates:

16 ☐ None 17 ☐ Low <$5k 18 ☐ Med $5-50k 19 ☐ Med-High $50-100k 20 ☐ High >100k

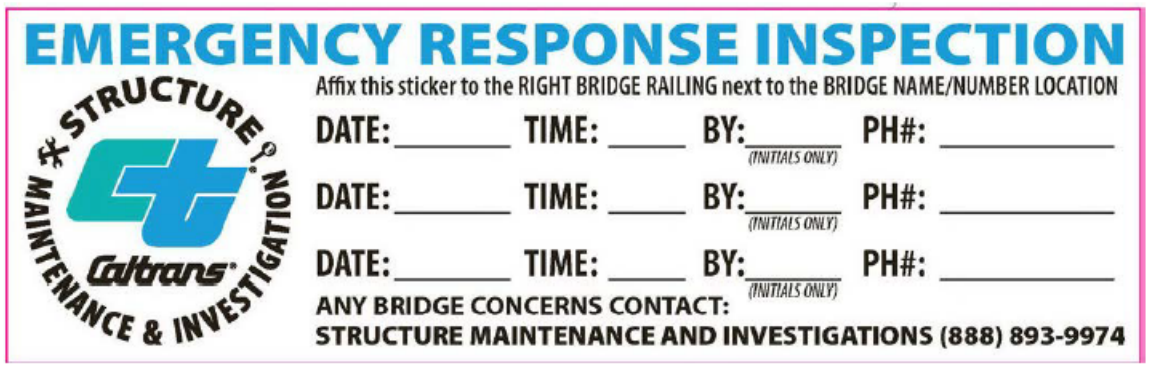
21 Detailed Cost Estimates: $ _____

Feature Damage: (Detailed Distress)

Approach Roadway:	
Approach Slabs:	
Superstructure:	
Wingwalls and Rails:	
Abutments:	
Expansion Joints:	
Hinges:	
Shear Keys:	
Bearings:	
Columns/Pier Caps:	
Foundation/Piles:	
Retrofit:	
Other _____:	

Structure Maintenance & Investigations 1801 30th Street, Sacramento, CA, 95816 Phone: (916) 227-8631 Fax: (916) 227-8357

Field Inspection



SMART

Structures Maintenance Automated Report Transmittal System

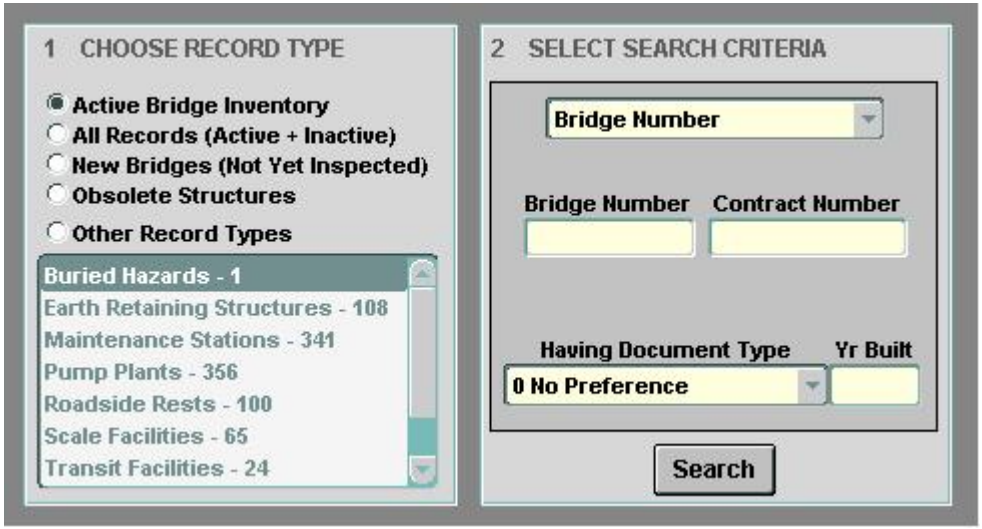
- *Introduced in 1997. Currently Version 2, 2002*
- *Integrated Oracle Form Application database*
- *Compatible with NBIS, National Bridge Inspection Standards, coding guides & data reporting requirements*
- *Consistent with the design of the AASHTOWare® Pontis® Bridge Management System database*
- *Supports the entire cycle of bridge management, including Inventory, Inspection and Project and Program Development*
- *Used on Bridge Routine Inspection, Specialized Inspections, Hydraulics, Load Rating & Project Development*

BIRIS

Bridge Inspection Records Information System

Provides an interface to as-built plans, inspection reports, and other documents pertaining to transportation structures in the state of California. The system currently contains over 950,000 documents.

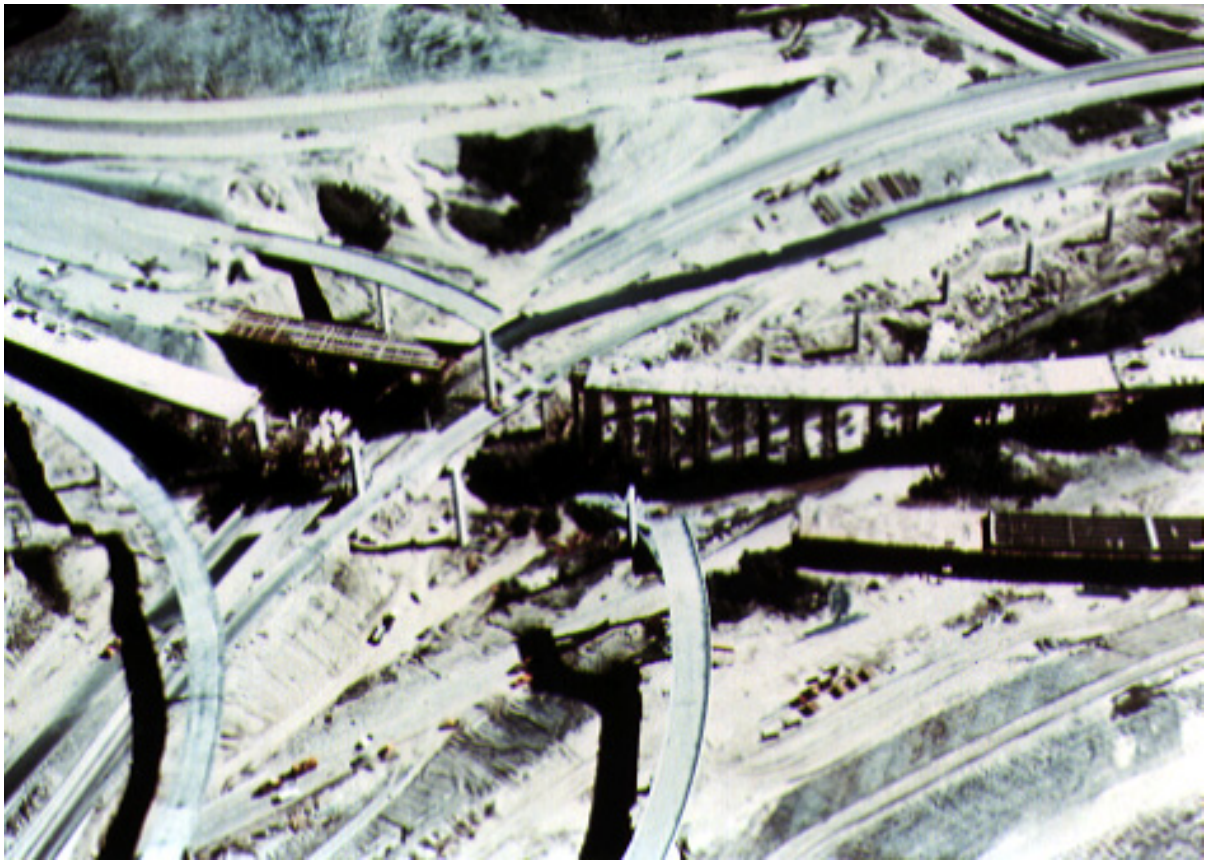
RECORD TYPE AND SEARCH CRITERIA



San Fernando Earthquake, 1971

Route 210/5 Interchange

San Fernando Earthquake,1971



Route 14/5 Interchange

Anchorage Failure at Base of Column

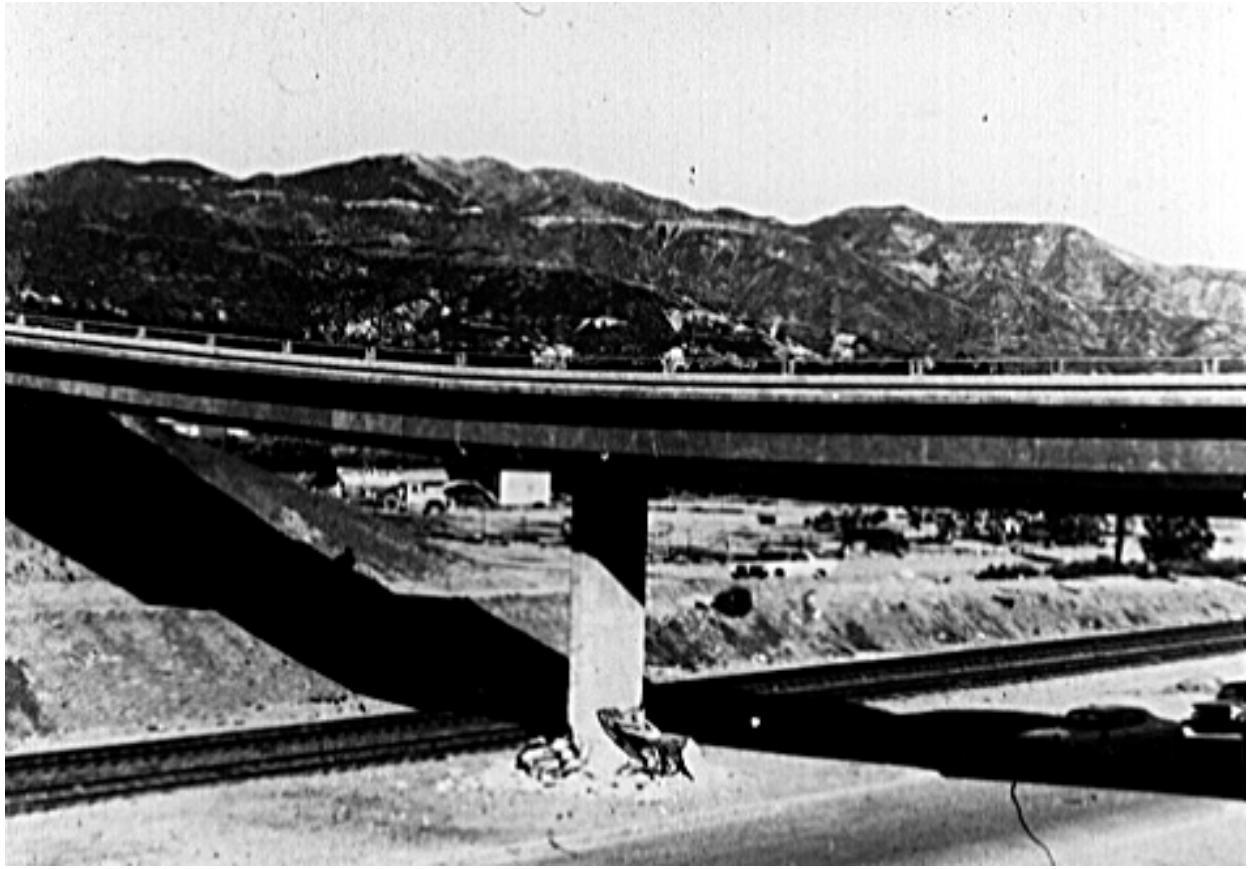
Lap Splices at Base or Lack of Development into the Footing

San Fernando Earthquake

Route 5/210 Interchange - Foothill Blvd. UP

Non-ductile failure: Lack of Confinement Resulted in Rapid Loss of Section and Consequently, Rapid Loss of Strength.

San Fernando Earthquake
San Fernando Road OH (Route 210)



Lack of Confinement

San Fernando Earthquake,1971

San Fernando Earthquake,1971

Balboa Blvd. OC, South Abut Failure in Shear of Superstructure and End Diaphragm at Soffit

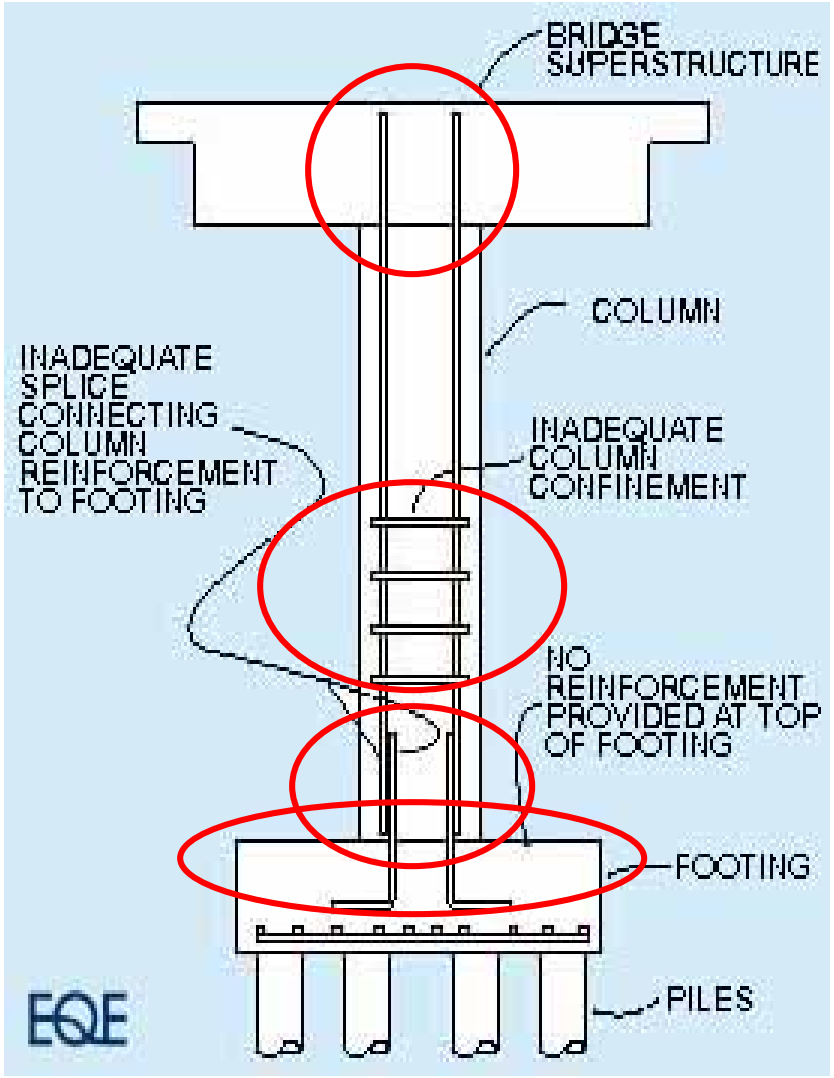
San Fernando Earthquake,1971

210 Interchange

Wingwall Damage at Abutment

Pre 1971 Caltrans Column Details

- ***Non-ductile details built by Caltrans had four main structural problems:***
  - ***Lack of confinement. (#4 @ 12” ties)***
  - ***Lap splice at the base of the column***
  - ***No top mat in footing***
  - ***Inadequate rebar development into the superstructure***



Earthquake Damage to Bridge

- ***Superstructure***
  - ***Loss of Girder Support***
  - ***Rotation due to High Skew***
- ***Substructure***
  - ***Column Flexural Failure***
  - ***Column Shear Failure***
  - ***Column Anchorage Failure***
- ***Abutments***
  - ***Abutment Movement/Failure***
  - ***Approach Settlement***
- ***Foundations***
  - ***Ground Movements***
  - ***Liquefaction***

Retrofit Approach

- ***Collapse prevention by:***
  - ***providing sufficient seat for displacement***
  - ***allowing max ductility in the supporting members (columns)***

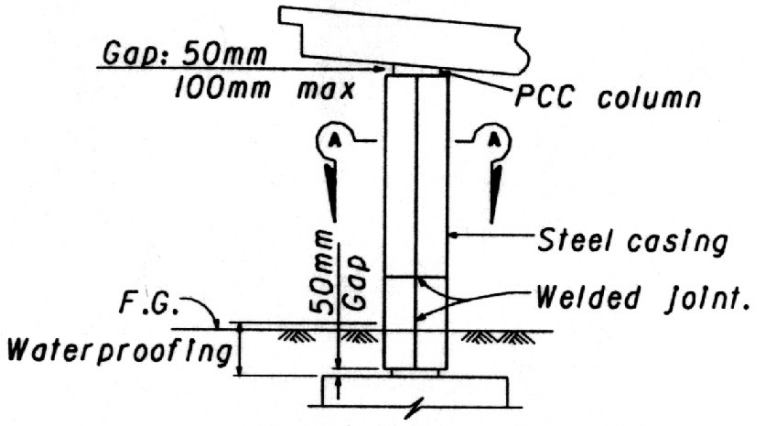
Column Retrofit

- ***Most common type of retrofit***
- ***Previous design approach relies heavily on column's inelastic capacity for ductile response***

Steel Column Casings

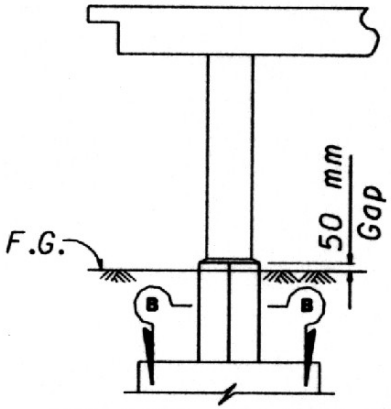
- ***Most Common Type of Column Retrofit***
- ***Increase Flexural Ductility Capacity***
- ***Develop Flexural Capacity of Existing Lap Splices***
- ***Increase Shear Capacity***

Column Retrofit-Steel Column Casings



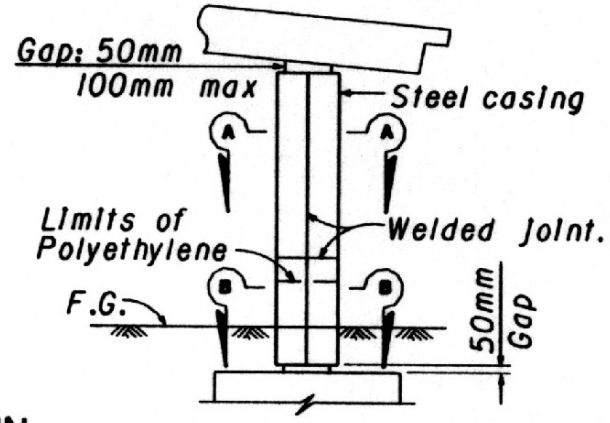
CLASS F COLUMN

Fixed-Fixed



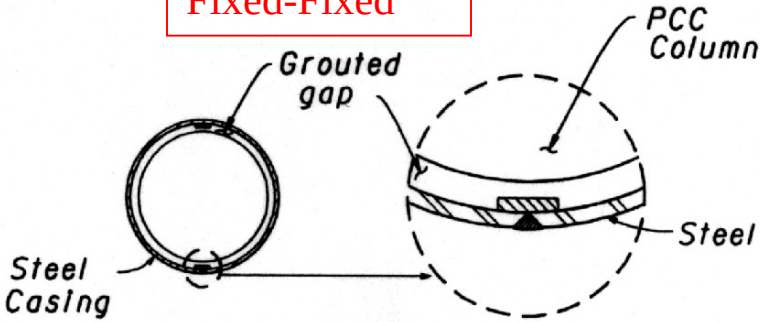
CLASS P COLUMN

Pinned base

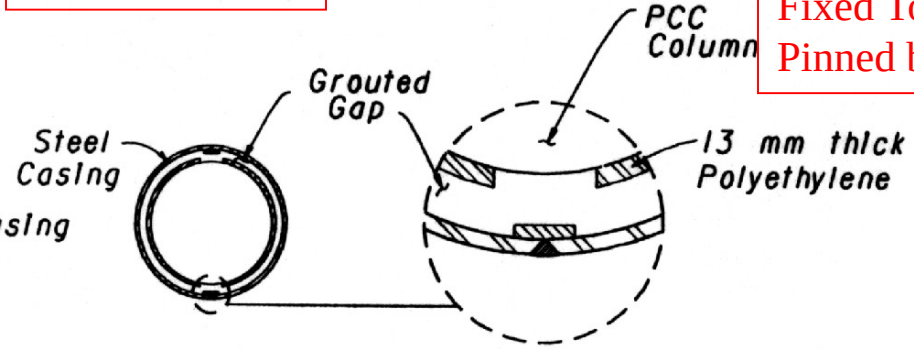


CLASS P/F COLUMN

Fixed Top-Pinned base



SECTION A-A
ROUND COLUMN



SECTION B-B
ROUND COLUMN

Steel Shell Encased Around Existing Column-Filled With Grout

Column Retrofit-Steel Column Casings

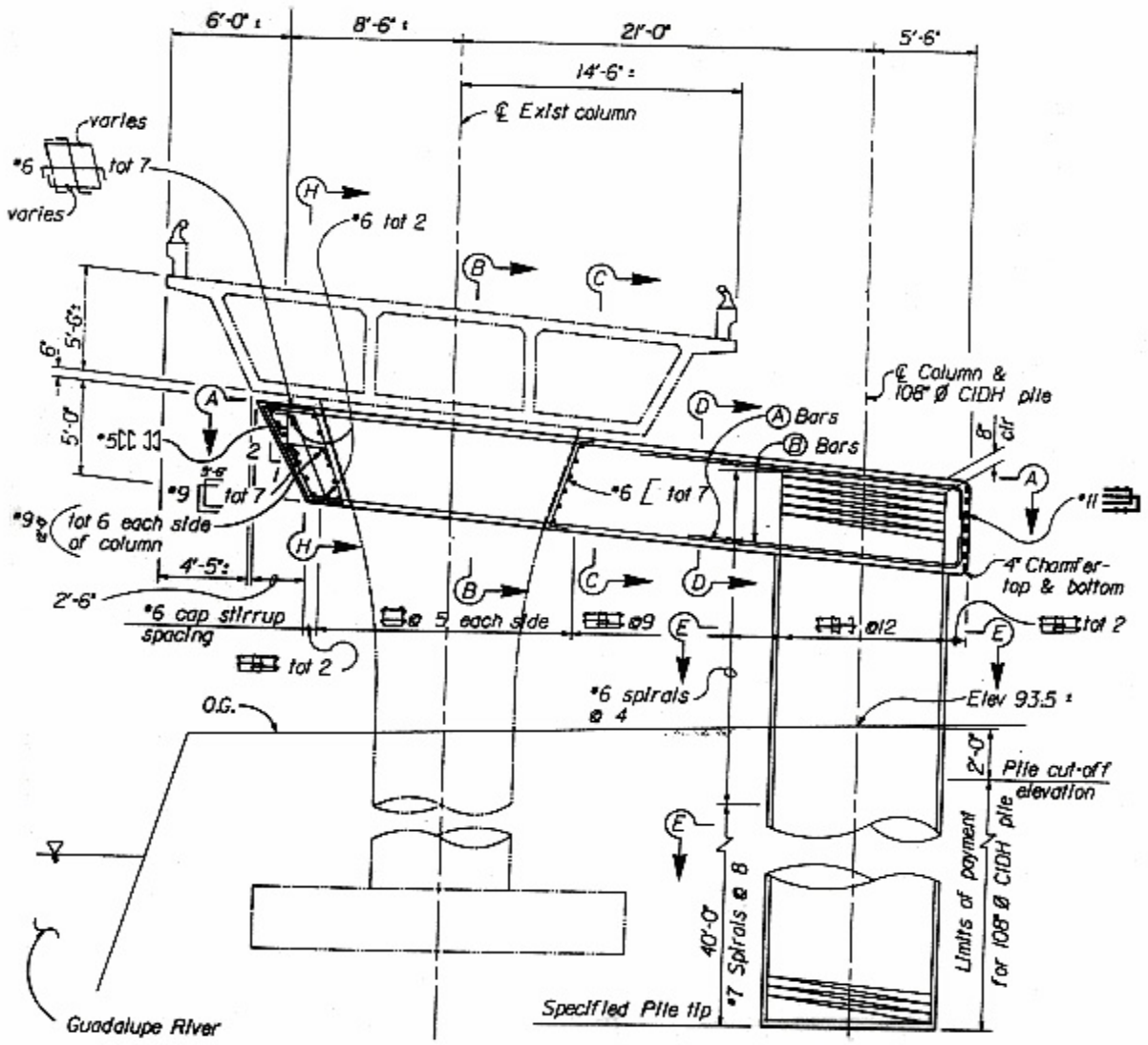
Thickness 5/8” min-1” max

2” Gap-Prevent Bearing on Soffit and Footing

Weld Seams

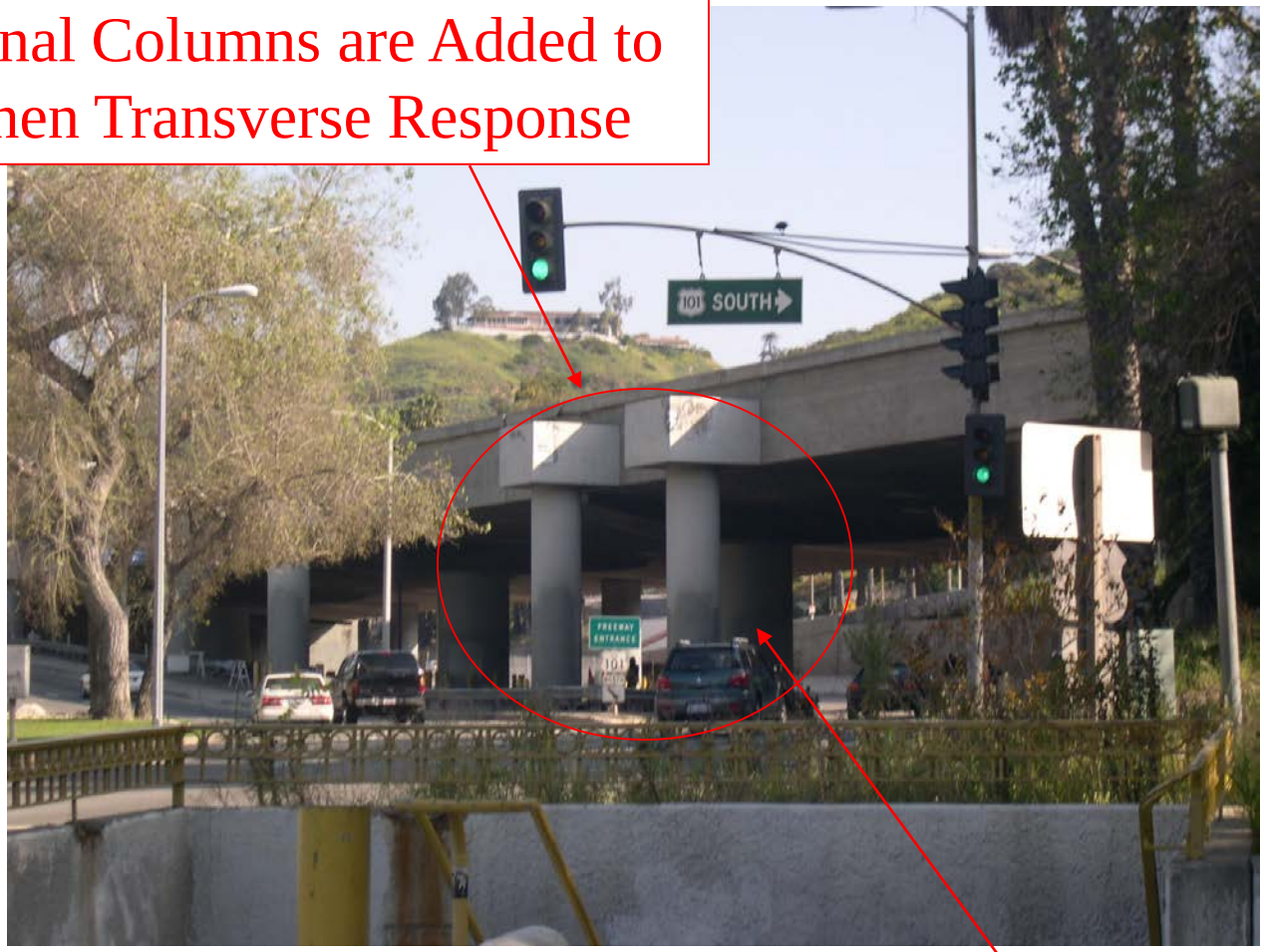
Common Shapes are Circular and Elliptical

Column Addition



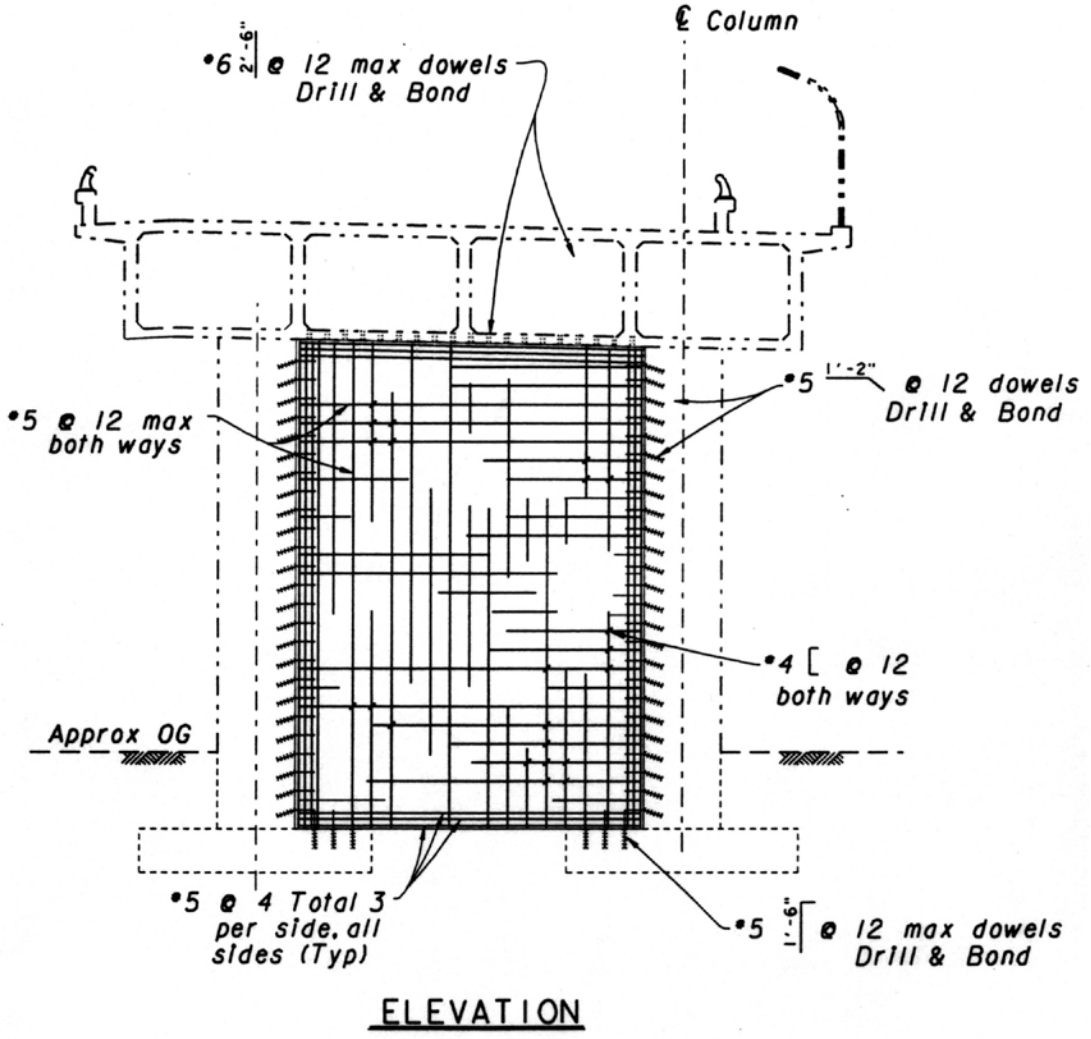
Column Addition

Additional Columns are Added to Strengthen Transverse Response



Originally a Single Column Bent

In-Fill Wall



Improves Stability in Transverse Direction

Acts Like a Shear Wall

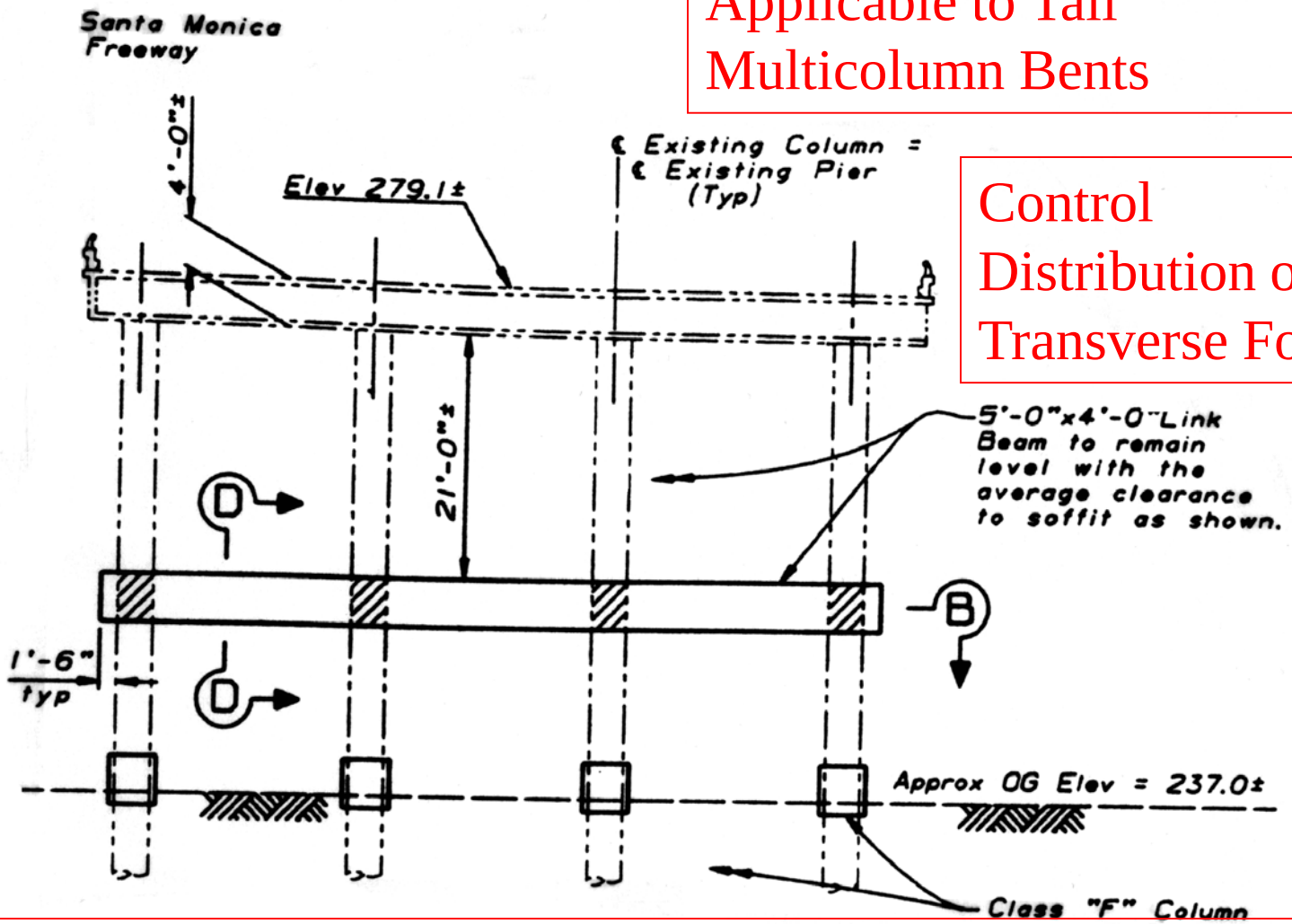
RC Wall Securing Two Adjacent Columns Together

In-Fill Wall

Not all bents are retrofitted-
Minimum one bent per frame

Link Beam Retrofit

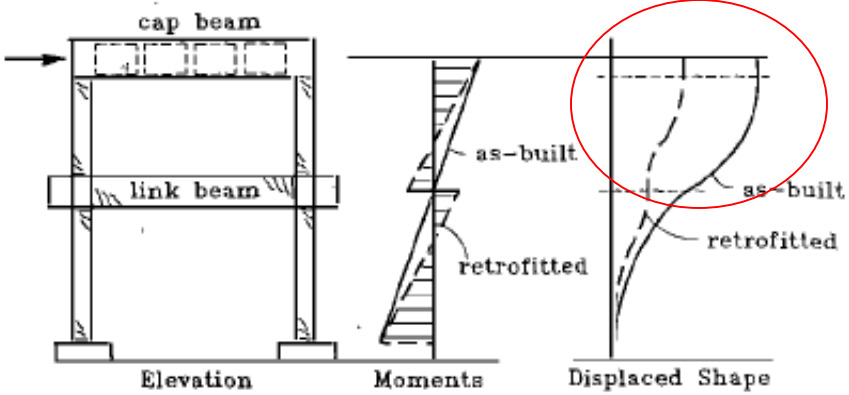
Applicable to Tall Multicolumn Bents



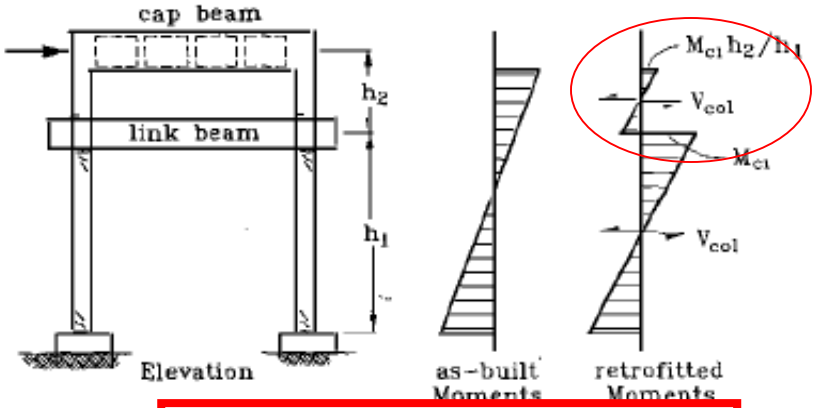
Control Distribution of Transverse Forces

Beam Element Connected to Columns Within a Bent

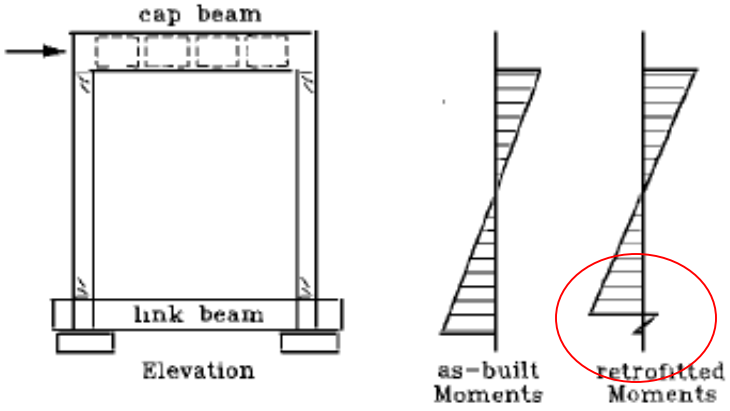
Link Beam Retrofit



(a) Retrofit for reduced displacements.



(b) Retrofit for reduced cap beam forces.

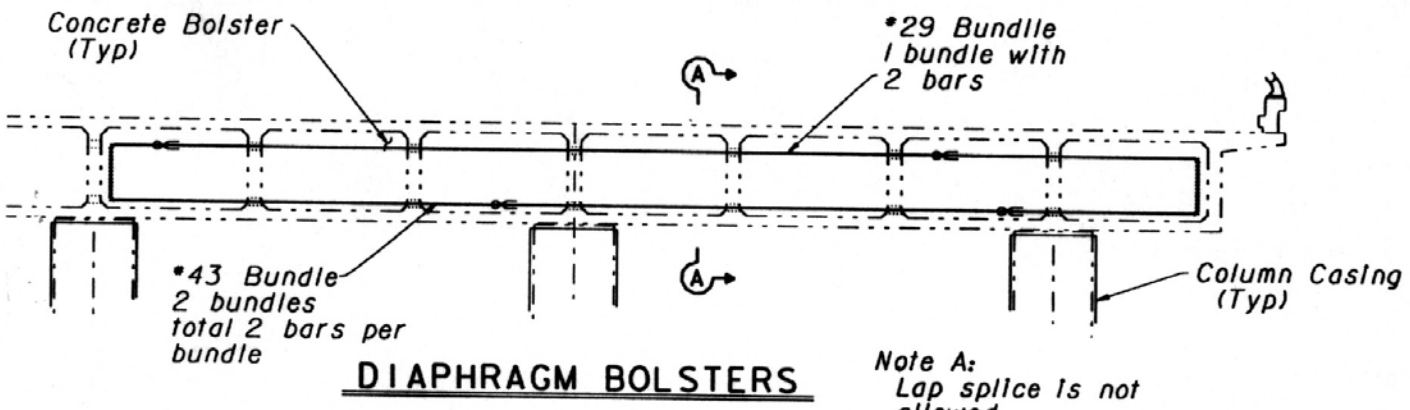


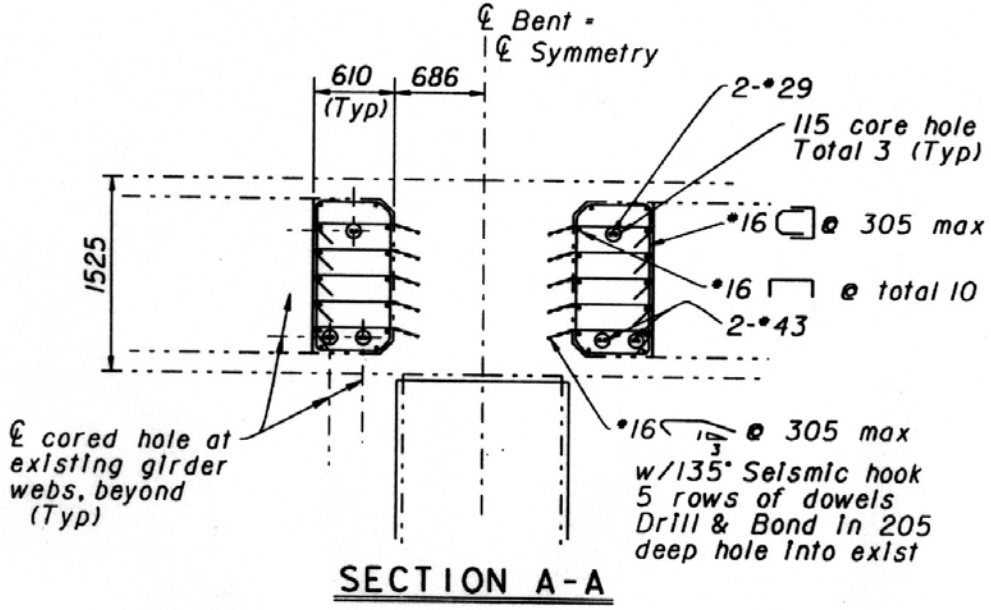
(c) Retrofit for reduced footing forces.

Link Beam Retrofit

Retrofitted for Reduced Cap Beam Forces

Bent Cap Retrofit





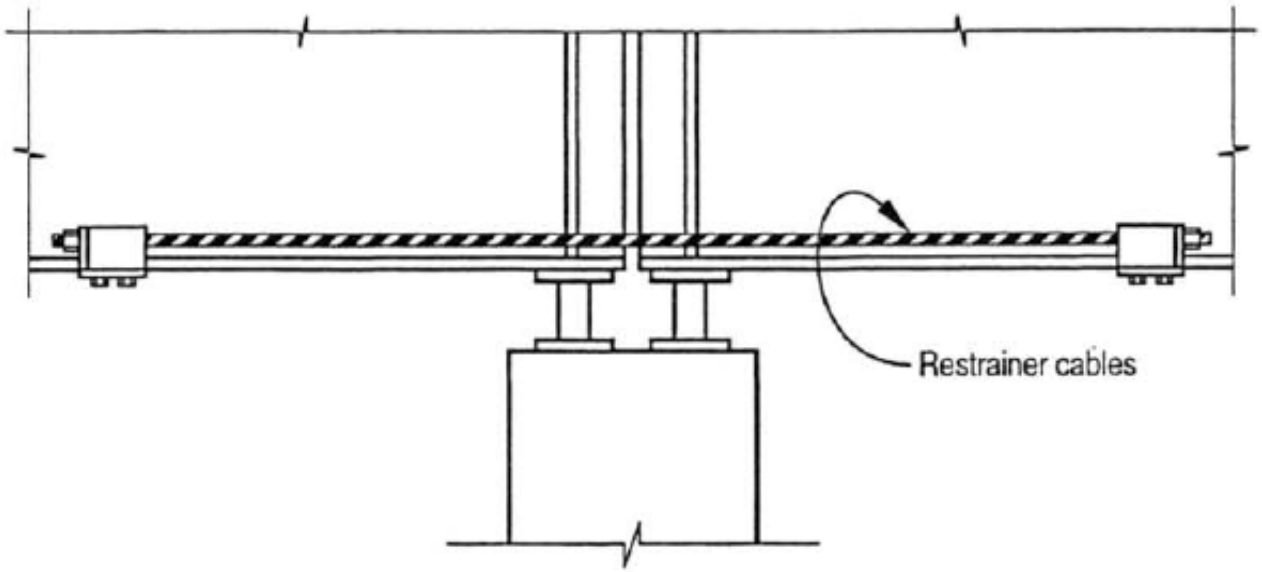
Additional Strength to Ensure Elastic Response of Bent Cap

Bent Cap Retrofit in Progress

Uses High Strength Threaded Bars

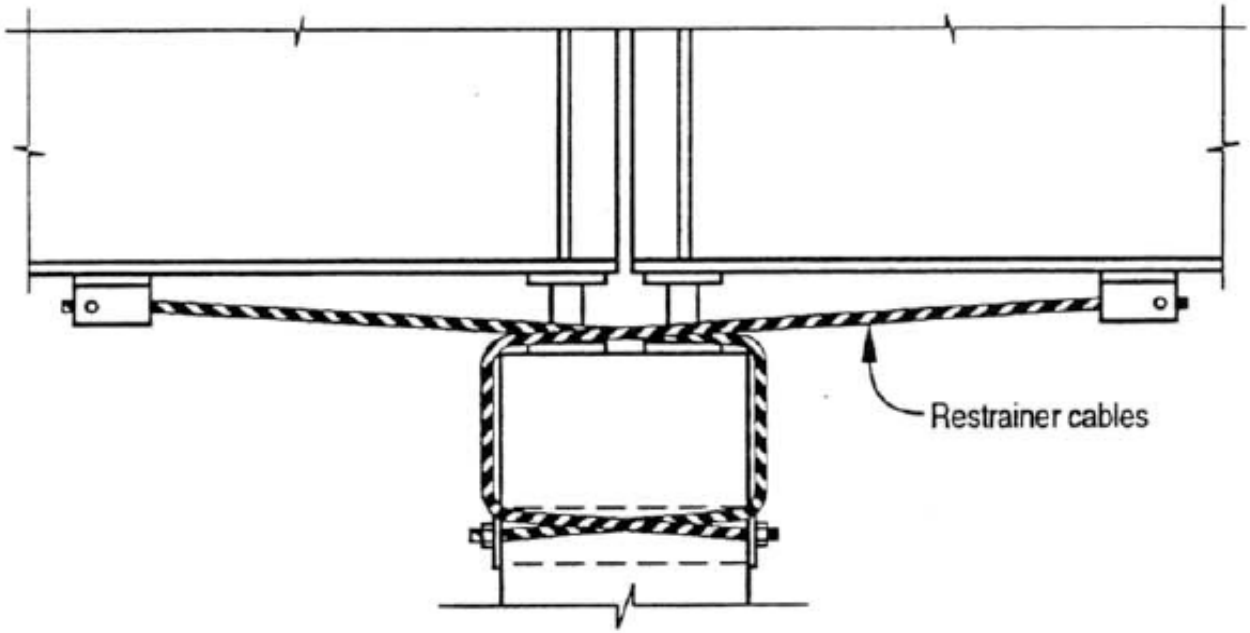
Access Openings at All Bays Indicates Retrofit Work

Cable Restrainer



Prevent girders from falling off their supports

Cable Restrainer



Preferred detail

-Tied into bent cap

-Each girder is tied independently


VALERO

Hinge Retrofit

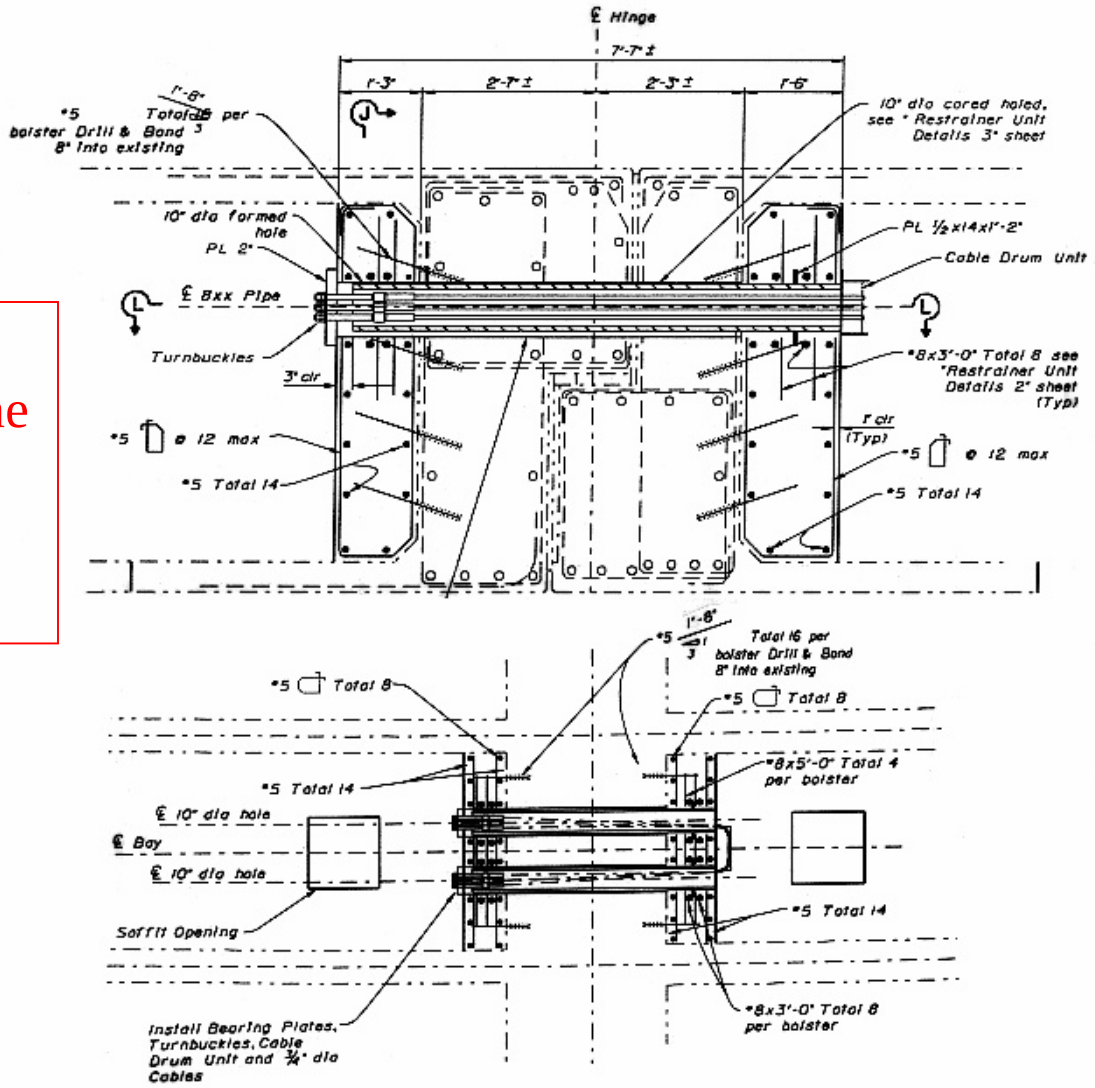
Unseating of Hinge Seat Leads to Collapse

Northridge Earthquake1994, M 6.8

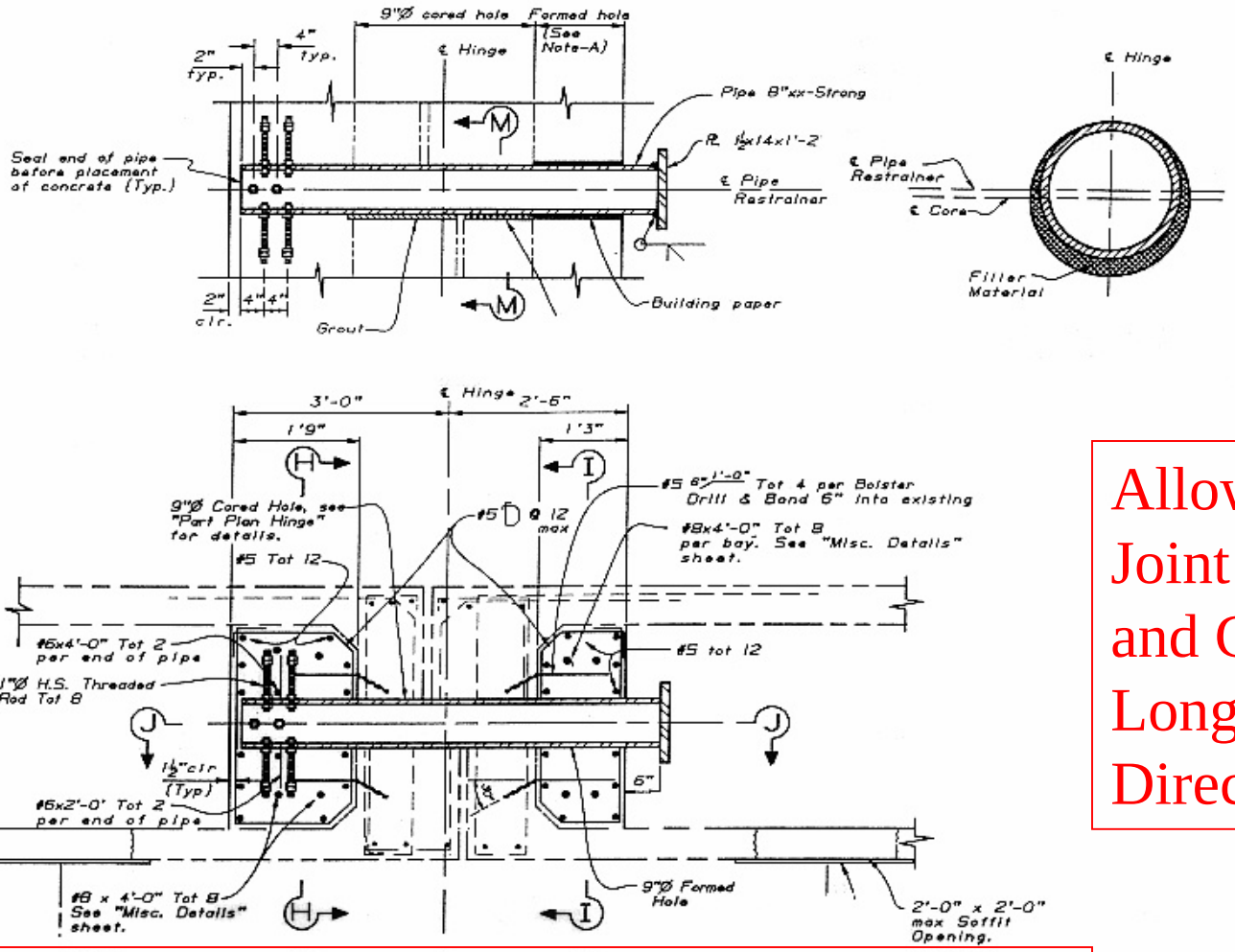
Gavin Canyon Undercrossing – Year Designed: 1965

Hinge Retrofit-Cable Restrainer

Uses Cables Anchored to One Side to Prevent Hinge From Unseating



Hinge Retrofit-Pipe Seat Extender



Allows Hinge Joint to Open and Close in Longitudinal Direction

Uses Steel Pipe Anchored to One Side of Hinge

Old way-seat width~8-12”

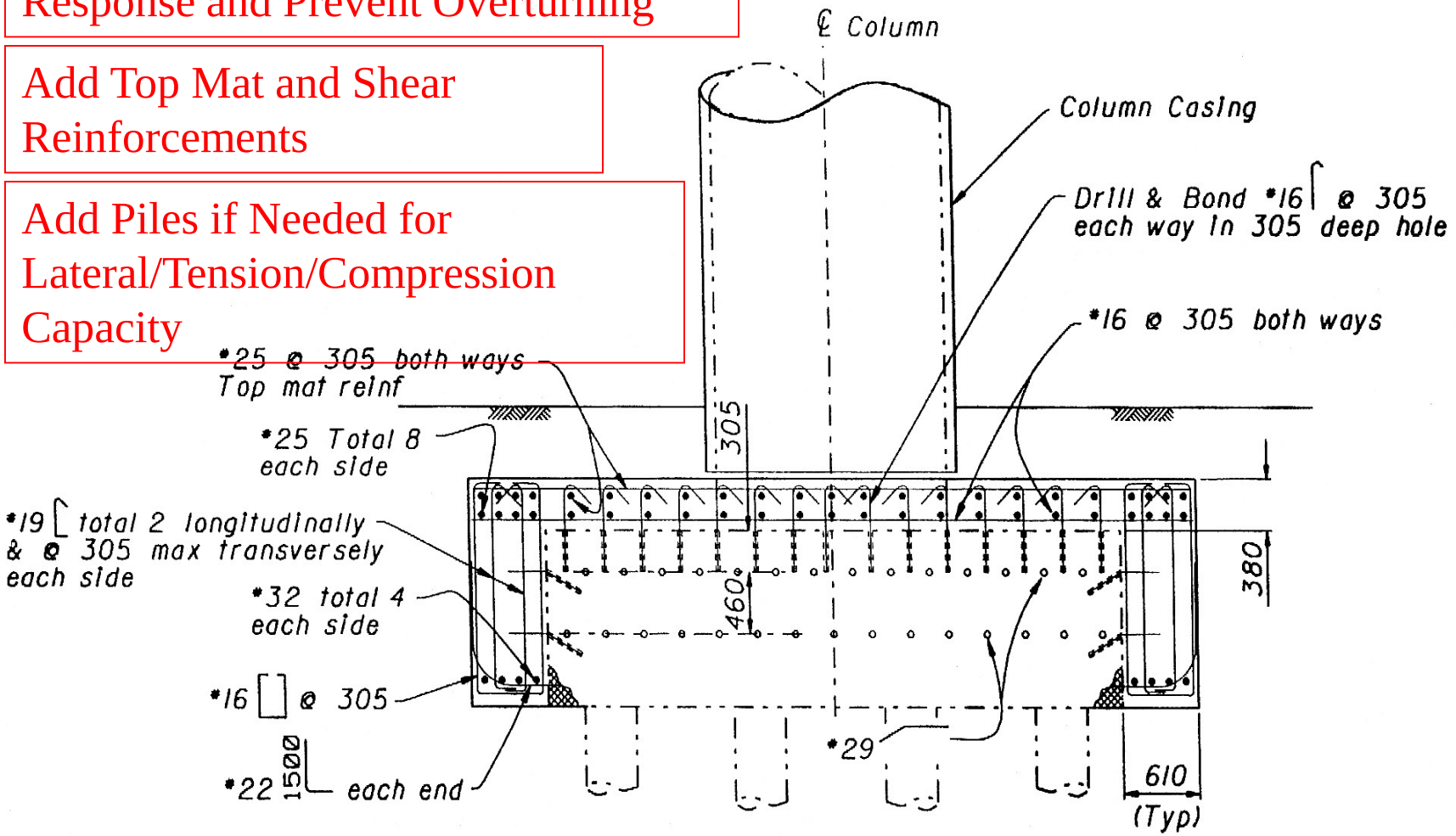

New way-Seat
width=24”min

Footing Retrofit

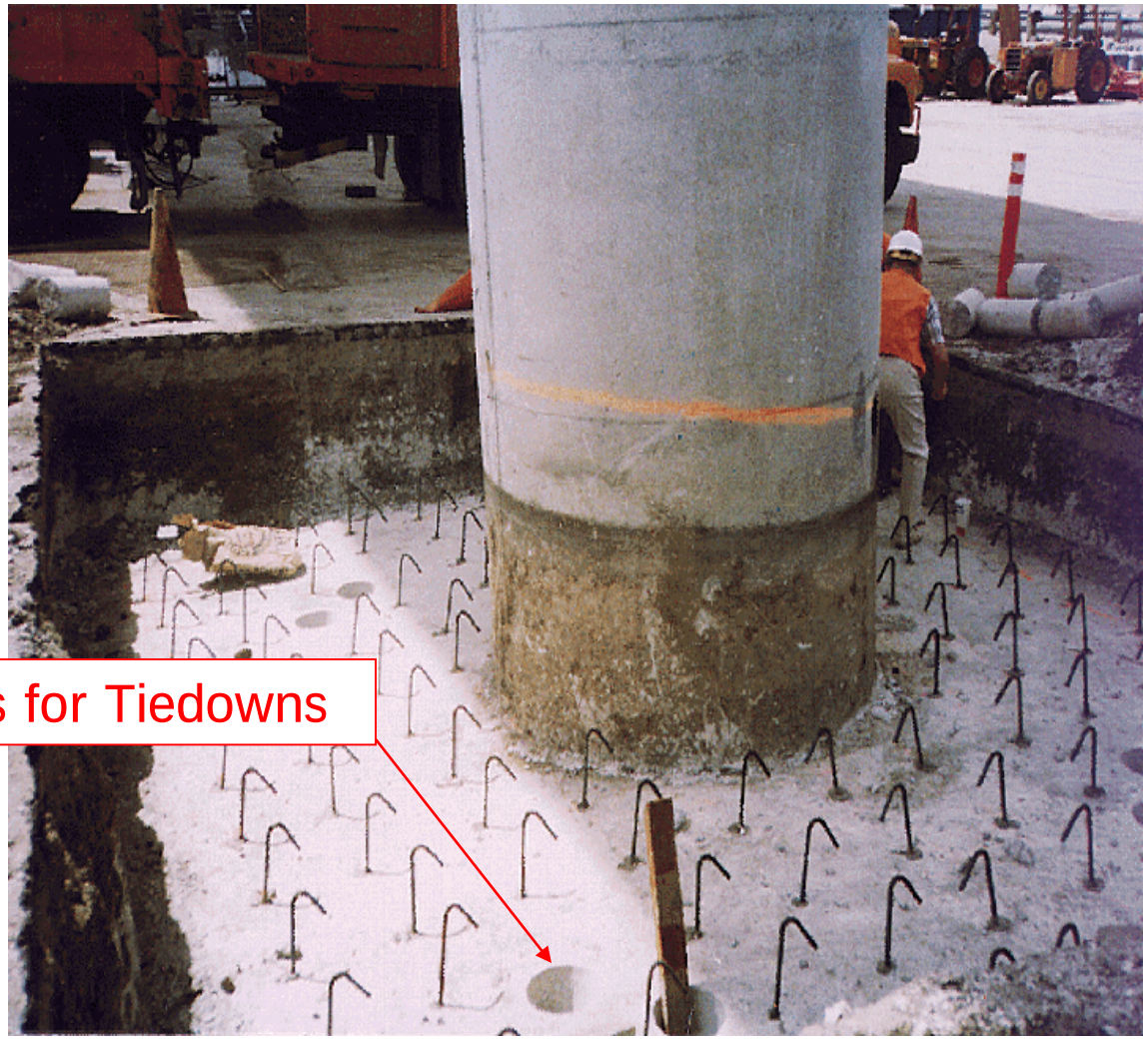
Enlarge Footing to Ensure Elastic Response and Prevent Overturning

Add Top Mat and Shear Reinforcements

Add Piles if Needed for Lateral/Tension/Compression Capacity



Footing Retrofit



Cored Holes for Tiedowns

Generally, Footing Retrofits are the Most Expensive

Footing Retrofit-Tiedown Anchors

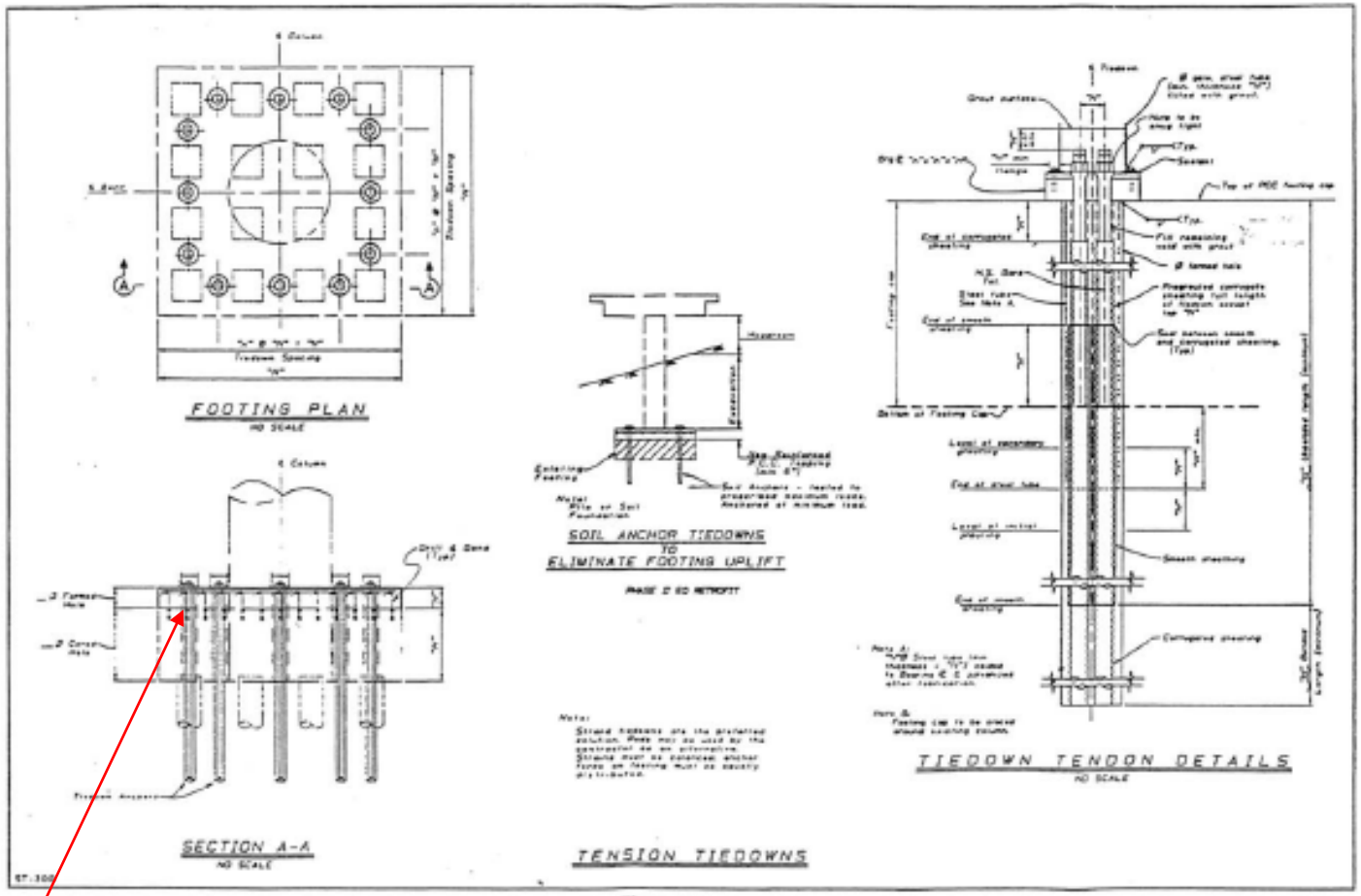


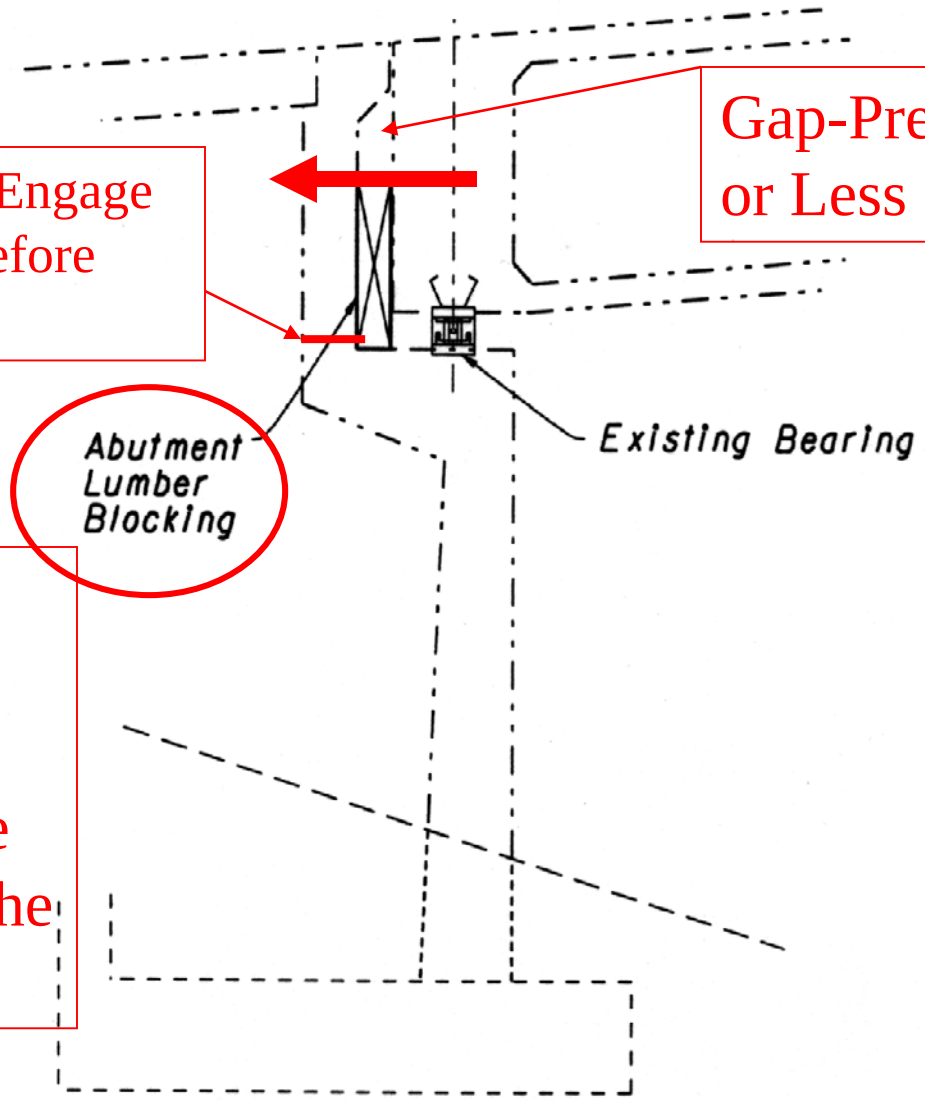
Figure 7

Uses Prestressed Anchors to Prevent Footing from Uplifting

Abutment Retrofit-Fill up Gap Behind Superstructure

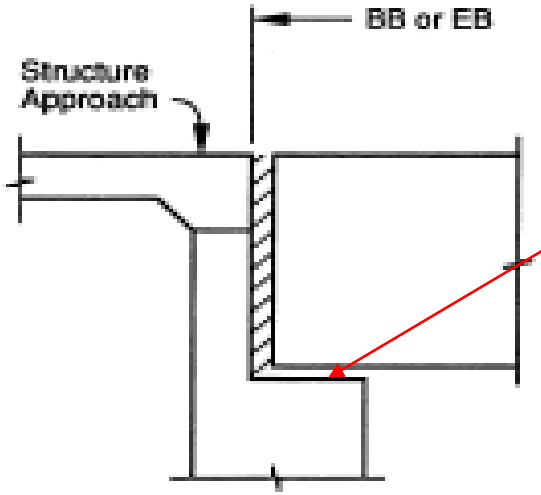
Gap-Preferred 2” or Less

Superstructure Should Engage and Break Backwall Before Damage to Columns



Soil Behind Abutment is Mobilized and Absorbs Earthquake Loads Away From the Bents

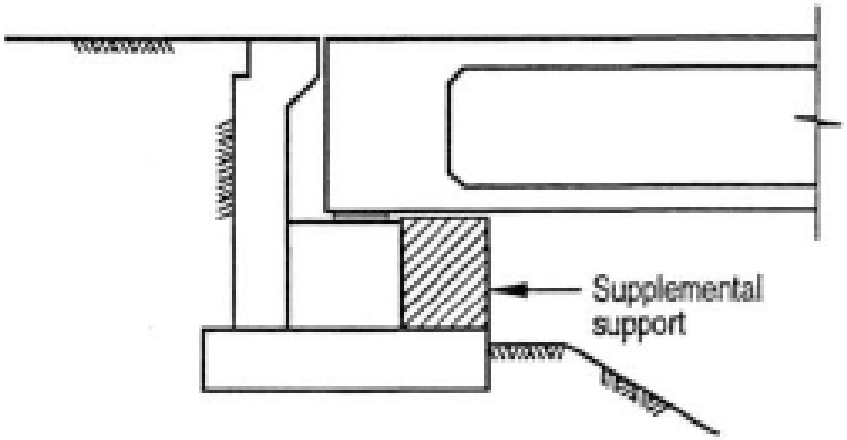
Abutment Seat

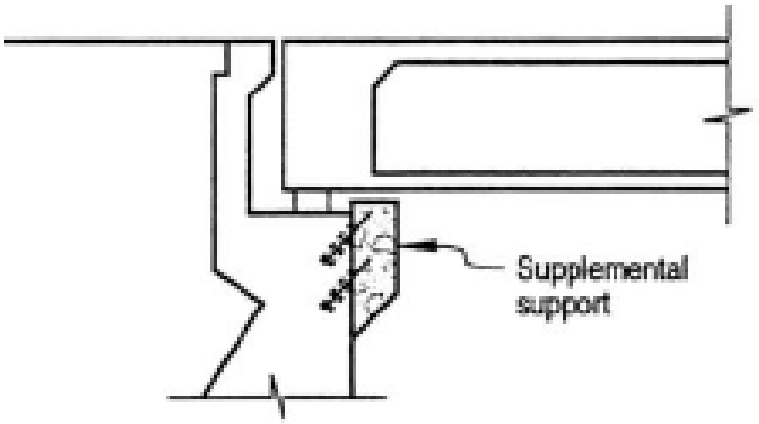


New Design-
30” Min

Abutment Retrofit

For Existing Bridge, Addition Seat Width May be Required

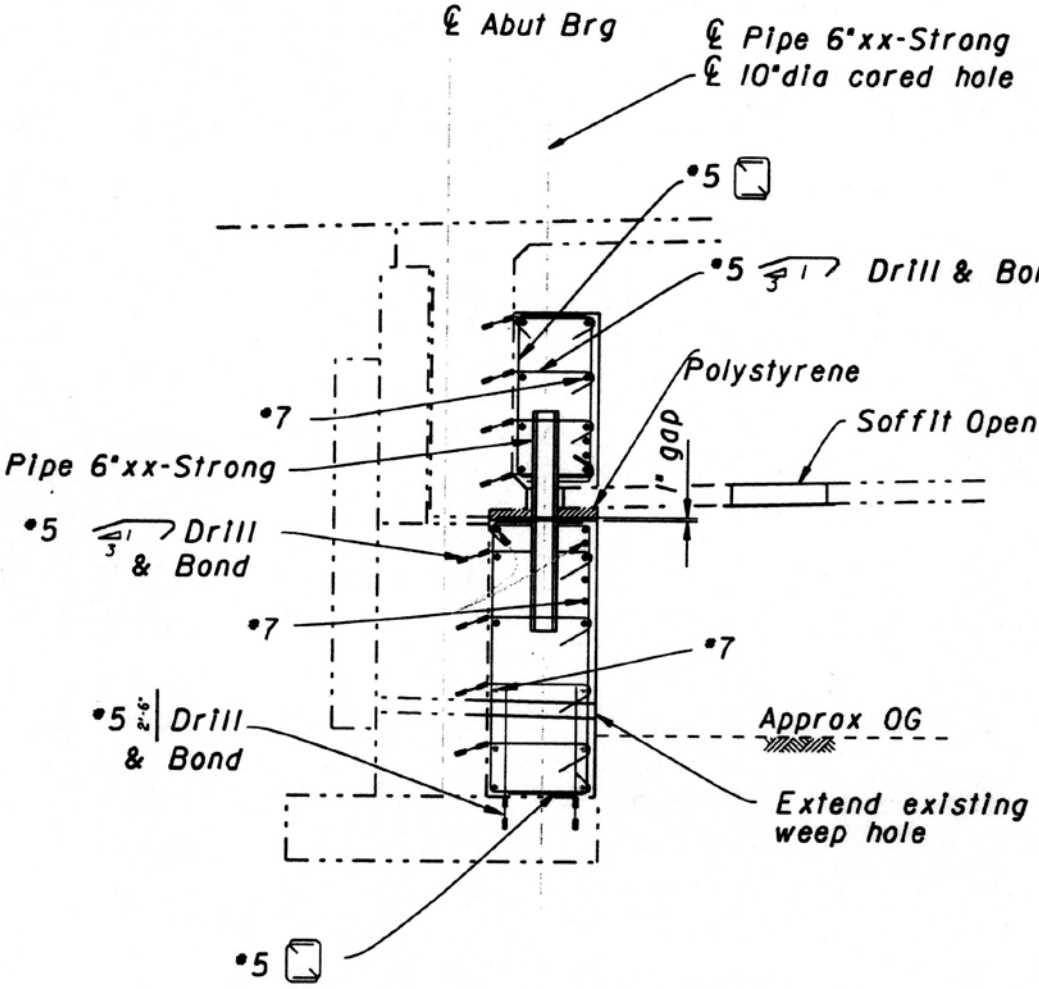




Seat Extender

Abutment Retrofit

Abutment Retrofit-Vertical Pipe Seat Extender

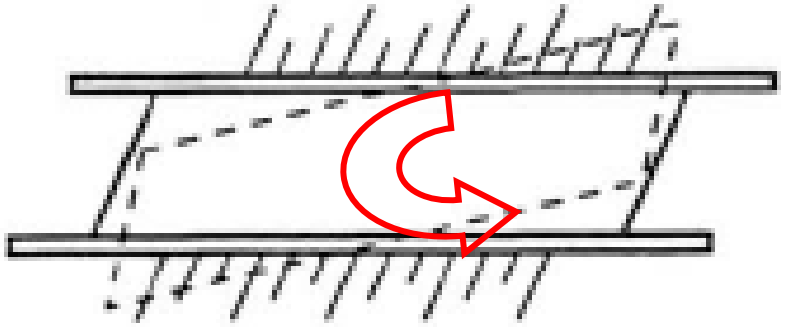


VERTICAL PIPE SEAT EXTENDER

Prevents Unseating at Abutment

Additional Restraint to Abutment

Abutment Retrofit-High Skew Bridges



Tendency to Rotate Could Lead to
Excessive Displacements at Abutments

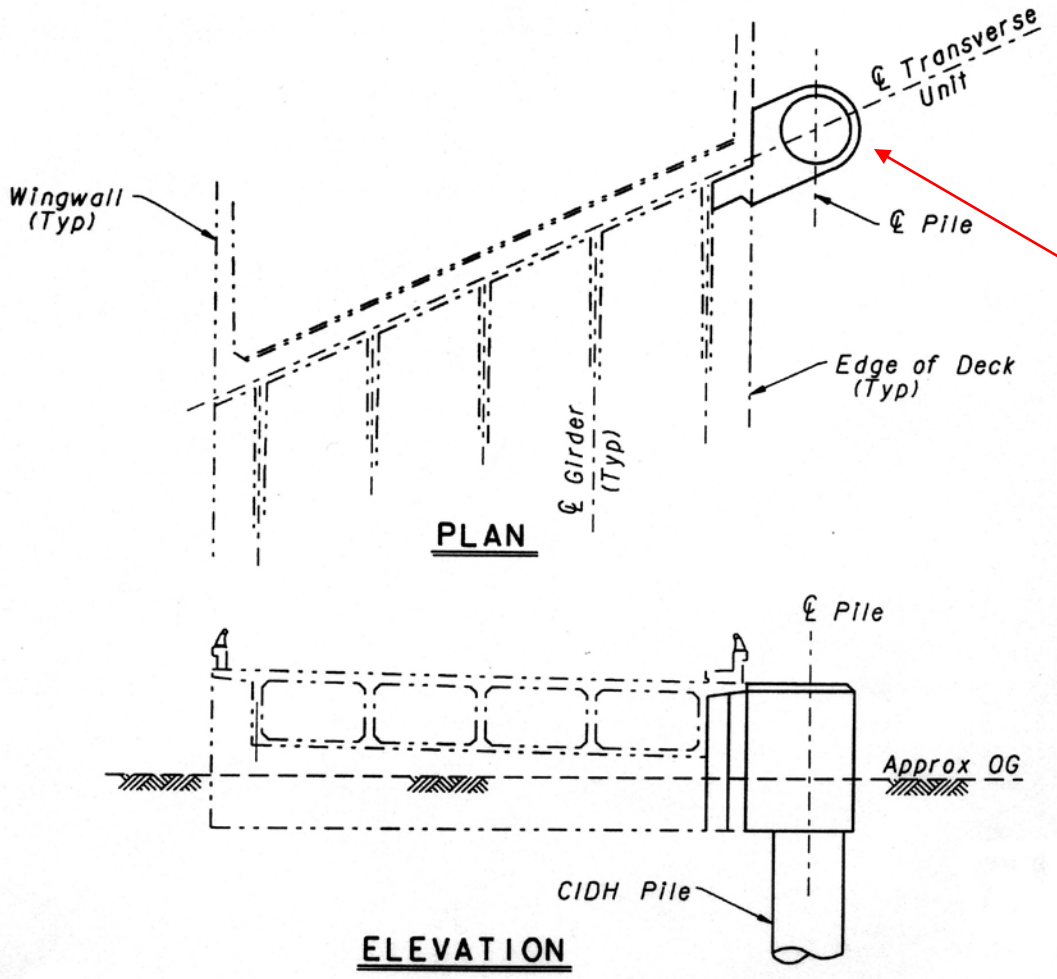
-Unseating at the Abutment
Leads to Collapse

Abutment Retrofit-High Skew Bridges

Excessive Displacement
Due to Rotation

Collapse of Superstructure

Abutment Retrofit-High Skew Bridges



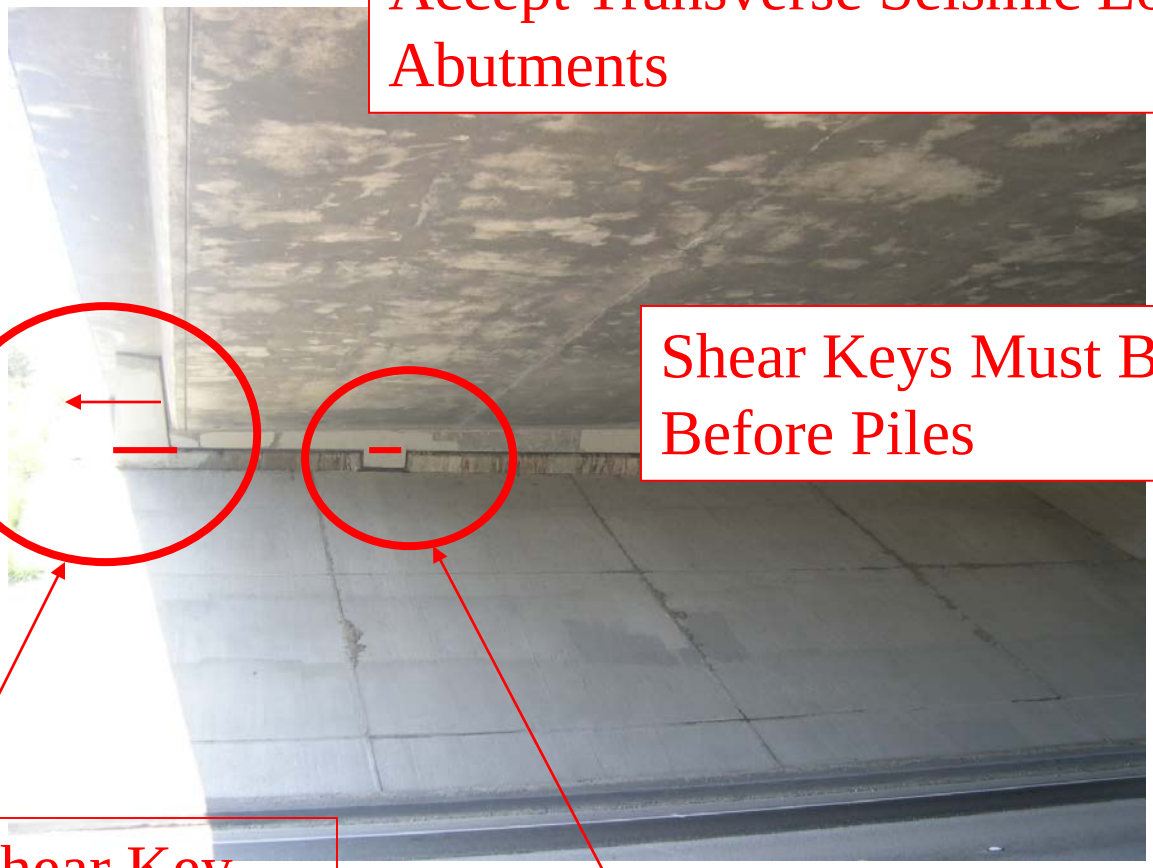
Provide External CIDH Pile at the Acute Corner of the Bridge

Abutment Retrofit-High Skew Bridges

Abutment Retrofit-High Skew Bridges

Shear Keys-New Bridge

Accept Transverse Seismic Loads at Abutments



Shear Keys Must Break Before Piles

External Shear Key

Internal Shear Key

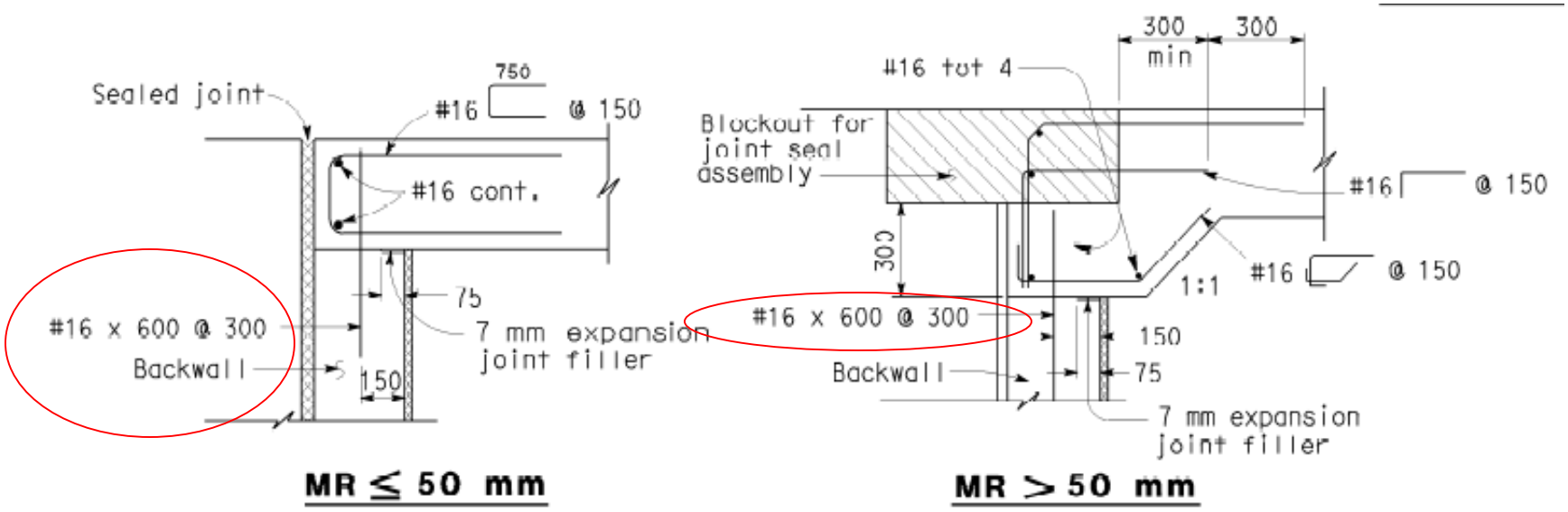
Not Preferred-Difficult to Repair

Approach Slabs

For *Important* Bridges on Lifeline Highways, Emergency Vehicles Must be Able to Get Accross

San Fernando Earthquake Rte. 5/210

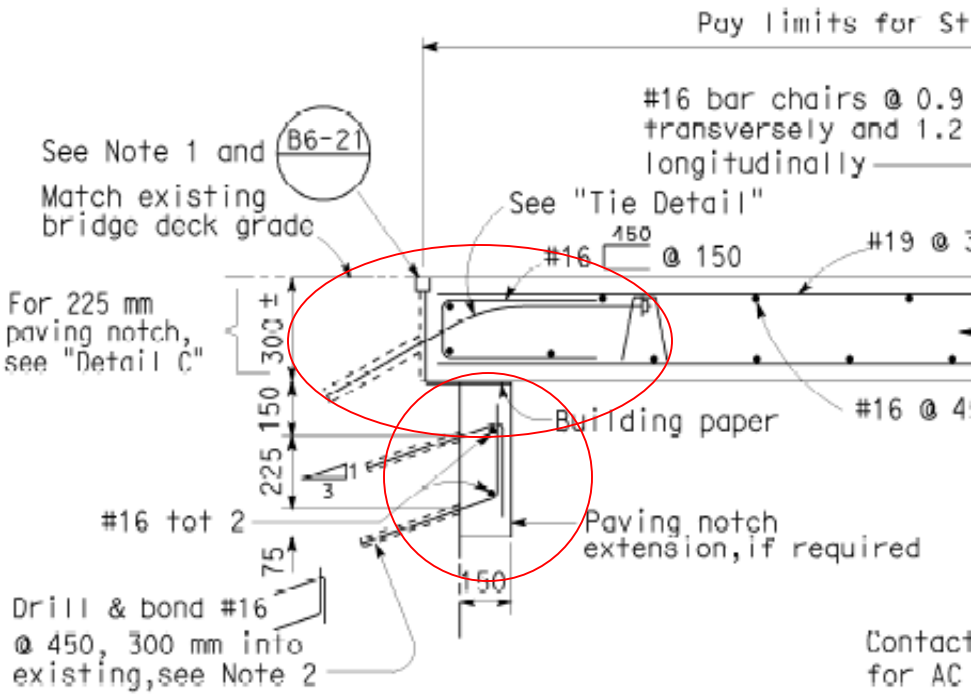
Approach Slab-New Bridge



SEAT TYPE ABUTMENT TIE DETAILS (SEE NOTE 1)

Tie bars to backwall are provided to prevent approach slab settlement

Approach Slab-Existing Bridge

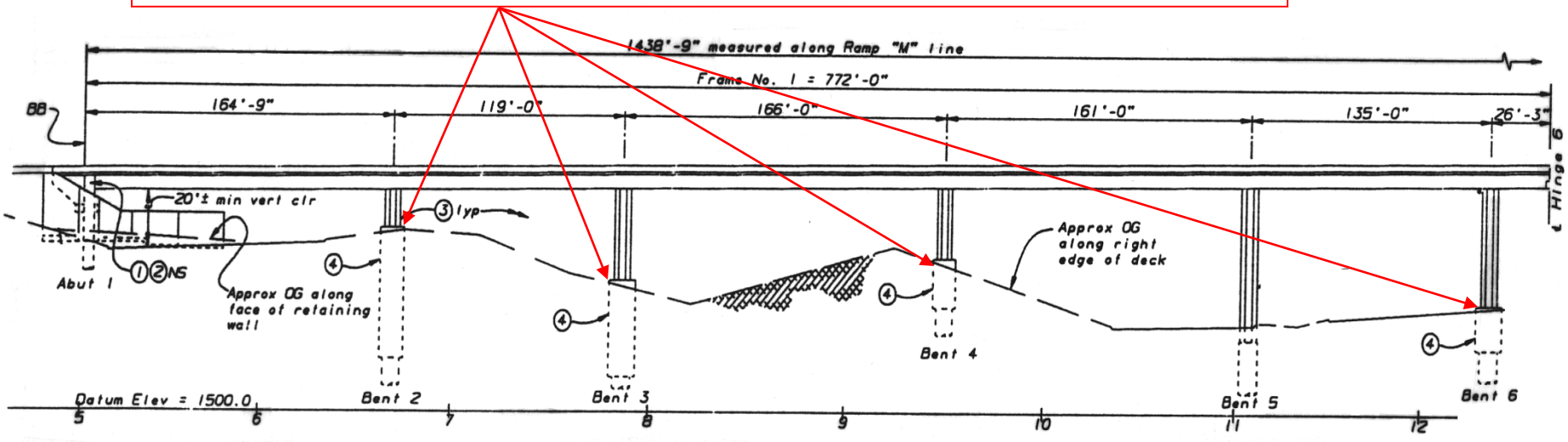


Paving Notch Extension and Ties Applicable to New Approach Slabs on Existing Bridge

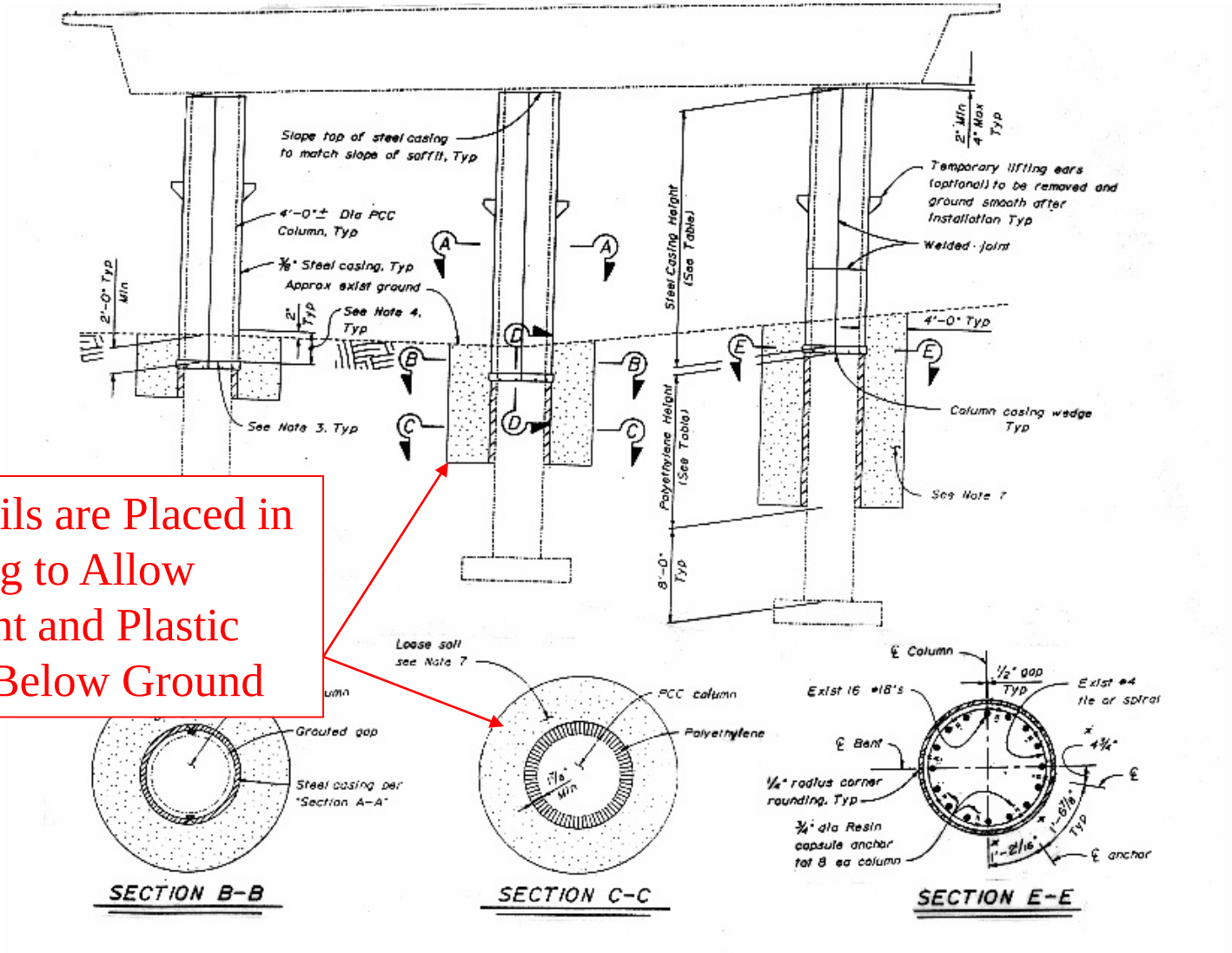
Column Isolation Casing

Balance frame stiffness is necessary to efficiently distribute earthquake loads

Isolation casings are provided to control columns stiffnesses across uneven grounds



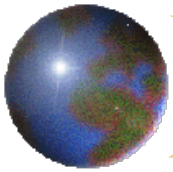
Column Isolation Casing



Loose Soils are Placed in the Casing to Allow Movement and Plastic Hinging Below Ground

Column Isolation Casing

External Debris and Dirt Should Be Prevented From Entering the Casing to Allow the Column to Move



Questions???

Pivotal Earthquakes for Bridge Design

- 1971 San Fernando
  - Hinge Retrofit
  - Ductile Details, Connections
- 1987 Whittier
  - Single Column Retrofit Program
  - Research on Design Details
- 1989 Loma Prieta
  - Multi-Column Retrofit Program
  - Joints, Continuity, Capacity Protection
- 1994 Northridge
  - Validated Retrofit Program
  - Balanced Geometry and System Effects

Caltrans

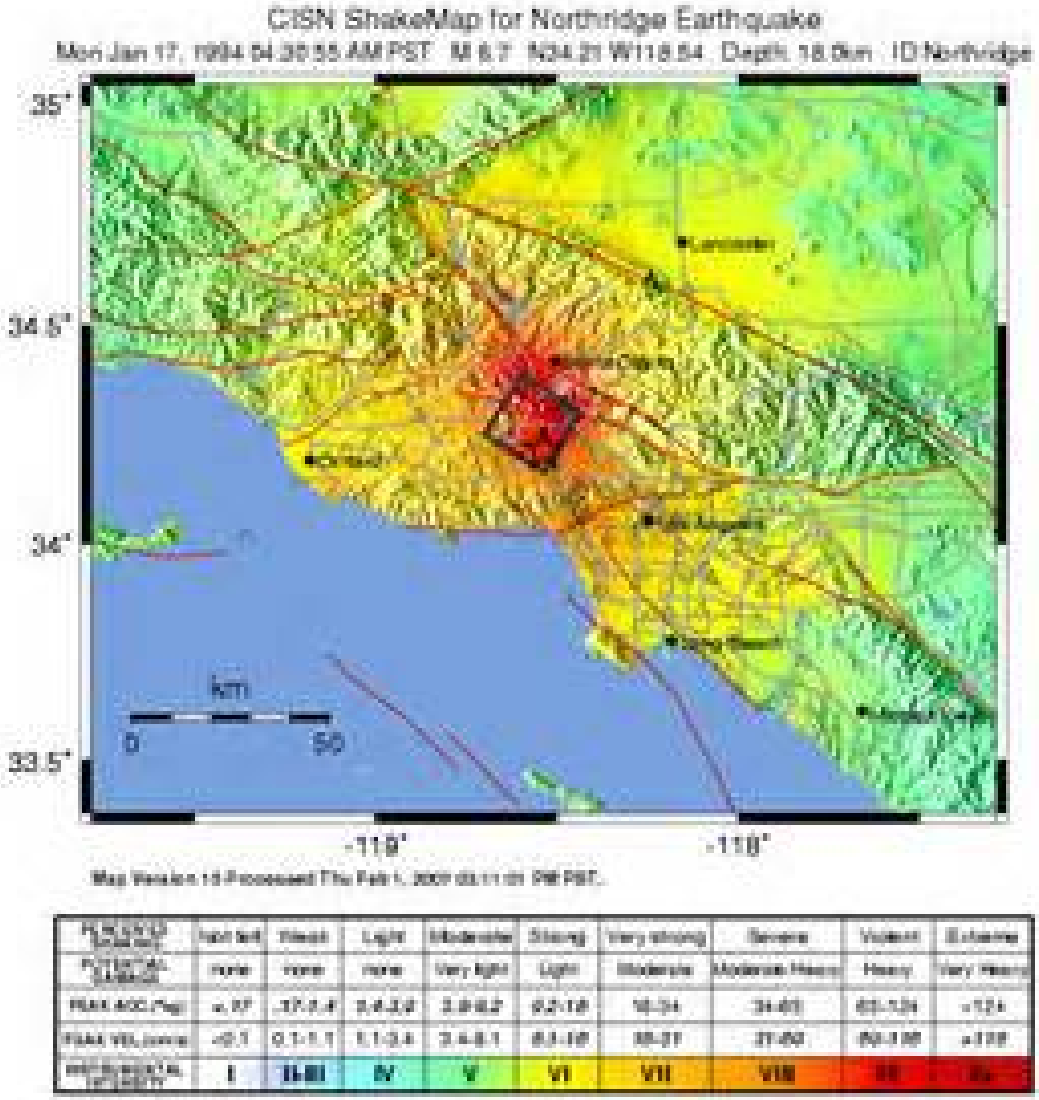
California Department of Transportation

Structure Maintenance and Investigation

Emergency Response Plan

2014

Caltrans



	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
	none	none	none	Very light	Light	Moderate	Moderate-Heavy	Heavy	Very Heavy
PGA (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PGV (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
	I	II-III	IV	V	VI	VII	VIII	IX	X+

Caltrans

Northridge Earthquake Response

- January 17 -- Within hours of the earthquake, a gubernatorial proclamation was issued directing all California state agencies to utilize available resources in responding to the emergency.
- Seven emergency orders were approved by the California Department of Transportation (Caltrans) and subsequent force account contracts were let to remove damaged structures, construct detours and install shoring to insure the safety of existing, standing structures.

January 17

- Caltrans maintenance and engineering staff began inspecting the freeway system throughout Los Angeles and Ventura counties. More than 1,000 structures were checked - that day alone.

- An Executive Order by the Governor suspended all rules imposing non safety-related restrictions on the delivery of food products. This order further suspended rules governing the hours during which deliveries could be made.

January18

- Representatives of the Los Angeles County Metropolitan Transportation Authority (LACMTA), Los Angeles Department of Transportation (LADOT), the Federal Highway Administration (FHWA), and Caltrans map out emergency response strategies and identify earthquake-related damage to local transportation facilities.

January 23

- A gubernatorial proclamation suspended all statutes, rules and regulations, which apply to Caltrans contracts that would hinder or delay the restoration of facilities and services as a result of the Northridge earthquake.

- This emergency proclamation modified contracting procedures and enabled Caltrans to respond more effectively and efficiently to the emergency. Innovative emergency contract procedures allowed Caltrans to put contractors to work immediately. The informal and streamlined bid process cut the time for advertising, awarding and approving contracts from a standard timeframe of four to five months to as little as three days.

- January 27 -- Caltrans issued guidelines to suspend usual contracting procedures. These guidelines included provisions to protect the public welfare, for example - ensuring ample competition, compliance with OSHA regulation, licensing, and participation by DBE firms.

- January 29 -- the first A+B contract was opened, awarded, executed and approved for Interstate 5. The A+B contract process called for contractors to submit bids that included both cost of the work and the time to complete the job. This contracting process was completed in one day instead of the standard five to seven weeks. On January 29, Caltrans also opened a newly paved, four-lane detour for the traffic on Interstate 5. This reopened a vital connection to and from Los Angeles.

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- January 30 -- less than two weeks after the earthquake, construction began on the bridge replacement at Interstate 5 at Gavin Canyon.

- April 12 -- Traffic service was restored on the I-10 Santa Monica Freeway, the busiest freeway in the nation. The freeway was reconstructed in 66 days, a total of 74 days ahead of schedule. By opening this $14.9 million reconstruction project to traffic significantly earlier than the 140 days previously bid and anticipated, Caltrans saved the Los Angeles economy approximately $1 million a day. The contractor received an incentive payment of $200,000 for each early day, totaling $14.8 million.

- May 17 -- Traffic servic was restored on the I-5 Golden State Freeway at Gavin Canyon, 33 days e ahead of schedule. By opening this $14.8 million project earlier than the 130 days previously anticipated, Caltrans saved the Los Angeles economy approximately $400,000 a day. The contractor received an incentive payment of $150,000 for each early day, totaling $4.95 million.

- July 8 -- Traffic was reopened on Stage one of the I-5/Route 14 Interchange, 35 days ahead of schedule. By opening this $19.6 million project earlier than the 132 days previously anticipated, Caltrans saved the Los Angeles economy approximately $1.6 million each day. The contractor received a bonus payment of $100,000 for each early day, totaling $3.5 million.

Caltrans

- Traffic service was completely restored to the Simi Valley Freeway (SR 118) approximately two weeks earlier than anticipated. This two-stage reconstruction project totaled $19.3 million. Stage one of the SR 118 reconstruction effort carried with it an incentive / disincentive payment of $50,000 per day for each day traffic was restored earlier than anticipated. A total of $450,000 was awarded as an incentive to the contractor. Stage two did not include an incentive/payment provision because of the effectiveness of Caltrans' temporary detour. The detour was in service one month after the earthquake. The detour was so efficient that it carried 110,000 vehicles daily - roughly 75% of the pre-quake traffic - while under final reconstruction.

- October 29 -- Traffic reopened along the first of the final two connector ramps which make-up Stage two of the 5/14 interchange. Traffic was completely restored to the entire interchange on November 4, one day earlier than anticipated.

- Caltrans was able to accelerate the openings of the Southland's major transportation arteries by challenging the private sector with a system of incentives and disincentives. Total bonus payments for the reconstruction projects were more than $20 million. According to the Governor's Office for Planning and Research, early traffic openings saved the local and state economy approximately $145 million.

  FOR EVERY ONE DOLLAR CALTRANS SPENT ON INCENTIVE BONUSES, THE CALIFORNIA ECONOMY SAVED MORE THAN $5.

Our response to a major disaster is built on three major elements –

- Prepare
- Response
- Recovery

PREPARE-

- The first component is to make sure our personnel have the training and tools to respond in short order when a quake strikes. This includes nearly 5,000 Maintenance crews stationed around the state. Their job when a quake hits is to check the system for any damage. More than 120 engineers in Caltrans' Structure Maintenance & Investigations (SM&I) are charged with ensuring the safety of all the state's highway bridges. Caltrans conducts periodic disaster training for its personnel and procedures for all personnel involved in responding are outlined in various Maintenance and Engineering manuals used by the Caltrans staff.

RESPONSE –

- Caltrans is connected to the California Integrated Seismic Network that provides immediate notification about disasters such as earthquakes.

- Upon notification of a disaster and based on the type of event and extent of the damage, Caltrans activates its Emergency Operations Center (EOC), which serves as the central command post for sharing information on all disaster response activities involving the state transportation system.

- Maintenance crews in the affected area are dispatched to make visual inspections of the system and to make an initial damage assessment. Caltrans is able to draw upon the nearly 5,000 Maintenance crews and thousands of engineers statewide to assist in making initial damage assessments.

- The Maintenance crew members check the system and determine whether damage at a particular warrants closure of the facility or a closer examination by licensed engineers with expertise in bridges, pavement or hydrology.

Following a major earthquake, Caltrans' Post Earthquake Inspection Team (PEQIT) collects information on damaged bridges with the goal of improving our understanding of structural performance in significant seismic events. The work of this team has led to research that has improved design procedures and the design details we employ today.

An inspection report is prepared documenting the damage and the repairs recommended. That report is made part of the official record maintained by Caltrans.

LIST OF STRUCTURES INVESTIGATED

Bridge No.	Bridge Name	Dist./County/Rte/PM
53-1917F	South Connector OC	07-LA-2-R18.72
53-1921F	Northeast Connector OC	07-LA-2-R18.81
53-1919S	Route 134/2 Separation	07-LA-2/134-R18.80/R8.92
53-1128	Pacoima Wash	07-LA-5-39.19
53-1220	Chatsworth Drive UC	07-LA-5-39.92
53-1797RL	Gavin Canyon UC	07-LA-5-R47.83
53-1984RL	West Sylmar OH	07-LA-5-R44.87
53-849	Weldon Canyon OH	07-LA-5-C45.75
53-849K	Weldon Canyon OH	07-LA-5-C45.76
53-996RL	Weldon Canyon OC	07-LA-5-C45.86
53-2327F	Southeast Connector OC	07-LA-5-39.30
53-1580	Fairfax-Washington UC	07-LA-10-R9.31
53-1603	Centinela-Pico UC	07-LA-10-R4.24
53-1609	La Cienega-Venice UC	07-LA-10-R8.83
53-1615	National Blvd. OC	07-LA-10-R6.31
53-1637F	Southeast Connector OC	07-LA-10-R5.65
53-1960F	Route 14/5 Separation & OH	07-LA-14/5-R24.73/R45.58
53-1960G	Route 14/5 Separation & OH	07-LA-14/5-R24.77/R45.52
53-1962F	Truck Connector OC	07-LA-14/5-R24.81/C45.74
53-1963F	South Connector OC	07-LA-14/5-R24.82/R45.69
53-1964F	North Connector OC	07-LA-14/5-R24.97/C45.95
53-1936RL	Sierra Hwy UC	07-LA-14/5-R25.13/C45.74
53-1936G	Sierra Hwy UC	07-LA-14/5-R25.13/C45.74
53-1936F	Sierra Hwy UC	07-LA-14/5-R25.13/C45.74
52-0266	Wendy Drive OC	07-Ven-101-7.89
53-1336R	Route 101/170/134 Separation	07-LA-101-11.75/R14.6/0.01
53-1442	Las Virgenes Road OC	07-LA-101-31.05
53-2204	Hayvenhurst Avenue UC	07-LA-118-R8.34
53-2205	Mission-Gothic UC	07-LA-118-R8.63
53-2206	Bull Creek Canyon Channel Bridge	07-LA-118-R8.84
53-2207	Woodley Avenue UC	07-LA-118-R9.04
53-2095	San Fernando Road OH	07-LA-118-R12.40
53-2395	Balboa Blvd. OC	07-LA-118-R7.80
53-2396	Ruffner Avenue OC	07-LA-118-R8.05
53-2329G	Southwest Connector OC	07-LA-118/5-R11.40/39.31
53-1989F	Southwest Connector OC	07-LA-210/5-R0.06/R43.99
53-1988F	North Connector Separation	07-LA-210-R0.12
53-1500	Devonshire Street UC	07-LA-405-46.24
53-1506	Rinaldi Street UC	07-LA-405-47.75
53-1044	Olympic Blvd. OC	07-LA-710-23.44

DAMAGE CATEGORIZATIONS

MAJOR DAMAGE (Collapsed Structure)

Gavin Canyon UC	53-1797R/L
Route 14/5 Separation & OH	53-1960F
North Connector OC	53-1964F
Mission-Gothic UC	53-2205
La Cienega-Venice UC	53-1609

MAJOR DAMAGE (No Collapse)

Fairfax-Washington UC	53-1580
Bull Creek Canyon Channel Bridge	53-2206
Route 14/5 Separation & OH	53-1960G
South Connector OC	53-1963F

MODERATE DAMAGE

Southwest Connector OC	53-2329G
Route 101/170/134 Separation	53-1336R

MINOR DAMAGE

Balboa Blvd. OC	53-2395
Rinaldi Street UC	53-1506
Ruffner Avenue OC	53-2396
South Connector OC	53-1917F
Northeast Connector OC	53-1921F
Pacoima Wash Bridge	53-1128
West Sylmar OH	53-1984RL
Southeast Connector OC	53-2327F
Centinela-Pico UC	53-1603
National Blvd. OC	53-1615
Southeast Connector OC	53-1637F
Truck Connector OC	53-1962F
Wendy Drive OC	53-0266
Las Virgenes OC	53-1442
Hayvenhurst UC	53-2204
Woodley Avenue UC	53-2207
San Fernando Road OH	53-2095
Southwest Connector OC	53-1989F
Devonshire Street UC	53-1500

NO DAMAGE

Olympic Avenue OC	53-1044
Chatsworth Drive UC	53-1220
Route 134/2 Separation	53-1919S
North Connector Separation	53-1988F
Weldon Canyon OH	53-849
Weldon Canyon OH	53-849K
Weldon Canyon OC	53-996RL
Sierra Hwy UC	53-1936RL
Sierra Hwy UC	53-1936G
Sierra Hwy UC	53-1936F

RECOVERY-

Once the extent of the damage has been determined, Caltrans initiates its recovery phase, which includes:

1) Enlisting the assistance of private construction companies to complete recommended repairs so facilities full traffic service can be restored soon as possible.
2) Working with local officials and transportation providers to restore a level of transportation service to the damaged area.

- Since 1990, Caltrans has retrofitted more than 2,300 bridges at a cost of more than $2 billion. In addition, seven of the state’s toll crossings were strengthened, including the replacement of the eastern span of the San Francisco-Oakland Bay Bridge, at a total cost of $7 billion.

- All of the bridges identified for seismic strengthening following the Loma Prieta and Northridge quakes have been completed

- Caltrans' seismic safety program, however, is an ongoing effort. As new technologies are developed and knowledge of earthquakes and the resulting effects are expanded, Caltrans will upgrade its facilities as needed.

SM&I Earthquake Field Damage Report

9/22/14

SM&I Disaster Command Center - Email: smidcc@dot.ca.gov Phone: (888) 893-9974

Bridge Number: _____ **Date:** _____ **Time (24hr):** _____

Bridge Name: _____

Inspector 1: _____ **Inspector 2:** _____

Unit: _____ Phone No: _____ Unit: _____ Phone No: _____

Current Status:

1 ☐ Open 2 ☐ Open with Shoring 3 ☐ Closed / Can Be Open 4 ☐ Closed

Restrictions: (Select all that apply)

5 ☐ No Restrictions
6 ☐ Operational
7 ☐ Structural
8 ☐ Investigate / Repair Prior to Open
9 ☐ No Permit Loads
10 ☐ Traffic Control Required for Repair
11 ☐ Lane Usage Restrictions

Damage:

12 ☐ Damage
13 ☐ No Damage
14 ☐ No Additional Damage

15 Damage Summary:

Repair Cost Estimates:

16 ☐ None 17 ☐ Low <$5k 18 ☐ Med $5-50k 19 ☐ Med-High $50-100k 20 ☐ High >100k

21 Detailed Cost Estimates: $ _____

Feature Damage: (Detailed Distress)

Approach Roadway:	
Approach Slabs:	
Superstructure:	
Wingwalls and Rails:	
Abutments:	
Expansion Joints:	
Hinges:	
Shear Keys:	
Bearings:	
Columns/Pier Caps:	
Foundation/Piles:	
Retrofit:	
Other _____:	

Structure Maintenance & Investigations 1801 30th Street, Sacramento, CA, 95816 Phone: (916) 227-8631 Fax: (916) 227-8357

EMERGENCY RESPONSE INSPECTION

STRUCTURE MAINTENANCE & INVESTIGATION

Caltrans

Affix this sticker to the RIGHT BRIDGE RAILING next to the BRIDGE NAME/NUMBER LOCATION

DATE:_____ TIME: _____ BY:_____ (INITIALS ONLY) PH#: _____

DATE:_____ TIME: _____ BY:_____ (INITIALS ONLY) PH#: _____

DATE:_____ TIME: _____ BY:_____ (INITIALS ONLY) PH#: _____

ANY BRIDGE CONCERNS CONTACT:
STRUCTURE MAINTENANCE AND INVESTIGATIONS (888) 893-9974

Caltrans

FLOOD SMS FIELD REPORT

Revised 10/18/05

Br # | Structure Name | Location

Date | Time | Inspected By: 1. | Inpected By: 2.

Current Status

- Open
- Open with Shoring
- Closed/Can be Open
- Closed

Restrictions

- Investigat/Repair Prior to Opening
- No Permit Loads
- Traffic Cntrl Reqd for Repair
- Lane Usage Restriction

High Water Mark | @

Max Exposed Pile Length

Foundation Not Visible

All Abut's | # of Abutments

All Piers | # of Piers

Debris Removal Reqd

Heavy | Moderate | Light | # of Piers/Columns

Damage Summary

- Damage
- No Visible Damage
- No Additional Damage

Repair Cost Estimate

None | Low <5K | Med 5-50K | Med-High 50-100K | High >100K | Detailed Cost Estimate

TEXT

USE BACK OF FORM TO CONTINUE FIELD NOTES

Approach Roadway	
Superstructure	
Wingwalls & Rails	
Abutments	
Embankments	
Bearings	
Hinges	
Columns, Piers/Caps	
Footings, Piles	
Scour	
Restriction	
Comments	

Caltrans

Northridge Earthquake1994, M 6.8

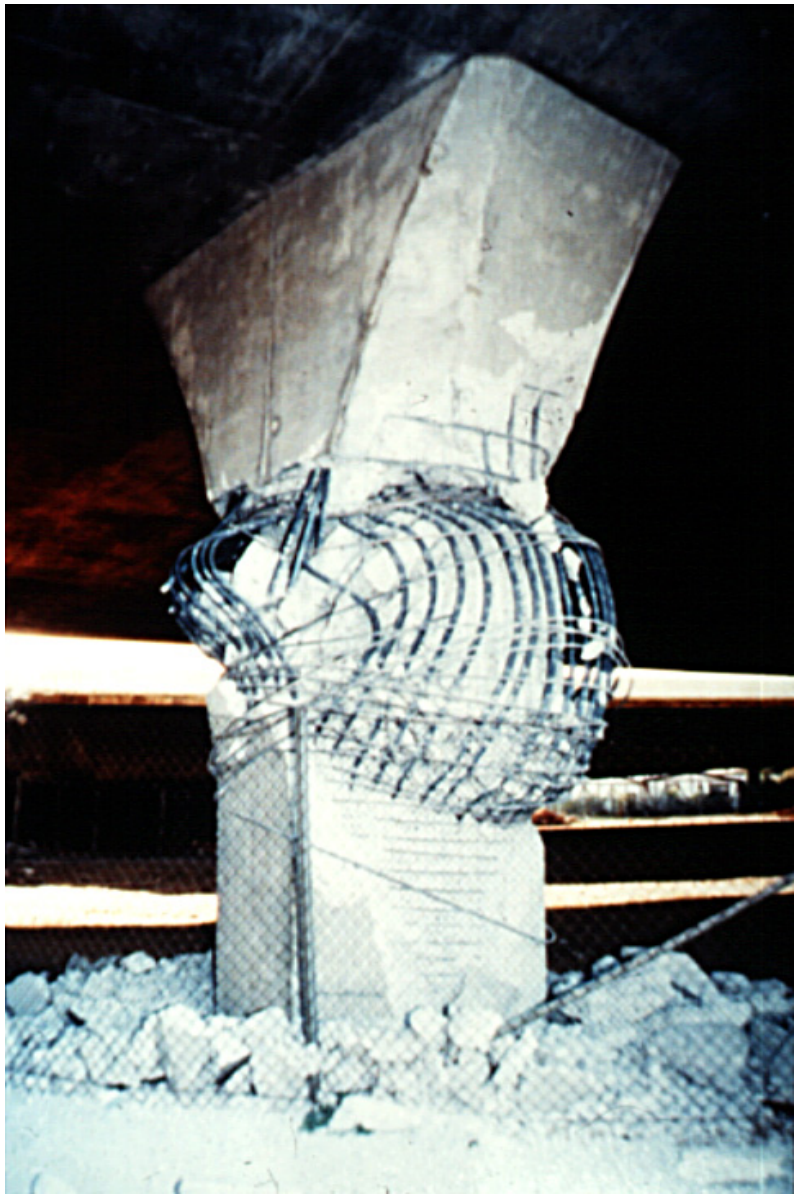
Gavin Canyon Undercrossing – Year Designed: 1965

Northridge Earthquake

Bull Creek Canyon Channel Bridge,Year Designed: 1973

Northridge Earthquake

Mission-Gothic Undercrossing – Column Failure before Architectural Flare




10 Fwy
WEST


It All Looks Better At Night