Transportation Systems

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California Roads 2014

State Highways:	~ 15,000 miles
	~ 13,500 bridges
Local Roads:	~ 140,000 miles
	~ 14,200 bridges

Bridge Seismic Safety Program Pre-1994

- 1971 Sylmar Earthquake (M 6.6)
  - First earthquake to cause significant damage to the State Highway System
  - Generated sweeping changes to the bridge seismic design codes
  - Caltrans initiated the bridge hinge restrainer retrofit program
- 1987 Whittier Earthquake (M 6.0)
  - Revealed vulnerability of multi-column bridges
- 1989 Loma Prieta Earthquake (M 6.9)
  - Legislated (SB36x) bridge seismic retrofit program
  - Significantly increase in seismic research

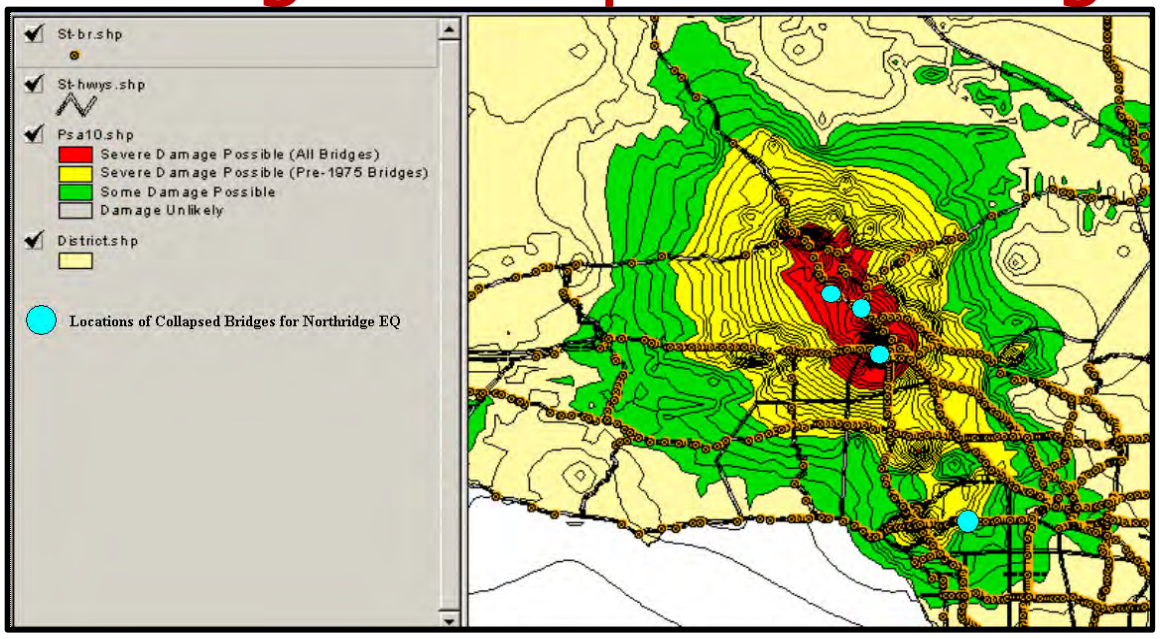
Northridge Impacts –Transportation

Vehicle Bridge Inventory -1994		
Location	Stated Owned	Locally Owned
Statewide	12,000	12,000
Los Angeles County	2,523	1,500*/800**

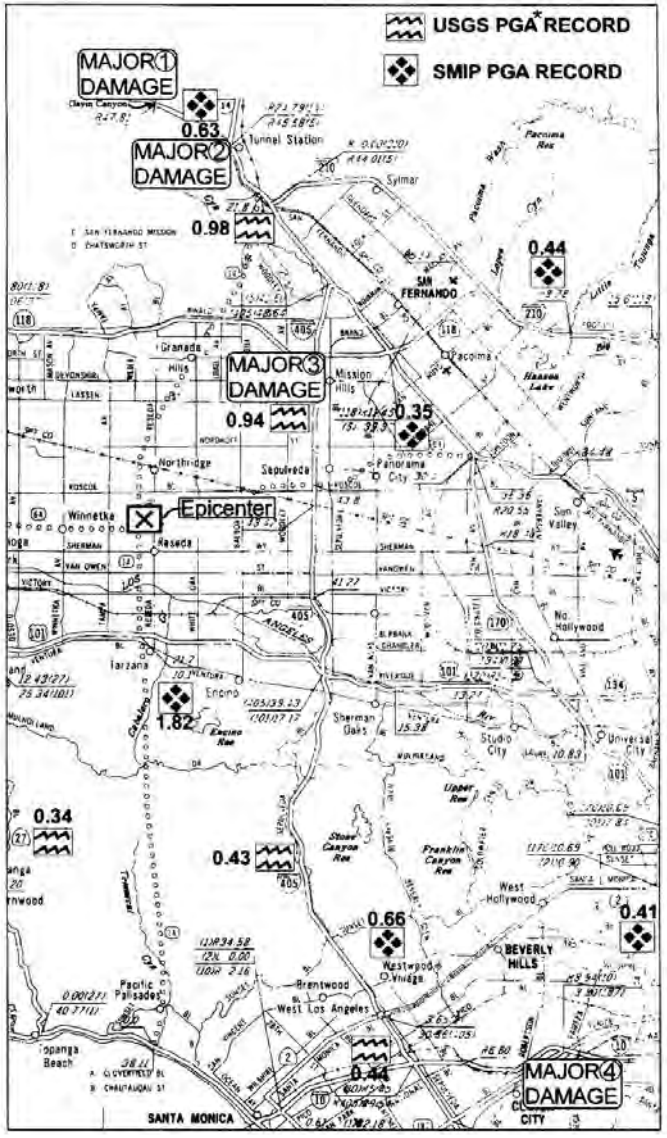
** County ** City*

State Bridges Damaged in Northridge Earthquake	
Damage State	# of Bridges
Collapse	7
Major Damage	39
Moderate/Minor Damage	194

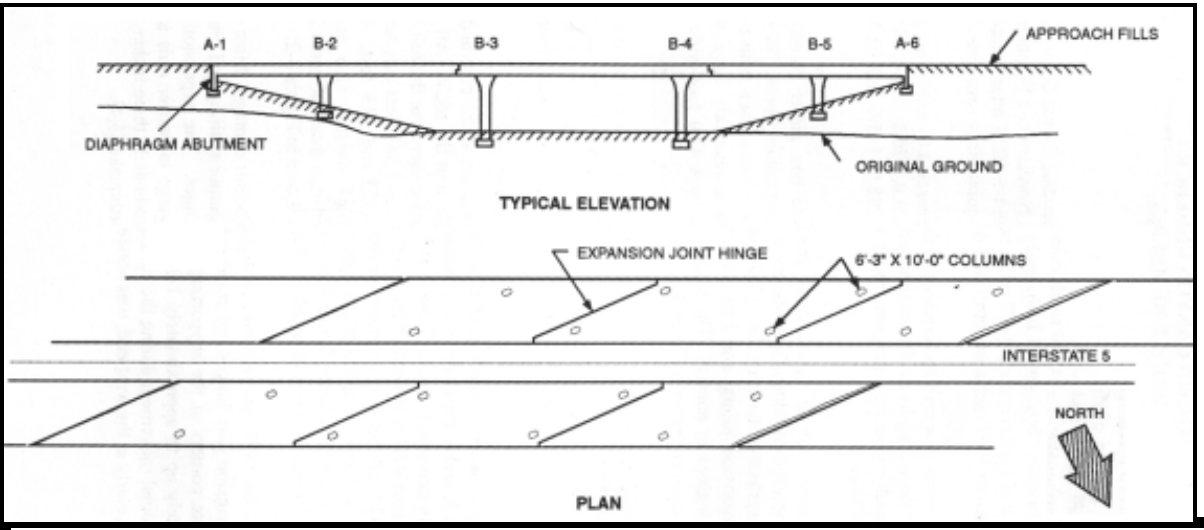
Bridge Collapses During the Northridge



Bridge Location	Bridge Name	Yr. Built
Gavin Canyon (I-5)	Gavin Canyon Bridge	1967
14/5 Interchange	Rte. 14 /5 Sep. & OH North. Conn. OC	1971-1974
118 west of the 405	Mission Gothic UC Bull Creek Cyn. Ch. Br.	1976 1976
I-10 near downtown	La Cienega-Venice UC Fairfax-Washington UC	1964 1964

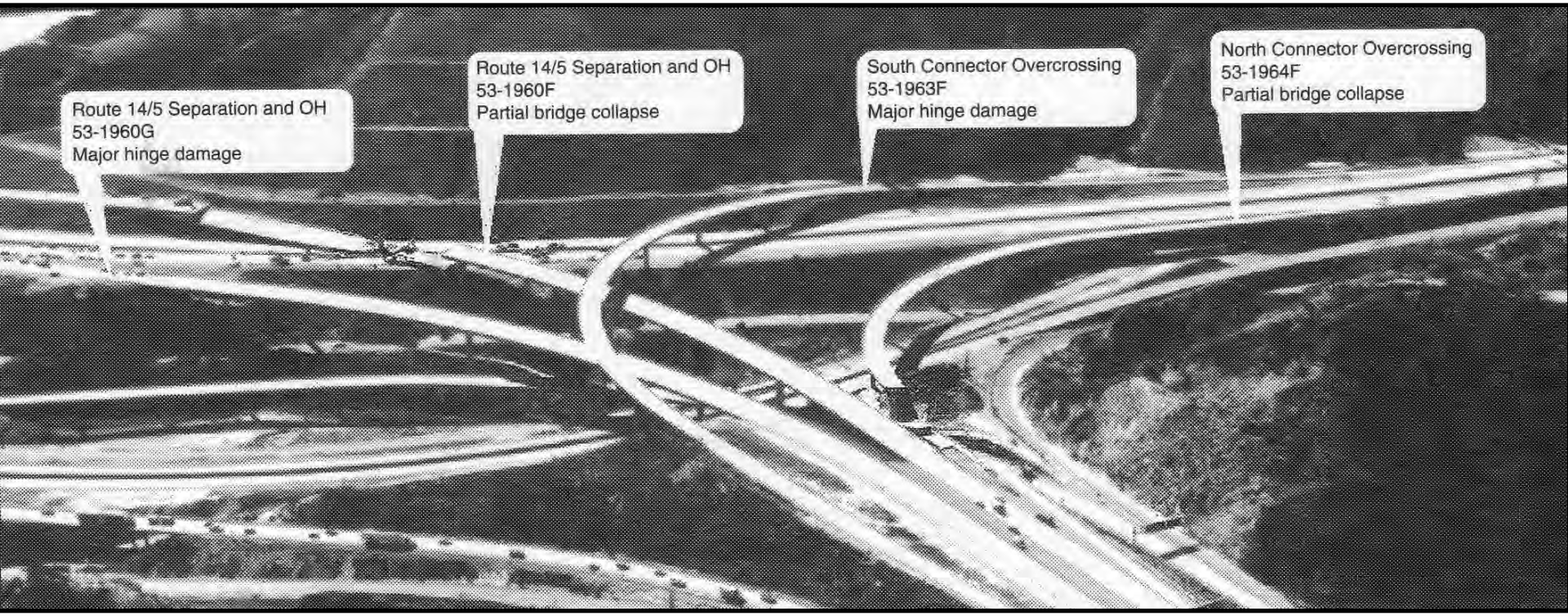


Damage-Gavin Canyon UC



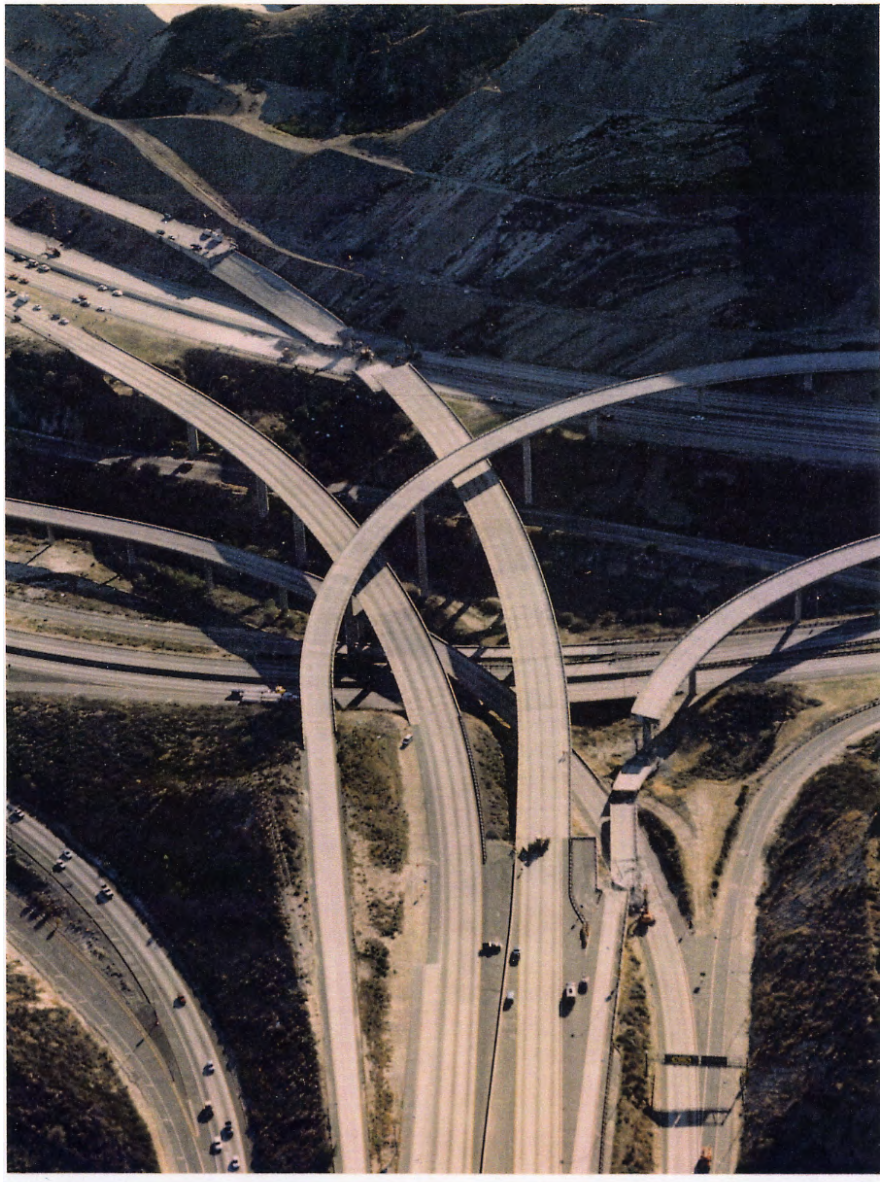
- Tall, highly skewed bridge
- Unseated on the obtuse corners during the earthquake.

Damage-SR 14/I-5 Interchange



- The 14/5 IC was previously damaged in the 1971 Sylmar EQ
- Every connector suffered damage or collapse during Northridge EQ

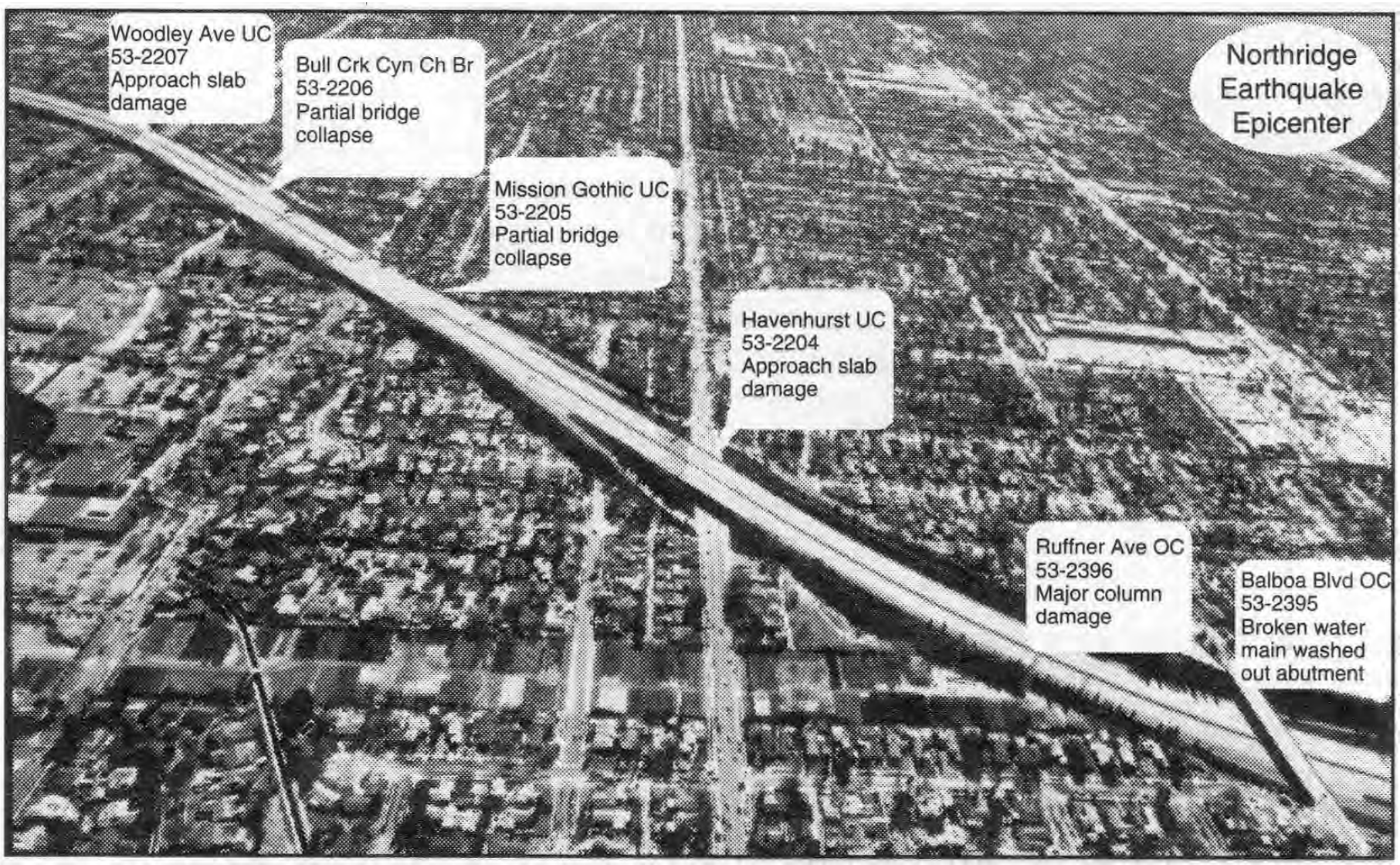
- I-5/SR-14 collapse was due to lack of stiffness and mass “Balance”



Route 14/Interstate 5 Interchange
Collapsed Connectors 53-1964F & 53-1960F

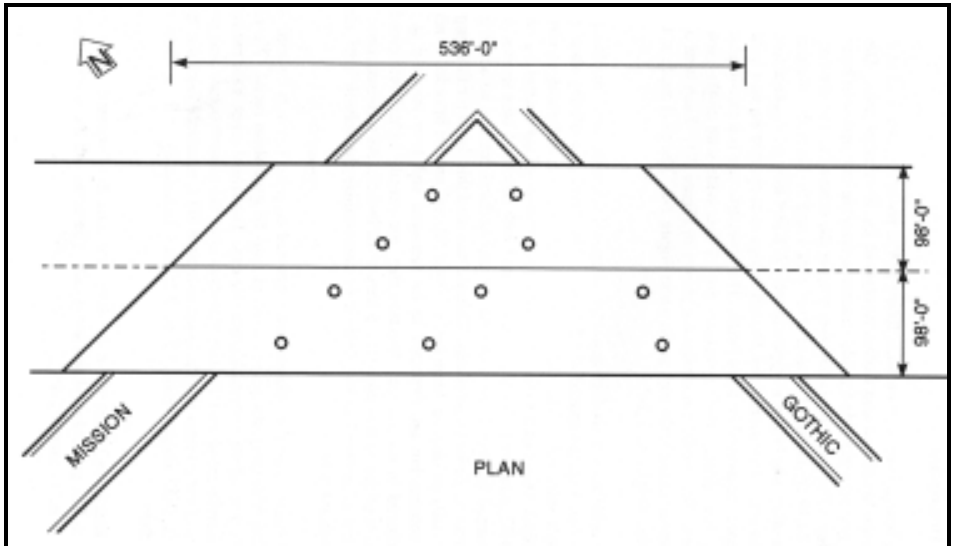
I-5/SR-14 Separation and Overhead

Damage SR-118



SR-118 Roadway Damage

Damage SR-118 Mission-Gothic Undercrossing

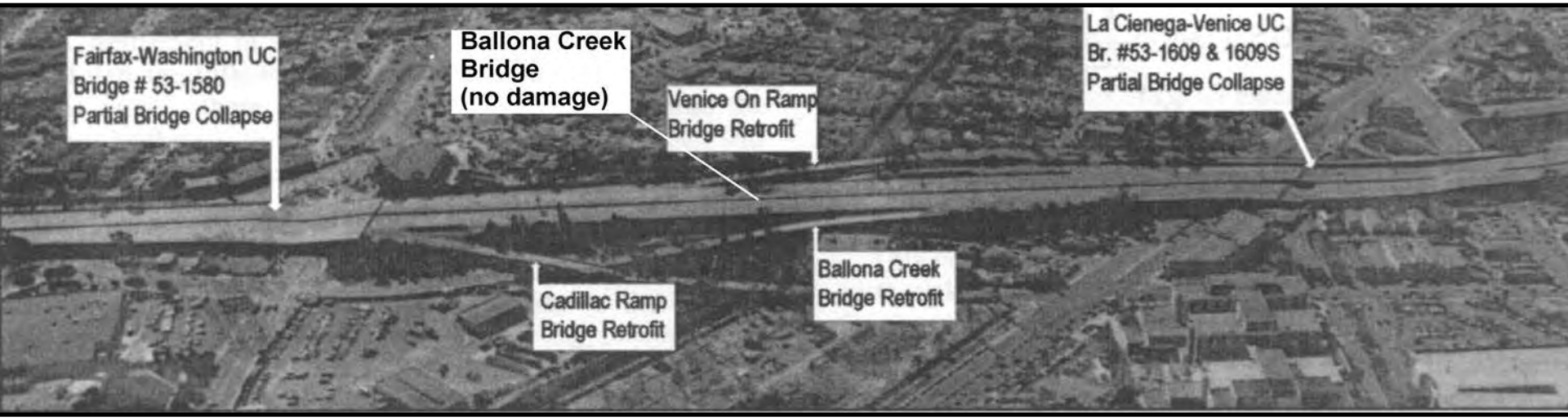


- Constructed in 1976-Post Sylmar
- Large and variable skews
- Heavily reinforced column flares

SR-118 Mission-Gothic Undercrossing

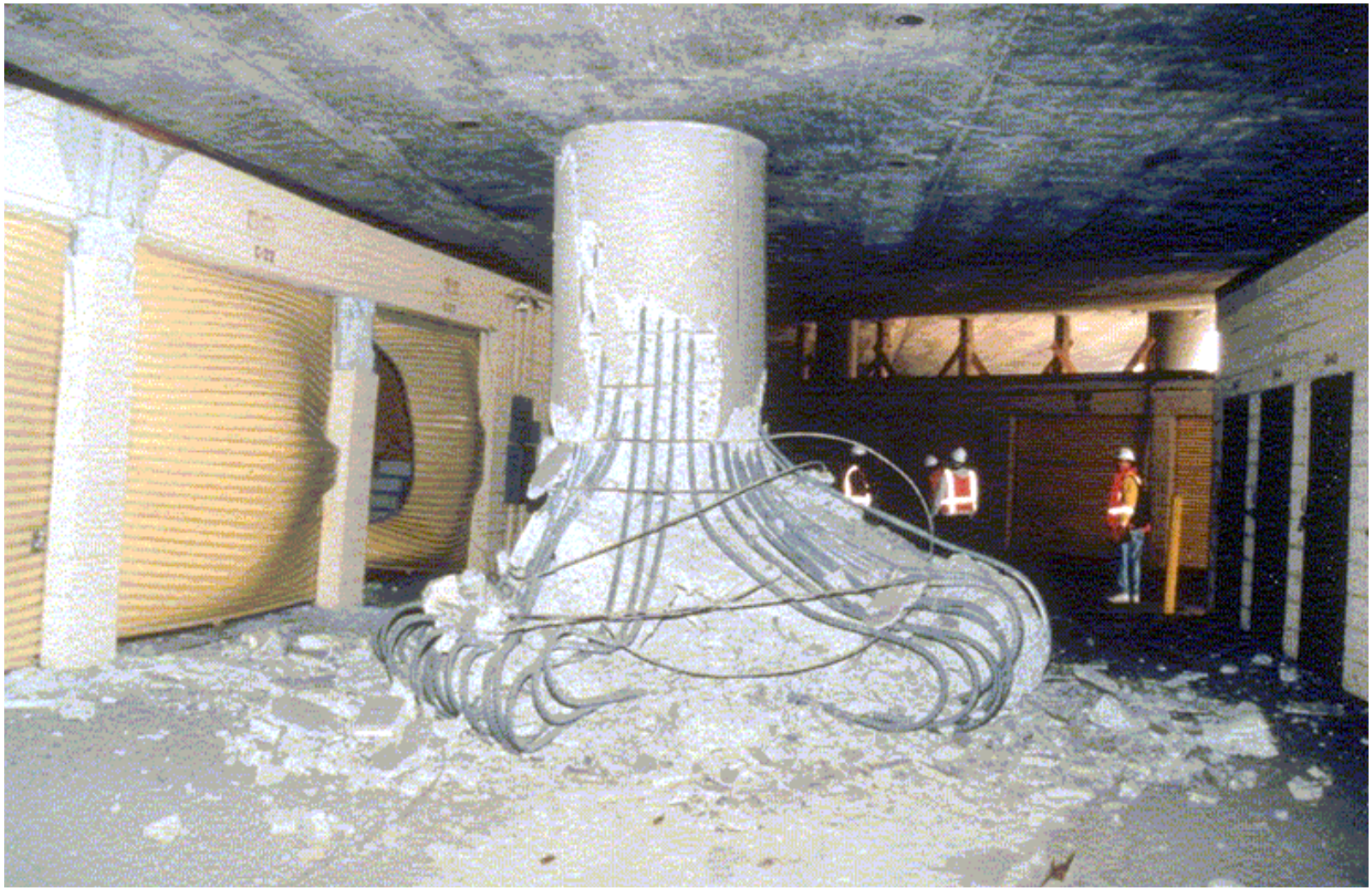
SR-118 Bull Creek Canyon Bridge

Santa Monica (I-10) Expressway Damage



- 16 miles south of the Northridge epicenter
- This area likely experienced higher shaking because of weak soil deposits
- Retrofitted bridges between the two collapsed bridges were undamaged

Santa Monica (I-10) La Cienega-Venice UC



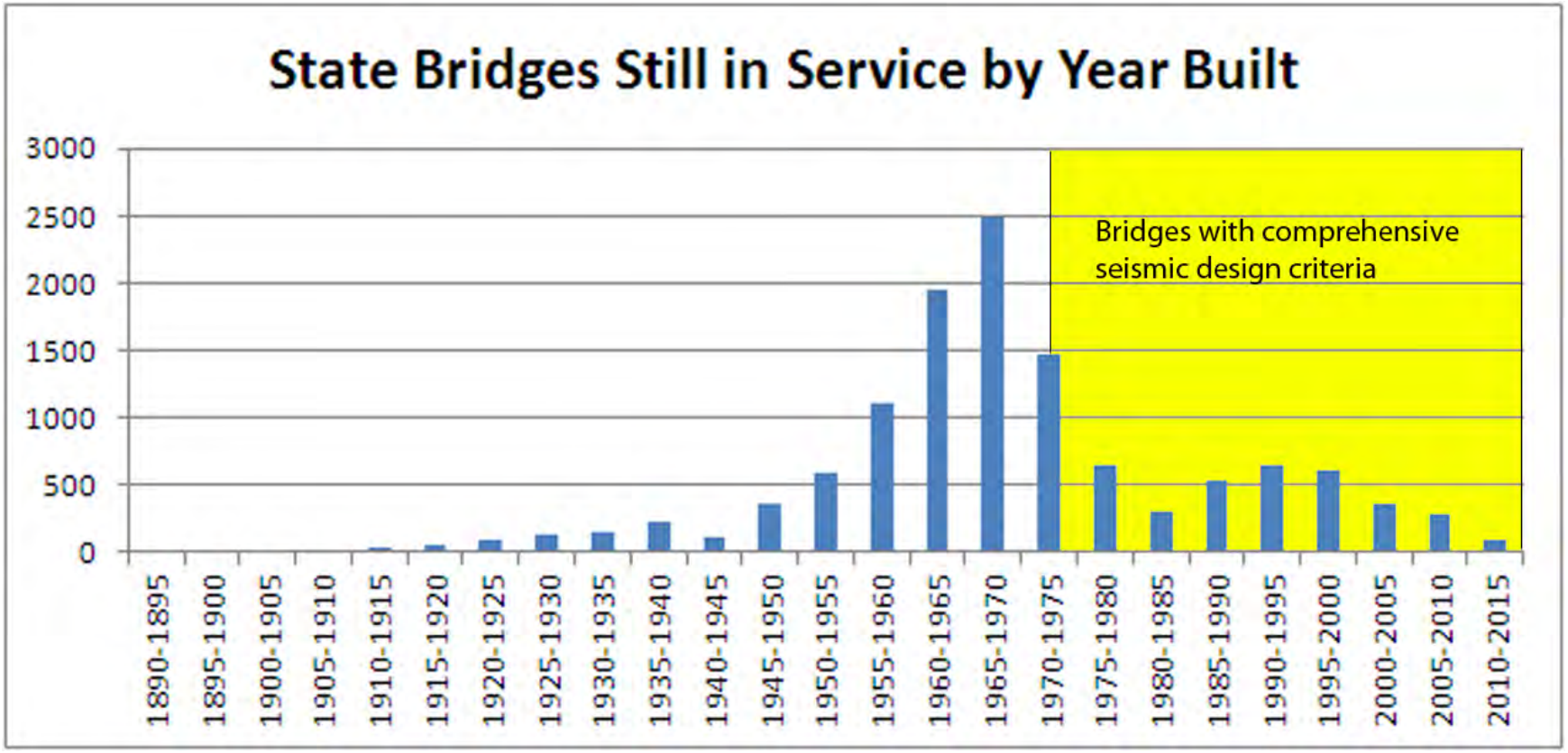
Impacts of Northridge EQ on Traffic

Route	Location	Pre EQ ADT	2/4/94 ADT	Percent
5	South of Rte. 170	156,880	149,663	95 %
10	East of Rte. 405	267,273	113,029	42%
101	West of Rte. 405	309,049	267,371	87%
105	East of Rte. 405	171,135	186,234	109%
118	West of Rte. 405	125,279	48,532	39%
134	East of 101/170 IC	197,973	264,908	134%
170	North of the Rte. 101	78,058	76,143	98%
405	North of Rte. 10	271,940	234,834	86%
405	South of Rte. 10	321,694	298,851	93%

Northridge Outcomes - Transportation

- Northridge provided a valuable test for the Caltrans design procedures in high intensity moderate magnitude earthquakes
  - Validated that bridges with post 1971 details performed reasonable well
  - Validated that seismically retrofitted bridges performed well
  - The post-Sylmar EQ expansion joint retrofitted bridges performed with mixed results

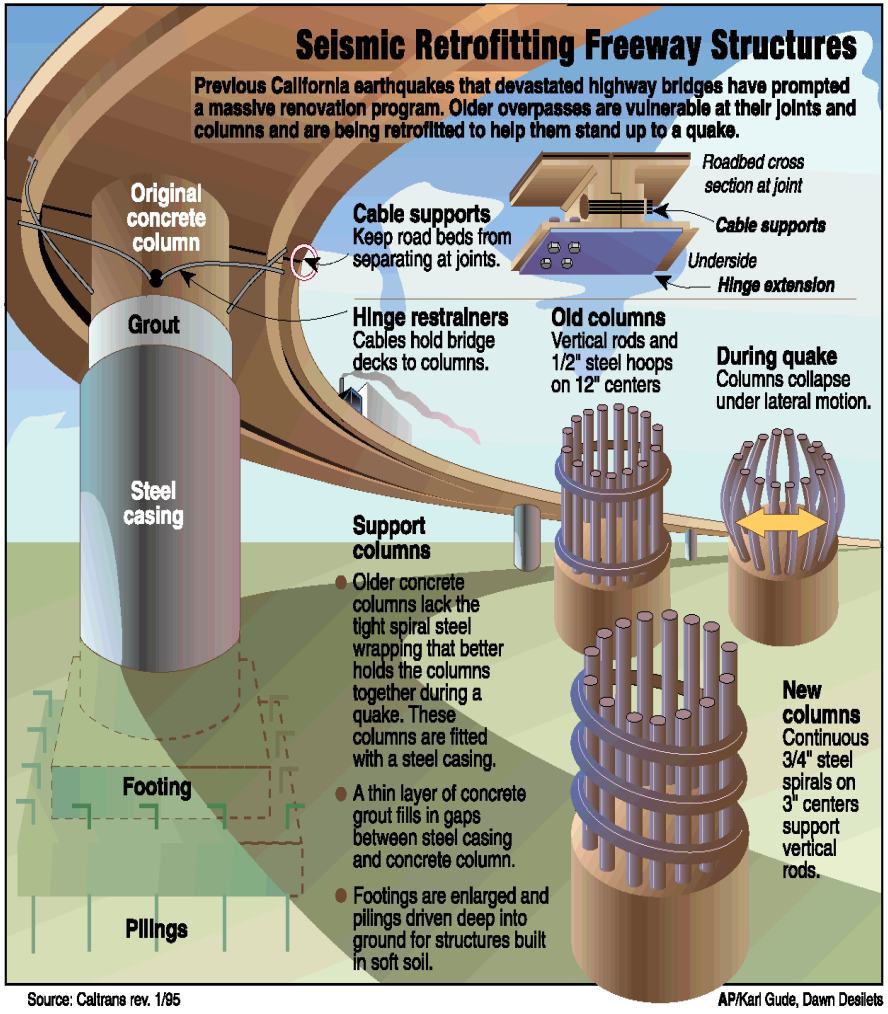
Northridge Outcomes – Statewide



Northridge Outcomes–Transportation

- Northridge provided the impetus for the passage of the Seismic Retrofit Bond Act of 1996 (Prop. 192)
  - The damage in Northridge demonstrated the need to expand the program to include multi-column bridges
  - Augmented the bridge seismic retrofit program initiated under emergency legislation (SB36x) after Loma Prieta
  - 1209 additional bridges were added to the program
  - Prop 192 provided $ 2 billion to fund the State owned toll bridges and the Phase II seismic retrofit program

State Bridge Retrofit Program



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

Phase 2, 99.99% Complete
1155 bridges
$1.35 billion

Local: 73% complete
912 of 1242 bridges
$1.96 billion

Toll: 100% complete
$8.69 billion

Bridge Seismic Retrofit Program

Location	Bridges	Stated Owned	Locally Owned
Statewide	Total Bridges	13,500	14,225
	Retrofitted Bridges	2,200	912
Los Angeles County	Total Bridges	2,124	2,749
	Retrofitted Bridges	555	282*

* 19 bridges in design or const.

Northridge Outcomes–Transportation

- Caltrans re-examined and modified its seismic screening and prioritization procedures.
- Near fault and thrust fault effects were incorporated into the seismic hazard characterization.
- New design criteria for new bridges and retrofitting bridges were adopted.
- Caltrans successfully employed incentive/ disincentive based contracting methods

Next Steps for Transportation

- Finish the Local Retrofit Program
- Continue seismic research …*in invaluable and indispensible investment…*
  - Advanced Materials
  - Multiple-Hazards
  - Earth Retaining Systems
  - Advanced Computational Techniques
- Improved Post-Earthquake Serviceability
  - Multi-Level Performance Criteria
  - Performance Based Earthquake Engineering

Next Steps for Transportation

- Rapid Repair and Recovery
  - Accelerated Modular Bridge Construction
- Post-Earthquake Assessment
  - Integrated structural instrumentation
  - Post-event investigation (worldwide)
  - Enhance web-based notification and assessment tools

Recommendations for Transportation

- Regularly re-assess the seismic hazard and engineering performance of the State's bridges including existing, retrofitted, and new structures.
- Regularly review and revise bridge seismic design criteria to reflect the latest seismology, geotechnical, and structural research findings.
- Continue to proactively initiate problem-focused seismic performance research for all transportation structures and systems.

Recommendations for Transportation

- Continue to develop performance based earthquake engineering methods that looks at bridges as part of an interconnected system.
- Continue to develop and implement expedited seismic design and construction techniques that allow for faster recovery from major seismic events.


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
Continuing Challenge
Stay Prepared
Competing Against Time (Maintain Interest)
Other Extreme Events
Challenge/ Opportunity Cycle

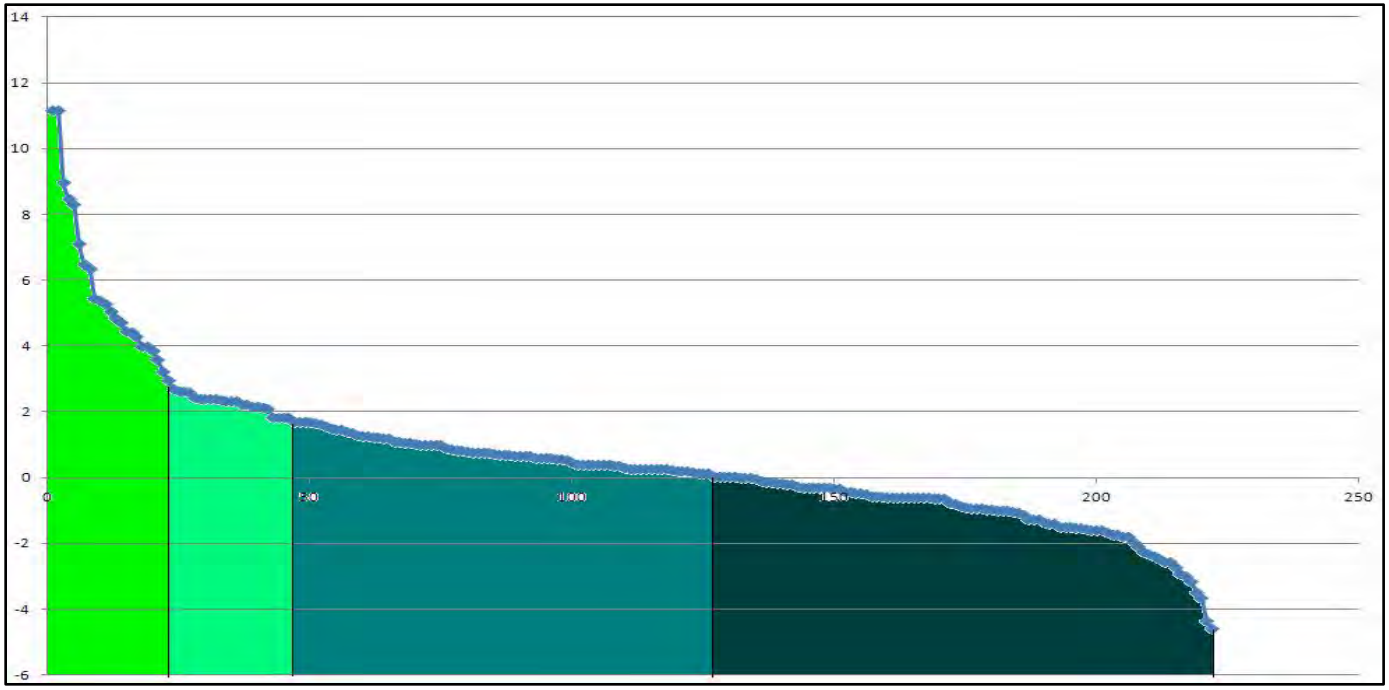
Earthquakes measure our actions, not our words.

Caltrans Seismic Advisory Board
"Race to Seismic Safety"

Next Steps for Transportation

- Caltrans is developing new algorithms to prioritize bridges for seismic vulnerabilities.

Score= (Vulnerability) x (Hazard)



Rank 1 Rank 2 Rank 3 Rank 4