Loma Prieta's Impact on California's Bridges

Loma Prieta Earthquake Commemorative Symposium
October 17, 2009

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Chief Engineer and Deputy Director, Project Delivery
California Department of Transportation

California Roads

State Highways: ~ 15,000 miles
~ 12,000 bridges
Local Roads: ~ 165,000 miles
~ 12,000 bridges

California Major Seismic Events

1906 San Francisco EQ – M 7.8

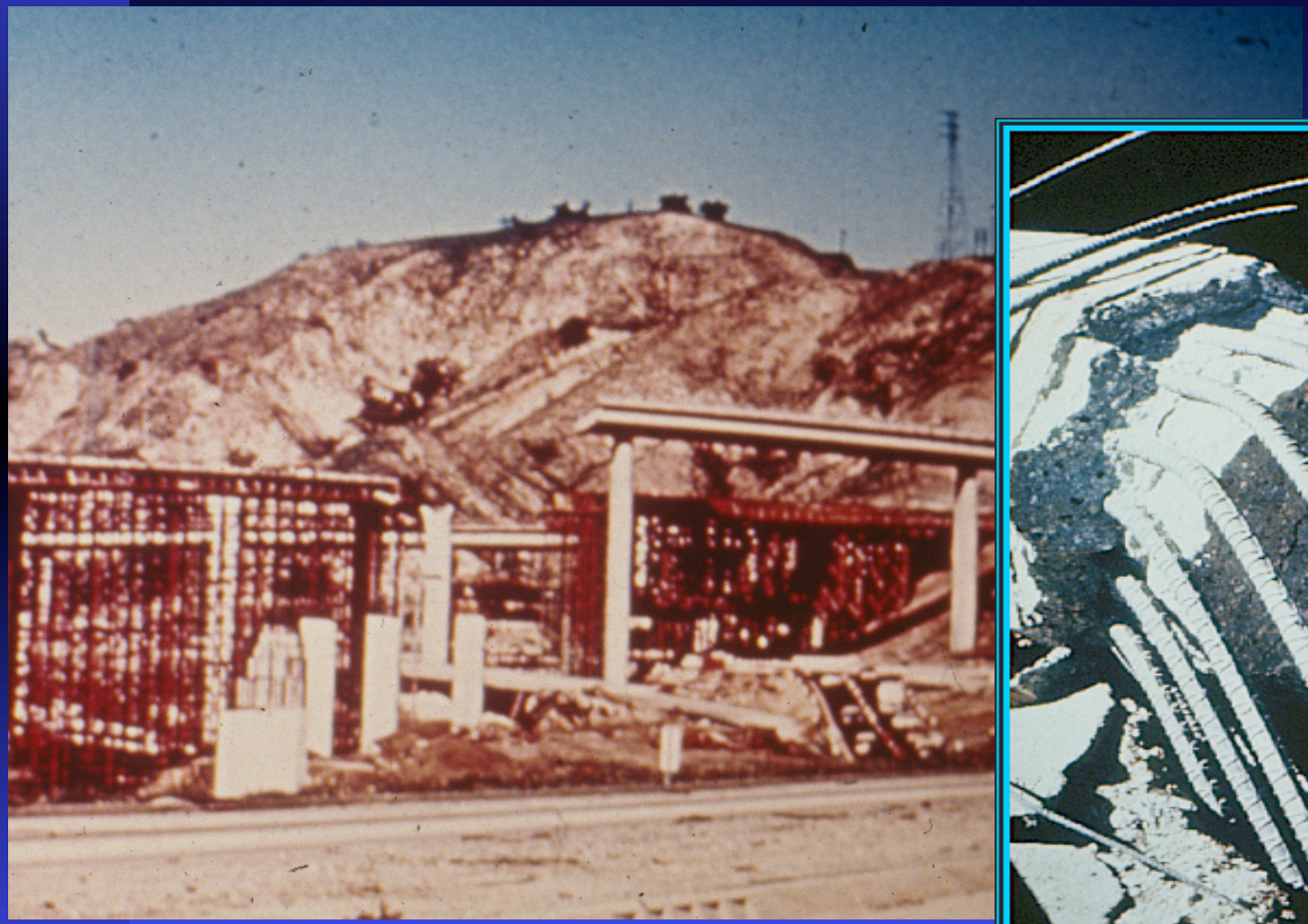
1971 San Fernando EQ – M 6.6

1988 Whittier Narrows EQ – M 6.0

1991 Loma Prieta EQ – M 6.9

1994 Northridge EQ – M 6.7

1971 SAN FERNANDO



1987 WHITTIER

1989 LOMA PRIETA

Loss of critical routes…

Loss of lives…

Loma Prieta Earthquake Commemorative Symposium

Governor's Board of Inquiry

COMPETING AGAINST TIME

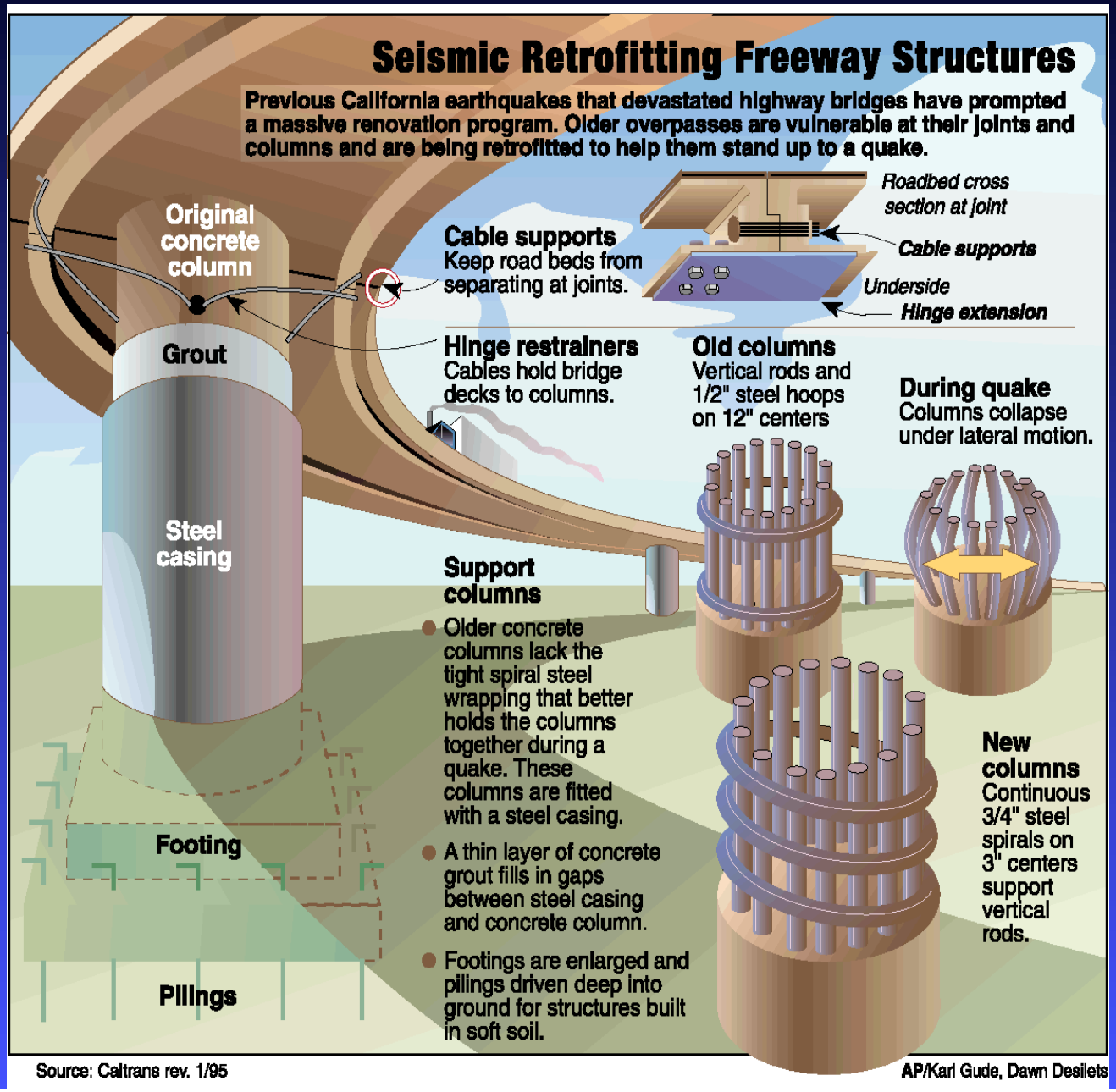
Report to Governor George Deukmejian
from
The Governor's Board of Inquiry
on the 1989 Loma Prieta Earthquake

George W. Housner, Chairman

May 1990

- Existing Structures
- New Construction
- Response and Recovery

Caltrans Seismic Retrofit Program



1994 NORTHRIDGE

Seismic Retrofit Bond Act of 1996 (Proposition 192)

Caltrans Seismic Retrofit Program

Non-Toll: Phase 1, 100% Complete
1039 bridges
$1.08 billion

Phase 2, 99.7%
Complete 1151 out of 1155 bridges
$1.35 billion

Local: 61% complete
733 out of 1193
$1.96 billion

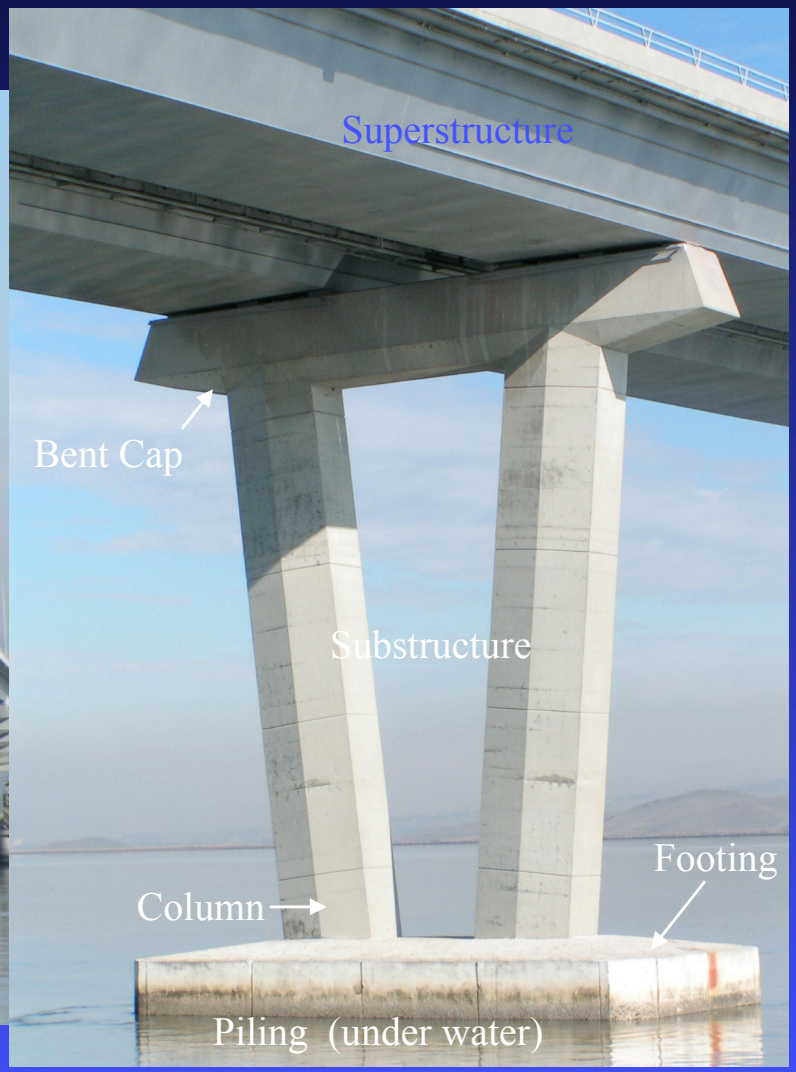
$13.08 billion

Toll: 6 out of 7 bridges
complete $8.69 billion

East Spans, San Francisco-Oakland Bay Bridge

Improving Major Bay Area Bridges

Dumbarton



Typical Main Channel Crossing Pier

Improving Major Bay Area Bridges

Antioch

Improving Major Bay Area Bridges

Doyle Drive

Improving Major Bay Area Bridges

Doyle Drive

Seismic Research

- Limited research until the mid-1980's
- Then, about $500,000 per year prior to Loma Prieta
- By 1991, 35 research projects at $7 million.
- Since 1994, averaged $5 million/year
- Over $90 million to date with significant focus on implementation of results

Seismic Devices

- Shear Links
- Dampers
- Bearings
- Lockup Devices

Needs:

- Long Term Performance
- Performance Verification
- Maintenance

Caltrans Current Seismic Design Practice

- Current State of the Practice in California
  - Displacement Based
  - Confinement to Develop Ductile Response
  - Continuity or Adequate Support Length
  - Capacity Design Principles
  - Redundancy
  - Proportioning and Balanced Geometry

Caltrans Current Seismic Design Practice

- Expected Performance of Standard Bridges
  - Major Earthquake will result in Major Damage
  - Risk to Loss of Life Minimized
- Expected Performance of Important Bridges
  - Post-EQ operational capacity

Future California Bridges

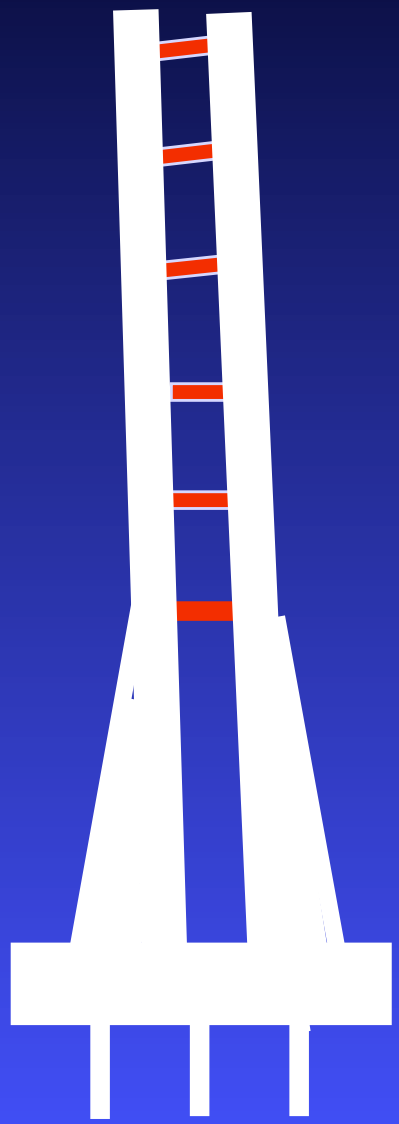
- Improved Post-Earthquake Serviceability
- Multi-Level Performance Based
- Rapid Post-Earthquake Assessment, Repair and Recovery
- Integrated with Accelerated Modular Bridge Construction Practices
- Must be:
  - Cost-Effective
  - Simple
  - Reliable
  - Verifiable
  - Long Lasting

East Spans Replacement - SFOBB

East Spans Replacement - SFOBB

Structural Fuses

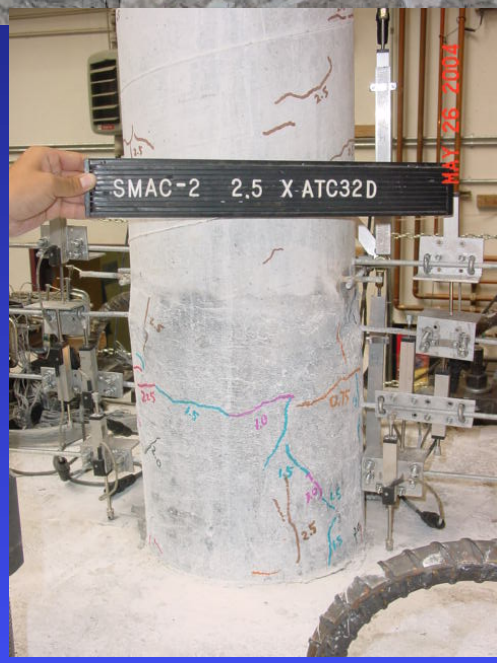
During Large Seismic Events



Linker Beams (shear beams) will deform beyond elastic into plastic range of deformation.
As they go plastic, they effectively protect the tower legs and superstructure by serving as a fuse.

Advanced Materials

- High Performance Concrete
- High Performance Steel
- Fiber Reinforced Polymer Composites
- Shape Memory Alloys
- Needs:
  - Material Performance
  - Degradation Models
  - Long Term Performance
  - Detailing
  - Specifications

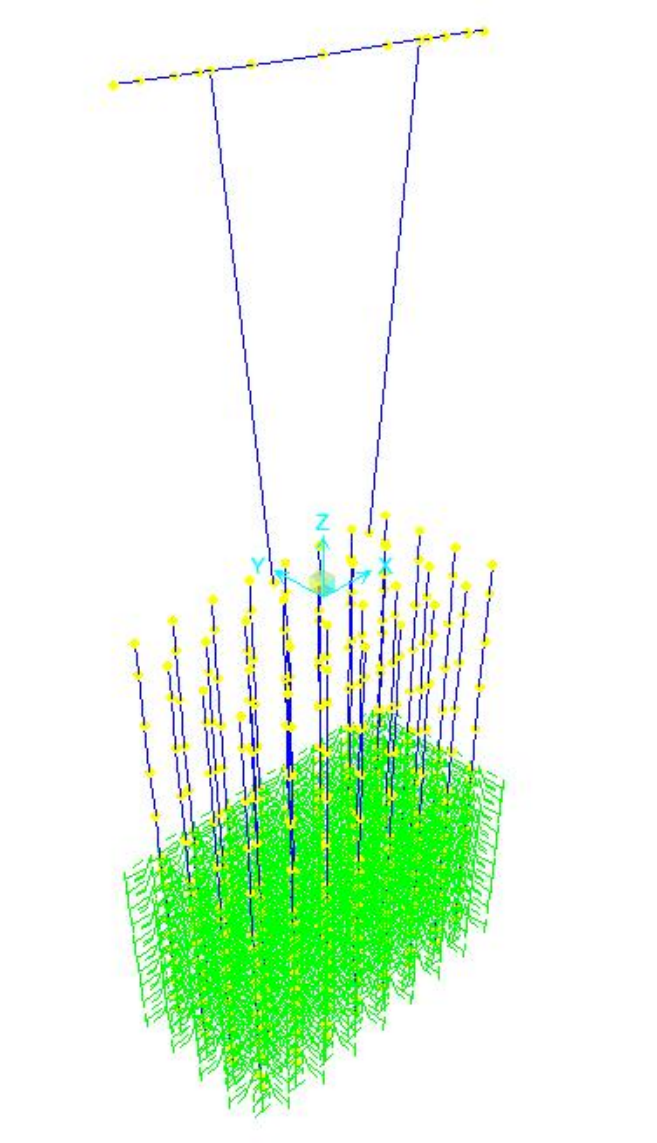


Precast Segmental Components

- Supports Accelerated Construction
- Needs:
  - Connections
  - Inelastic Performance
  - Predictive Modeling

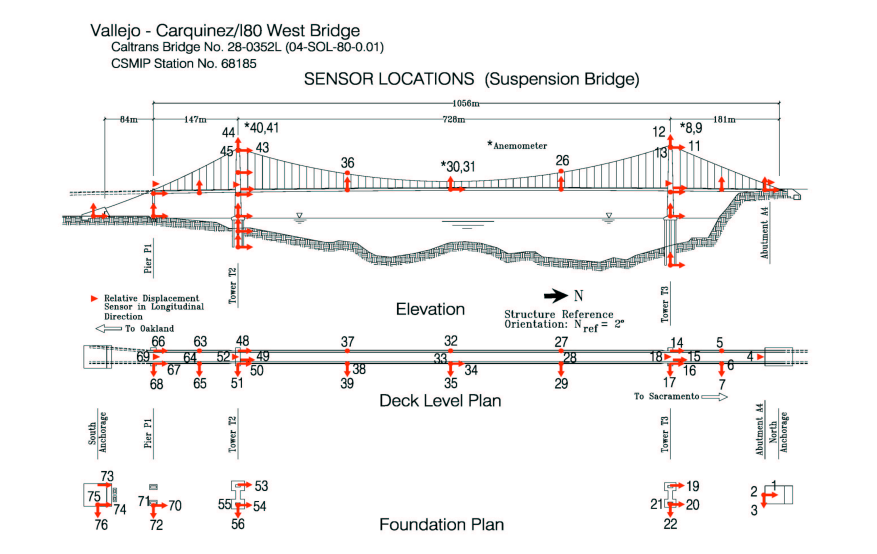
Improved Analytical Capabilities

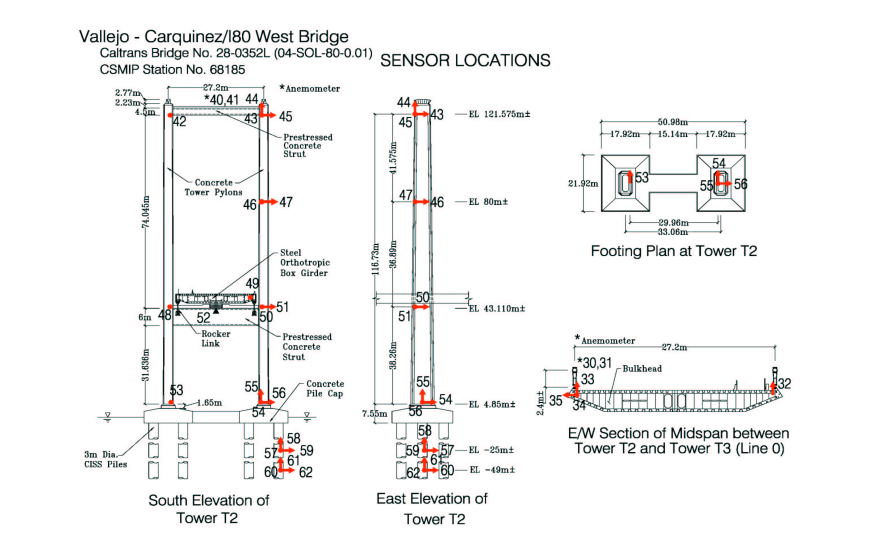
- Standardization of Methodologies
- Efficient, Reliable Model Development
- Foundation and Abutment Mathematical Models
- Research System Testing
- Real Event Verification



Monitor Bridge Performance

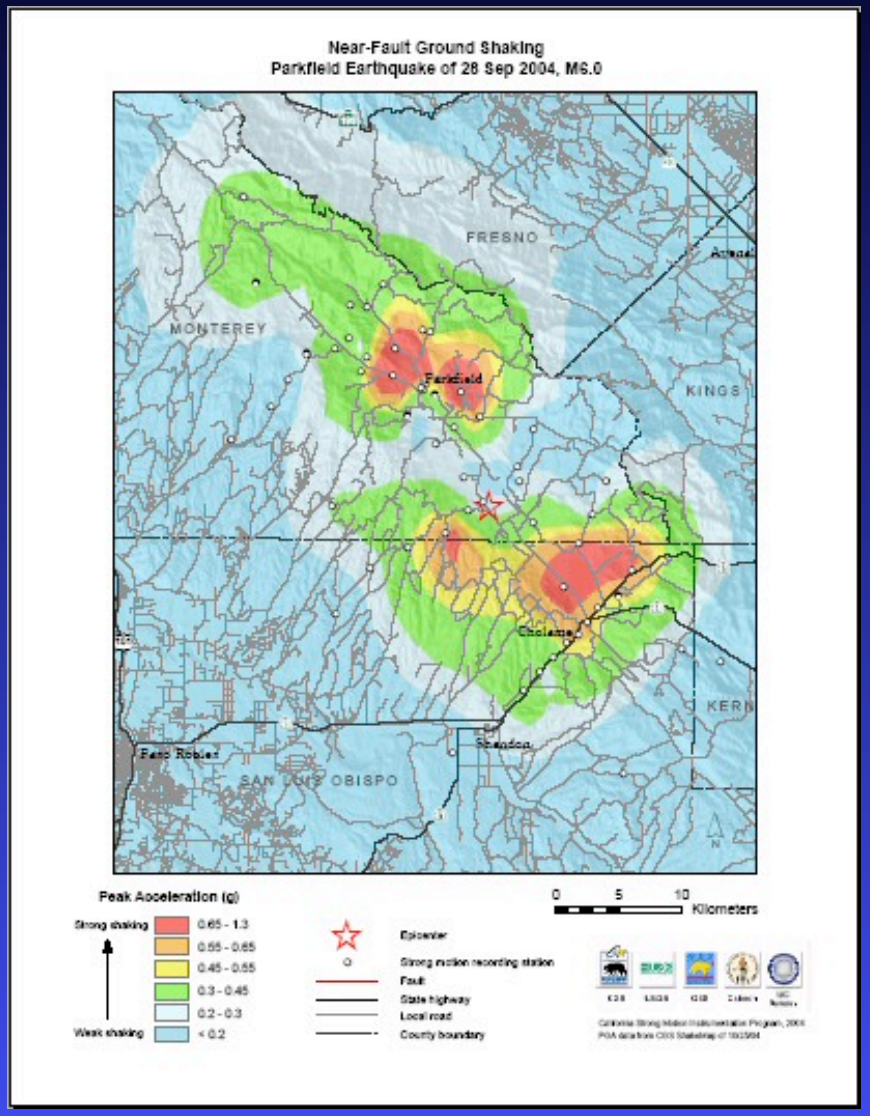
- Caltrans Strong Motion Instrumentation Program
  - Verification of Predictive Models
  - Archive Analytical Models
- FHWA Long Term Bridge Performance Program





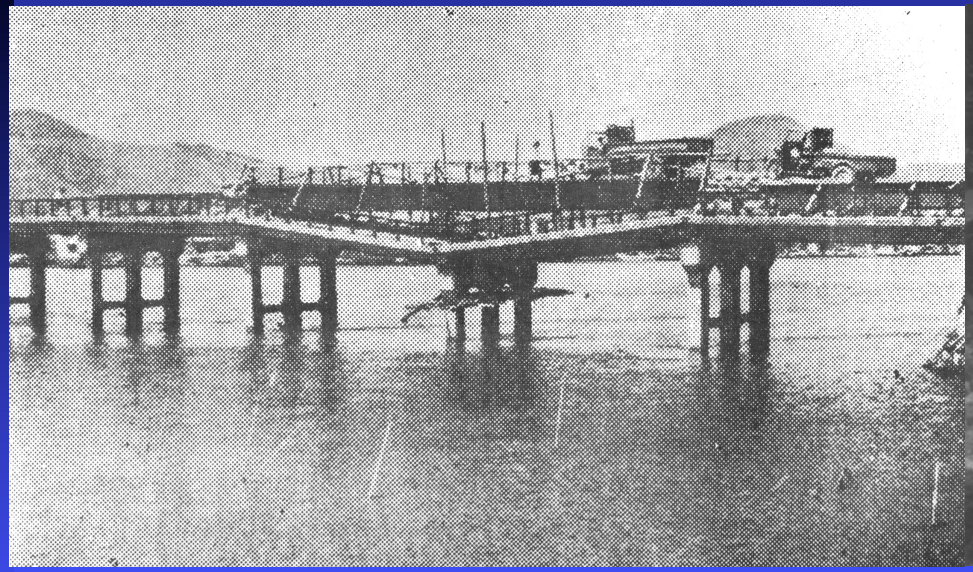
Understanding Seismic Hazards

- Ground Motion
  - Lessons Learned 2004 Parkfield EQ
  - Time History Selection and Site Application
  - Attenuation
  - Near Fault Effects
  - Energy or Duration



Understanding Seismic Hazards

- Other EQ Hazards
  - Fault Rupture
  - Tsunami
  - Liquefaction
  - Landslides

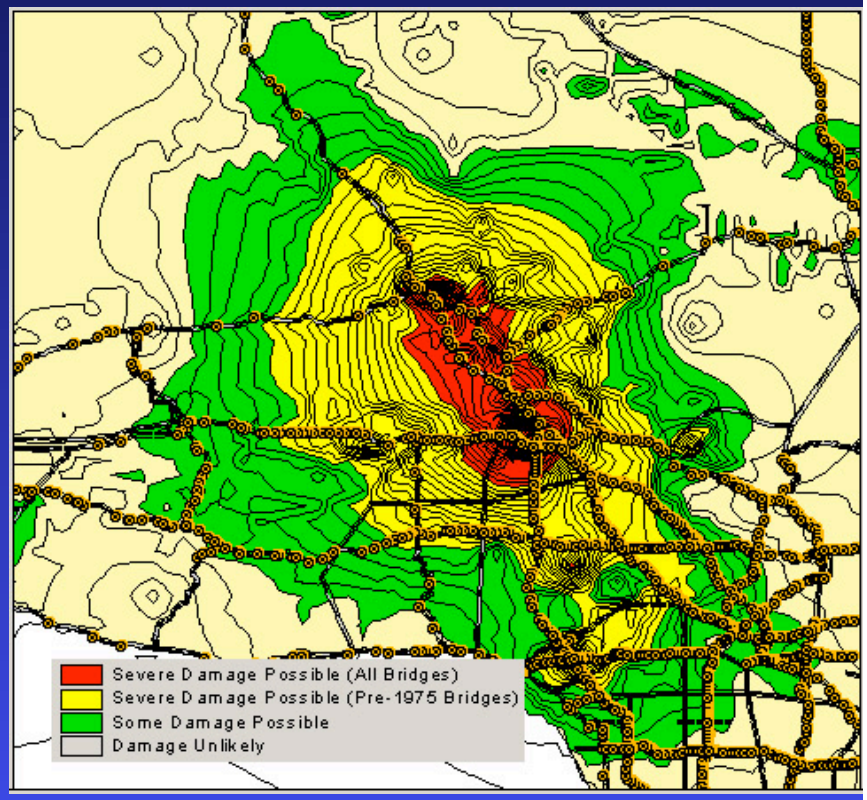


Non-Bridge Structures

- Earth Retaining Structures
- Soundwalls
- Tunnels

Assessment and Recovery

- Assessment
  - Training and Tools
  - Non-Destructive Evaluation
  - Remote Monitoring
  - Determine Remaining Capacity
- Rapid Recovery
  - Repair and Rehabilitation



Conclusions

- Are We Done? - No
- Working to Meet California Goals
  - Mobility
  - Safety
  - Stewardship
- To Meet Goals
  - Requires Innovative Solutions
    - Cost-Effective, Simple, Reliable, Verifiable, Long Lasting
  - Research
  - Pilot Projects
  - Engage with Partners Nationally and Internationally


Challenge / Opportunity Cycle
Challenge
Seismic Event / Extreme Event
Initial Response "Emergency"
History of Events and Lessons Learned
Action Proposed
Opportunity
Legislative and Programmatic Changes
Get Prepared
Continuing Research and Advance State-of-the-Art Practice
Opportunity
National Code Changes
International Collaboration
Stay Prepared
Continuing Challenge
Competing Against Time (Maintain Interest)
Other Extreme Events

THE RACE TO SEISMIC SAFETY

PROTECTING CALIFORNIA'S TRANSPORTATION SYSTEM

Submitted to the
Director, California Department of Transportation
by the
Caltrans Seismic Advisory Board
Joseph Penzien, Chairman
December 2003

"Earthquakes measure our actions, not our words."

- Caltrans Seismic Advisory Board, December 2003