

POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Purdue University and
Joint Transportation Research Board

PROJECT TEAM (Purdue University)

- Prof. Julio RAMIREZ
- Prof. Robert FROSCH
- Prof. Mete SOZEN
- Dr. Murat TURK

Workshop Speakers

- Prof. Mete SOZEN, Purdue University
- Prof. Julio RAMIREZ, Purdue University
- Prof. Marc EBERHARD, U. of Washington
- Wayne DITTELBERGER, INDOT
- Dr. Murat TURK, Purdue University
- Prof. Robert FROSCH, Purdue University

Goal

- Develop an effective system to train INDOT personnel of various backgrounds in the safety evaluation of roads and bridges after a major earthquake

Activities

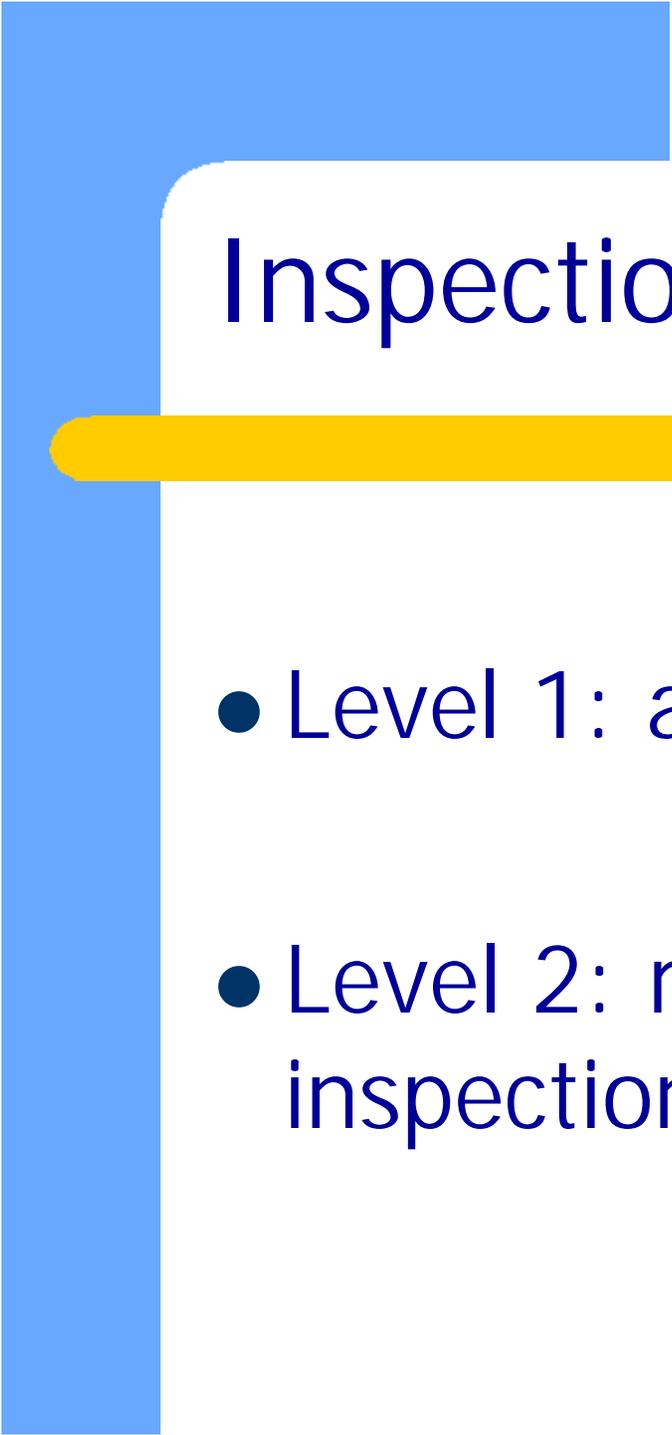
- Material
 - Handbook
 - Field Guide
- Workshop Presentation
March 6/7, 2000
 - Videotape

Contents of Workshop

- Introduction to EQ. Engineering
- Seismology of Indiana
- Typical Bridges and Damage
- Bridge Closing Procedures
- Equipment and Inspection Forms
- Temporary Repairs and Long-Term Monitoring Techniques

Description

- A training workshop presented in two sessions according to inspection levels



Inspection Levels



- Level 1: all personnel
- Level 2: maintenance and INDOT inspection engineers

Objectives of Level 1 Inspection: Quick Response

- Close obviously unsafe bridges and highways
- Identify routes where transit of vehicles is not feasible
- Identify geographical extent of the damage

Example Bridge



Objectives of Level 2 Inspection

- Inspection of Level 1 yellow tagged bridges
- Close unsafe bridges
- Identify restrictions to traffic
- Inspect in more detail Level 1 red tagged bridges in critical routes
- Identify temporary repair and monitoring measures

Contents of Training Session

- Introduction to EQ. Engineering (M. A. Sozen)
- Seismology of Region (M. A. Sozen)
- Typical Bridges, Behavior and Damage (J. Ramirez and M. Eberhard)
- Closing Procedures (W. Dittelberger)
- Equipment and Forms (M. Turk, and R. Frosch)
- Review Examples (M. Turk, and R. Frosch)
- Temporary Repair and Monitoring Measures (R. Frosch)

Example





SCOTCH CAP LIGHT STATION, 1 April 1946

01:30 hours

Memorandum kept by H B
Sanford at Unimak A/F Station

“I felt a severe earthquake. All
crew was awakened. There were
no signs of volcanic activity.”

1:30 hours

“Intending to call Scotch Cap Station, I went to operations. Pitts had already done so and that they were pretty scared but in good health.”

1:57 hours

“At a second quake was felt. Scotch
Cap Station was contacted again.

No damages reported.”

2:18 HOURS

“A terrible roaring sound was heard followed almost immediately by a very heavy blow against the side of the building.

About 3 inches of water appeared in the galley, recreation hall, and passageway.”

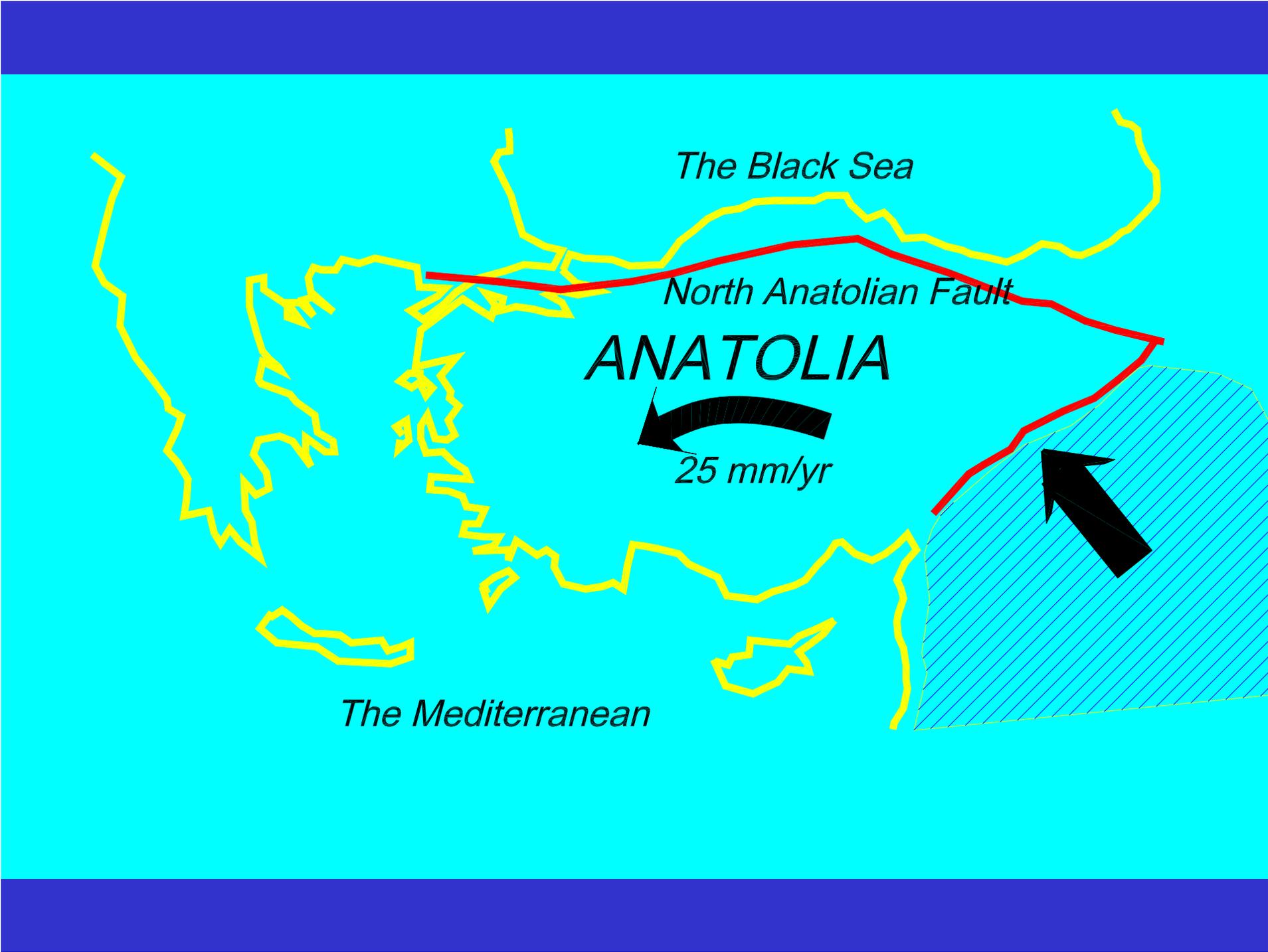
2:18 HOURS

“From the time the noise was heard until the sea struck was a matter of seconds.

I called Scotch Cap.

No answer!”

- **Cost of Inappropriate Response Unacceptable**

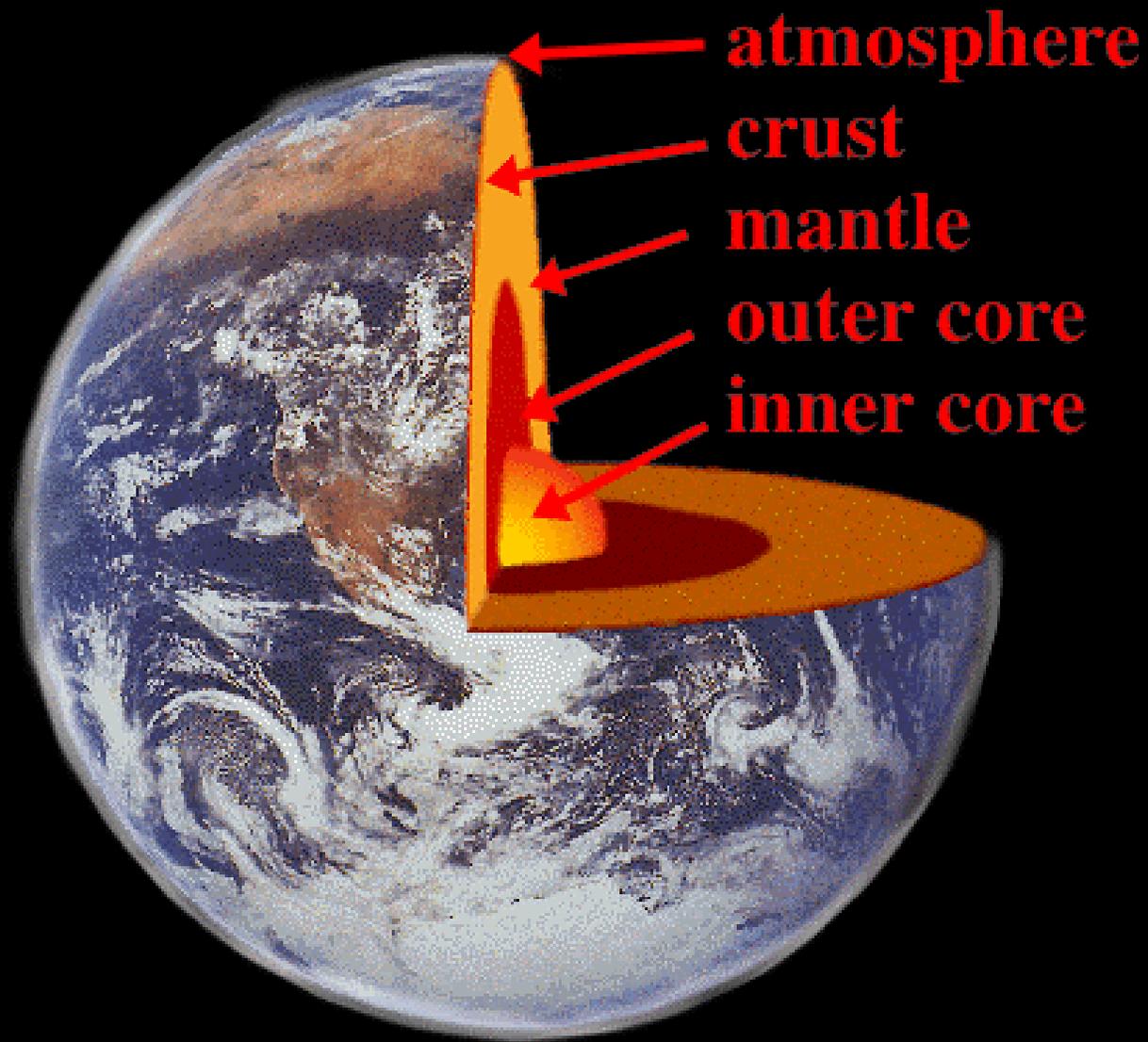


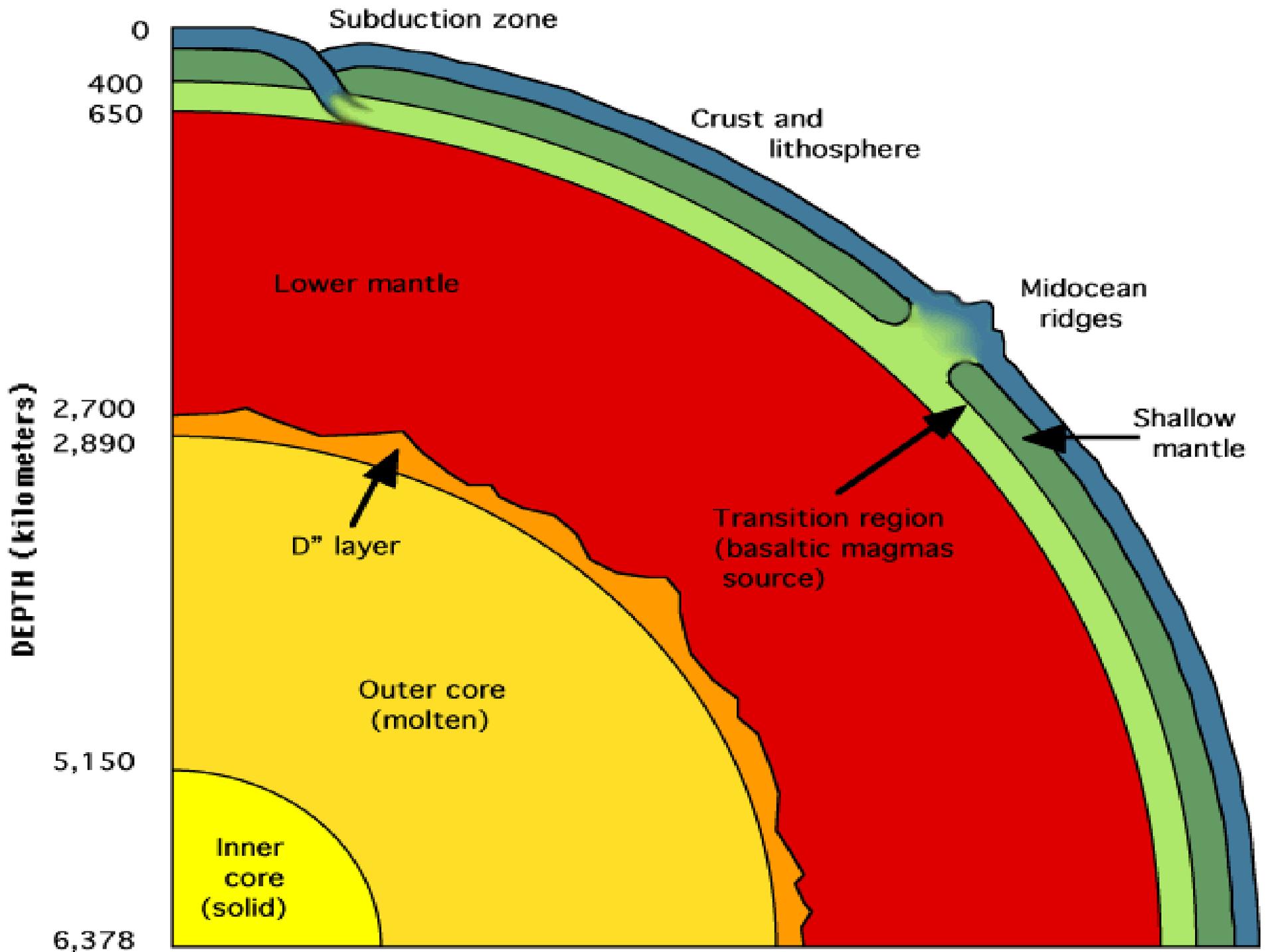


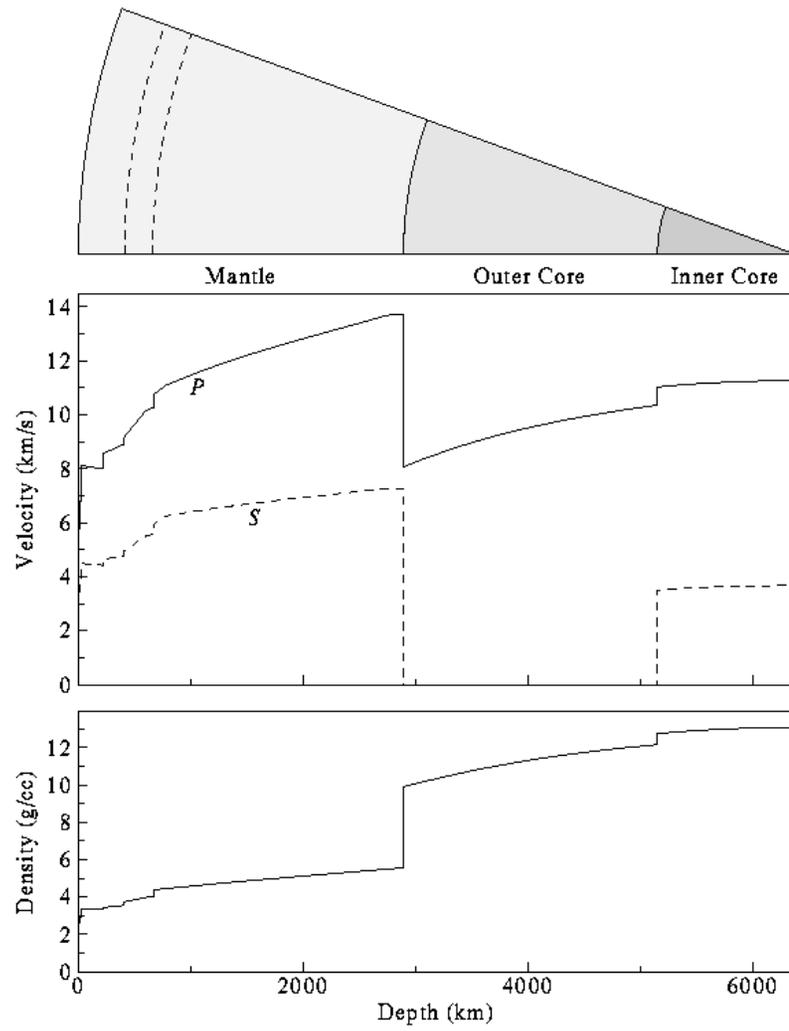


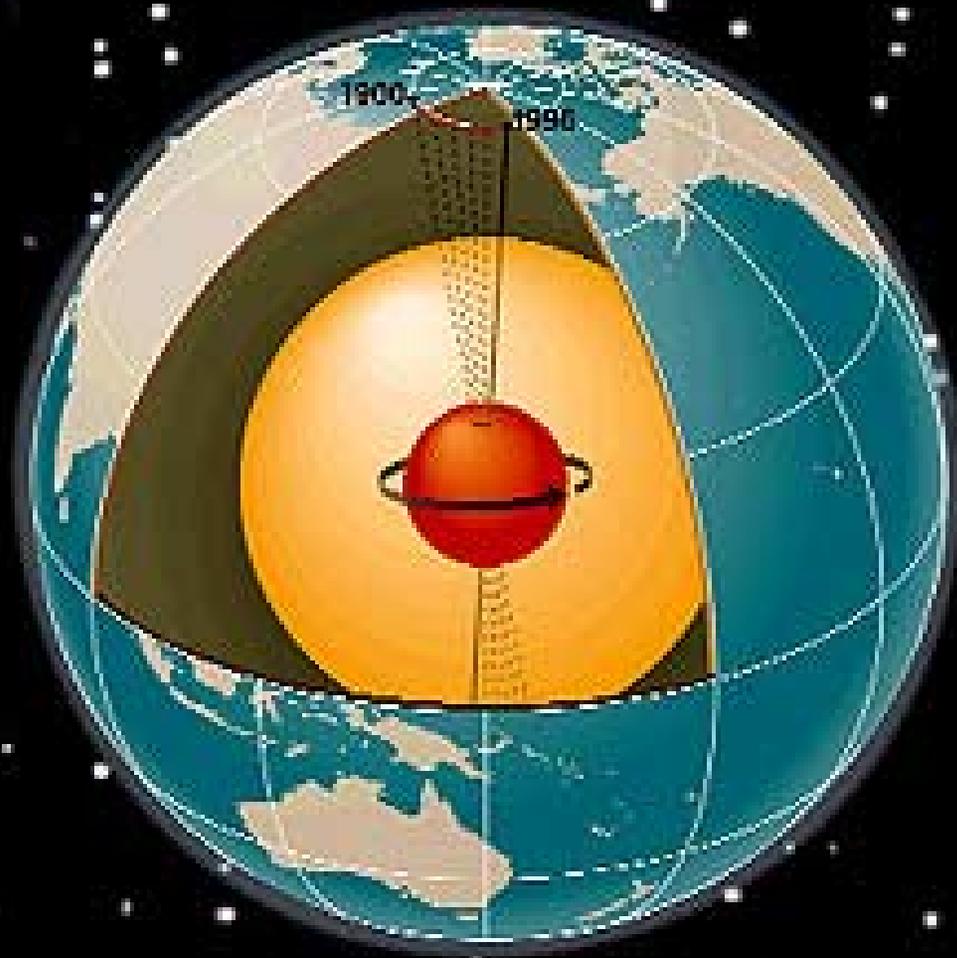
- **Cost of Inappropriate Response Unacceptable**











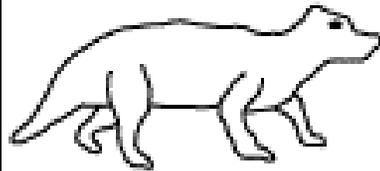


The distribution of glacial features can be best explained if the continents were part of Pangaea.



Grooves carved by glaciers (shown by arrows) provided evidence for continental drift. This diagram assumes the continents were in their present-day locations.

Cynognathus



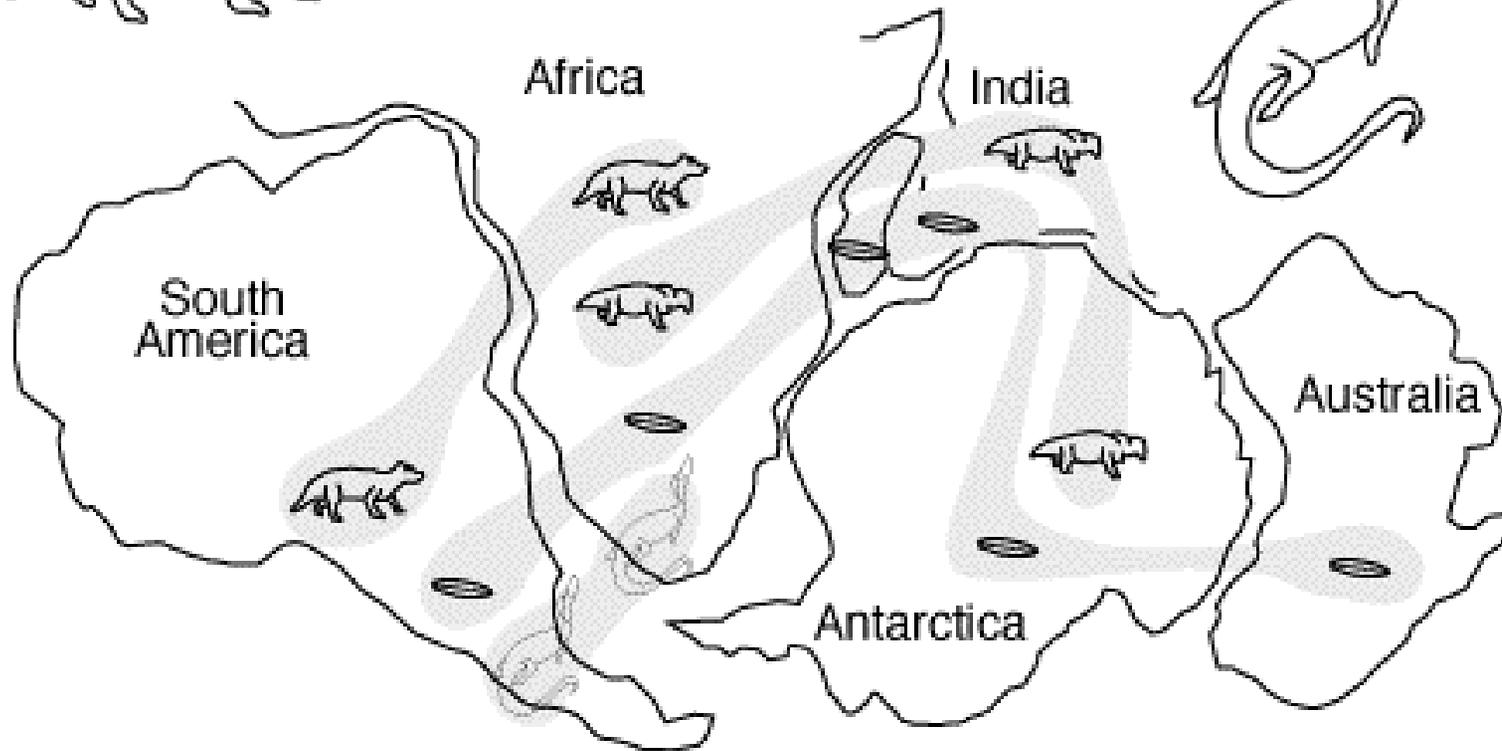
Glossopteris



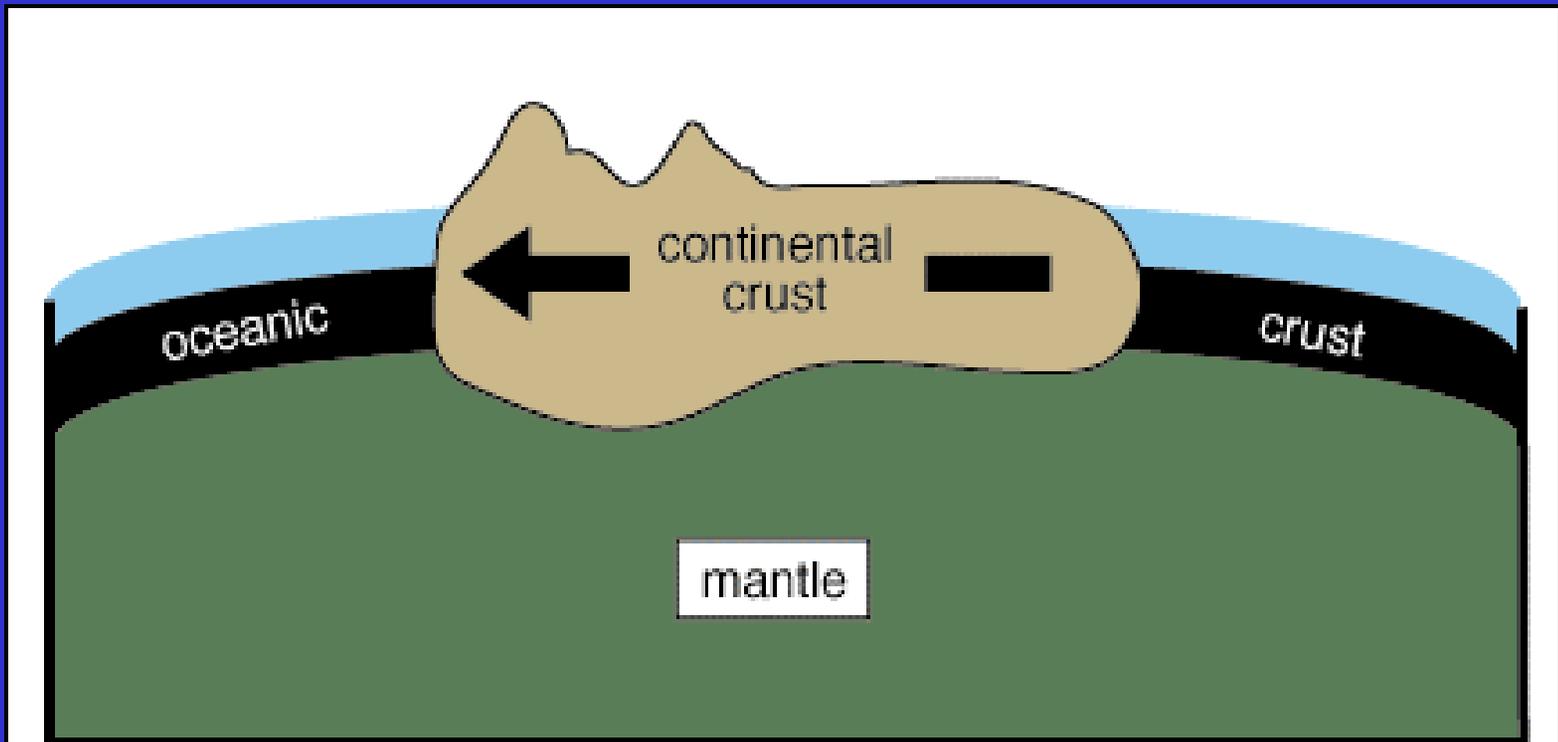
Lystrosaurus



Mesosaurus

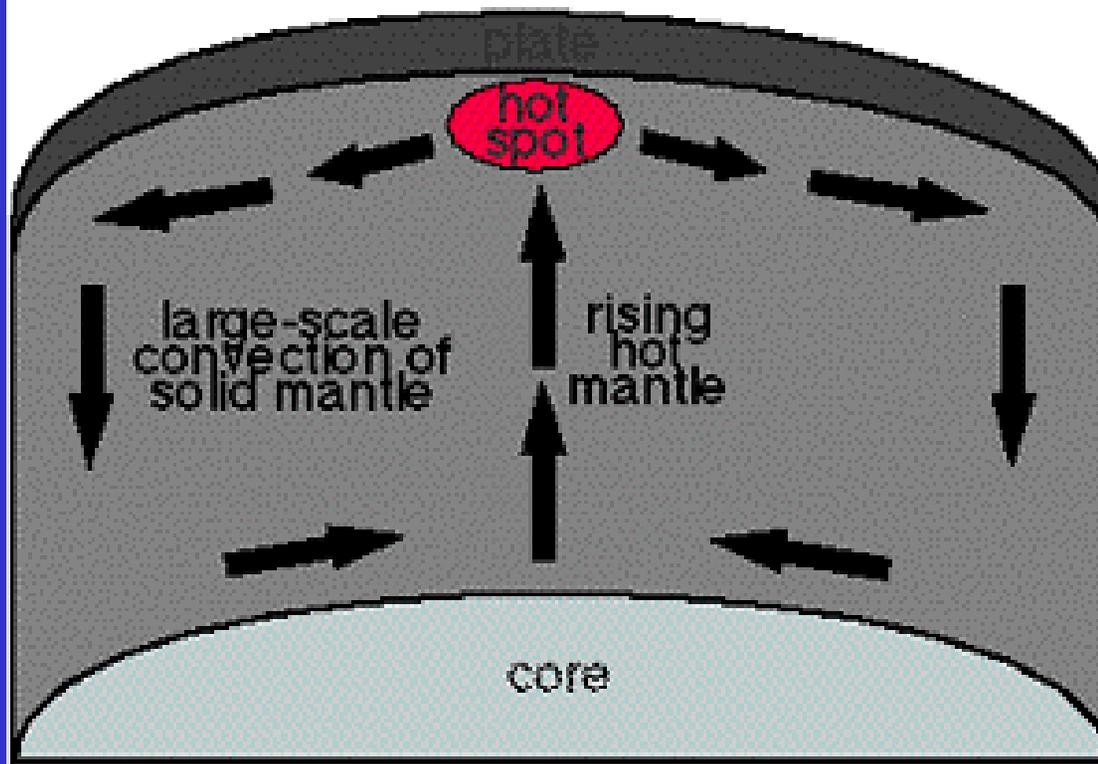


Distribution of fossils across the southern continents of Pangea.



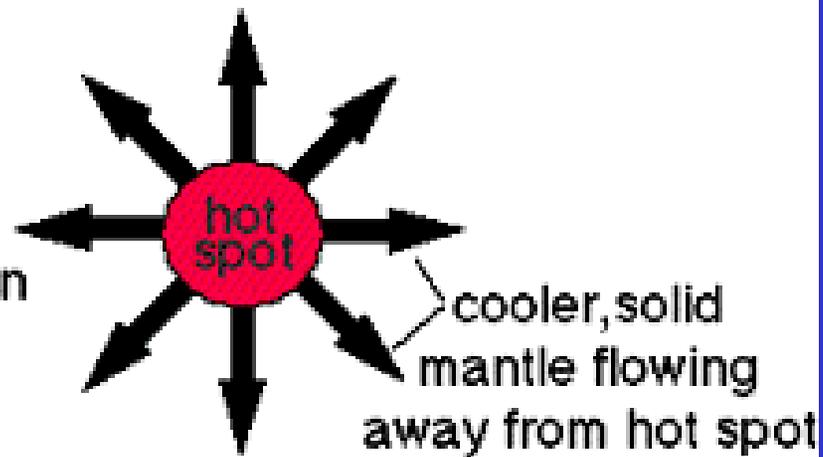
Wegener's proposal that continents plowed through oceanic crust was not accepted by other geologists.

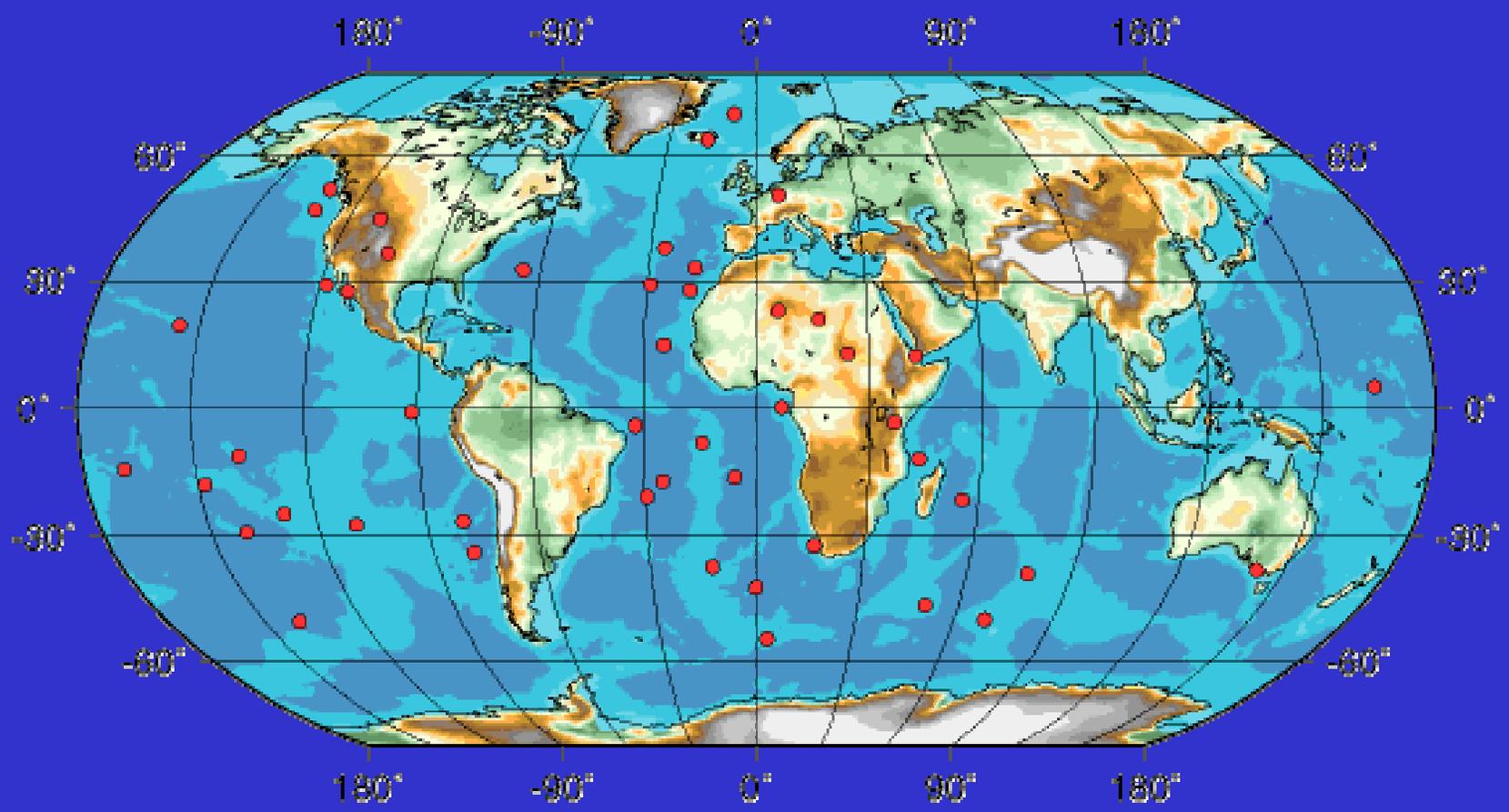
Cross-section

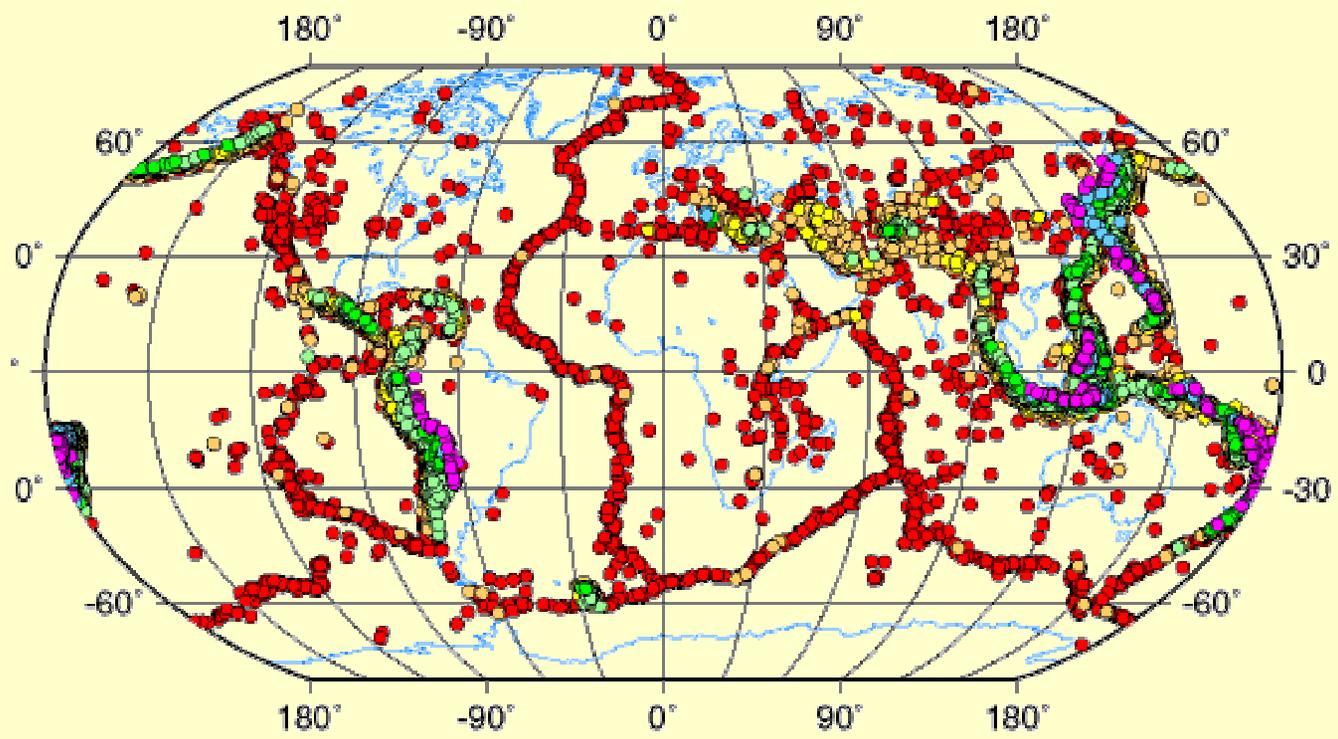


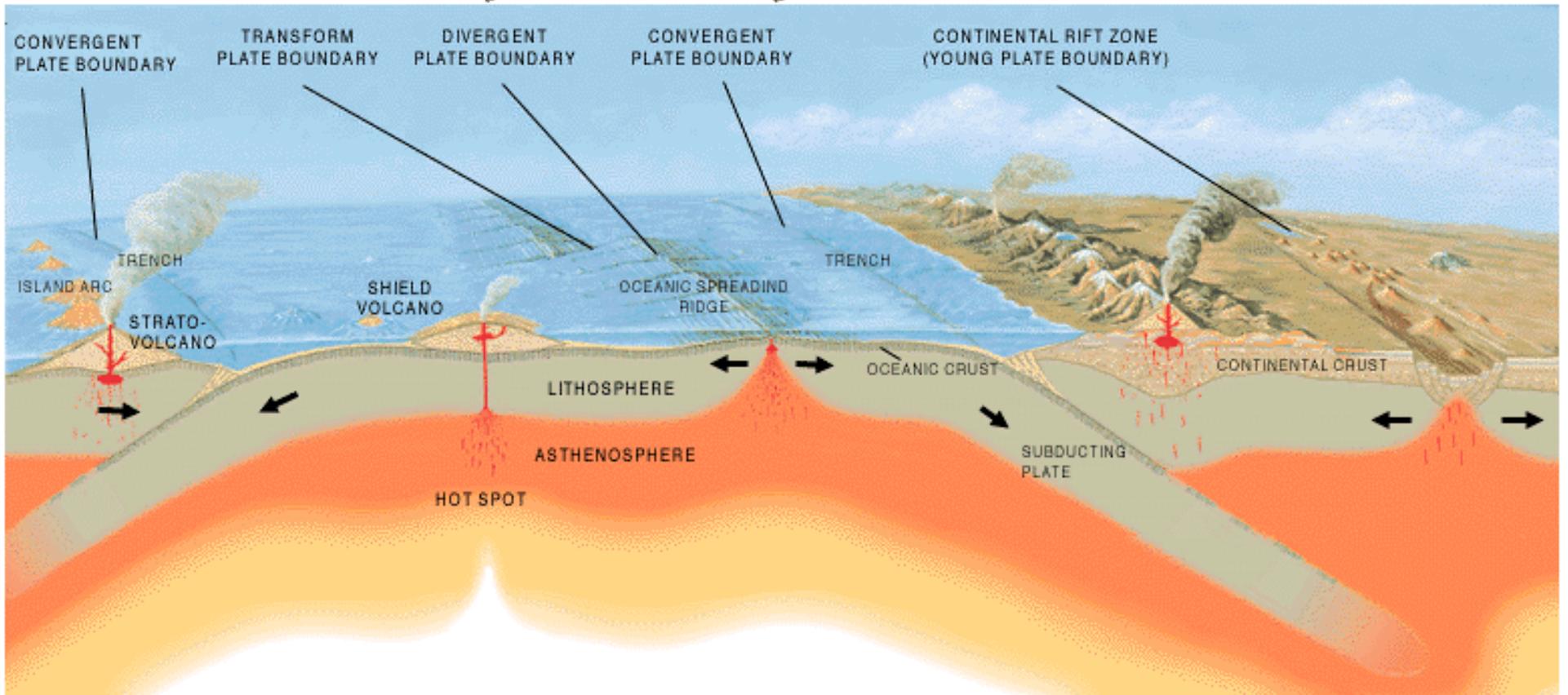
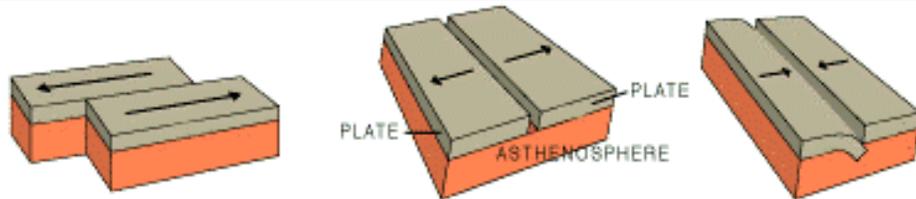
Map view

Looking down
on the
hot spot







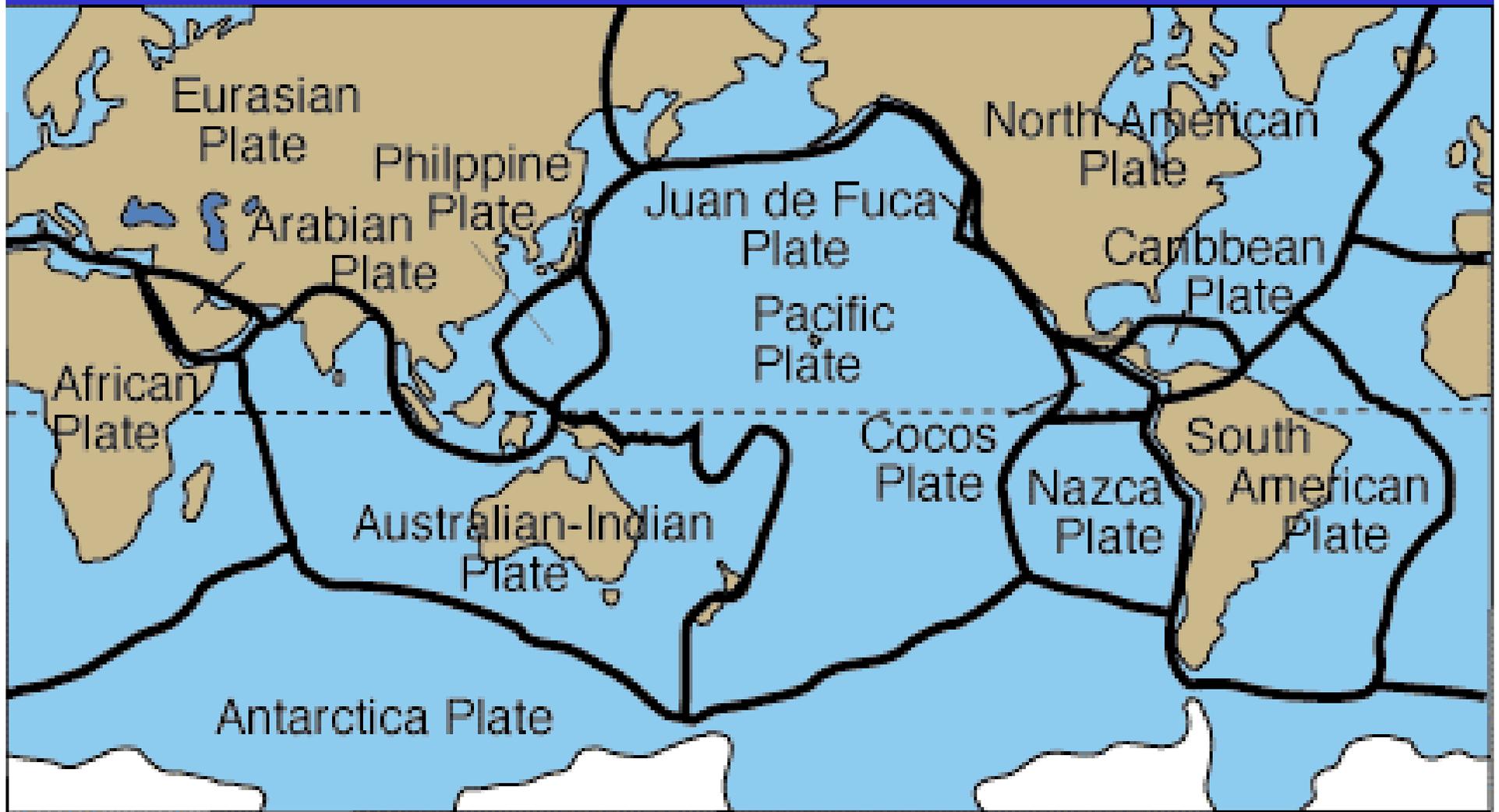






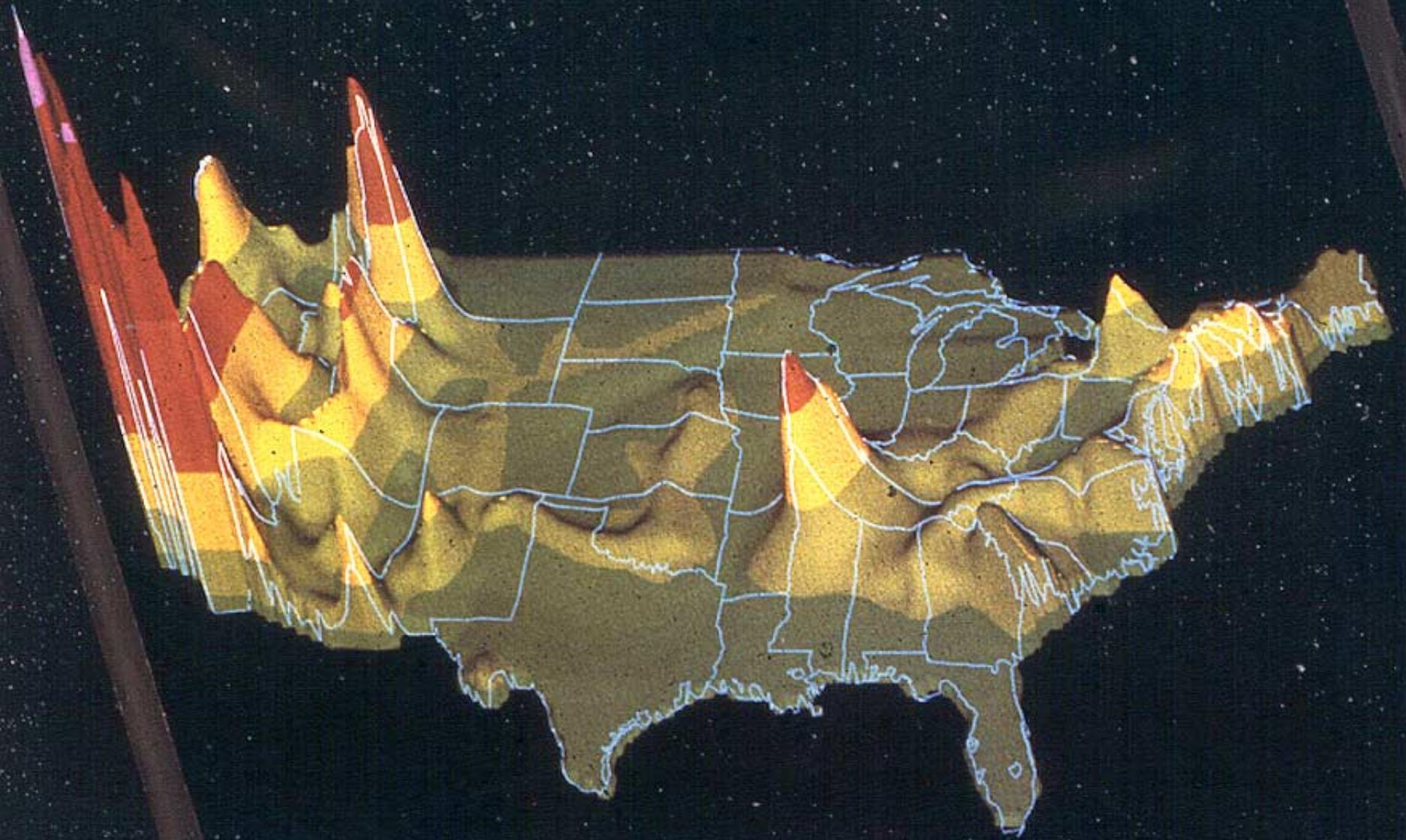


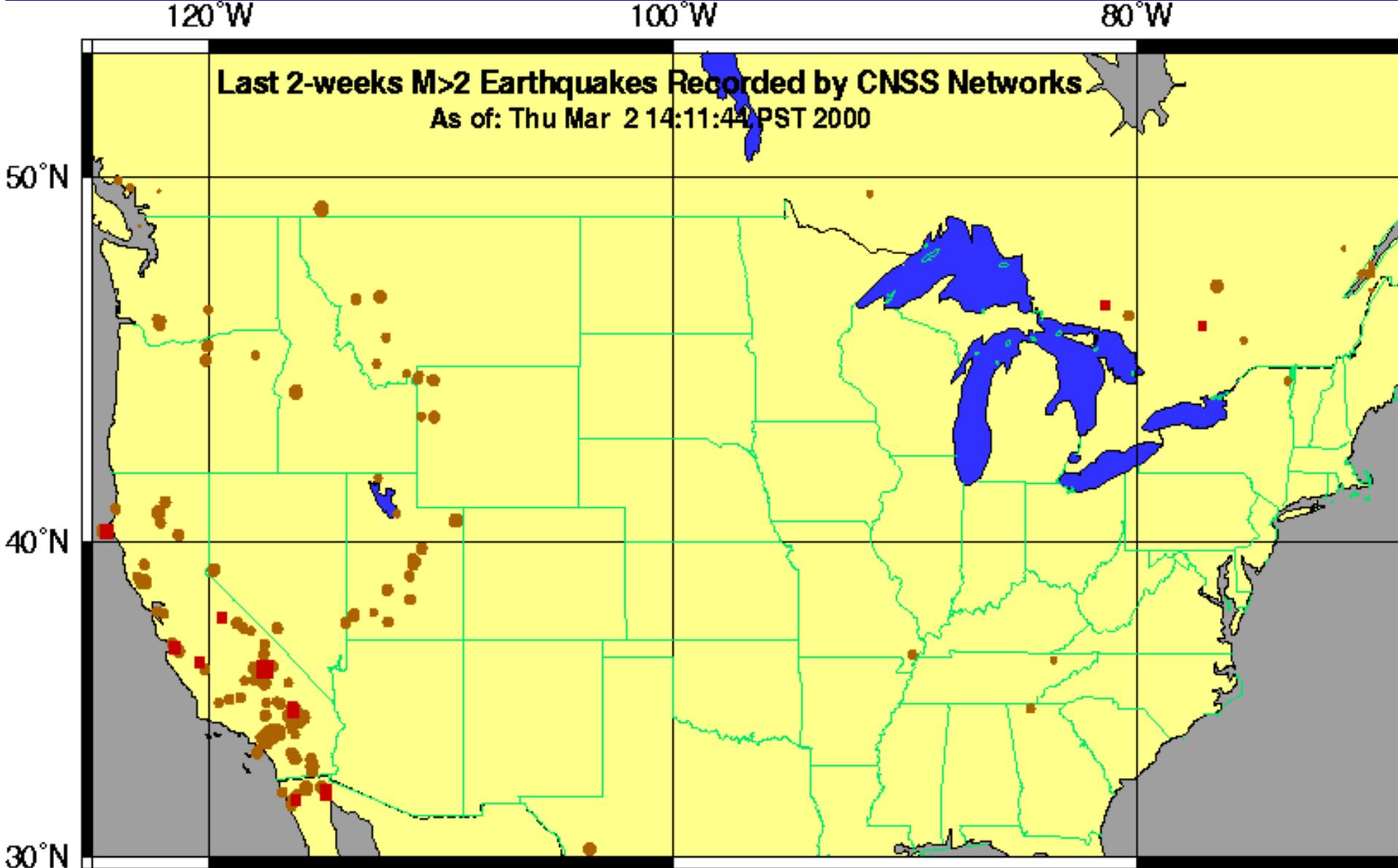
FAULT TRACE SPLITS TREE



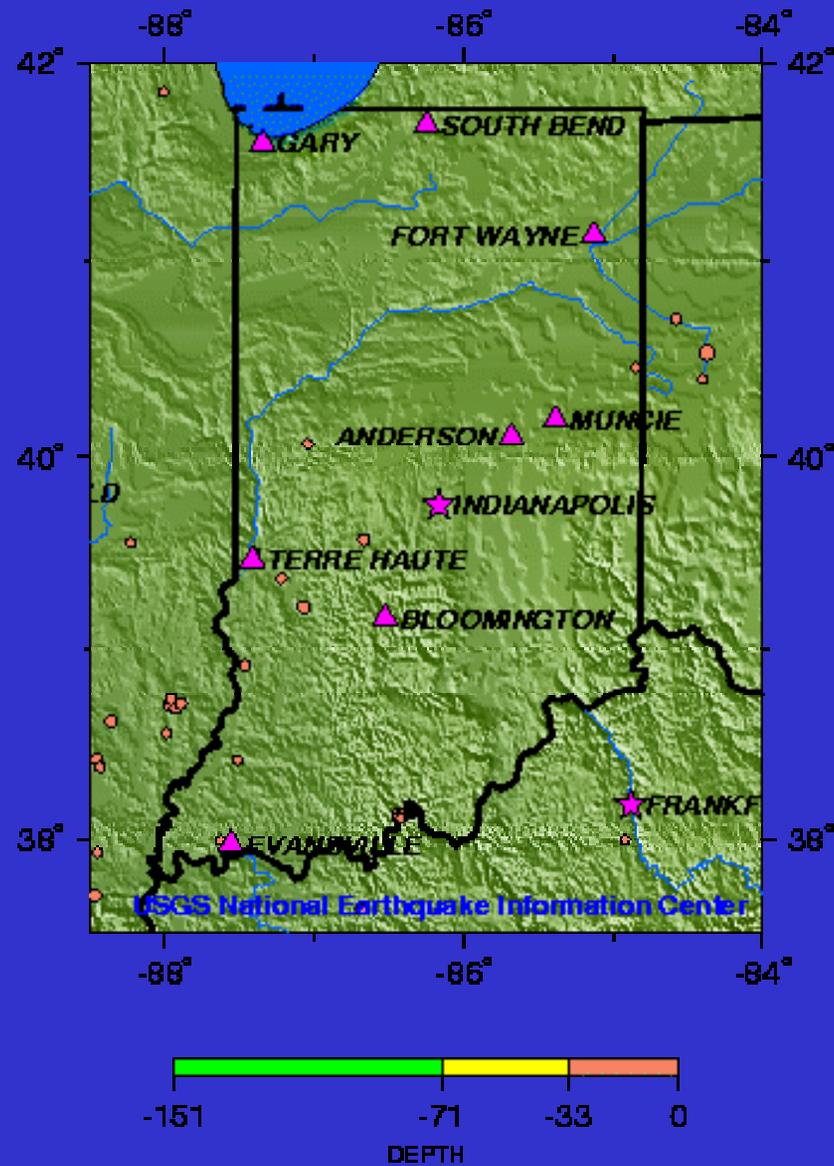
Major tectonic plates of the world.

COMPARISON OF SEISMIC RISK

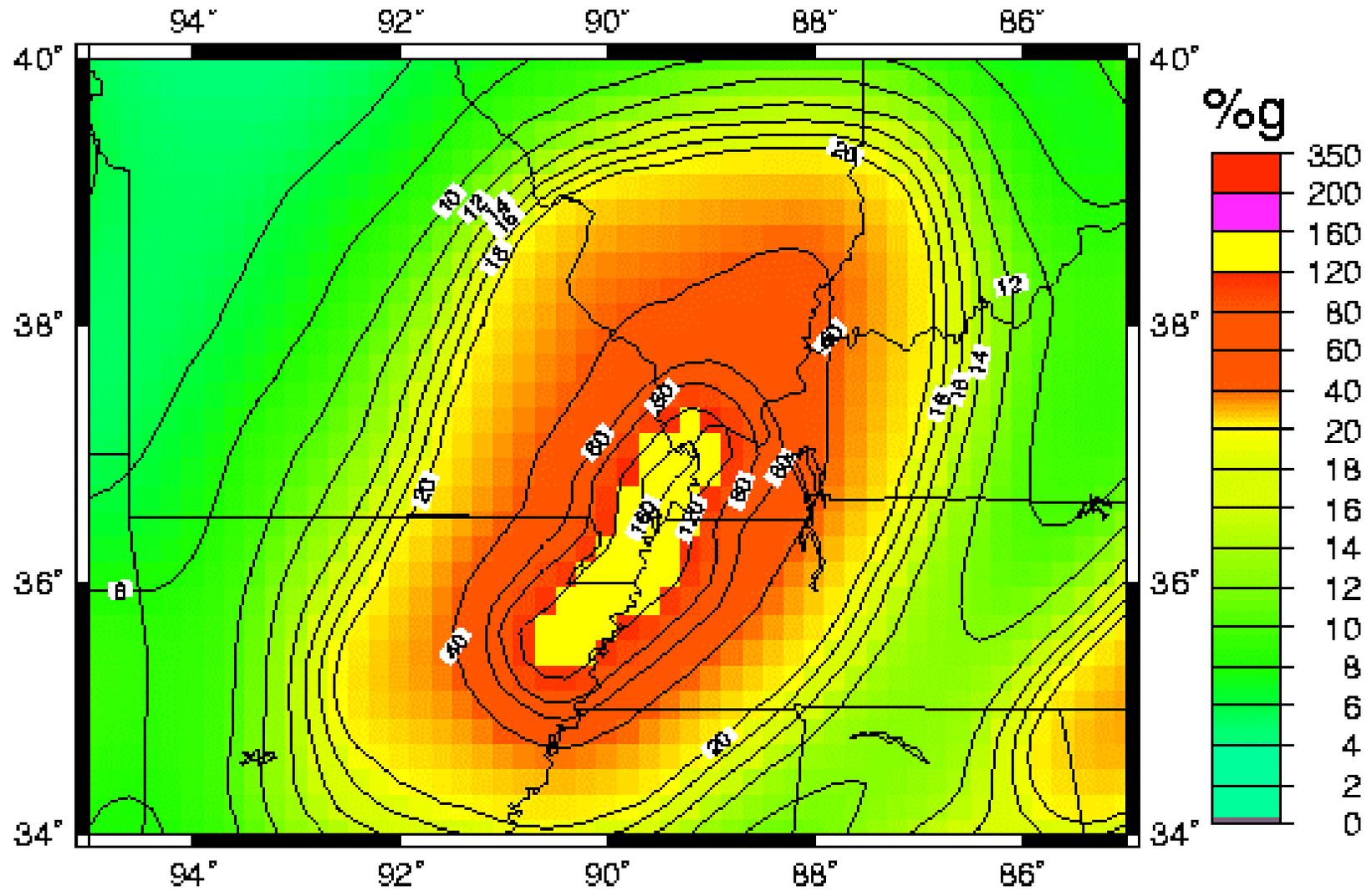


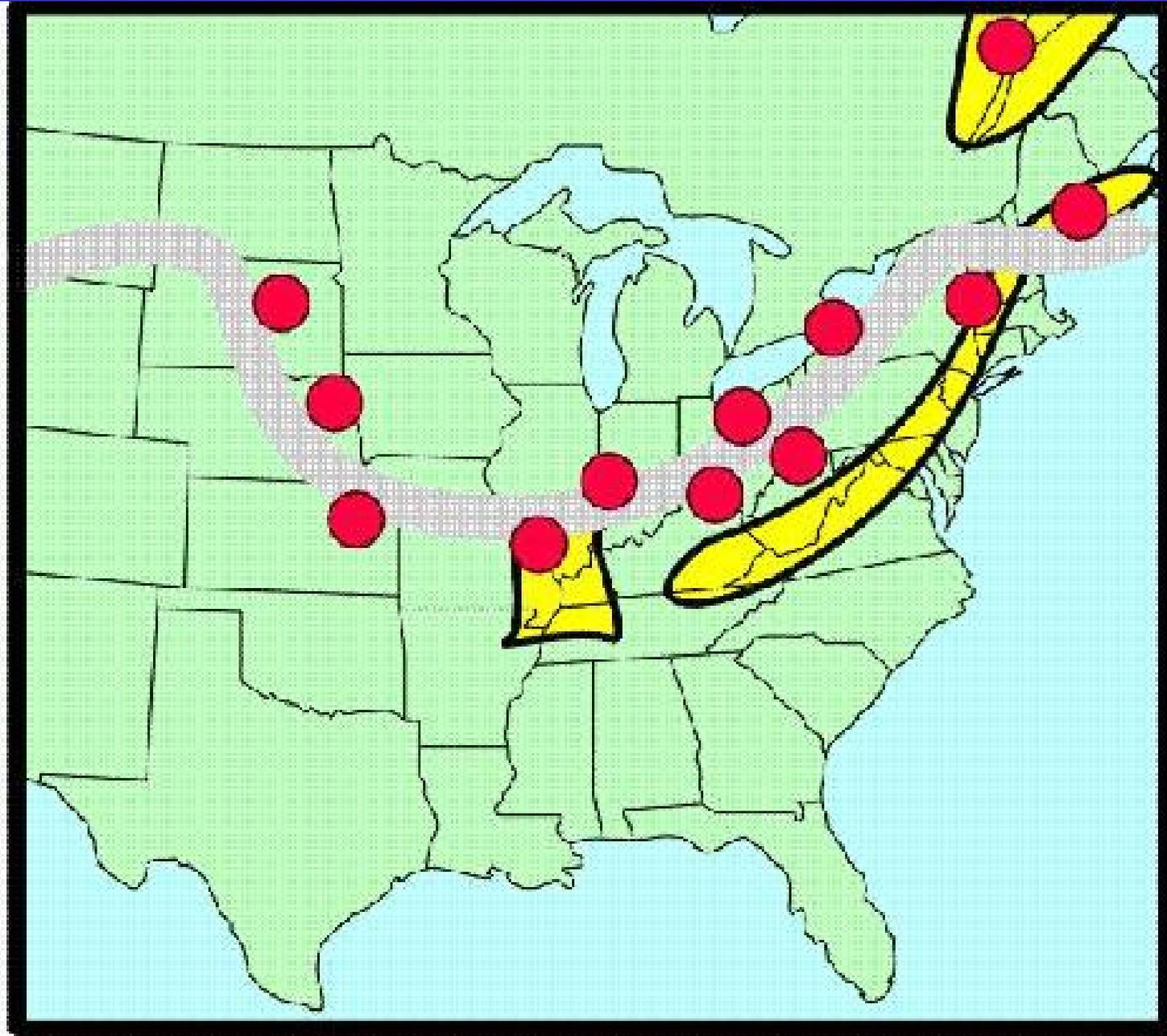


Seismicity of Indiana 1977 - 1996



Peak Acceleration (%g) with 02% Probability in 50 Years





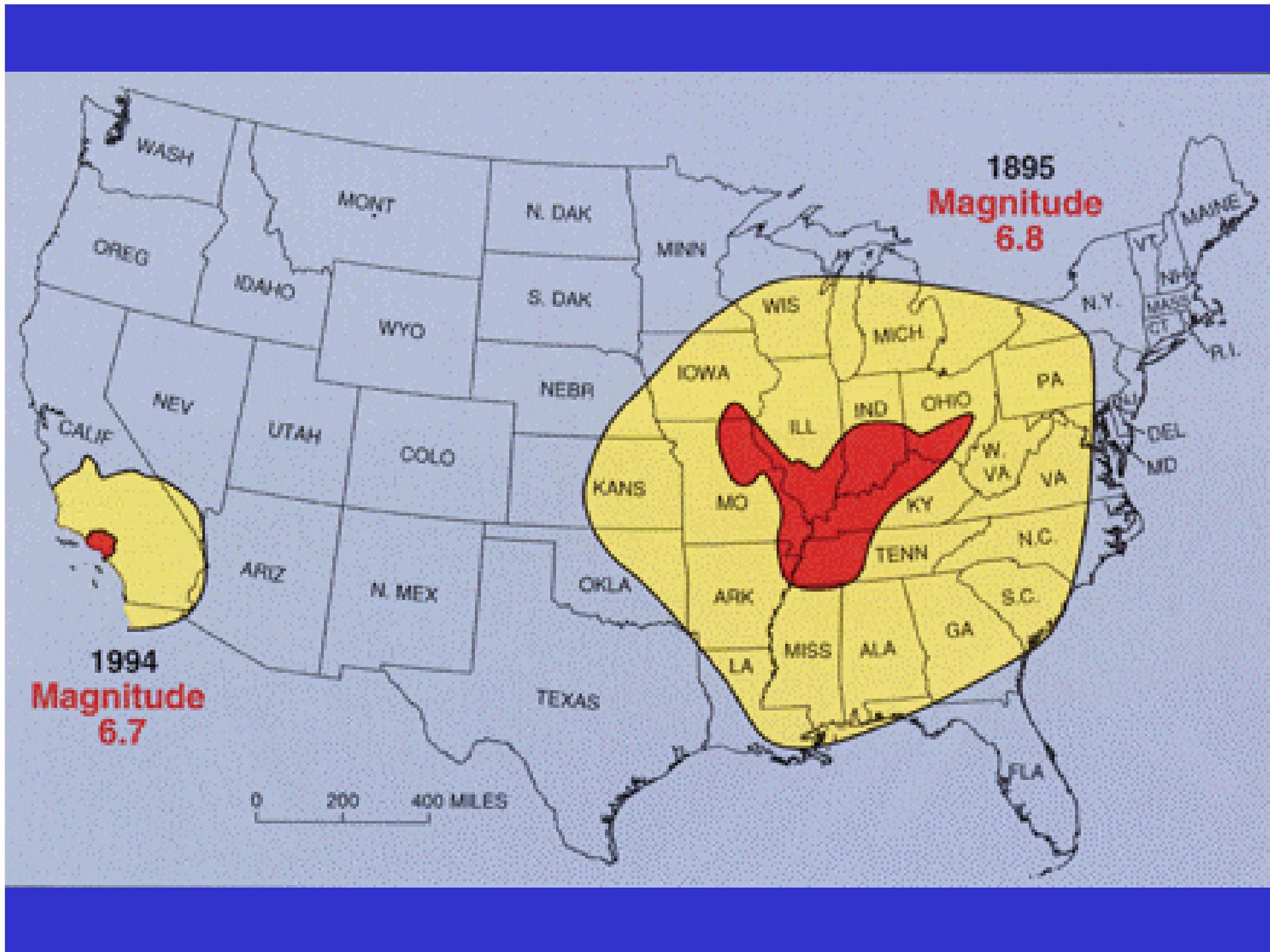
Glacial limit



Epicentre cluster



Region of Seismic activity



Intensity Scale

MM : Modified Mercalli-Medvedev

Roman Numerals:I to XII

Intensity Scale, MM

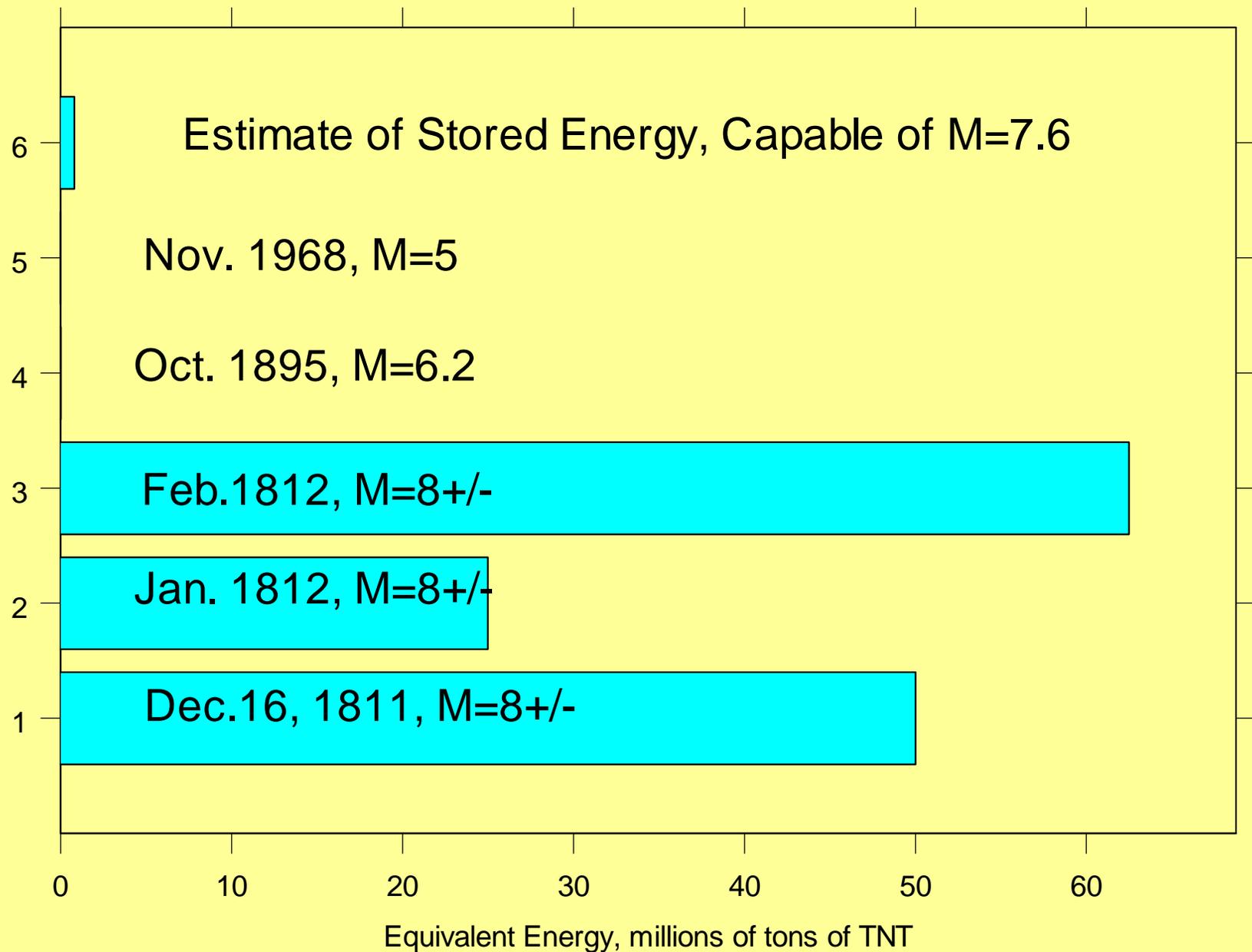
IV: ..walls make creaking sound

Intensity Scale, MM

VI: ...many run outdoors ...

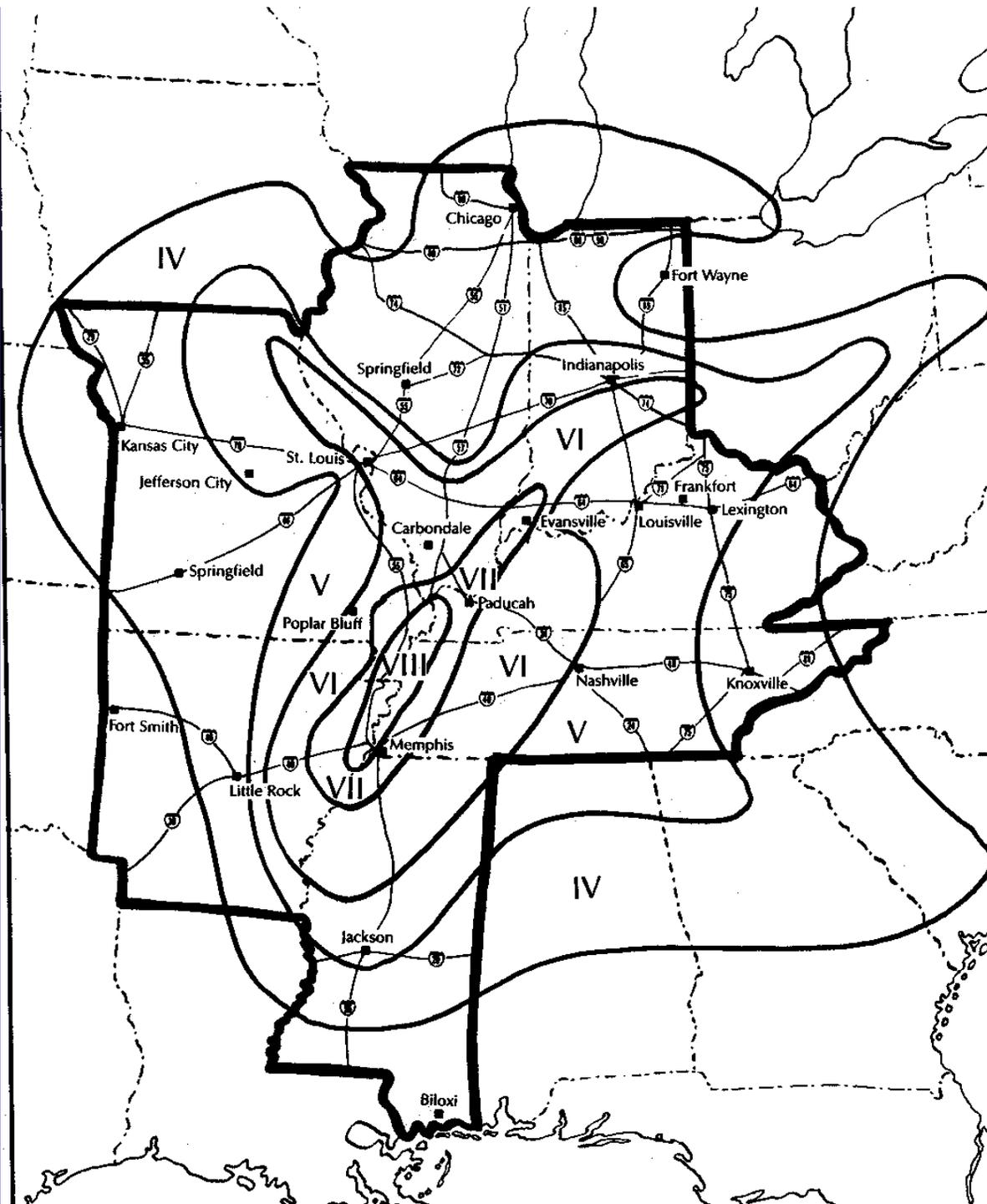
Intensity Scale, MM

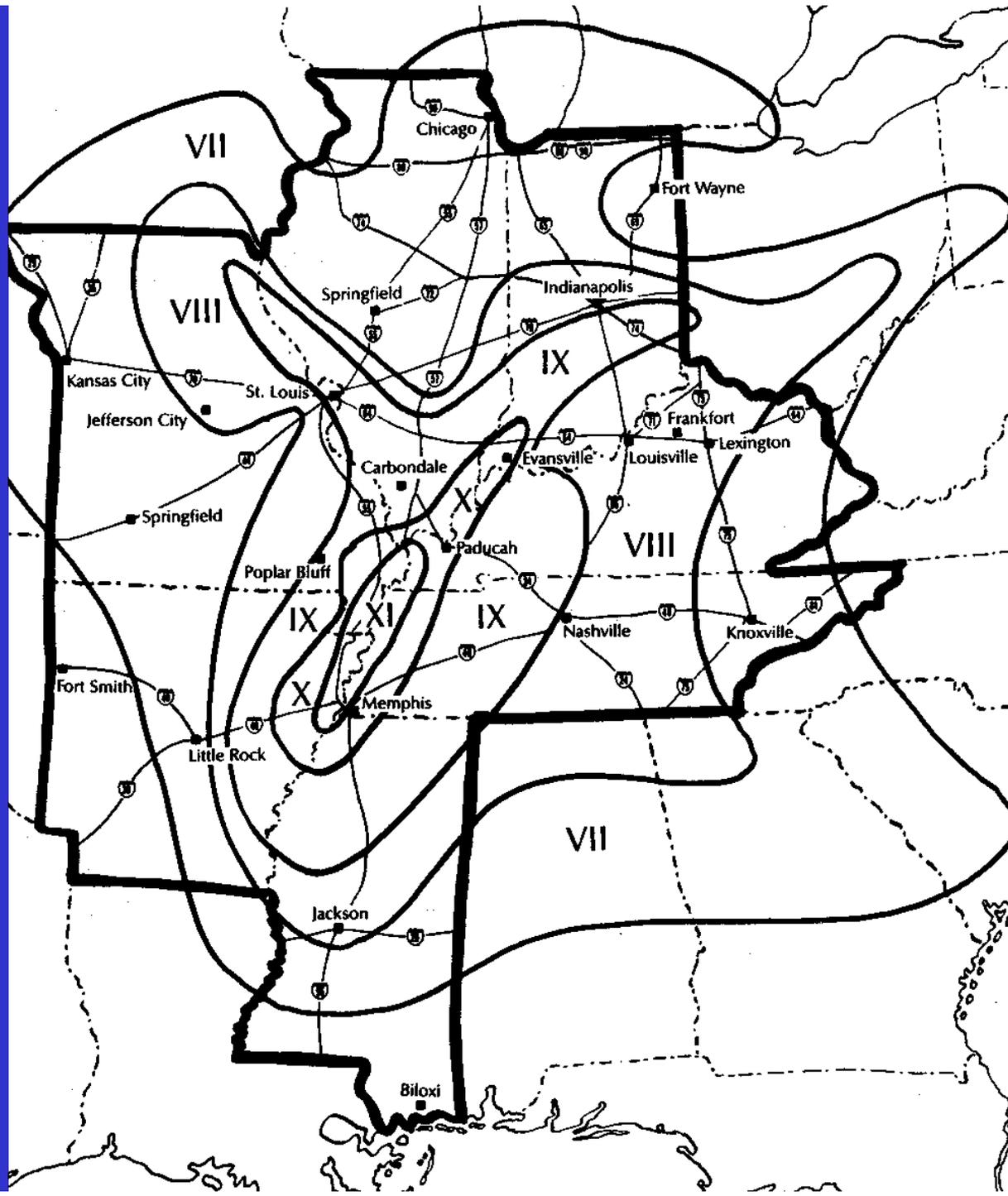
VII: ...everybody runs outdoors ...



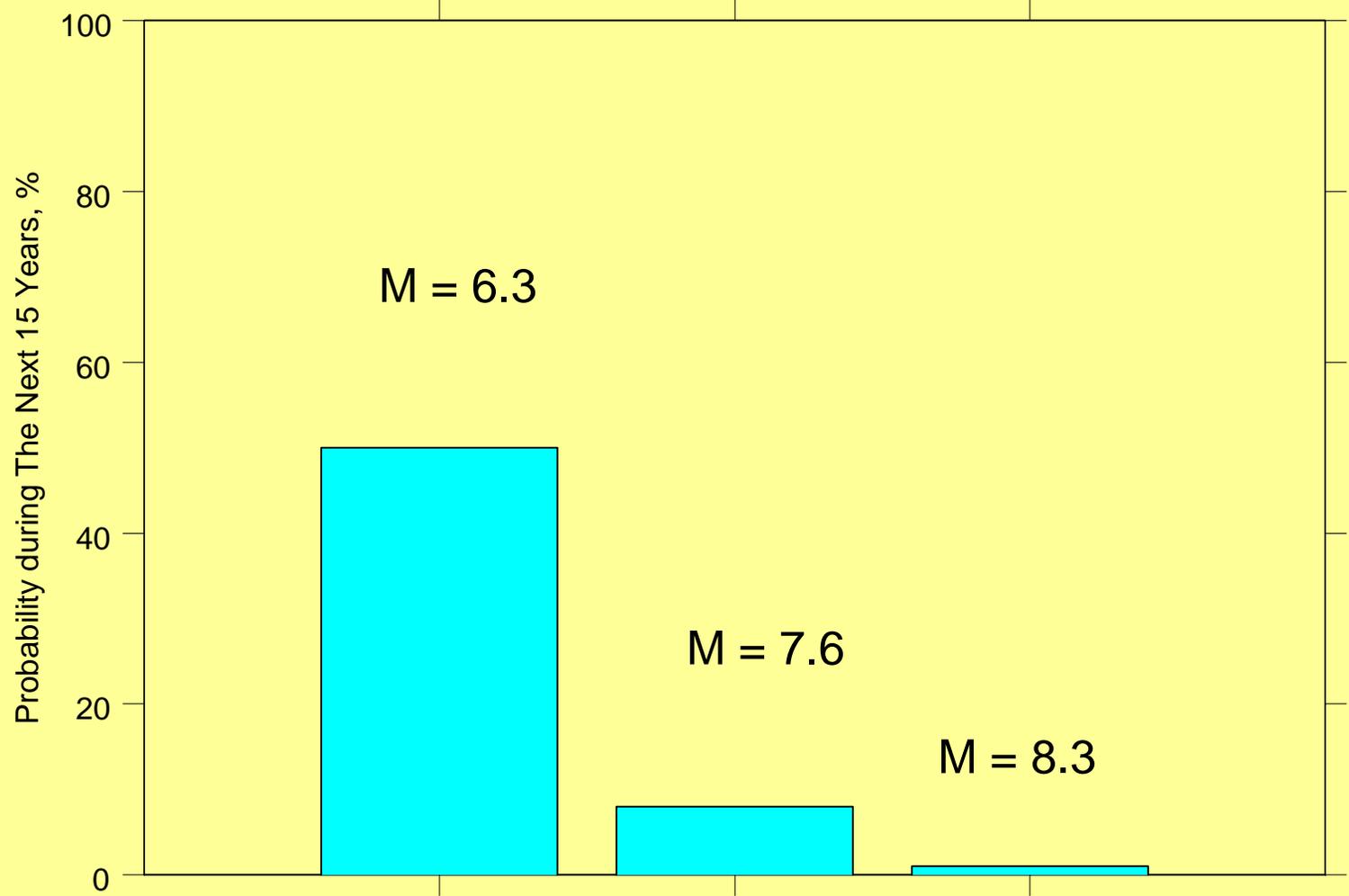
THE TOP FIVE

Magnitude	Date	Location
9.2	1964	Prince William Sound
9.1	1957	Andreanof Islands
8.6	1899	Yakutat Bay
8.3	1899	Yakutat Bay
8.3	1900	Kodiak Island

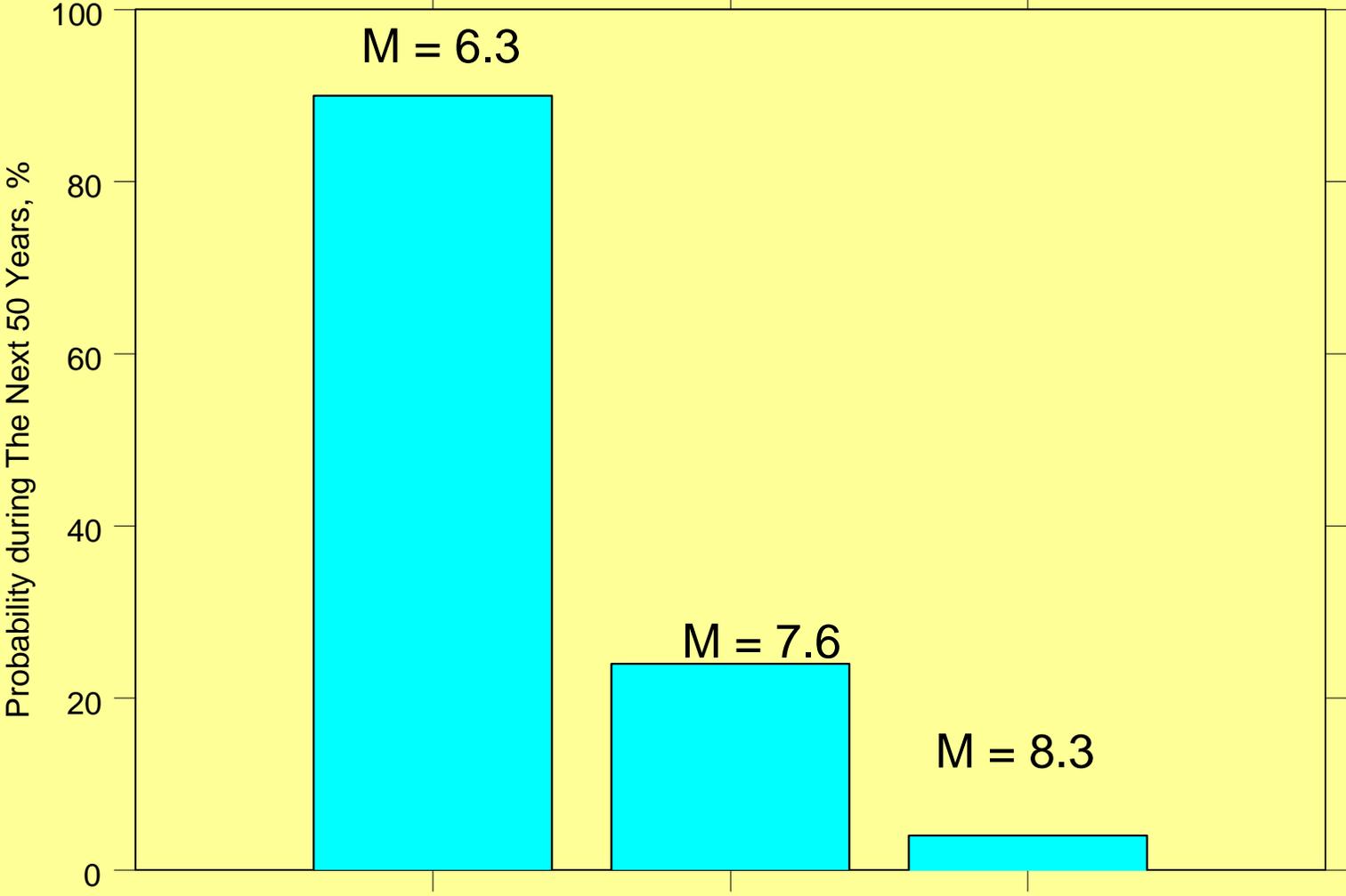




New Madrid Earthquake



New Madrid Earthquake



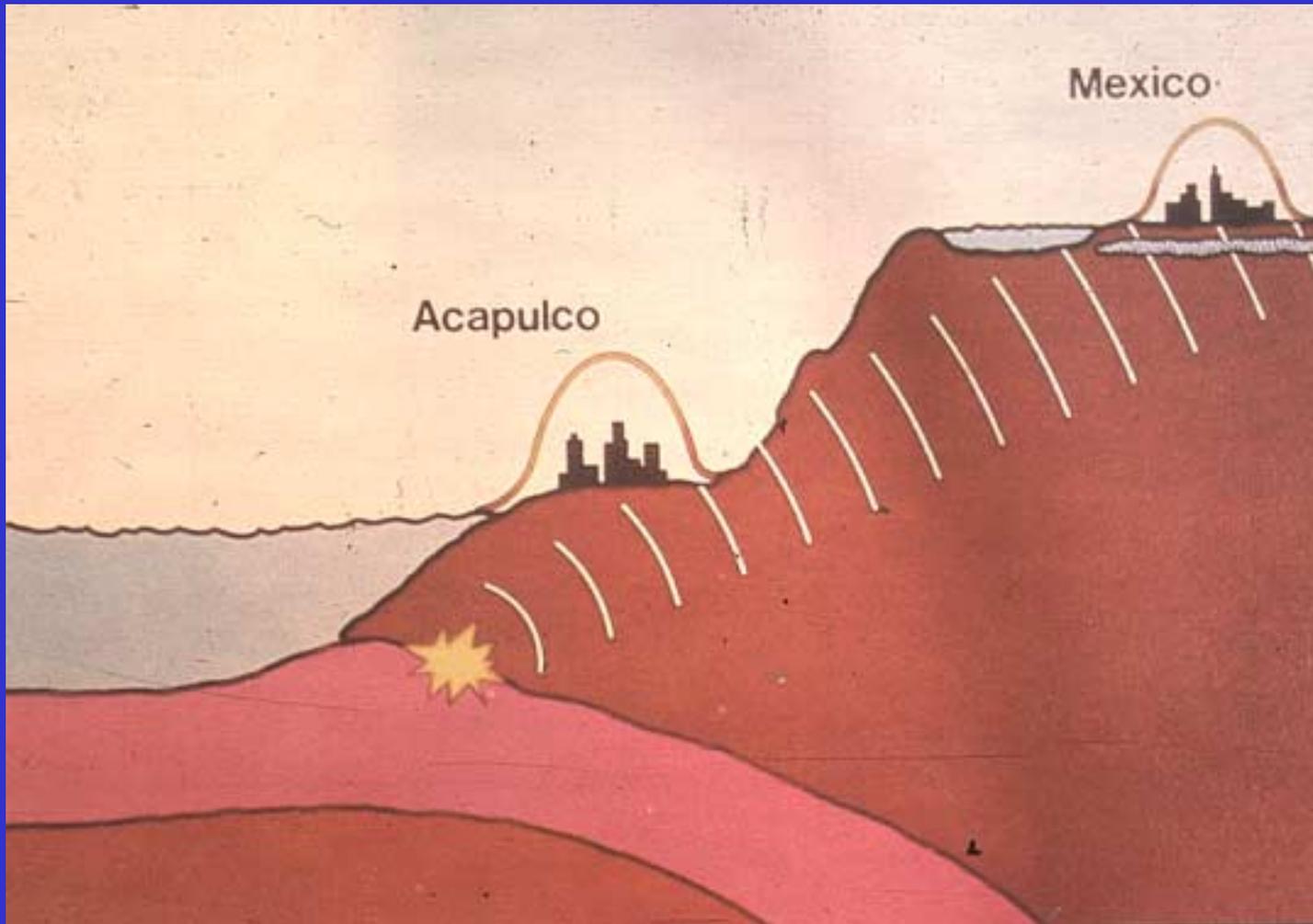
- Risk Poorly Understood
- Large Affected Population
- Ground Motion Uncertain

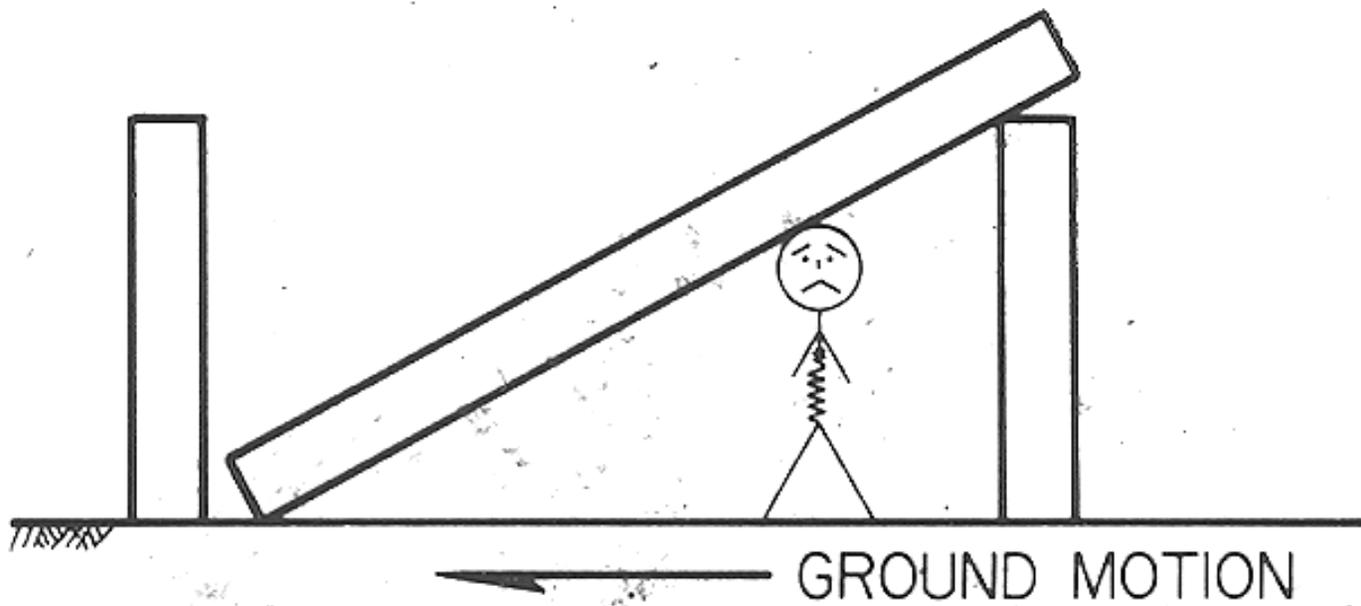
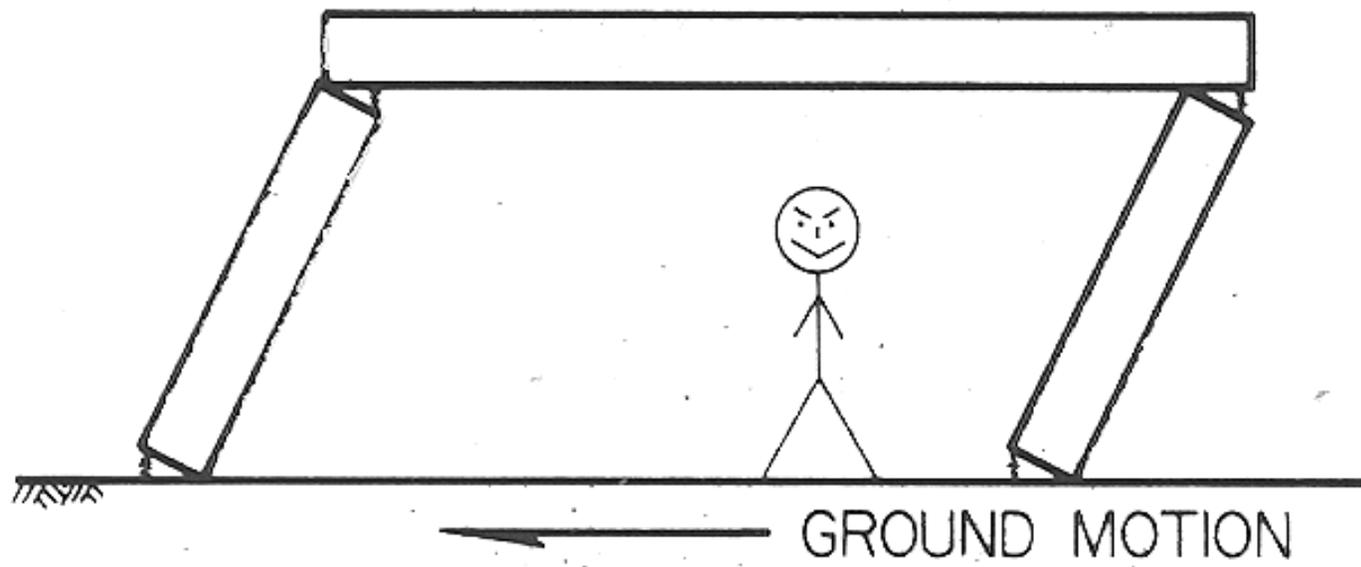






Ground Motion

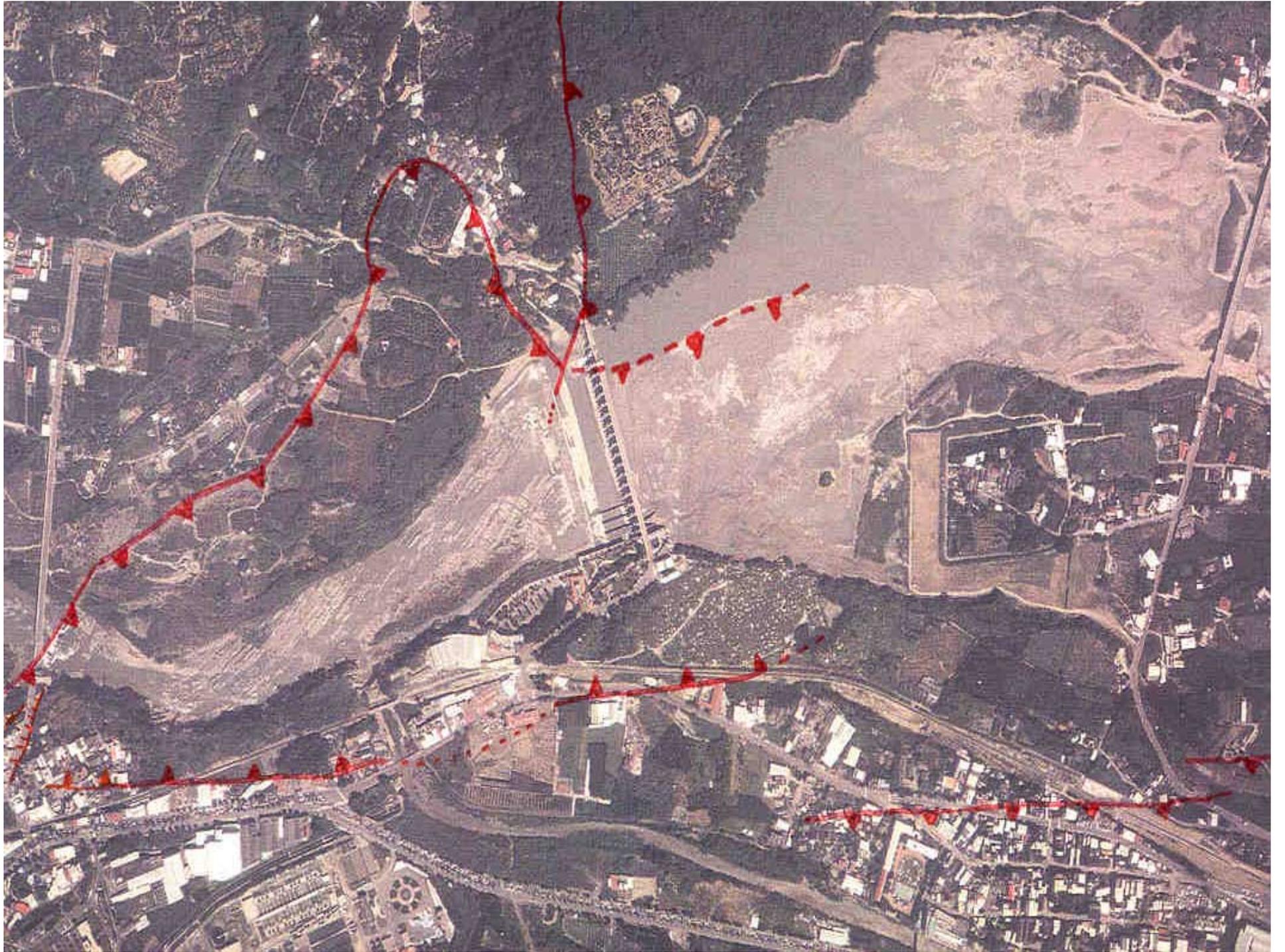


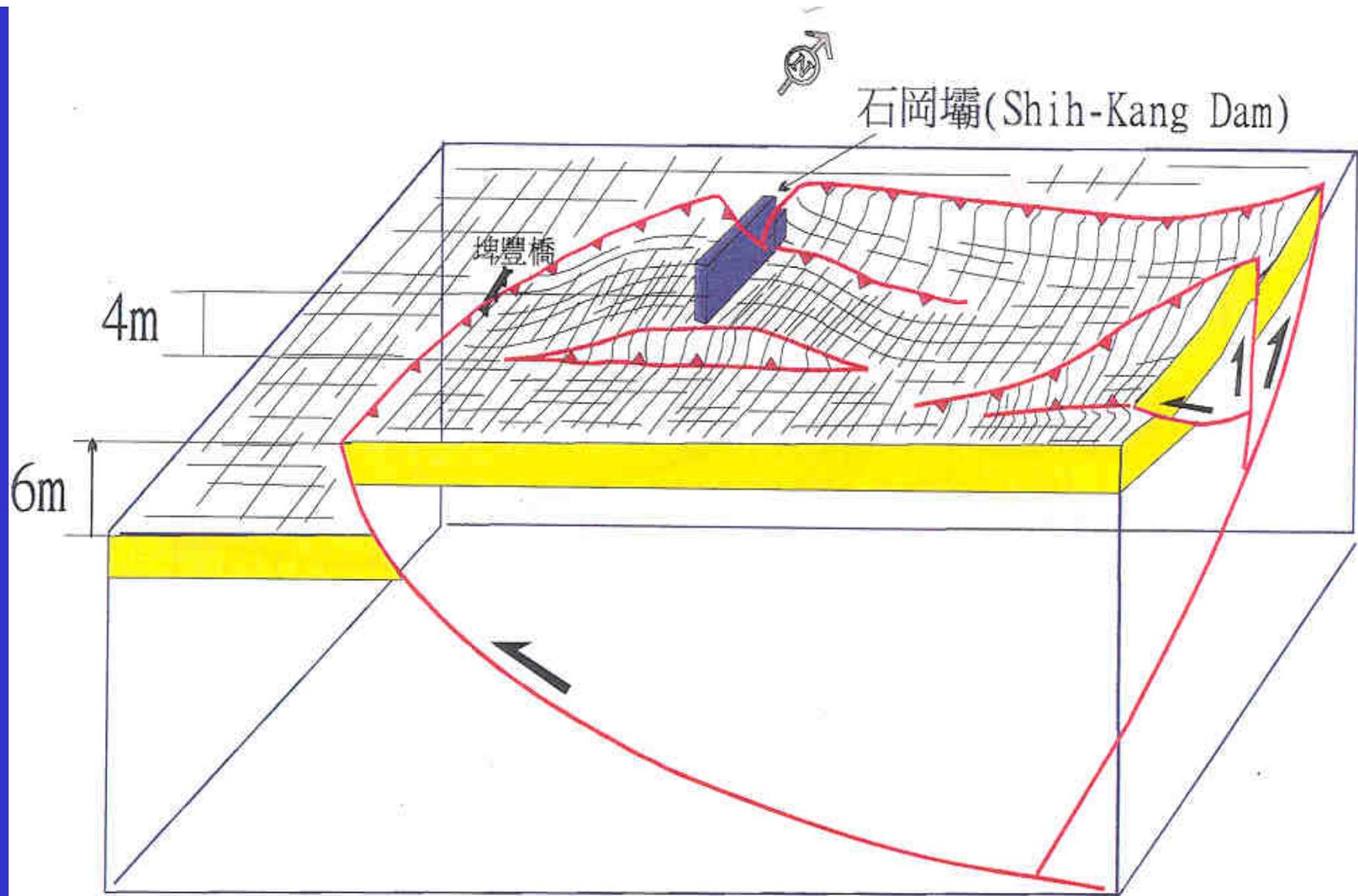






Ground Distortion (Tearing)





李元希等(1999)，經濟部中央地質調查所

Lee Yuan-Hsi, et al.(1999), Central Geological Survey, MOEA .











BOLU VIADUCT

Length: 2313 m

Width: 1 x 17.5 m

Total number of piers 58 per carriage way

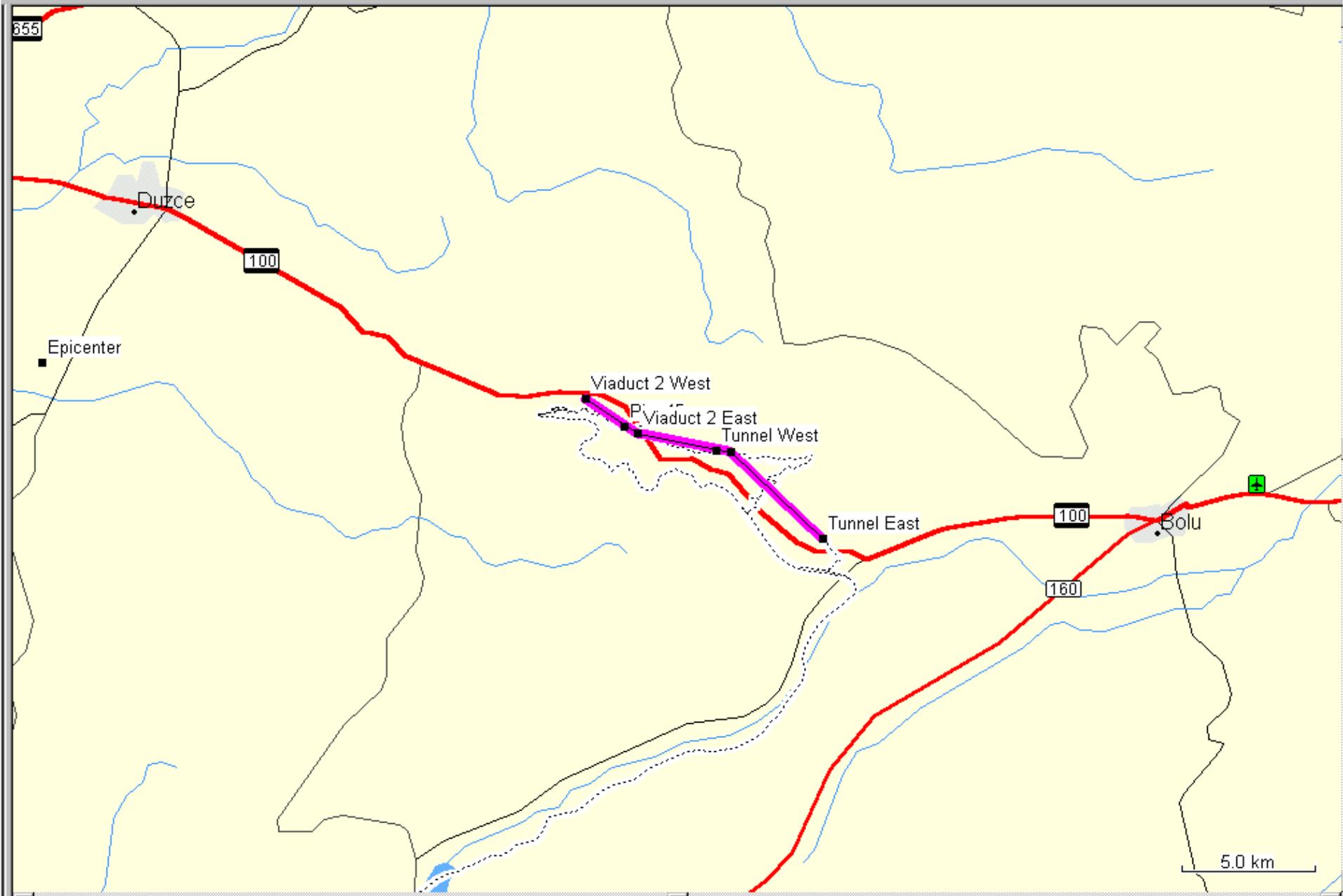
Maximum pier height: 49 m

Maximum span: 39.6 m

Pier foundations: 12-pile group with 1.8-m diameter friction pile





















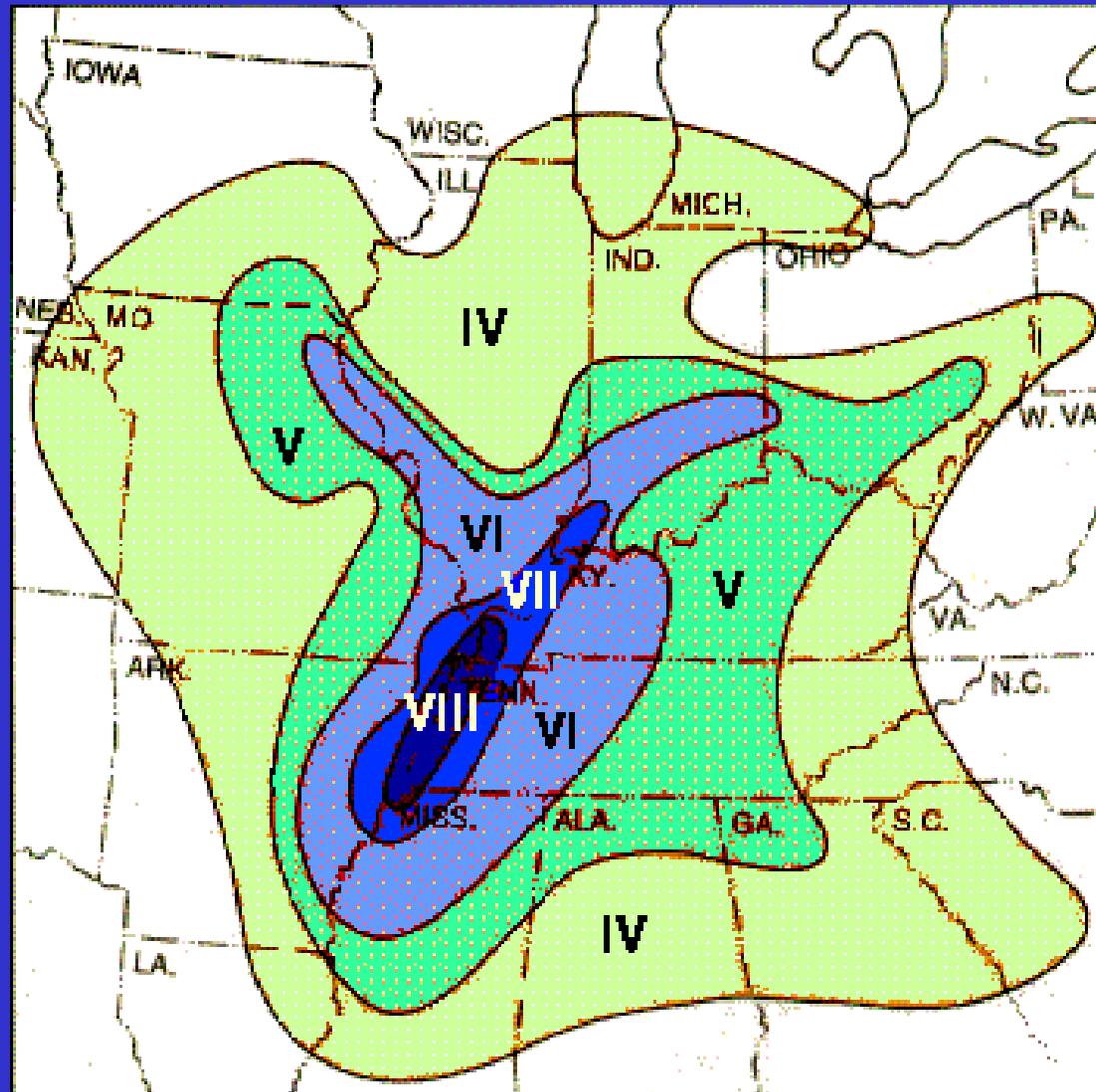
Ground Failure

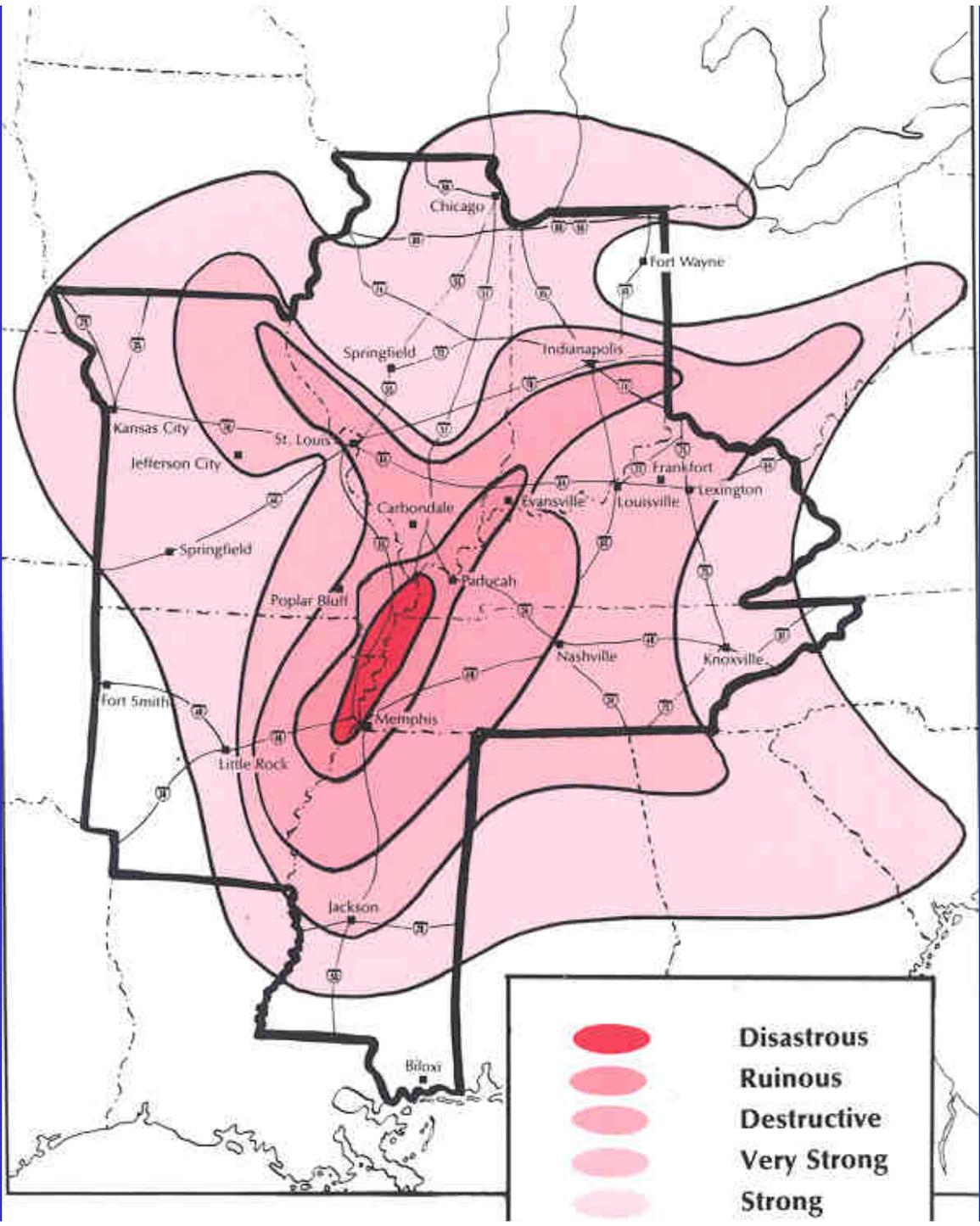




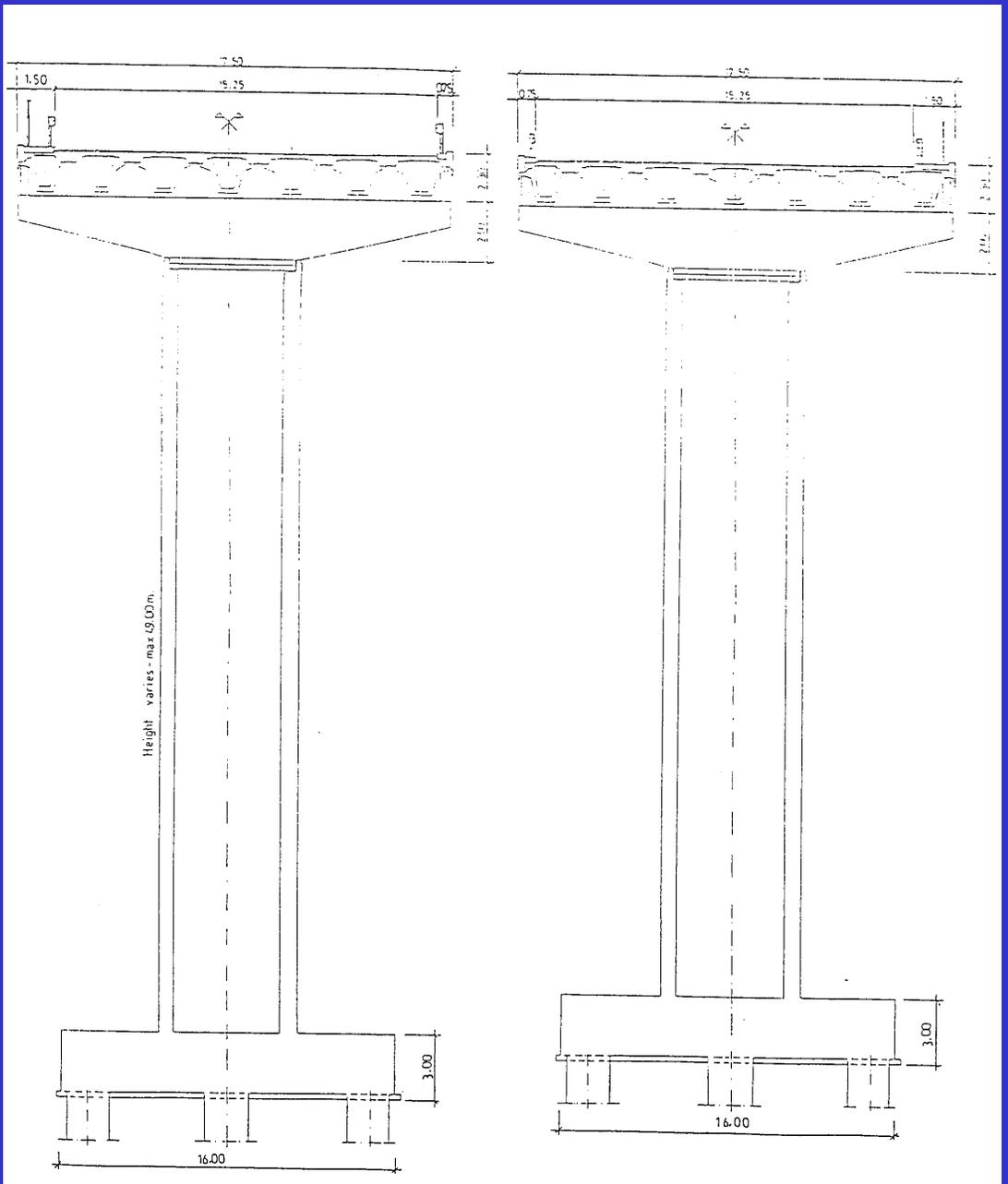








- **Cost of Inappropriate Response Unacceptable**



POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Bridges and Damage Examples

Julio RAMIREZ

Purdue University

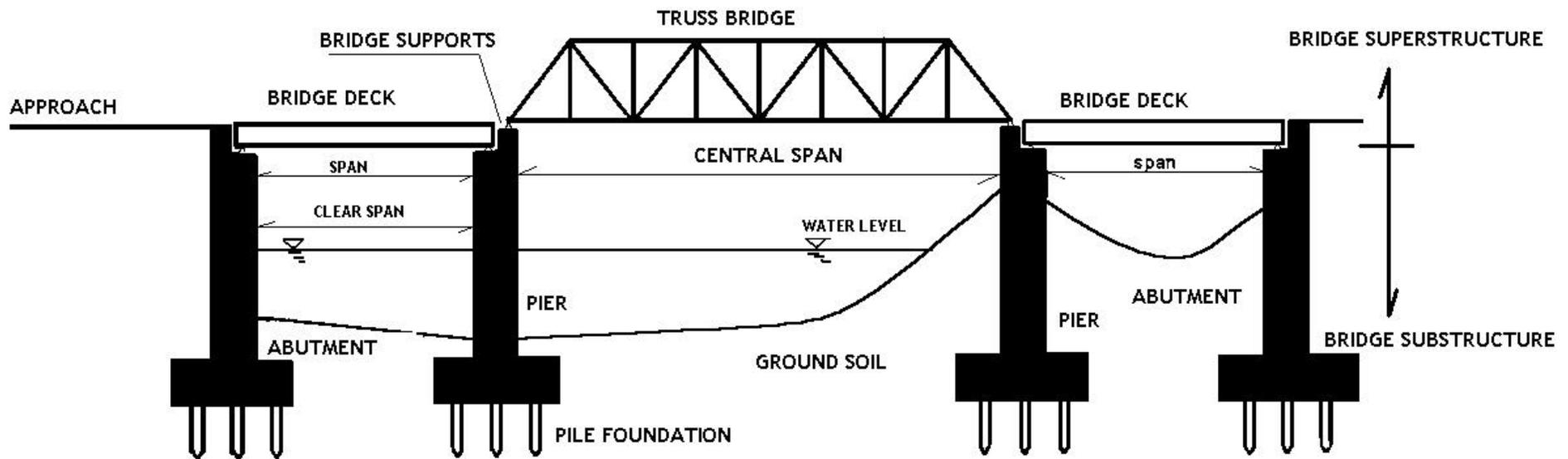
Training Level 1 Inspection Teams

- Key bridge components (Chapter 4)
- Typical Indiana bridges (Chapter 4)
- Bridge behavior (Chapter 2, page 14)
- Damage classification
(Chapter 5, pages 34)
- Bridge and road damage
(Chapter 5, page 35)

Training Level 1 Inspection Teams

- Key bridge components (Chapter 4)
 - Approaches
 - Superstructure
 - Girders, Trusses, Arches and Slabs
 - Joints and Bearings
 - Substructure
 - Abutments, Piers, Footings and Piles

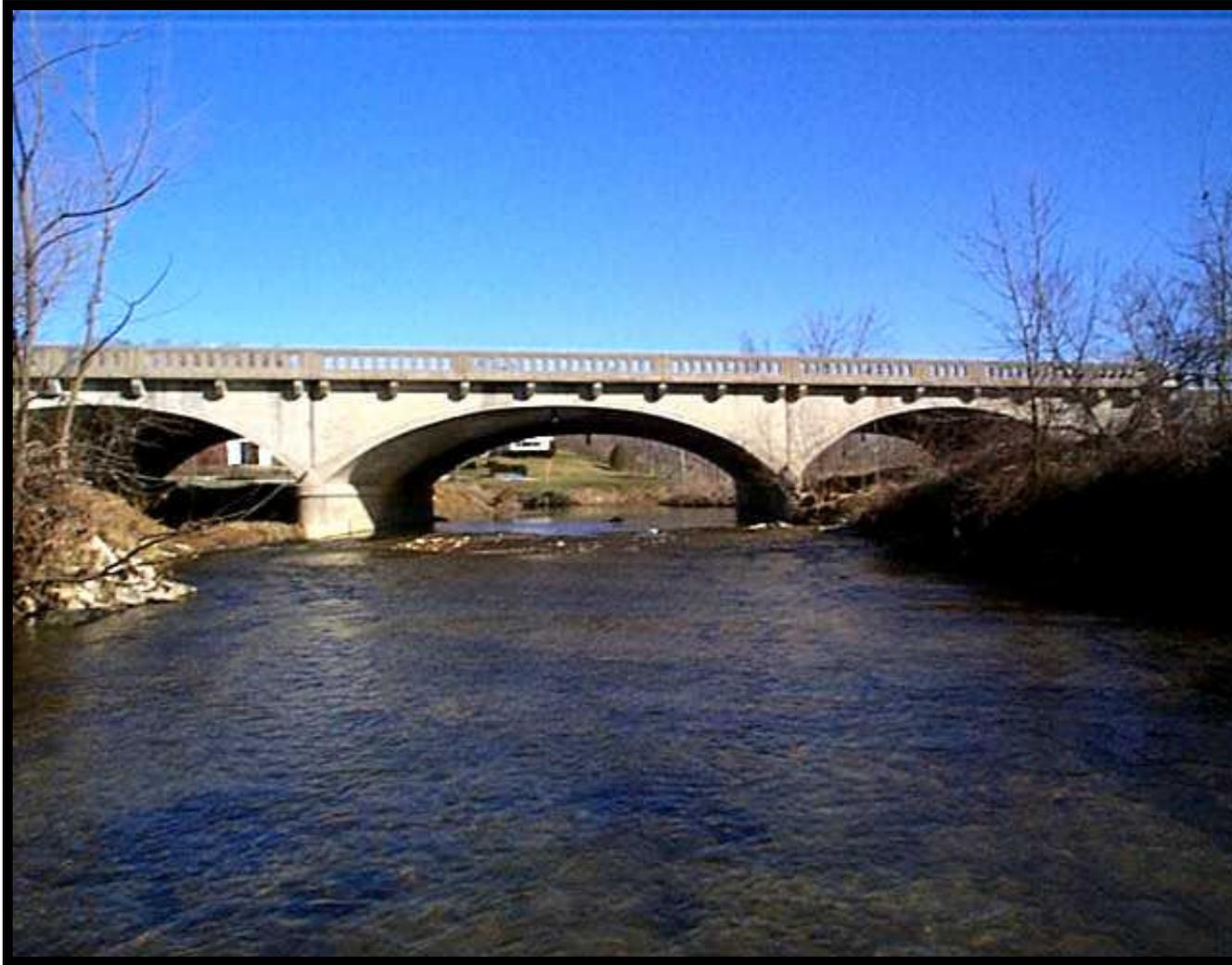
Training Level 1: Highway bridge components



Training Level 1 Inspection Teams

- Typical Indiana bridges (Chapter 4)

Reinforced Concrete Arch



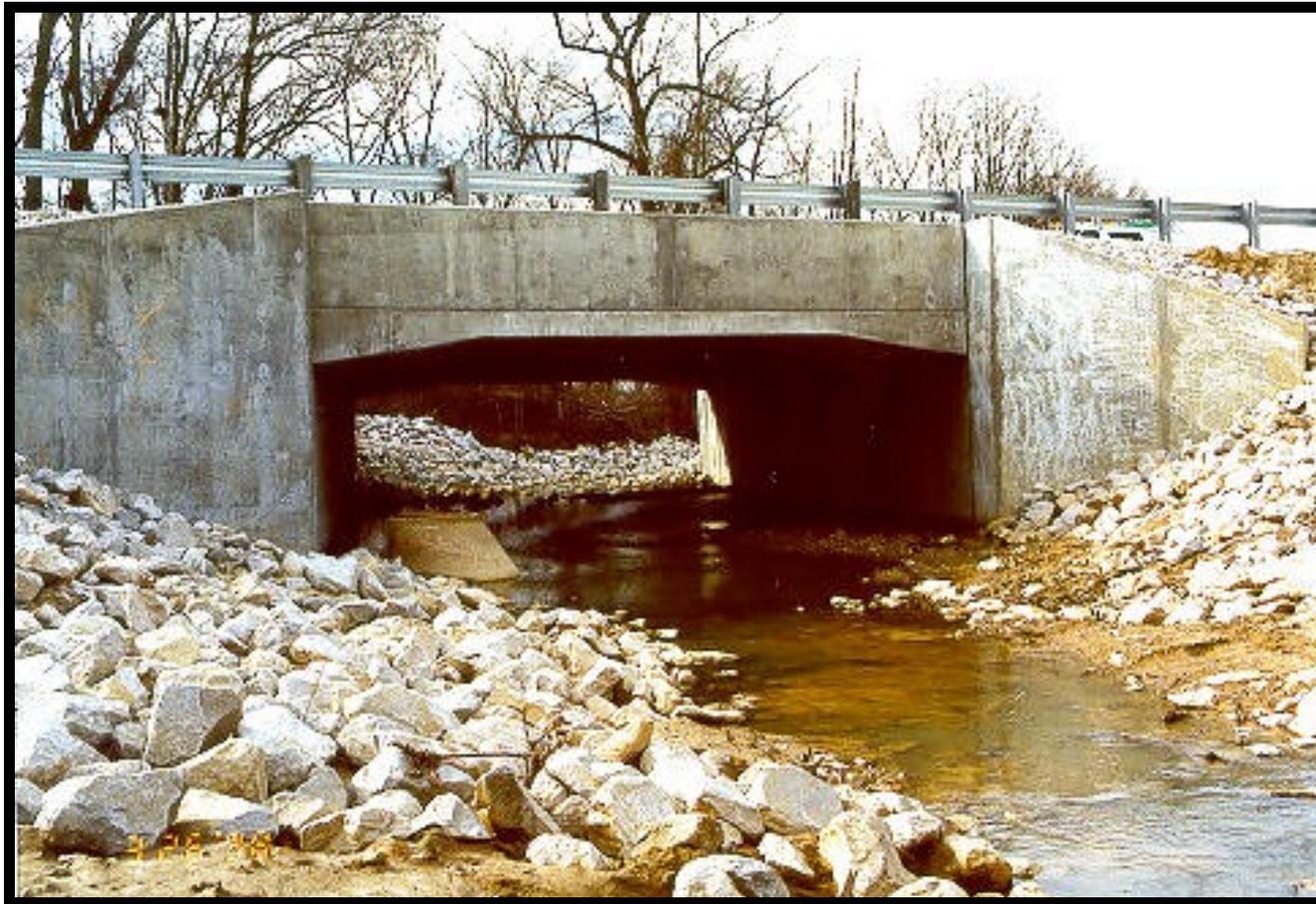
Precast Concrete Arch



Continuous R/C Slab



Precast Concrete Slab Under Fill



Steel Girder Bridge



Steel Box Girder Bridge



Rocker Bearing



Elastomeric Bearing



Riveted Plate Girder Bridge



P/C Spread Box Girder Bridge



P/C I-Beam Bridge



Bearings and Diaphragm



Continuous P/C I-Beam Bridge



Steel Truss



Steel Tied Arch Truss



Restrainer



Attached Lifelines



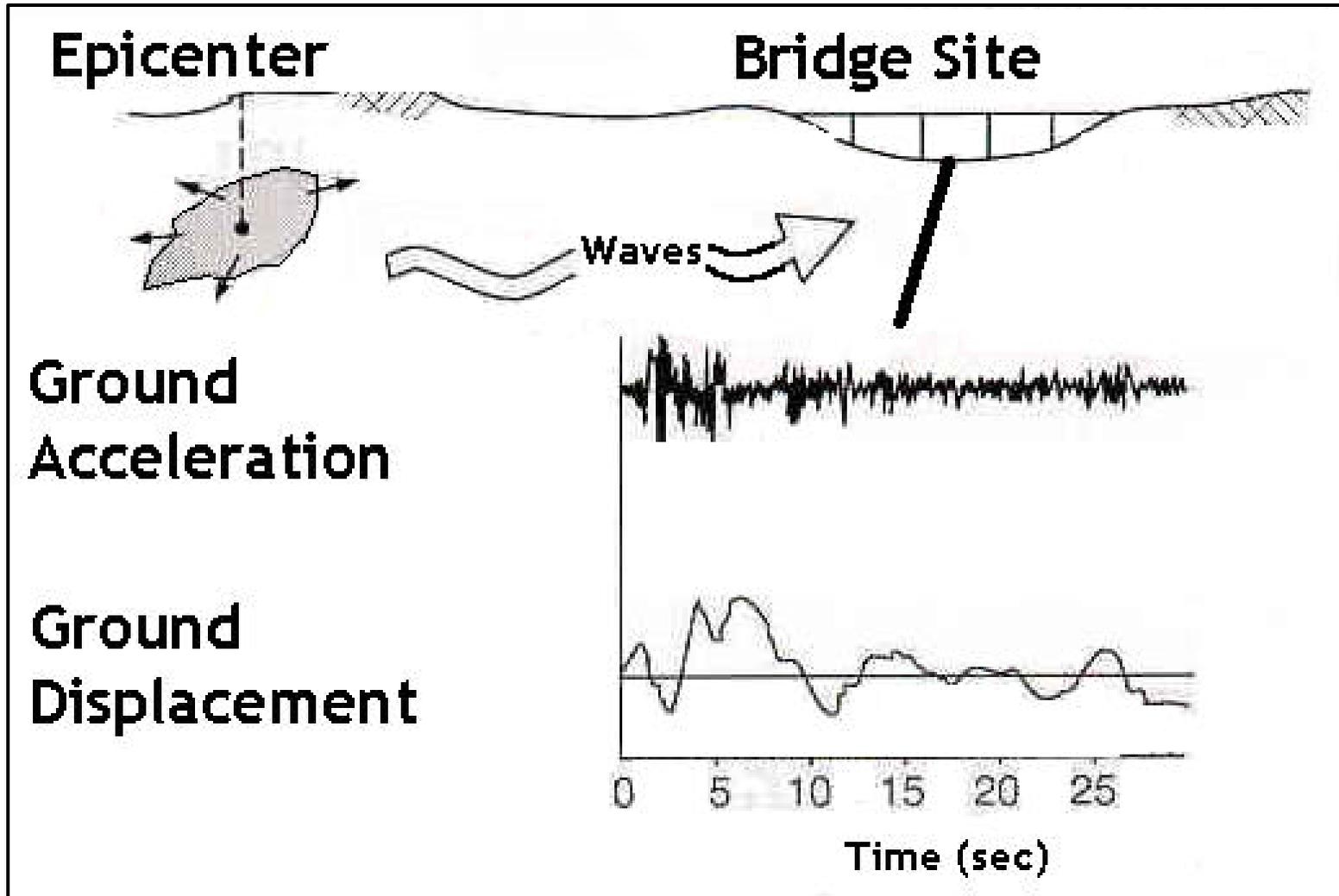
Attached Lifelines



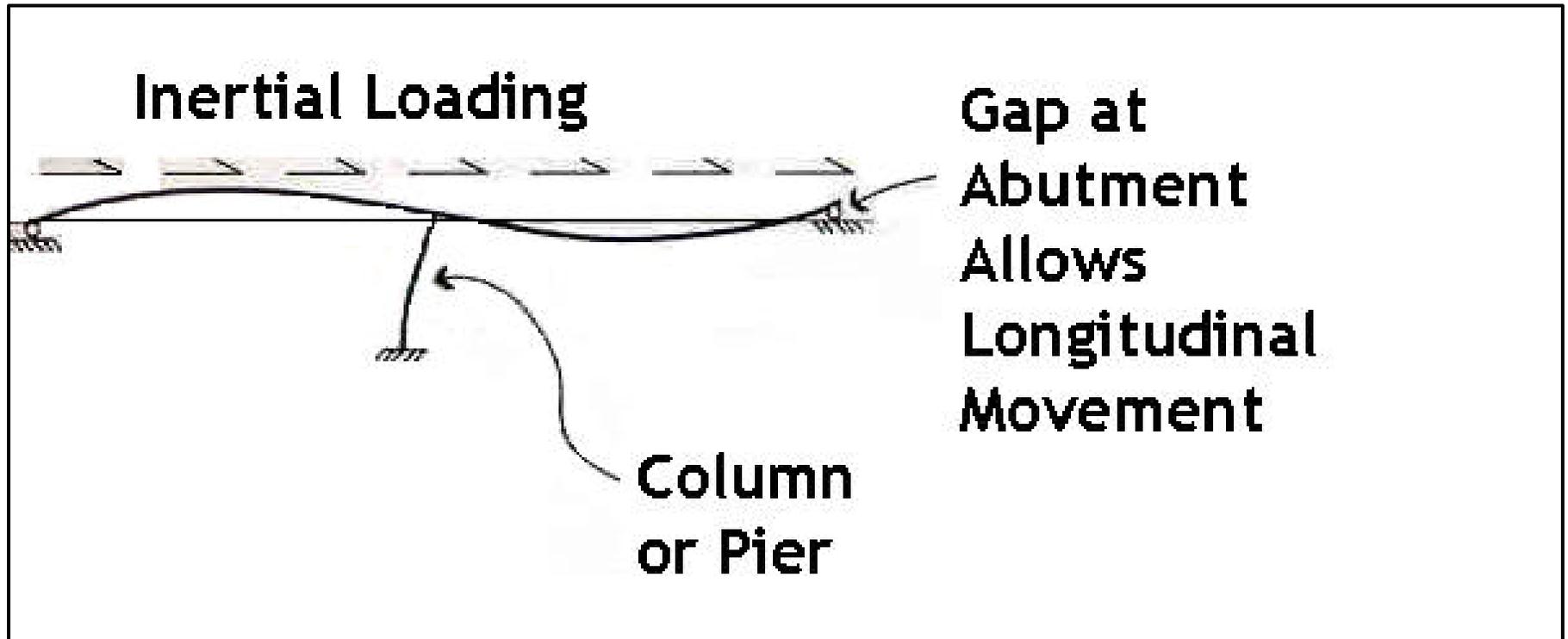
Training Level 1 Inspection Teams

- Bridge behavior
(Handbook Chapter 2, page 14)

Earthquake Effects

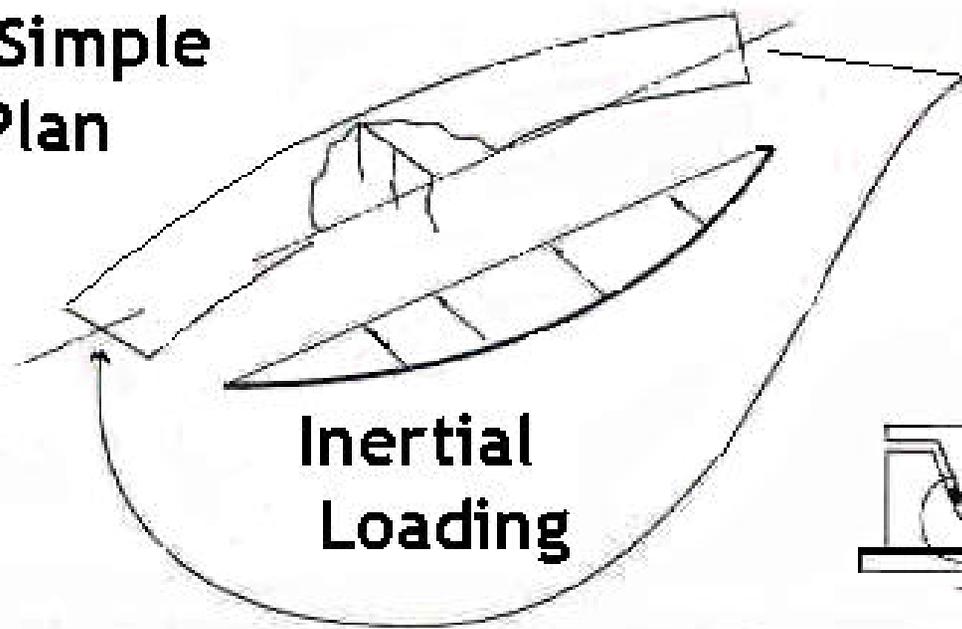


Longitudinal Action

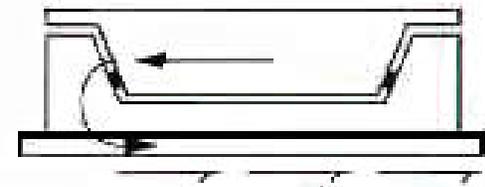


Lateral Action

**Superstructure
Acts as a Simple
Beam in Plan**



**Abutments
Resist Most
of the
Force**



Training Level 1 Inspection Teams

- Damage classification
(Handbook Chapter 5, pages 34)

Damage Classification: Level 1 Evaluation

- Green Tag- Safe for traffic
- Yellow Tag- Requires Level 2 Evaluation
- Red Tag- Unsafe (must be closed)

Damage Classification Table

	GREEN TAG	YELLOW TAG	RED TAG
Traffic Barriers and Railings	damage does not impede traffic	damage impedes traffic	
Movement at Expansion Joints	1) < 1in. offset in vertical or horizontal alignment 2) spalling of concrete cover	1) 1 to 6 in. offset in vertical or horizontal alignment 2) local buckling of steel stringers	> 6 in. offset in vertical or horizontal alignment
Seats at Expansion Joints	< 1 in. reduction in seat length	> 1in. reduction in seat length	unseating
Bearings		visible damage	

Damage Classification Table

	GREEN TAG	YELLOW TAG	RED TAG
Columns, Cross-Beams and Piers	1) vertical cracks in RC beams. 2) horizontal cracks in RC columns and piers	1) diagonal cracks in RC beams, columns and piers. 2) loss of concrete cover 3) any crack in steel beams or columns	1) bar buckling in RC beams, columns and piers 2) local buckling in steel columns
Column/ Beam Joints		1) any cracks. 2) loss of concrete cover	
Footings/ Pile Caps	space between columns and surrounding earth	any other damage (e.g., cracks, spalling, rotation)	

Damage Classification Table

	GREEN TAG	YELLOW TAG	RED TAG
Abutments	spalling at expansion joint	any other damage (e.g., cracks, spalling, rotation)	
Approach/ Abutment interface	< 1 in. settlement	1 to 6 in. settlement	> 6 in. settlement
Roadway	Normal Driving Conditions	Reduced Speed, or Quickly Repairable	Impassible

Training Level 1 Inspection Teams

- Bridge and road damage
(Chapter 5, page 35)

**Roadway closure/fault rupture after
Izmit EQ 8/17/1999 (KOERI)
Red Tag**



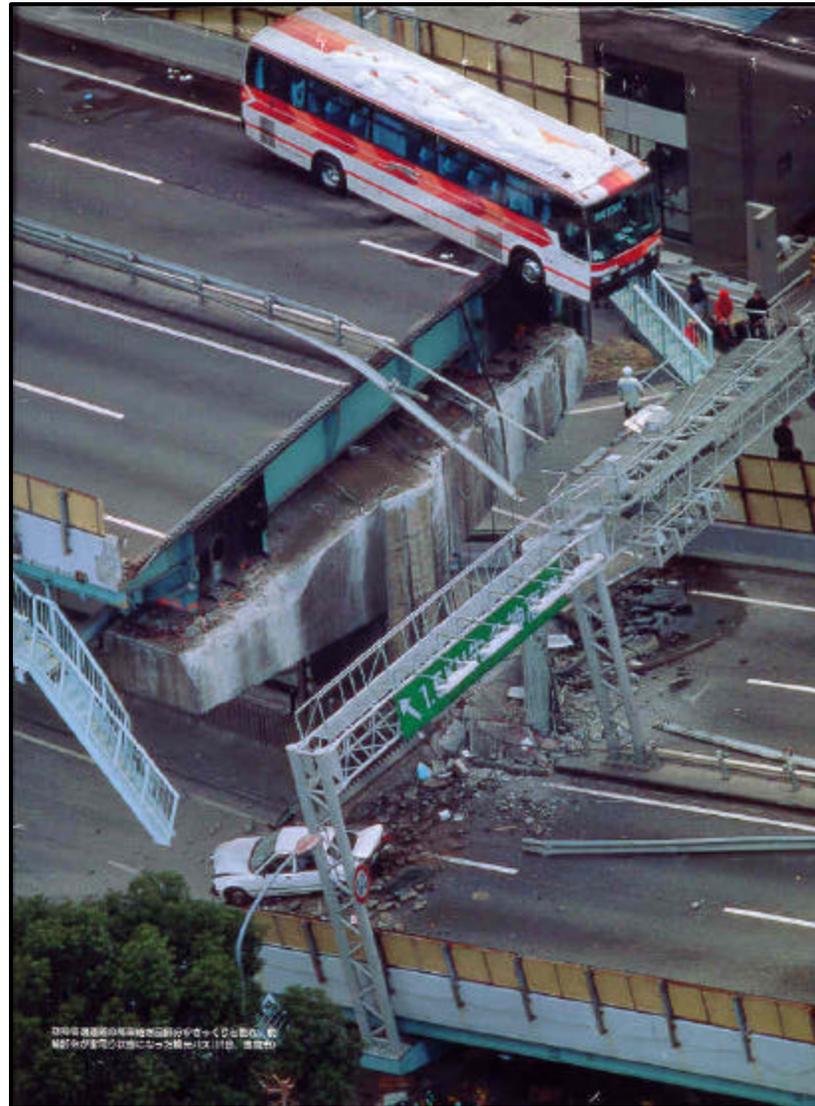
**P/C box beam bridge collapse after Izmit EQ
8/17/1999 (KOERI)
Red Tag**



RC girder bridge after Loma Prieta EQ 1989 (EERC) -Red Tag



Collapse of steel bridge Kobe 1995 EQ Red Tag



Other Types of Superstructure Damage

Longitudinal movement > 6"
Taiwan EQ 1999- Red Tag



1" < Movement of expansion joints < 6" after Taiwan EQ 1999- Yellow Tag



Deck settlement >6" (UCSD) Red Tag



Steel box girder damage due to pounding after Kobe EQ 1995 (EERC)- Red Tag



Damaged RC girder Northridge EQ 1994 (EERC)- Red Tag



Shear cracks RC girder near support (UCSD)- Red Tag



Twisted steel bracing (EERC)- Yellow Tag



SUBSTRUCTURE DAMAGE

Abutment damage after Northridge/1994 (EERC)- Red Tag



Pounding damage at abutment (EERC) Yellow Tag



Transverse movement of abutment (EERC)- Yellow Tag



BEARING DAMAGE

Tilted rocker bearings (INDOT)- Yellow Tag



Elastomeric bearing after Izmit EQ 1999 (KOERI)- Yellow Tag



Damaged bearing (Taiwan EQ) Yellow Tag



SOIL PROBLEMS

Cracks at abutment wingwall and slope (UCSD)- Yellow Tag



Diagonal ground crack extending under bridge (EERC)- Yellow Tag



Settlement around pier on pile foundation (EERC)- Yellow Tag



POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Damage to Bridge Structures

Marc O. EBERHARD

University of Washington

Purpose: Triage of Damage

- Green Tag - Safe for Traffic
- Yellow Tag – Require Detailed Evaluation (or quickly repairable)
- Red Tag - Unsafe for Traffic

Outline

- Damage to Superstructures
- Damage to Intermediate Supports
- Damage to Abutments and Roadways

Damage to Superstructures

- Pounding
- Unseating at Expansion Joints
- Bearing Damage

Pounding

I5-14 Interchange,
1994 Northridge Eq



Pounding

I5-14 Interchange,
1994 Northridge Eq.
(M.O. Eberhard)



Pounding



I5-210, 1994 Northridge Earthquake (M.O. Eberhard)

Pounding



15-14, 1994 Northridge Earthquake (M.O. Eberhard)

Unseating at Expansion Joints



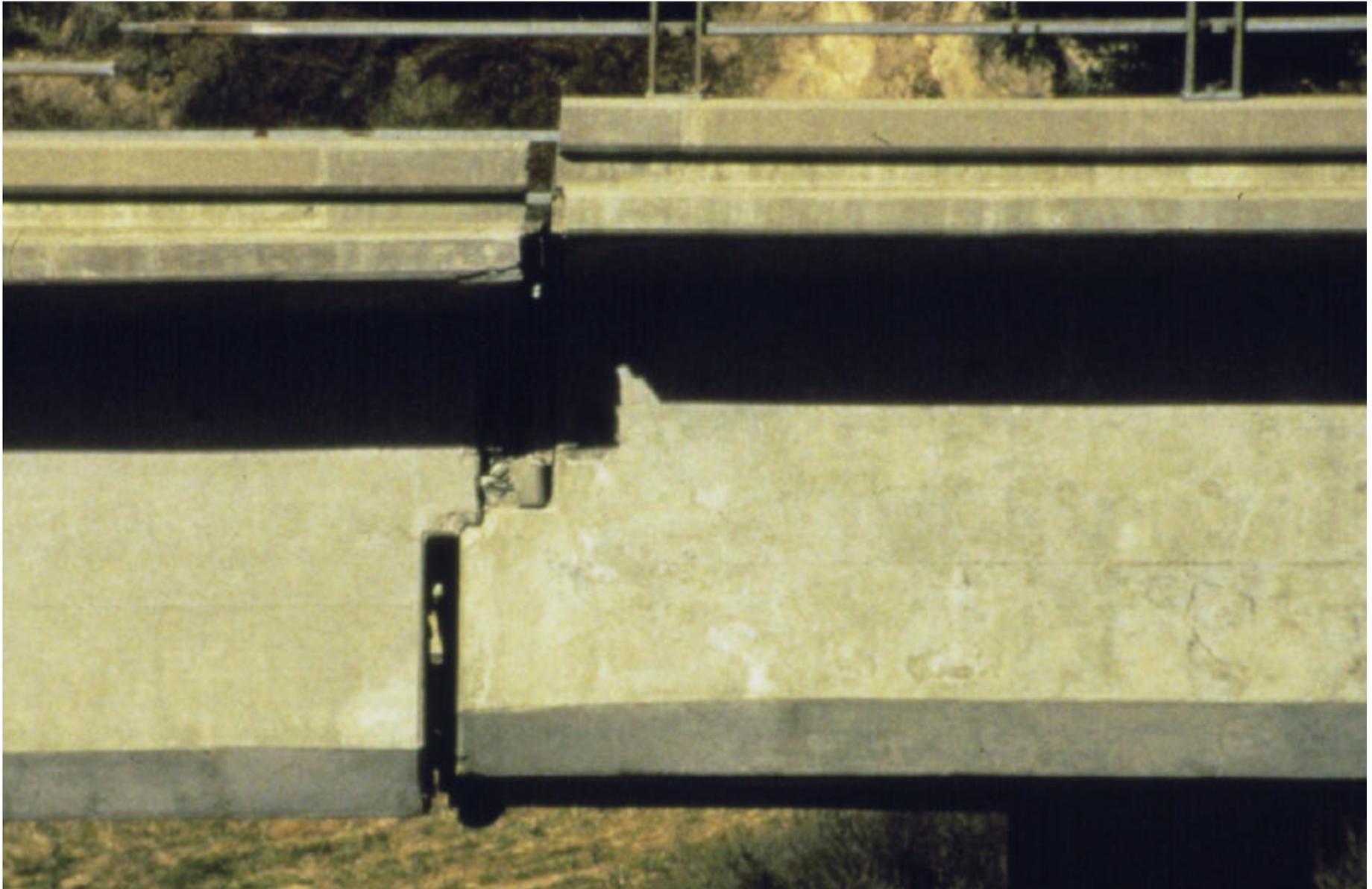
15-14, 1994 Northridge Earthquake (M.O. Eberhard)

Unseating at Expansion Joints



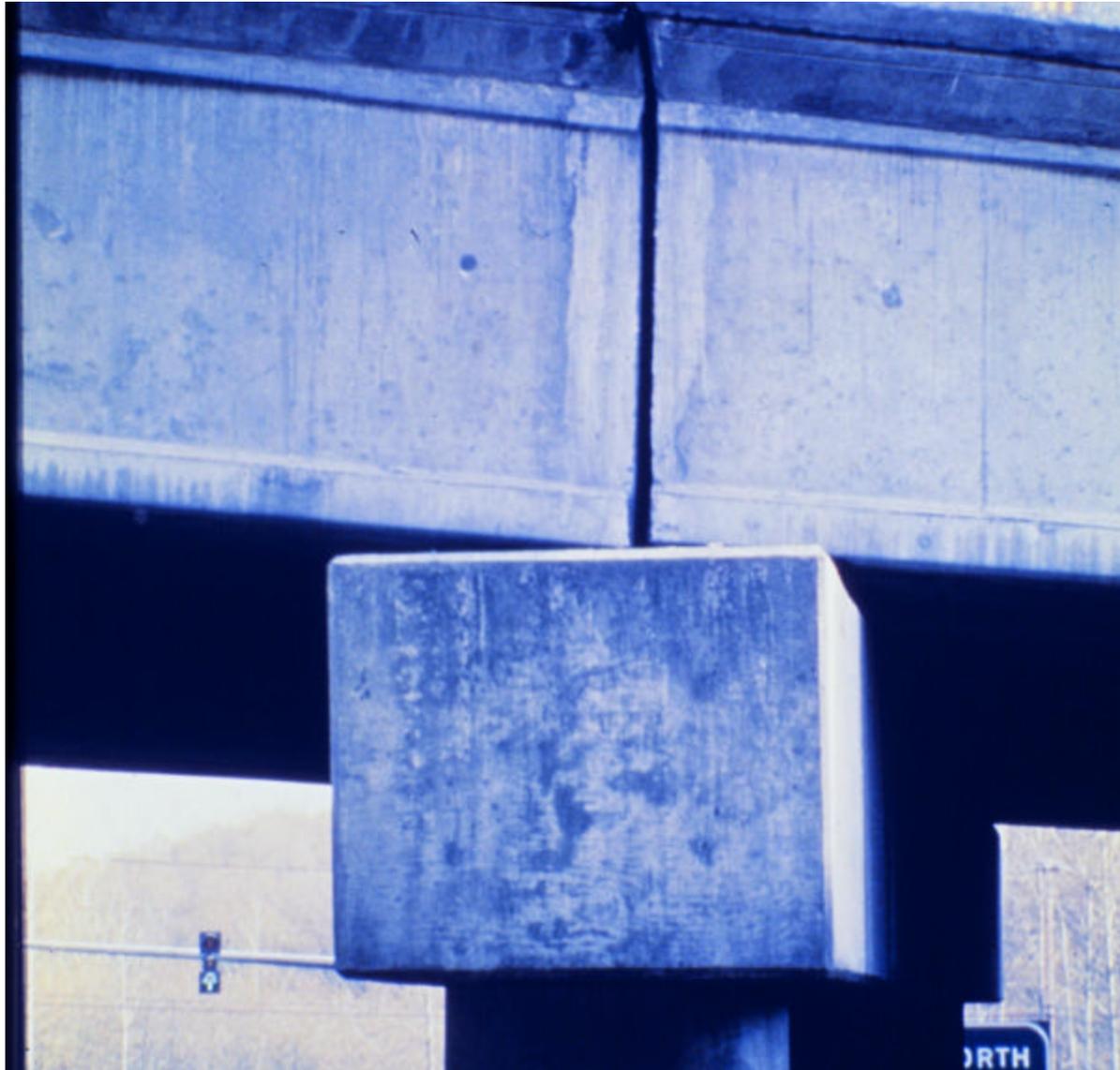
(WSDOT)

Unseating at Expansion Joints



I5-14 Interchange, 1994 Northridge Earthquake (M.O. Eberhard)

Unseating at Expansion Joints



(WSDOT)

Unseating at Expansion Joints

Showa Bridge
1964 Niigata Eq.
(Godden
Collection, EERC
Library)

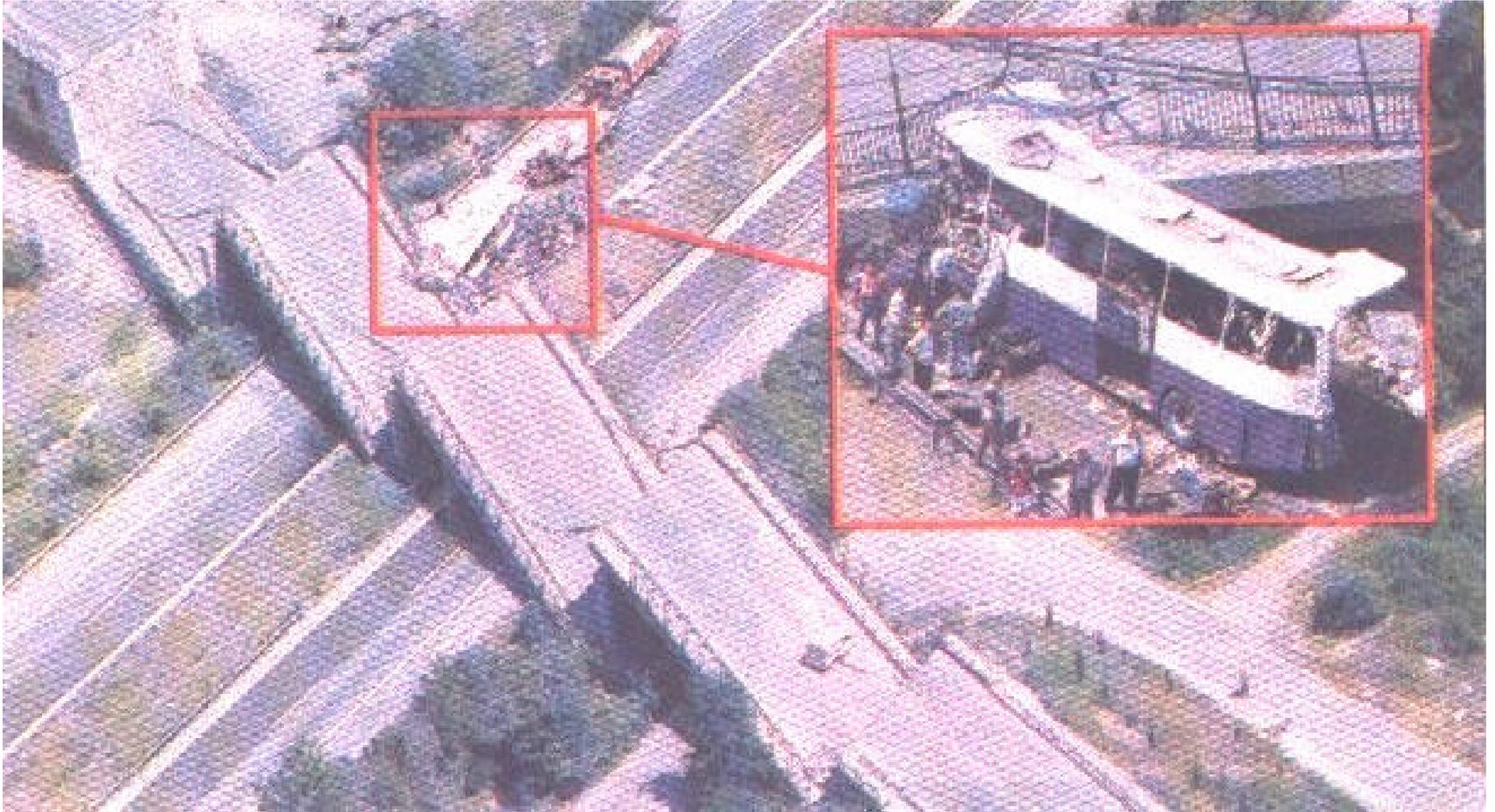


Unseating at Expansion Joints



S.F.-Oakland Bay Bridge, 1989 Loma Prieta Eq.
(Loma Prieta Collection, EERC Library)

Unseating at Expansion Joints



Overpass, Arifiye Junction, 1999 Kocaeli Eq. (KOERI)

Unseating at Expansion Joints



I-Jiang Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Bearing Damage



Sakarya Viaduct, 1999 Kocaeli Eq. (KOERI)

Bearing Damage



Sakarya Viaduct, 1999 Kocaeli Eq. (KOERI)

Bearing Damage



Sakarya Viaduct, 1999 Kocaeli Eq. (KOERI)

Bearing Damage



1-3 Expressway Link, 1999 Chi-Chi Eq. (M.O. Eberhard)

Bearing Damage



1-3 Expressway Link, 1999 Chi-Chi Eq. (M.O. Eberhard)

Bearing Damage



1-3 Expressway Link, 1999 Chi-Chi Eq. (M.O. Eberhard)

Summary: Damage to Superstructures

Traffic Barriers and Railings	damage does not impede traffic	damage impedes traffic	
Movement at Expansion Joints	1) < 1in. offset in vertical or horizontal alignment 2) spalling of concrete cover	1) 1 to 6 in. offset in vertical or horizontal alignment 2) local buckling of steel stringers	> 6 in. offset in vertical or horizontal alignment
Seats at Expansion Joints	< 1 in. reduction in seat length	> 1in. reduction in seat length	unseating
Bearings		visible damage	

Damage to Intermediate Supports

- Columns:
 - Flexural Damage
 - Shear Failure
- Piers
- Beams
- Joints

Columns: Flexural Damage



New River Bridge, 1979 Imperial Valley Eq.
(Steinbrugge Collection, EERC)

Columns: Flexural Damage



I-90 Bridge Test
(Marc O. Eberhard)

Columns: Flexural Damage

I-90 Bridge Test
(Marc O. Eberhard)



Columns: Flexural Damage

I-90 Bridge Test
(Marc O. Eberhard)



Columns: Flexural Damage



Cable-Stayed Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Columns: Flexural Damage



Cable-Stayed Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Columns: Shear Failure

I10 at Fairfax Ave.,
1994 Northridge Eq.
(M.O. Eberhard)



Columns: Shear Failure

I10 at Venice/La
Cienega Ave.,
1994 Northridge Eq.
(M.O. Eberhard)



Columns: Shear Failure

Toong-Tour
Bridge

1999 Chi-Chi
Eq.

(M.O.
Eberhard)



Columns: Shear Failure



Toong-Tour Bridge, 921 Taiwan Eq. (1999) (M.O. Eberhard)

Piers: Shear Failure



U-Shi Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Beams



Cable-Stayed Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Beams



Cable-Stayed Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Beams



Cable-Stayed Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Joints



Embarcadero Freeway, 1989 Loma Prieta Eq. (M.O. Eberhard)

Joints

Embarcadero
Freeway (SF),
1989 Loma Prieta
Earthquake.
(M.O. Eberhard)



Joints

I280 (SF),
1989 Loma Prieta
Earthquake.
(M.O. Eberhard)



Joints

I280 (SF),
1989 Loma Prieta
Earthquake.
(M.O. Eberhard)



Joints

Cypress Structure
1989 Loma Prieta
Earthquake
(Loma Prieta
Collection, EERC
Library)



Summary: Damage to Intermediate Supports

	Green Tag	Yellow Tag	Red Tag
Columns, Cross-Beams and Piers	1) vertical cracks in RC beams. 2) horizontal cracks in RC columns and piers	1) diagonal cracks in RC beams, columns and piers. 2) loss of concrete cover 3) any crack in steel beams or columns	1) bar buckling in RC beams, columns and piers 2) local buckling in steel columns
Column/ Beam Joints		1) any cracks. 2) loss of concrete cover	
Footings/ Pile Caps	space between columns and surrounding earth	any other damage (e.g., cracks, spalling, rotation)	

Damage to Abutments and Roadways

- Abutments
- Approaches
- Roadways

Abutments



New River Bridge, 1979 Imperial Valley Eq.
(Steinbrugge Collection, EERC)

Abutments

15-18 Interchange,
1994 Northridge Eq.
(M.O. Eberhard)



Abutments

15-210 Interchange,
1994 Northridge Eq.
(M.O. Eberhard)



Abutments



I-5-14 Interchange, 1994 Northridge Earthquake (M.O. Eberhard)

Abutments

15-14 Interchange,
1994 Northridge Eq.
(M.O. Eberhard)



Approaches



I-118, 1994 Northridge Earthquake (M.O. Eberhard)

Approaches



New River Bridge, 1979 Imperial Valley Eq.
(Steinbrugge Collection, EERC)

Approaches



New River Bridge, 1979 Imperial Valley Eq.
(Steinbrugge Collection, EERC)

Roadways: (pipe failure)



1971 San Fernando Eq. (Steinbrugge Collection, EERC)

Roadways: (Surface Rupture)



Roadway, 1999 Kocaeli Eq. (KOERI)

Roadways: (Landslide)



Puget Sound Earthquake, 1965. (Steinbrugge Collection, EERC)

Roadways: (Landslide)



15 Near Gavin Canyon, 1994 Northridge Earthquake
(M.O. Eberhard)

Summary: Damage to Abutments and Roadways

	Green Tag	Yellow Tag	Red Tag
Abutments	spalling at expansion joint	any other damage (e.g., cracks, spalling, rotation)	
Approach/ Abutment interface	< 1 in. settlement	1 to 6 in. settlement	
Roadway	Normal Driving Conditions	Reduced Speed, or Quickly Repairable	Impassible

Summary of Severe Damage

- Most common causes of bridge collapse:
 - span unseating
 - column shear failure
- Damage to bearing and approaches often affects functionality
- Complex structure can have unexpected types of damage

Summary of Triage Criteria

- GREEN

- Key is That Traffic Can Flow Safely!
- Damage to Railings and Barriers
- Pounding Damage
- Flexural Cracks in Structural Members
- Minor Soil Movement Around Bridge
- Small Displacements and Settlements of Roadway

Summary of Triage Criteria (cont.)

- RED
 - Key is that Structure be Collapsed or Nearly Collapse
 - Unseating
 - “Shattered” Columns or Joints
- YELLOW
 - Everything Else

EXTRA SLIDES

Unseating at Simple Supports



1923 Tokyo Eq. (Steinbrugge Collection, EERC Library)

Columns



Mhau-Luo-Shi Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Columns



Mhau-Luo-Shi Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Columns



Mhau-Luo-Shi Bridge, 1999 Chi-Chi Eq. (M.O. Eberhard)

Columns

I5-118 Interchange,
1994 Northridge Eq.
(M.O. Eberhard)



Abutments

New River Bridge,
1979 Imperial
Valley Eq.
(Steinbrugge
Collection, EERC)



Summary of Severe Damage

- Unseating most common cause of span collapse.
 - bridges with unrestrained, short seats
 - skewed or curved bridges
 - bridges subjected to ground movements
- Bearing damage often affects functionality

Summary of Severe Damage

- Column failures usually attributable to inadequate ductility
 - Inadequate transverse reinforcement in reinforced concrete columns
 - Local buckling in steel columns
- Damage to shear keys and approach slabs often reduce functionality

Summary of Severe Damage

- Complex structures often have unique failures
 - Cypress Structure
 - Cable-Stayed Bridge (Chi-Chi Earthquake)
 - Oakland-San Francisco Bay Bridge
 - Outrigger column bents

POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Level 1 Inspection Procedure

A. Murat TURK

Purdue University

Level 1 Inspection:

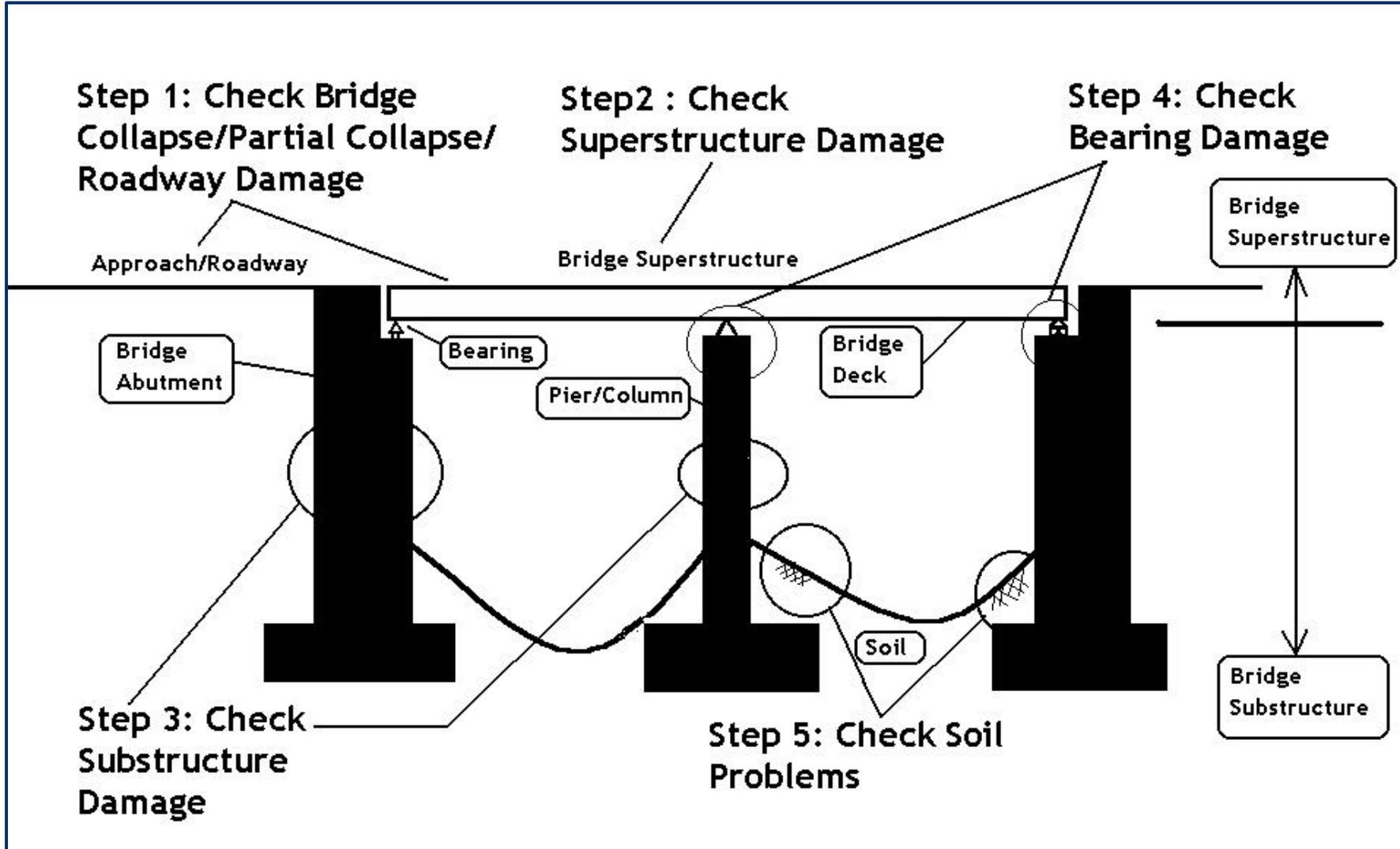
- Bridge Inspection Form for each Pre-Assigned Route
- One Bridge per Row in the Form
- Two-Person Teams
- Inspect All Bridges in the Pre-Assigned Route
- Quick and Accurate Visual Inspection

- Get your inspection tools
- Inform Unit/ District/ Subdistrict for any serious deficiency on the roadway
- Record the minor/major roadway deficiencies on the route.
- Upon arrival, review and verify bridge number
- Record arrival time on the form
- Check traffic on the bridge

Approach with caution and never walk immediately upon arrival directly under or over the bridge (Courtesy of KOERI)



- Do not cross the bridge without first sighting down the curb/rail line and checking the underside for structural damage
- Prepare inspection routine for the different components of the bridge and assign inspection tasks
- Inspect the superstructure and substructure elements to verify condition and note elements in need of additional investigation



STEP 1. Check Bridge Collapse/ Partial Collapse / Roadway Damage (Courtesy of KOERI)

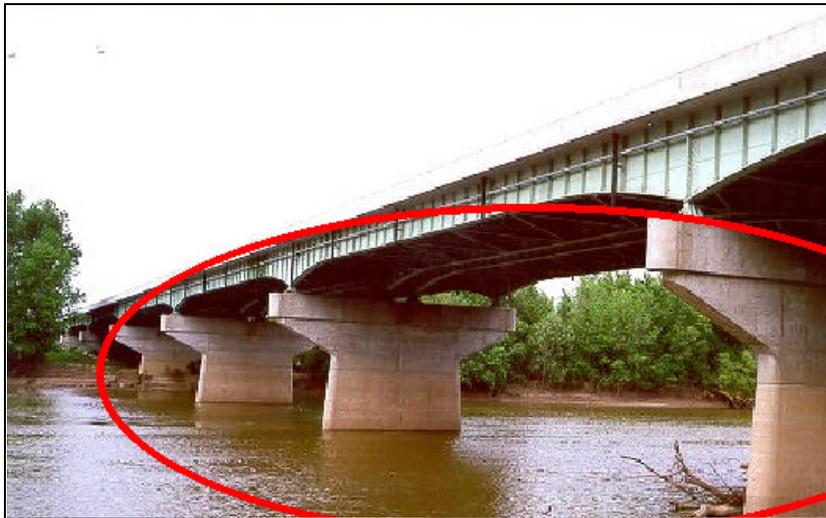


STEP 2. Check the Superstructure Damage (Courtesy of INDOT)

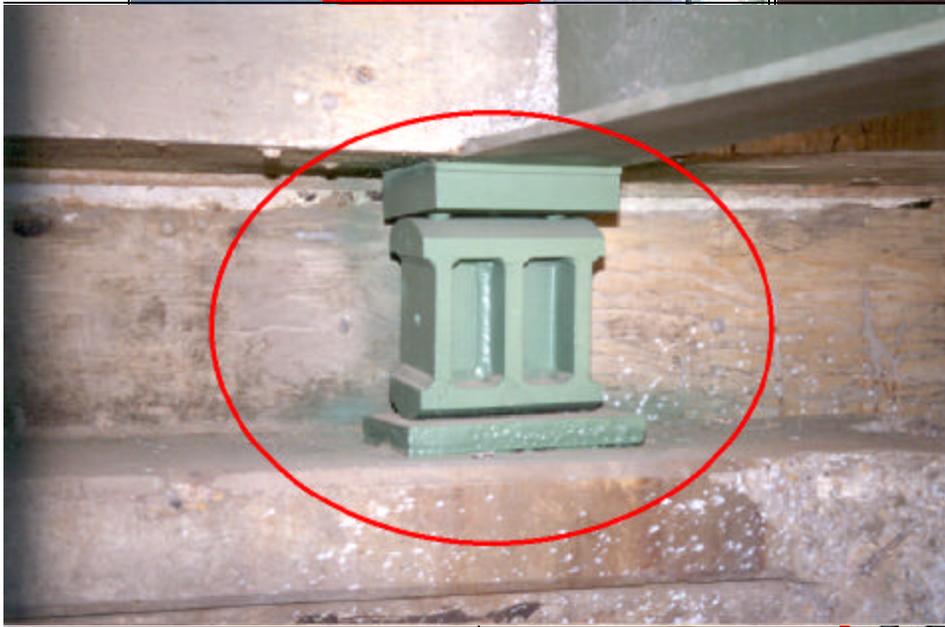
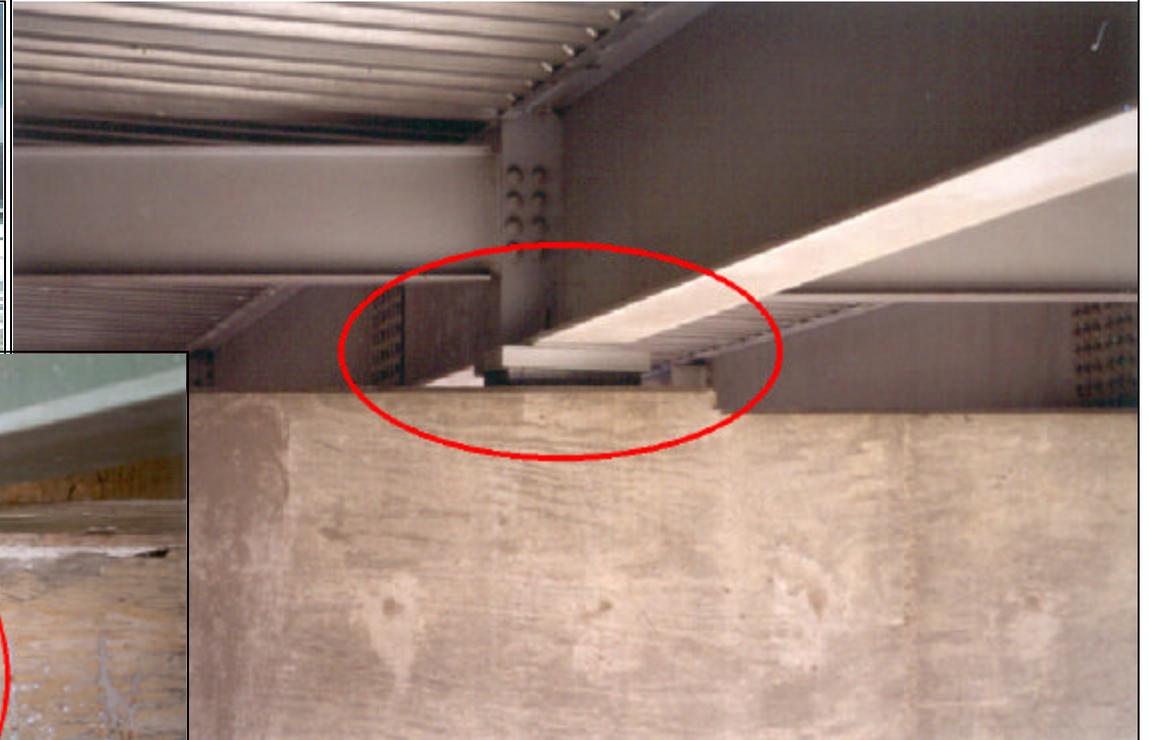




STEP 3. Check the Substructure Damage (Courtesy of INDOT)



STEP 4. Check Bearing Damage (Courtesy of INDOT)



STEP 5. Check Soil Problems (Courtesy of INDOT)



- Discuss the observations with other members of the team and make a decision regarding the condition
- Fill out the form (Level 1) according to the observations
- If bridge received at least one YES for the damage types 1 through 5, either a **RED** tag for closure, or if a more detailed inspection is needed (Level 2) a **YELLOW** tag should be entered. In case of No Damage, a **GREEN** tag should be noted

- Additional recommendations and observations about the bridge and roadway can be written in the box provided at the bottom of the form.
- If the bridge is given a **RED** tag or barricades are required, Unit/District/Subdistrict should be informed immediately.
- If the bridge can be traversed, but repairs are needed, place a **YELLOW** ribbon, if it is undamaged use a **GREEN** ribbon. Attach ribbons to the bridge sign post and write time/date/inspector initials

Recommended tools to perform Level 1 inspection:

- Radio and cellular phone for communication
- Inspection procedures field book
- Primary and county route maps, state maps
- List of bridges on the routes
- Recommended List (Handbook Ch.6)

Level 1 Bridge Inspection Example 1

Santa Clara River Bridge,
Interstate 5, 53-0687, CA
after Northridge EQ, 1994

(Courtesy of EERC, Northridge Collection,
University of California, Berkeley)

Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Courtesy of EERC, Northridge Collection,
University of California, Berkeley



Level 1 Bridge Inspection Example 2

Bridge #1309,
Parkfield Highway, CA
(after Parkfield California EQ,
June 27-29 1966)

Courtesy of EERC, Steinbrugge Collection,
University of California, Berkeley)



Courtesy of EERC, Steinbrugge Collection,
University of California, Berkeley



Courtesy of
EERC,
Steinbrugge
Collection,
University of
California,
Berkeley



Courtesy of
EERC,
Steinbrugge
Collection,
University of
California,
Berkeley



Courtesy of
EERC,
Steinbrugge
Collection,
University of
California,
Berkeley



Courtesy of EERC, Steinbrugge Collection,
University of California, Berkeley



Courtesy of EERC, Steinbrugge Collection,
University of California, Berkeley

For the Following Bridge Pictures
Please Complete the Level 1 Form

Interchange Bridge
between I-5 and I-210, CA
after San Fernando EQ, 1971

(Courtesy of EERC, Godden Collection,
University of California, Berkeley)

Courtesy of EERC, Godden Collection,
University of California, Berkeley



Courtesy of EERC, Godden Collection,
University of California, Berkeley



Courtesy of EERC, Godden Collection,
University of California, Berkeley



Courtesy of EERC, Godden Collection,
University of California, Berkeley



Courtesy of EERC, Godden Collection,
University of California, Berkeley



Courtesy of EERC, Godden Collection,
University of California, Berkeley



POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Level 2 Inspection Procedure

Robert FROSCH

Purdue University

Level 2 Inspection

- Inspect Yellow Tag Bridges
 - Follow up of Level 1
 - Note Current Condition
 - Consider aftershocks
- Establish Monitoring Plan if Required
- Inspect Red Tag Structures
 - Follow up of Level 1

Level 2 Form

INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route:		Date and Local Time:	
Bridge ID:		Bridge Location :	
DAMAGE OBSERVED:			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
COMMENTS FOR REPAIR AND RECOMMENDATIONS:			
1. BARRICADE NEEDED 2. IMMEDIATE SHORE AND BRACE 3. REPAIR 3a. In-House Repair Possible 3b. Outside Contractor Needed 4. EMERGENCY VEHICLE USE ONLY 5. MONITORING UNDER SERVICE NEEDED 6. OTHER (explain)			

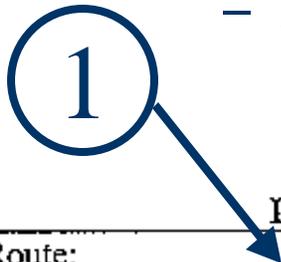
Overall Rating For the Bridge:

SAFE (Green Tag): _____ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE (Red Tag): _____

Name of the Inspector(s): _____

Level 2 Procedure

1. Obtain Necessary Tools
2. Record Part 1 Information
 - Arrival / Departure Times



INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route:	Date and Local Time:
Bridge ID:	Bridge Location :
DAMAGE OBSERVED:	
1. ROADWAY/APPROACHES	4. SUPERSTRUCTURE
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat	Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A

Procedure...

3. Examine Level 1 Inspection Report
4. Check Traffic
5. Prepare Inspection Plan / Assignments
6. Inspect Structure
 - Superstructure
 - Substructure



Procedure...

7. Note Damage

Check Boxes

- Follow Order

INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

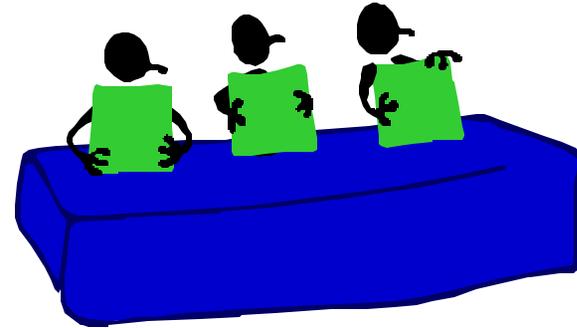
Route:		Date and Local Time:	
Bridge ID:		Bridge Location :	
DAMAGE OBSERVED:			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	

Procedure...

8. Discuss Observations

Agree on Condition

9. Provide Rating



- 2. IMMEDIATE SHORE AND BRACE
- 3. REPAIR
 - 3a. In-House Repair Possible
 - 3b. Outside Contractor Needed
- 4. EMERGENCY VEHICLE USE ONLY
- 5. MONITORING UNDER SERVICE NEEDED
- 6. OTHER (explain)

Overall Rating For the Bridge:

SAFE (Green Tag): _____ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE (Red Tag): _____

Name of the Inspector(s): _____

10. Red Tag



– Contact Unit, Subdistrict, and District Immediately

Procedure...

11. Recommendations

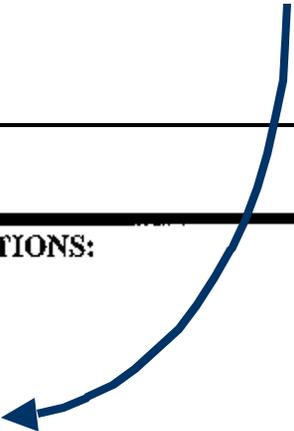
- Notify appropriate authorities
- Note recommendations in box or back of form

<input type="checkbox"/> Shearing or Pullout of Bolts	<input type="checkbox"/> Other
<input type="checkbox"/> No Damage	<input type="checkbox"/> No Damage
	<input type="checkbox"/> N/A

COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
 - 3a. In-House Repair Possible
 - 3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:
SAFE (Green Tag): _____ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE (Red Tag): _____
Name of the Inspector(s): _____



Procedure...

12. Attach Ribbons on Bridge



Concrete Elements

- Examine Flexural and Shear Cracks
 - Possible Complications
 - Spalled Concrete
 - Exposed Reinforcing Steel
- Mark Cracks
- Record Crack Path and Location
 - Make Sketch
 - Note Crack Width

Mark Cracks



Steel Elements

- Inspect
 - Plates
 - Anchor Bolts
 - Details
 - Hangers
 - Welds
- Note
 - Sheared Bolts
 - Buckling
 - Shifted Girders
 - Other

Anchor Bolts Details



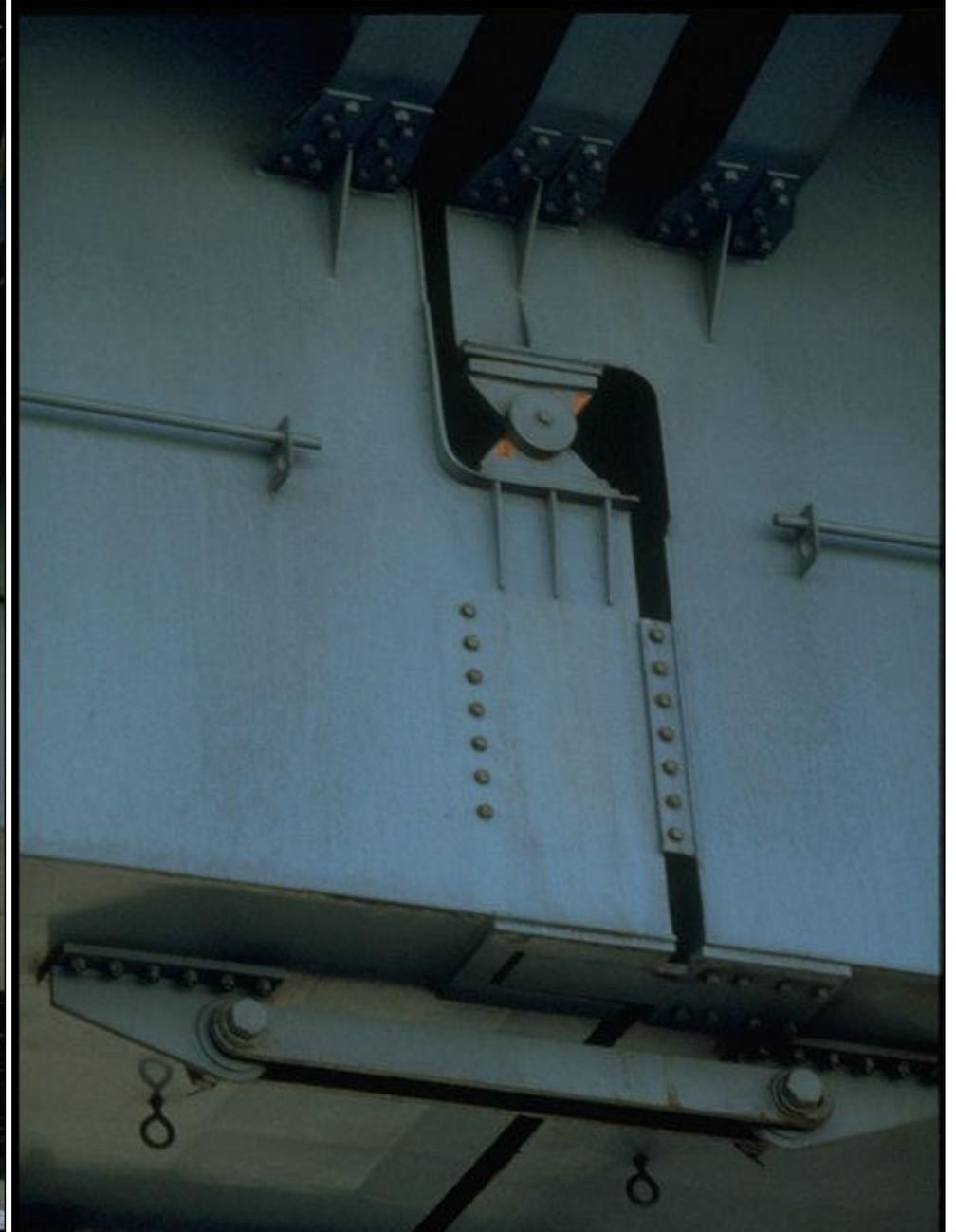
Shifted Girders



Buckling



Hangers



Other Issues

- Elements Not Readily Inspected
 - Box Girders
 - Piles
- Provide Access
 - Open Box Girder Holes
 - Excavate Soil around Footings

Box Girders



Foundation Problems

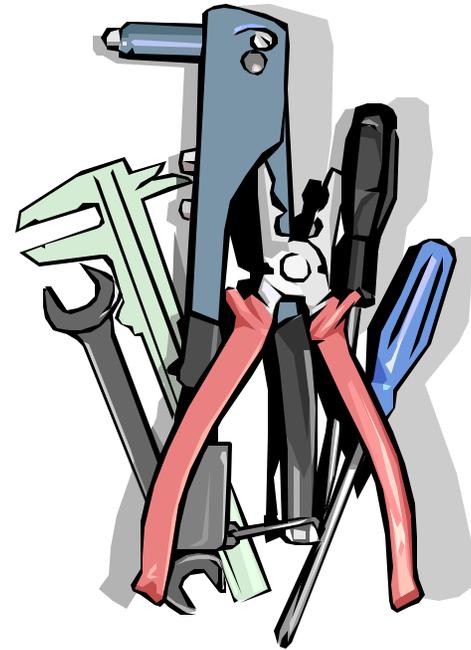


Level 2 Inspection Tools

- Level 1 Inspection Data
- Bridge Inventory Book
- Primary and County Route Maps
- Water, food, tents, shelter and supplies
 - 3 days per person
- Level 2 Inspection Form
 - Each Bridge

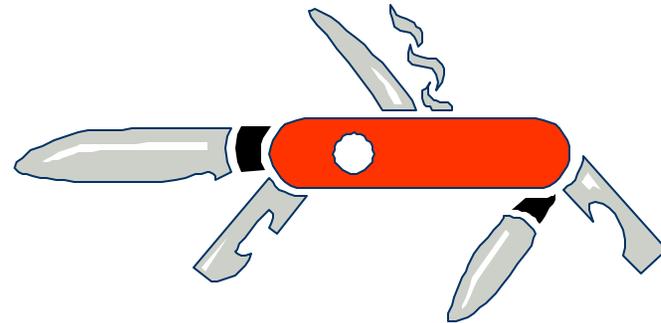
Inspection Tools

- Recommended List
 - Handbook (Ch. 6)



Additional Tools

- For Detailed Inspection
 - Additional Tools Necessary
 - Handbook (Ch. 6)



POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Level 2 Inspection Examples

Robert FROSCH

Purdue University

Level 2 Form

INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route:		Date and Local Time:	
Bridge ID:		Bridge Location :	
DAMAGE OBSERVED:			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
COMMENTS FOR REPAIR AND RECOMMENDATIONS:			
1. BARRICADE NEEDED 2. IMMEDIATE SHORE AND BRACE 3. REPAIR 3a. In-House Repair Possible 3b. Outside Contractor Needed 4. EMERGENCY VEHICLE USE ONLY 5. MONITORING UNDER SERVICE NEEDED 6. OTHER (explain)			

Overall Rating For the Bridge:

SAFE (Green Tag): _____ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE (Red Tag): _____

Name of the Inspector(s): _____

Example 1

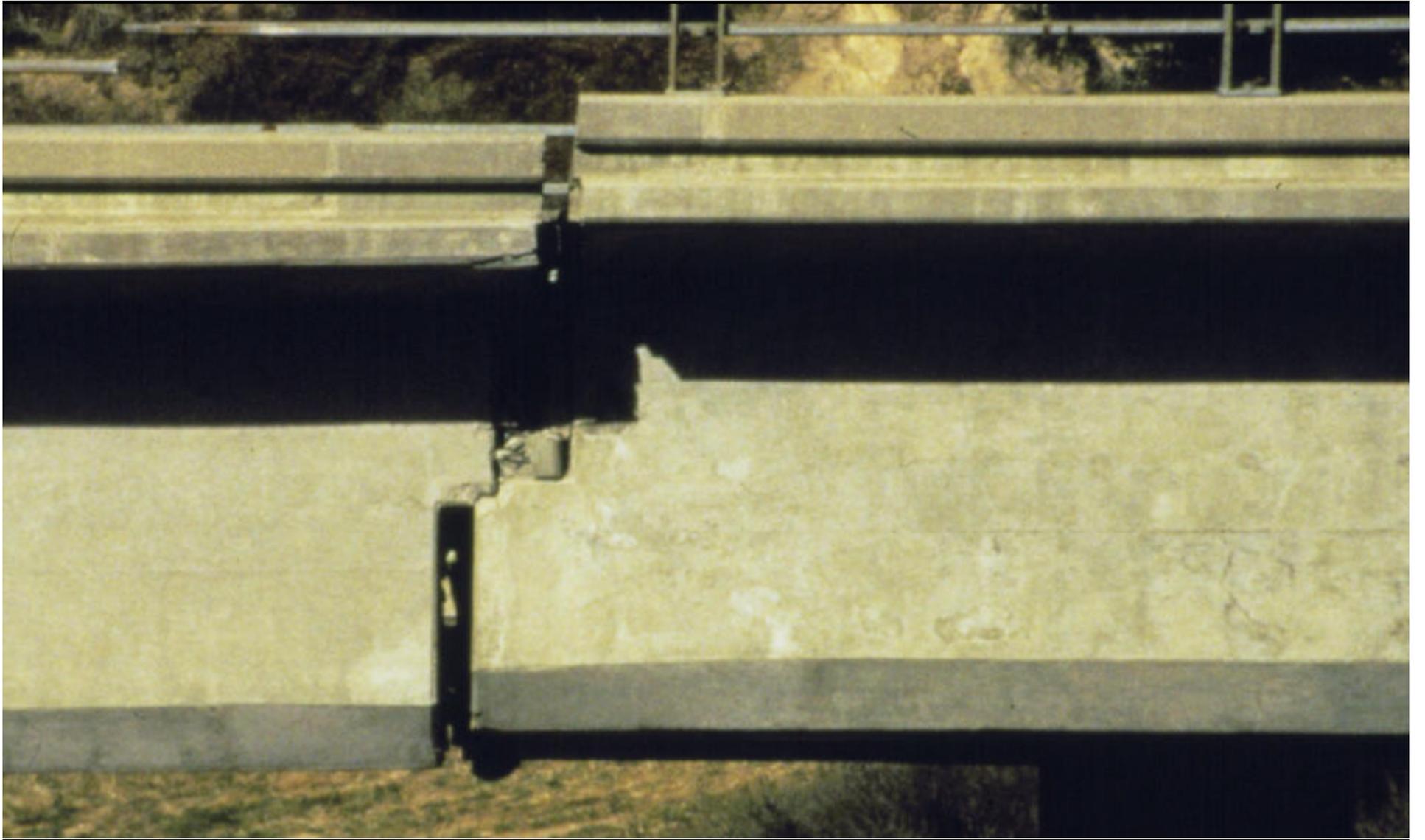
I5-14 Interchange
1994 Northridge Earthquake

Courtesy of Marc O. Eberhard













INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R14		Date and Local Time: 1/28/94 2:30 PM	
Bridge ID: 53-1620D		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Pounding Damage to Abutment and Girder			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	

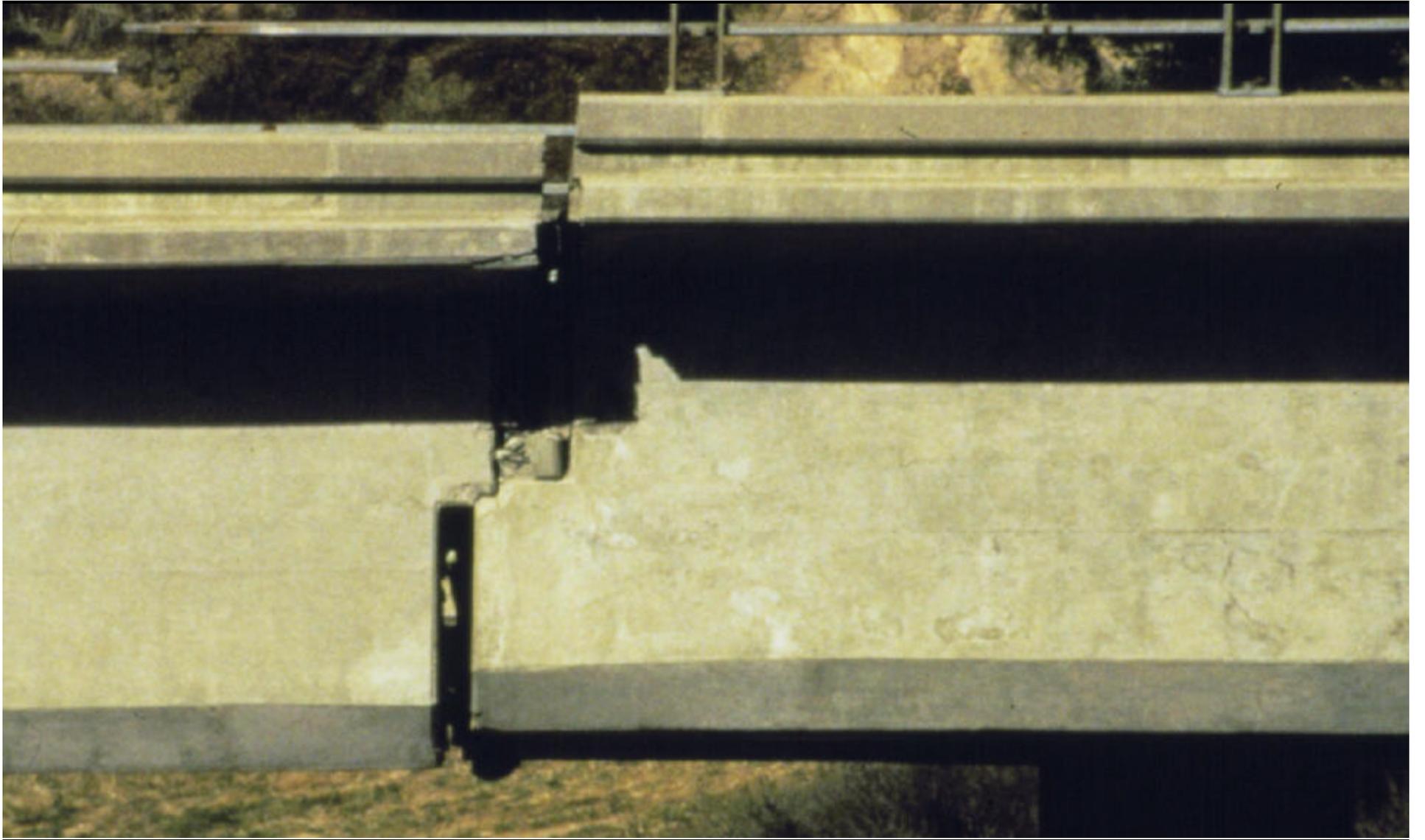


INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R14		Date and Local Time: 1/28/94 2:30 PM	
Bridge ID: 53-1620D		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Pounding Damage to Abutment and Girder			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input checked="" type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input checked="" type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	







INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R14		Date and Local Time: 1/28/94 2:30 PM	
Bridge ID: 53-1620D		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Pounding Damage to Abutment and Girder			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input checked="" type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Loss of Seating	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input checked="" type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input checked="" type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	



INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R14		Date and Local Time: 1/28/94 2:30 PM	
Bridge ID: 53-1620D		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Pounding Damage to Abutment and Girder			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input checked="" type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Loss of Seating	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input checked="" type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input checked="" type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input checked="" type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input checked="" type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> N/A	

3. BEARINGS

- Failure of Bearings
(Integral, Contact, Rocker,
Elastomeric)
- Movement of Bearings
- Shearing or Pullout of Bolts
- No Damage

6. GEOTECHNICAL

- Slope Failure
- Settlement
- Soil Liquefaction
- Fault Movement
- Other
- No Damage
- N/A

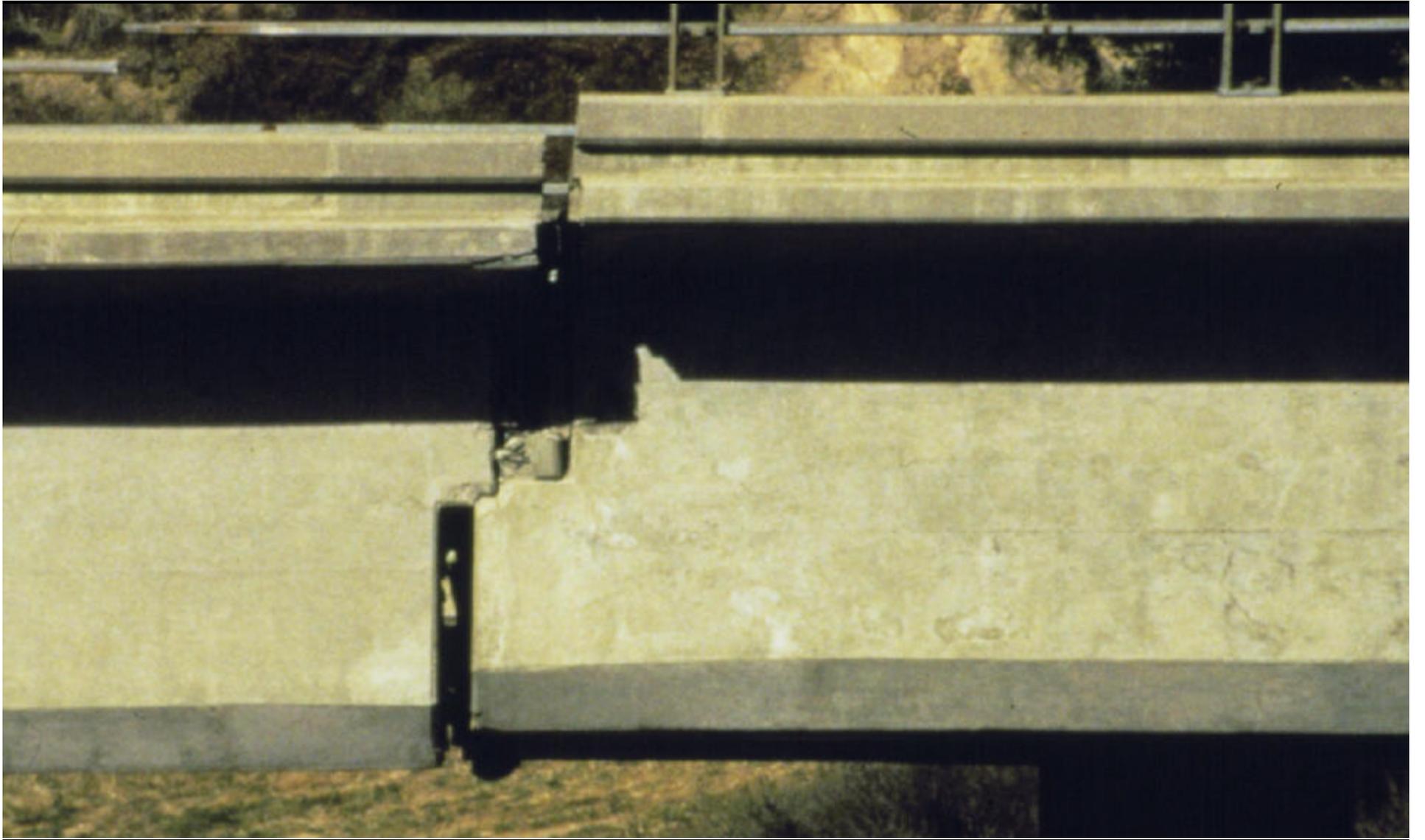
COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
 - 3a. In-House Repair Possible
 - 3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:

SAFE (Green Tag): _____ MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE (Red Tag): X

Name of the Inspector(s): Joe Inspector



Example 2

I5-Route 126 Separation 1994 Northridge Earthquake

Courtesy of Northridge Collection
EERC, Univ. of California, Berkeley





ROUTE 5/126
SEPARATION
BRIDGE 53-1626
5 LA R55 48











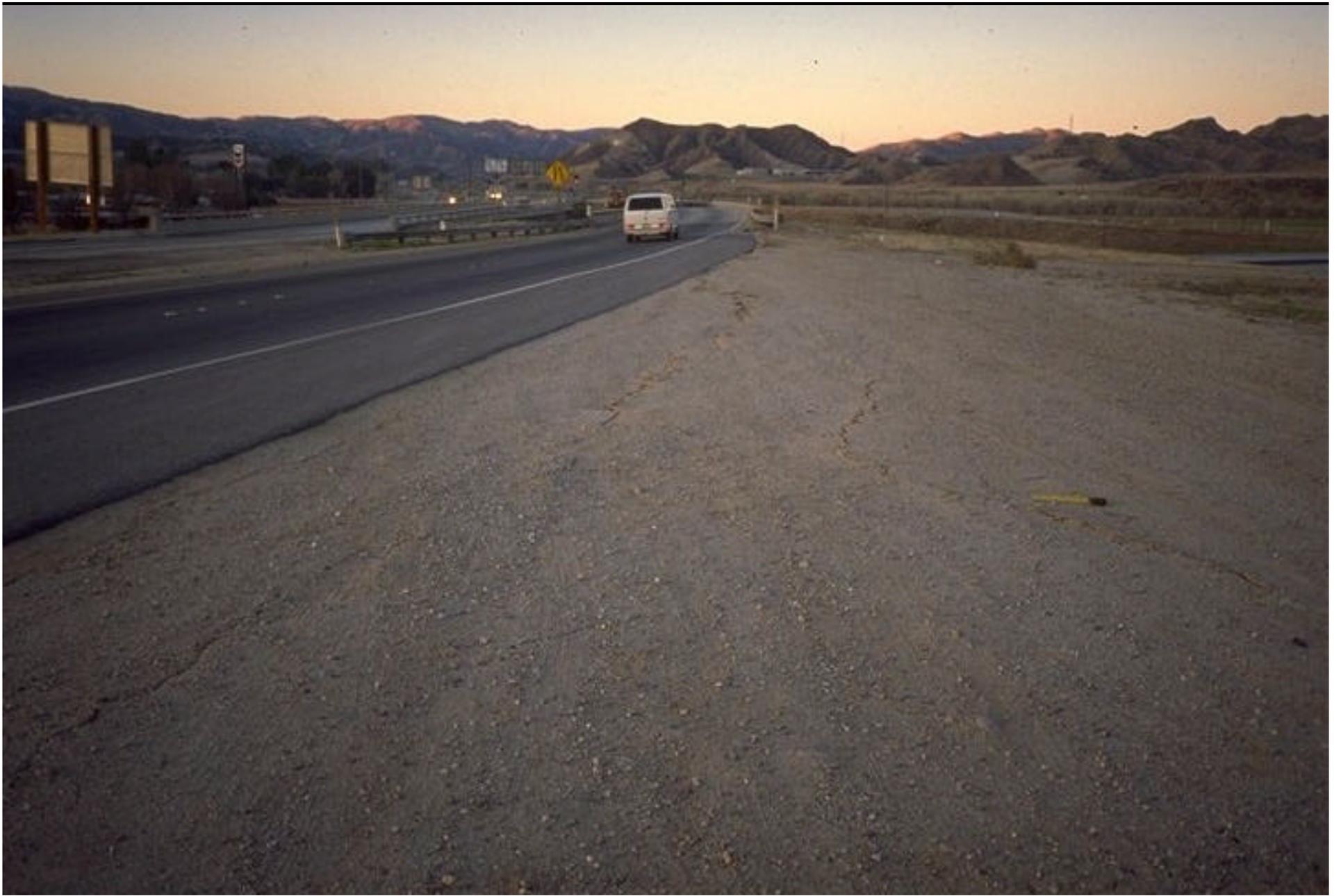














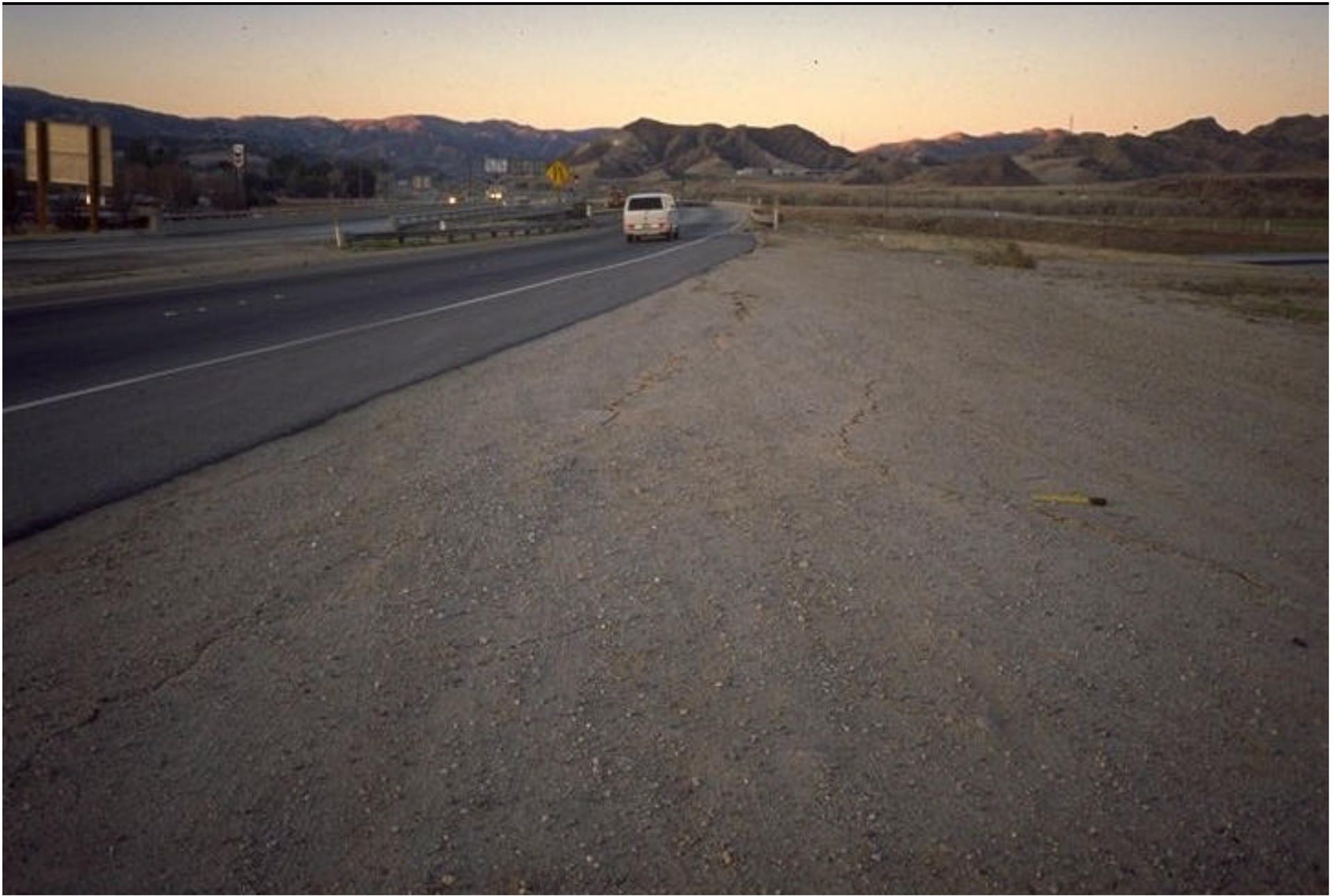






INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R126		Date and Local Time: 1/28/94 4:30 PM	
Bridge ID: 53-1626		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Spalling of Columns			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input type="checkbox"/> Other (explain)		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	







INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R126		Date and Local Time: 1/28/94 4:30 PM	
Bridge ID: 53-1626		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Spalling of Columns			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> Other (explain) Embankment Cracks Roadway Cracking		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input checked="" type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	





INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R126		Date and Local Time: 1/28/94 4:30 PM	
Bridge ID: 53-1626		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Spalling of Columns			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> Other (explain) Embankment Cracks Roadway Cracking		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input checked="" type="checkbox"/> No Damage		Abutments <input type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input type="checkbox"/> Backfill Settlement <input type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	









INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R126		Date and Local Time: 1/28/94 4:30 PM	
Bridge ID: 53-1626		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Spalling of Columns			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> Other (explain) Embankment Cracks Roadway Cracking		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input checked="" type="checkbox"/> No Damage		Abutments <input checked="" type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input checked="" type="checkbox"/> Backfill Settlement <input checked="" type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	





INDOT DETAILED BRIDGE INSPECTION REPORT (LEVEL II)

Route: I5-R126		Date and Local Time: 1/28/94 4:30 PM	
Bridge ID: 53-1626		Bridge Location: Interstate 5 - Northridge	
DAMAGE OBSERVED: Spalling of Columns			
1. ROADWAY/APPROACHES		4. SUPERSTRUCTURE	
<input type="checkbox"/> Not Operational <input type="checkbox"/> Roadway Settlement <input type="checkbox"/> Off Bridge Seat <input type="checkbox"/> Excessive Transversal Movement <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> Other (explain) Embankment Cracks Roadway Cracking		Reinforced Concrete Slab <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Culverts <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Connection Failure <input type="checkbox"/> Metal Pipes Distortion & Deflection <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel Truss Members, Floor Beams, Stringers <input type="checkbox"/> Local Buckling <input type="checkbox"/> Upper Chord <input type="checkbox"/> Lower Chord <input type="checkbox"/> Diagonals <input type="checkbox"/> Connection Failure <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Concrete Arches <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Spandrel Wall Cracking/Collapse <input type="checkbox"/> No Damage <input checked="" type="checkbox"/> N/A Steel/Concrete Girders, Beams <input type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Connection Failure <input type="checkbox"/> Local Buckling <input checked="" type="checkbox"/> No Damage <input type="checkbox"/> N/A	
2. DECK		5. SUBSTRUCTURE	
<input type="checkbox"/> Longitudinal Joints Enlarged <input type="checkbox"/> Expansion Joints Enlarged <input type="checkbox"/> Wearing Surface Cracking <input type="checkbox"/> Wearing Surface Spalling <input type="checkbox"/> Deck Cracking/Spalling <input type="checkbox"/> Misalignment of Guard Rails, Curbs, Pavement Lines <input checked="" type="checkbox"/> No Damage		Abutments <input checked="" type="checkbox"/> Wall Movement/Rotation <input type="checkbox"/> Pounding Damage <input type="checkbox"/> Wingwall Movement <input type="checkbox"/> Wingwall Separation <input checked="" type="checkbox"/> Backfill Settlement <input checked="" type="checkbox"/> Foundation Movement <input type="checkbox"/> Abutment Pile Damage <input type="checkbox"/> Cracking on the Walls <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Piers <input type="checkbox"/> Joint Failure <input type="checkbox"/> Moment Failure <input type="checkbox"/> Shear Failure <input type="checkbox"/> Inadequate Splice Failure <input checked="" type="checkbox"/> Flexural Cracks <input type="checkbox"/> Shear Cracks <input type="checkbox"/> Local Buckling <input type="checkbox"/> Foundation Failure <input type="checkbox"/> No Damage <input type="checkbox"/> N/A Hinge Spalling	
3. BEARINGS		6. GEOTECHNICAL	
<input type="checkbox"/> Failure of Bearings (Integral, Contact, Rocker, Elastomeric) <input type="checkbox"/> Movement of Bearings <input type="checkbox"/> Shearing or Pullout of Bolts <input checked="" type="checkbox"/> No Damage		<input type="checkbox"/> Slope Failure <input type="checkbox"/> Settlement <input type="checkbox"/> Soil Liquefaction <input type="checkbox"/> Fault Movement <input type="checkbox"/> Other <input type="checkbox"/> No Damage <input type="checkbox"/> N/A	







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3. BEARINGS

- Failure of Bearings
(Integral, Contact, Rocker,
Elastomeric)
- Movement of Bearings
- Shearing or Pullout of Bolts
- No Damage

6. GEOTECHNICAL

- Slope Failure
- Settlement
- Soil Liquefaction
- Fault Movement
- Other
- No Damage
- N/A

COMMENTS FOR REPAIR AND RECOMMENDATIONS:

1. BARRICADE NEEDED
2. IMMEDIATE SHORE AND BRACE
3. REPAIR
 - 3a. ~~In-House Repair Possible~~
 - 3b. Outside Contractor Needed
4. EMERGENCY VEHICLE USE ONLY
5. MONITORING UNDER SERVICE NEEDED
6. OTHER (explain)

Overall Rating For the Bridge:

SAFE (Green Tag): X MORE REVIEW NEEDED (Yellow Tag) _____ UNSAFE (Red Tag): _____

Name of the Inspector(s): Joe Inspector



POST-EARTHQUAKE SAFETY EVALUATION OF BRIDGES AND ROADS

Temporary Repairs and Long
Term Monitoring Techniques

Robert FROSCH

Purdue University

Temporary Repairs



- Emergency Access
- Open Lifelines for Recovery
- Temporary Measures

Repair Feasibility

- How Widespread is Damage?
- Safety Issue?
- Cause of Damage?
- Consequences of Damage?
- Similar Problems Elsewhere?
- Is Intervention Possible?

Types of Damage

- Local
 - Risks to Users
 - No Risk to Structure
 - Temporary Repair Possible
- Global
 - Risks to Safety of Users
 - Stability of Structure
 - Temporary Repair Not Possible

Local Damage (Coursery of UCSD)



Global Damage (Courtesy of KOERI)



Repair Strategy

- No Repair / Monitoring Required
- Partial Repair



Temporary Repair

- Replace / Redesign Elements
- Replace Structure



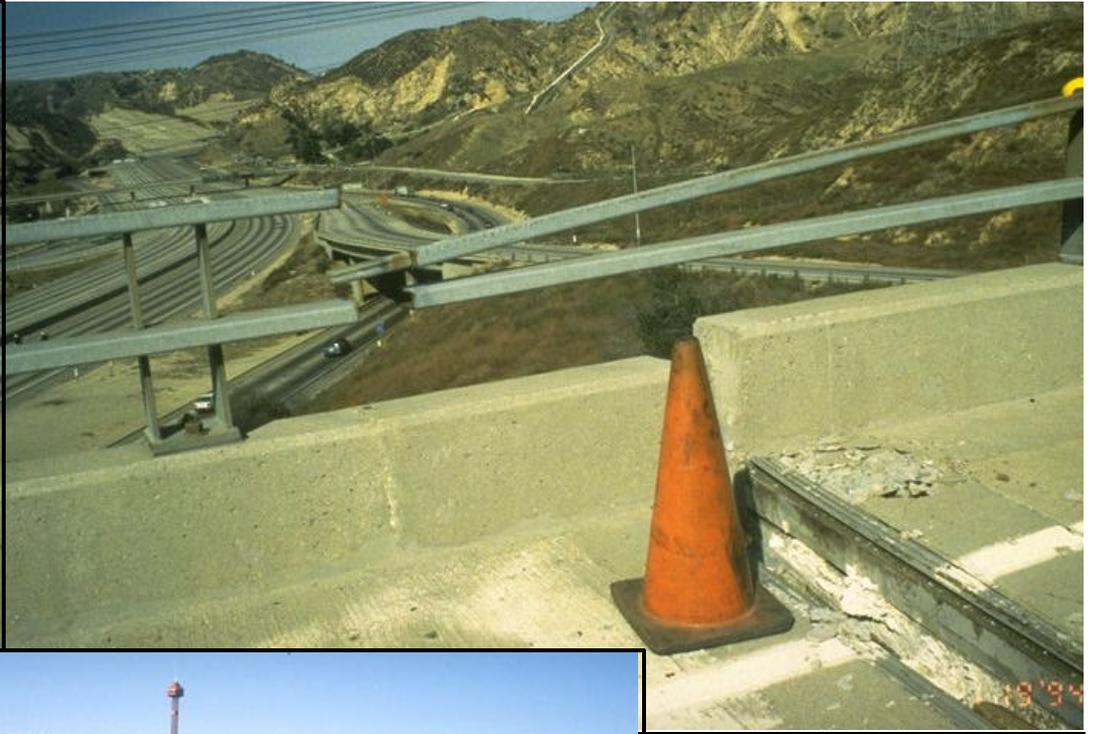
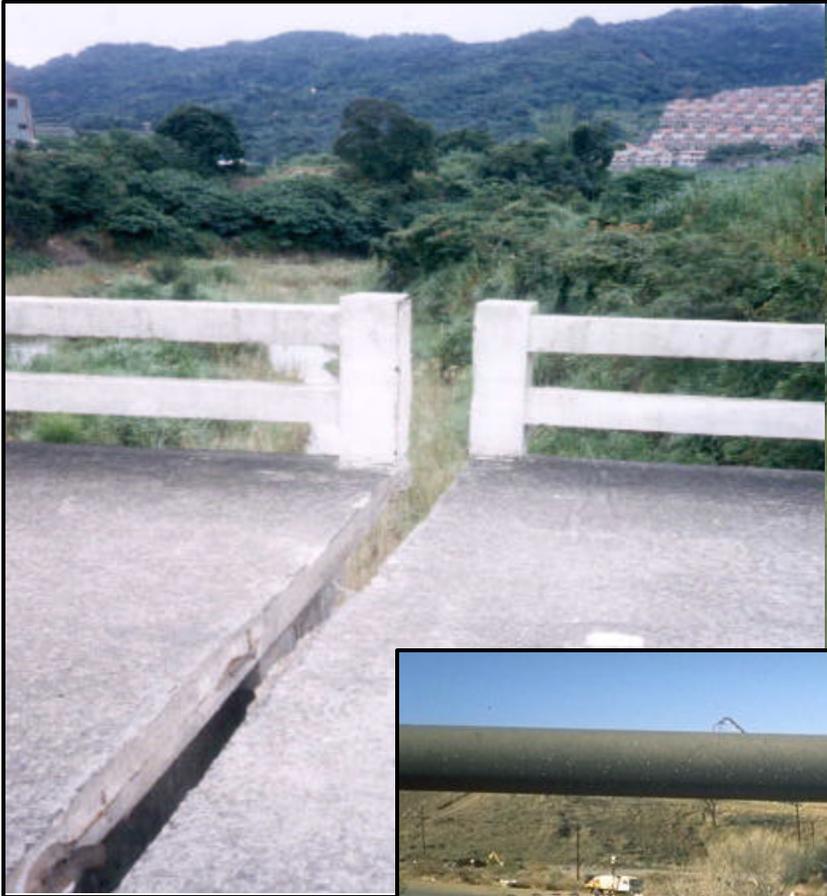
Permanent Repair

Transition Repair

- Superstructures Displaced Vertically
 - Approach Settlement
 - Bearing Damage
- Damaged Roadways
 - Discontinuous Riding Surface



Courtesy of
EERC and UCSD



Courtesy
of
EERC



Courtesy of
EERC and KOERI

Repair Procedures

- Steel Plates
 - Bridge Gaps
 - Vertical Offsets
- Fill
 - Roadways
 - Vertical Offsets
- Jacking
 - Reset/Replace Bearings

Steel Plates



Fill





Jacking (Courtesy of INDOT)



Shoring

- Open Structure to Operation
 - Severe Damage
 - Support Loading
- Prevent Collapse
 - Maintain Access
 - Underlying Roadway

Open Structure to Operation



Support Loads





Maintain Access



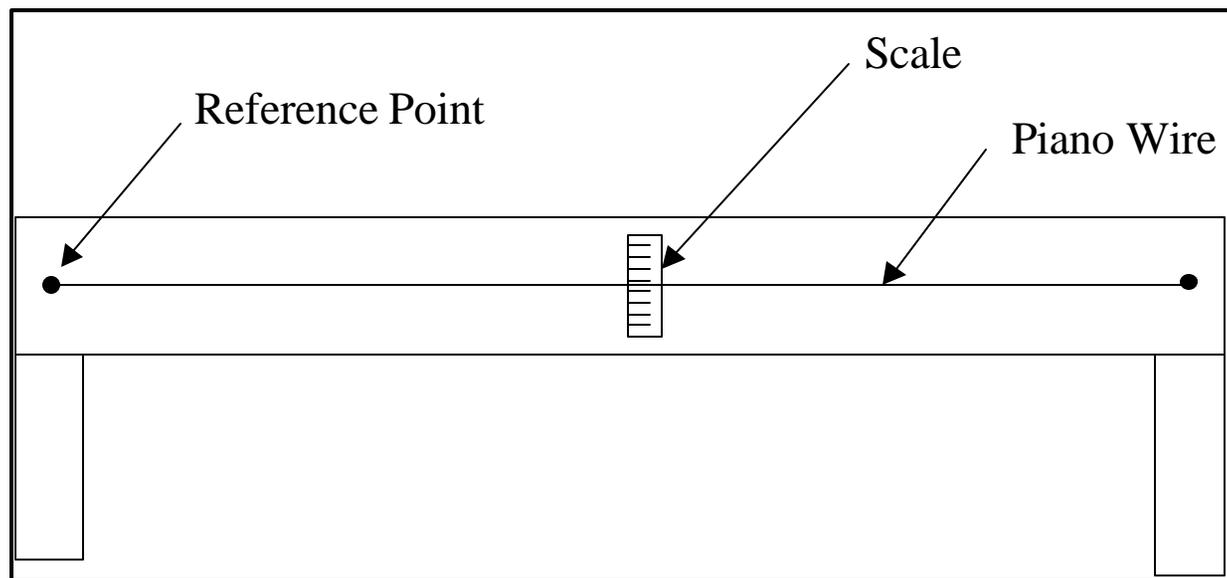
Long-Term Monitoring

- Indicate Changes in Behavior
- Support Adequate Performance
 - No Closure Required
- Indicate Safety Problem
 - Closure Required
- Simplest Method is Best

Deflections

- Stiffness
 - Stable Deflection - No Deterioration
 - Increasing Deflection - Deterioration
- Support Structure Operation

Deflection Measurement



Cracks

- Continuation of Damage
- Unstable Crack Growth
 - Unstable Structural Damage

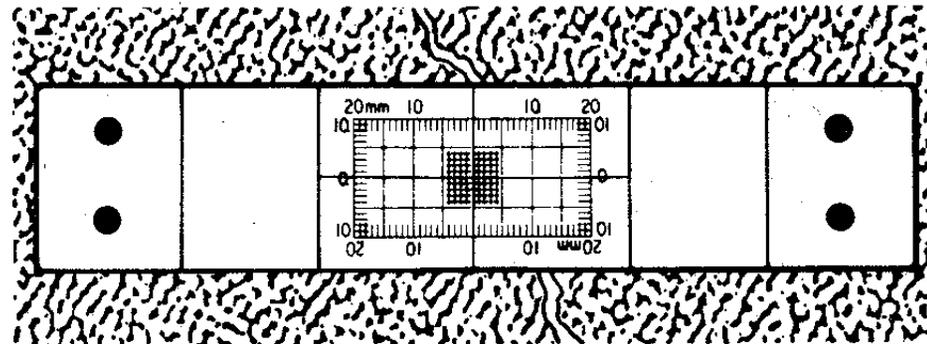
Crack Monitoring Techniques

- Plaster Cracks
 - Cracks Moving
- Crack Comparator
 - Measure Crack Width
- Tape Measure
 - Large Crack Widths
- Avonguard
 - Crack Displacement and Rotation

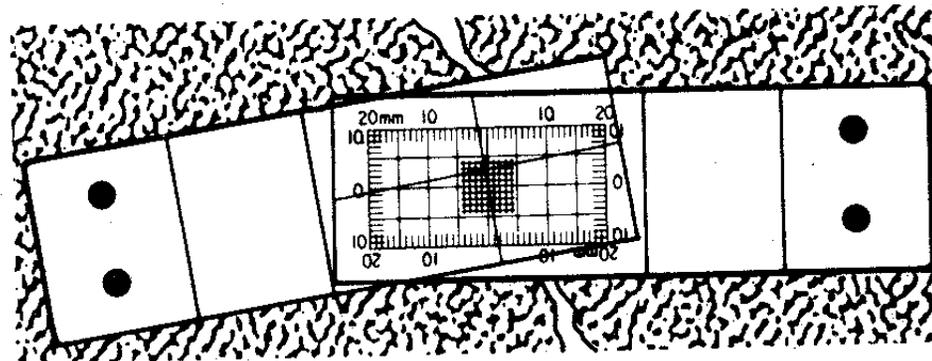
Crack Comparator



Avonguard



Newly Mounted Monitor



Monitor After Crack Movement

Strain

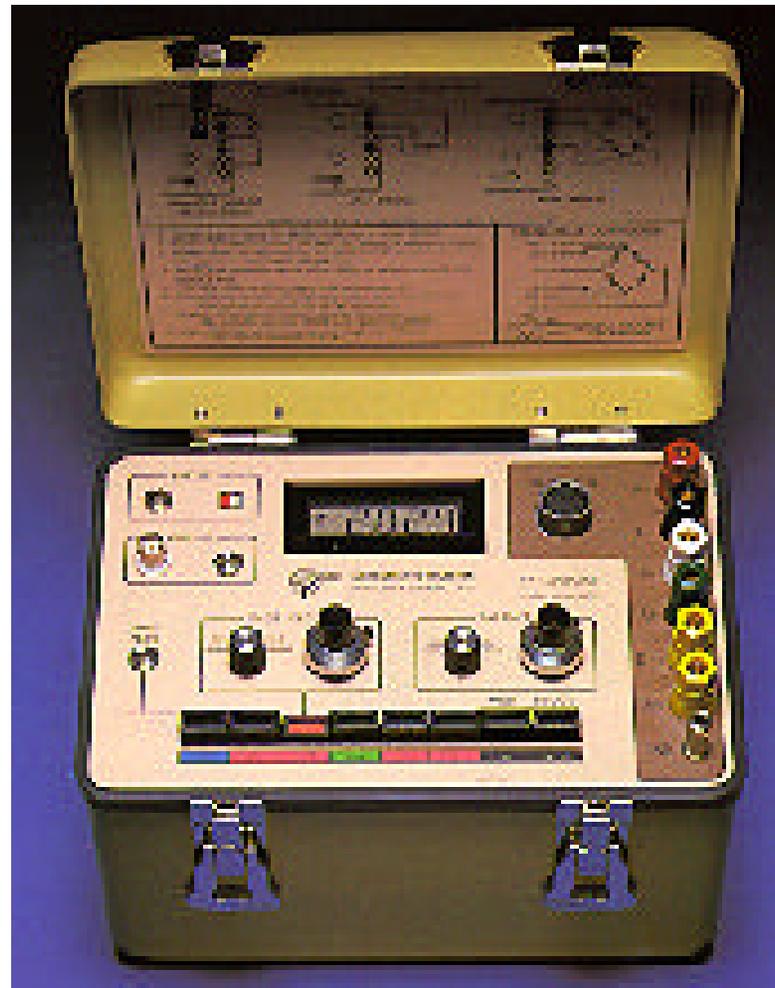
- Overall Structural Performance
- Component Performance
- Most Involved Technique

Strain Measurement

- Electrical Resistance Gage
- Readings
 - Hand Held Bridge Balancing Box
 - Portable
 - Field Monitoring
 - Few Gages
 - Computer Data Acquisition
 - Many Gages
 - Complex



Balancing Box



Repair / Monitoring

- Maintain / Open Lifelines
- Safety of Structures
- Safety of Traveling Public