Comparison of Major Earthquakes

Earthquake	Loma Prieta 1989	Northridge 1994	Kobe, Japan 1995	Kocaeli, Turkey 1999	Chi-Chi, Taiwan 1999	El Salvador 2001	Bhuj, India 2001	Bam, Iran 2004
Magnitude	7.0	6.7	7.1	7.4	7.6	7.6	7.7	6.6
Mitigation effort	moderate	moderate	Low	v. low	low	nil	nil	nil
Deaths	63	57	5,400	18,000	2,000	1,200	20,000	40,000+
Severely Damaged Buildings	5,700	1,000	150,000	115,000	80,000+	250,000+	1,120,000	>60% of structures collapsed

Failed column during the 1989 LPE and mitigation by wrapping with steel jackets

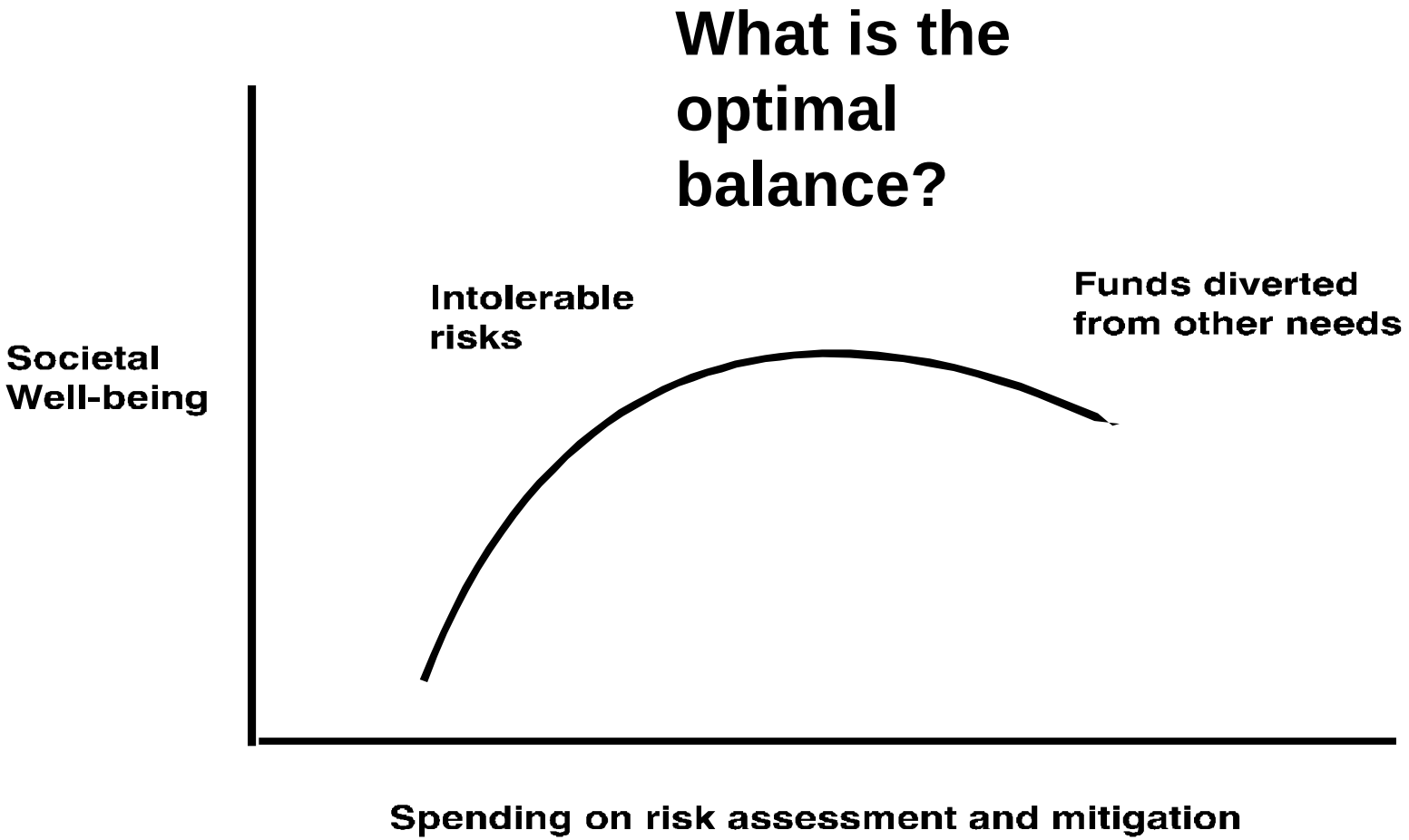
Steel Jacket

Carbon Fiber Jacket

Collapsed Murrah Building in OK City

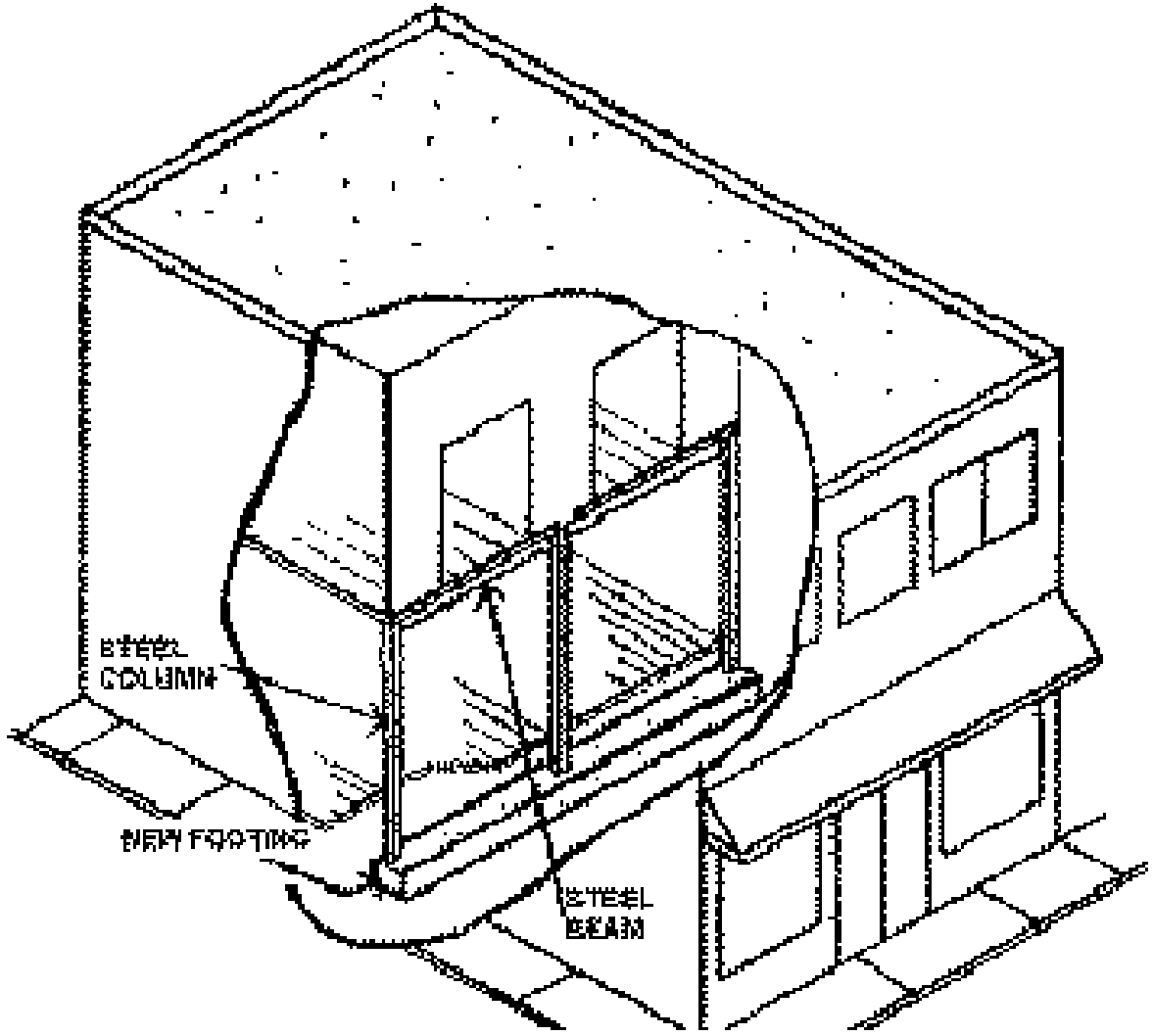
Even moderate EQ Design Measures Benefit Other Hazards

Expenditure on mitigation involves making judgments of losses



Soft first-story failure of unreinforced masonry during the 1989 Loma Prieta Earthquake (garage was on first floor)

Steel bracing added to avoid soft first-story failure:



Bracing installed in the garage of a San Francisco Marina District home following the 1989 LPE

Infilling openings to avoid soft first-story failure

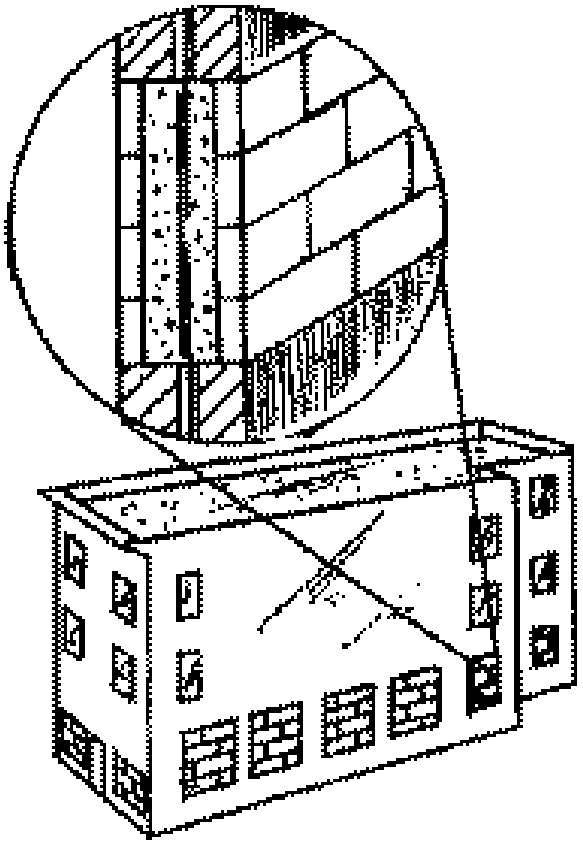
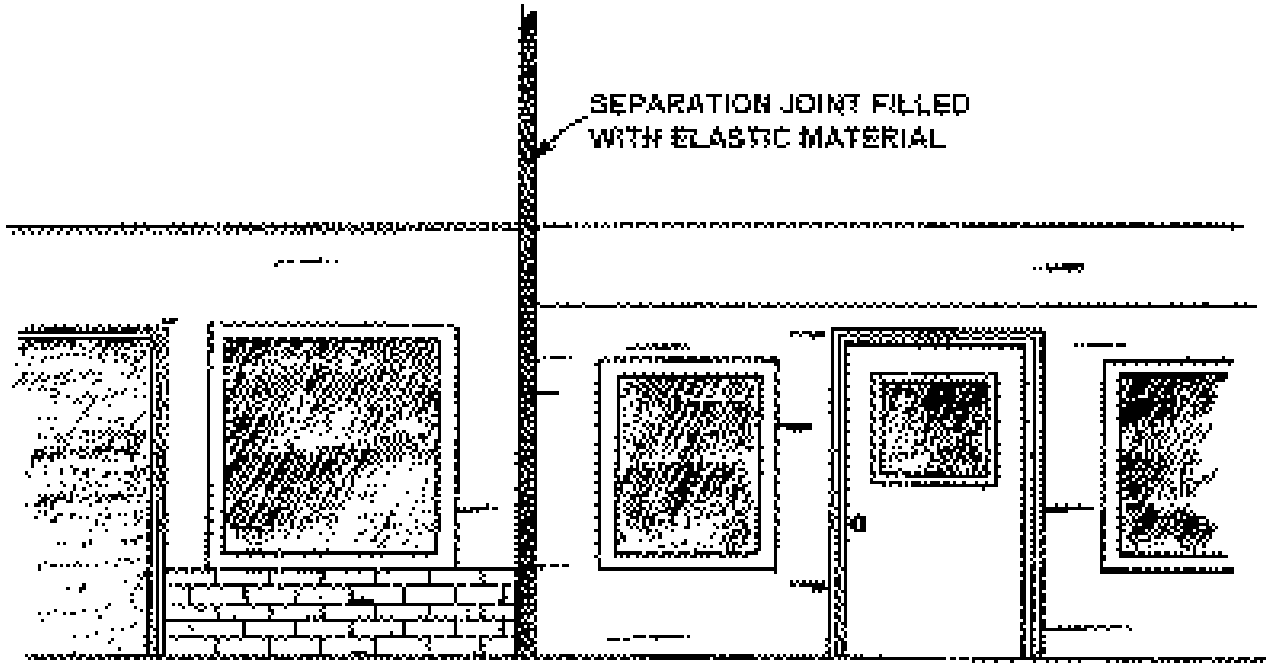


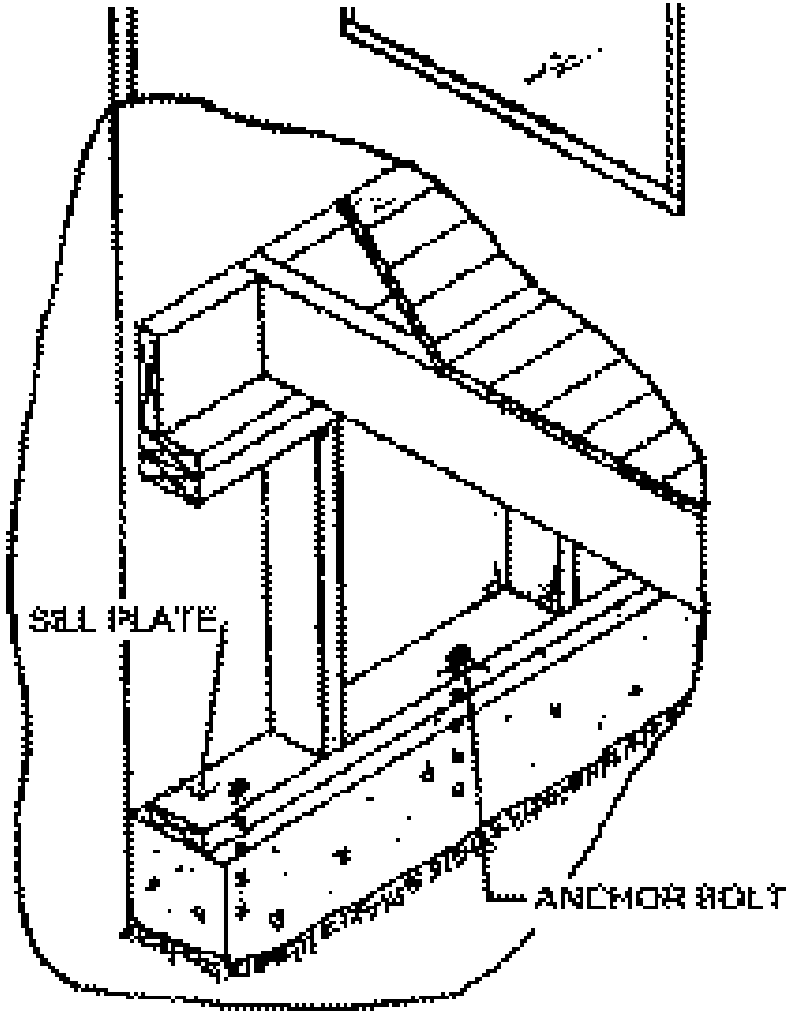
Photo of infilling openings to avoid soft first-story failure

Credit: NOAA (1999)

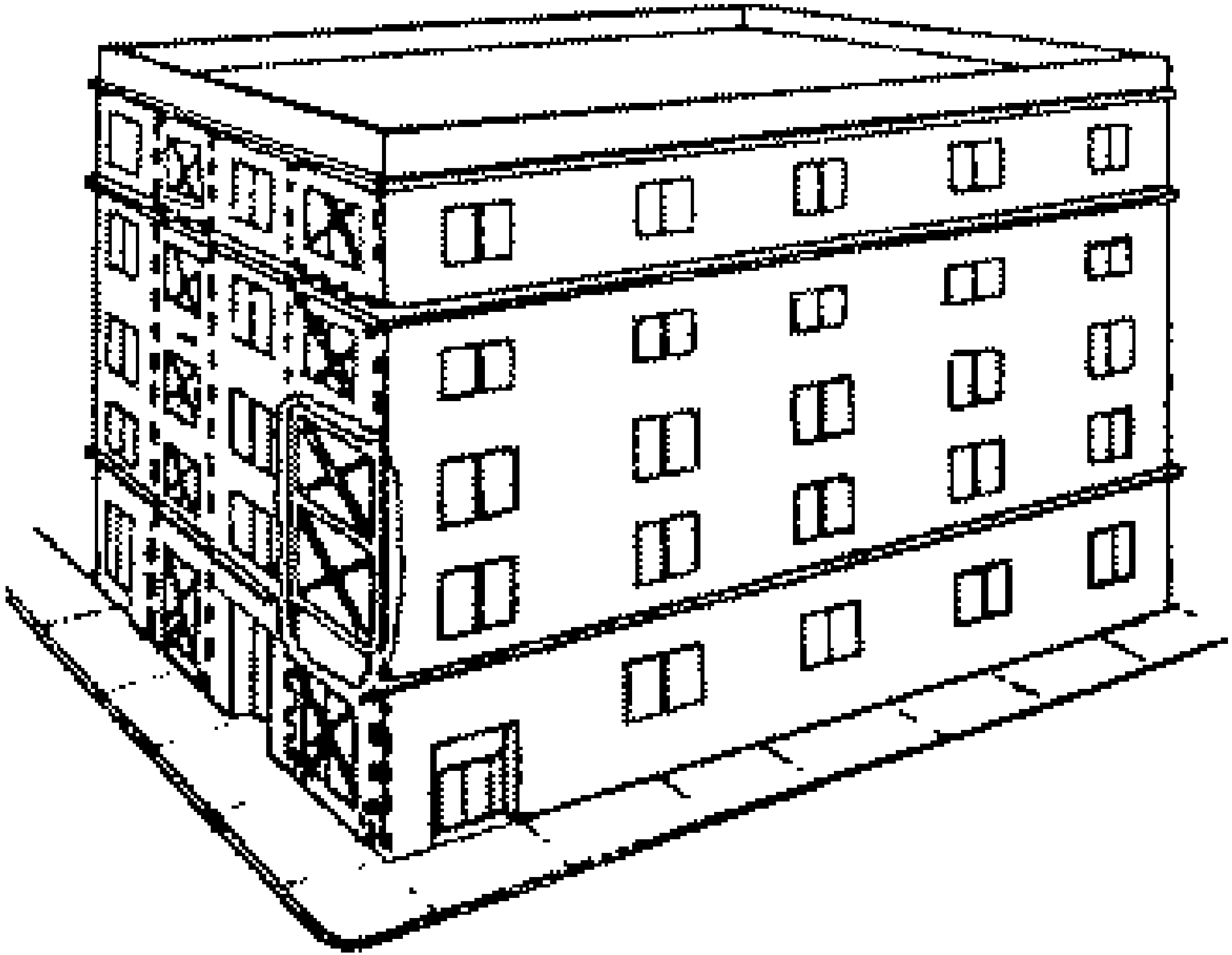
Separation joint filled with elastic material to prevent pounding



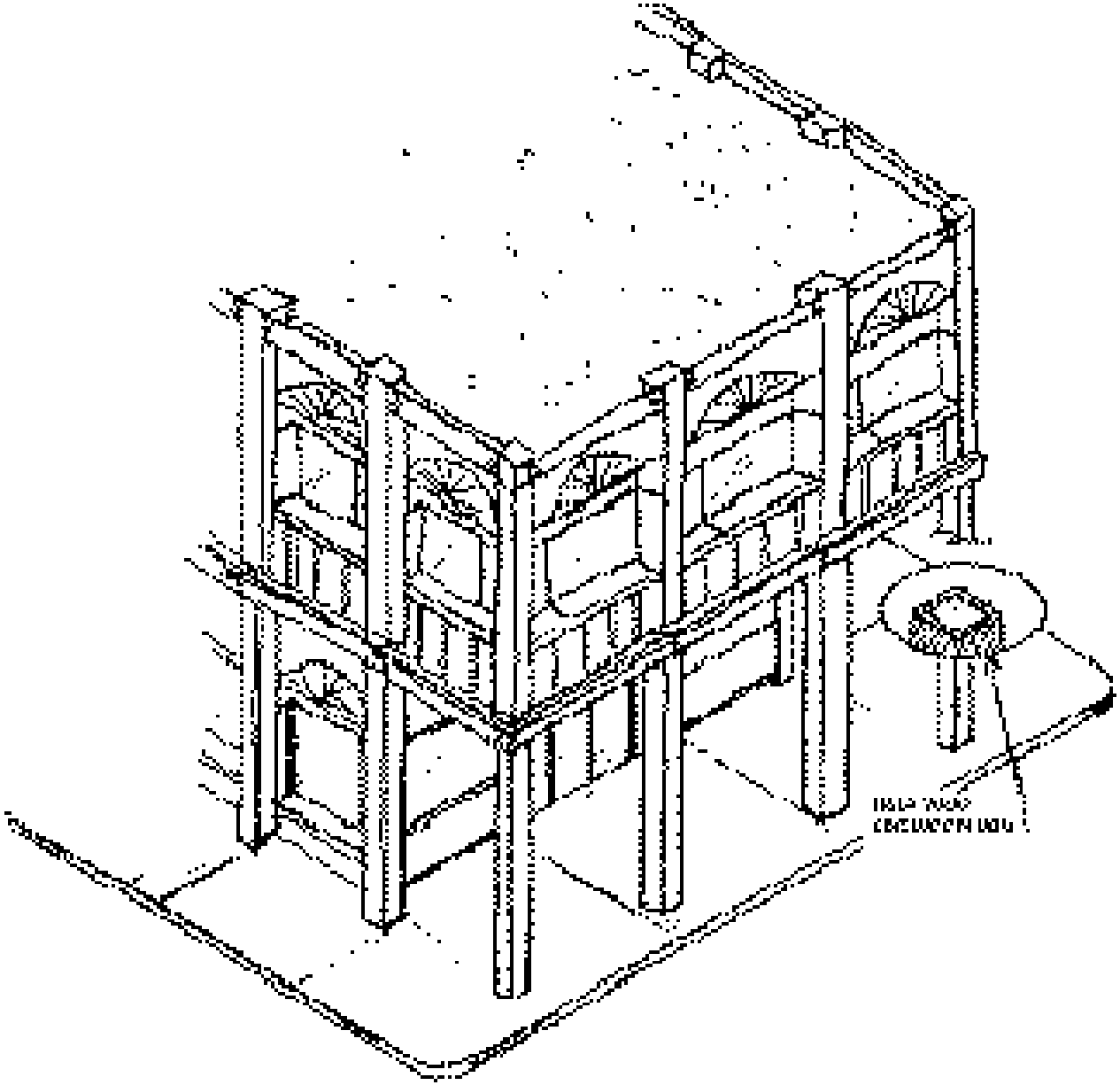
Bolting of sill plate to foundation (wooden structure)



Steel cross bracing added to increase seismic resistance (steel-framed building)

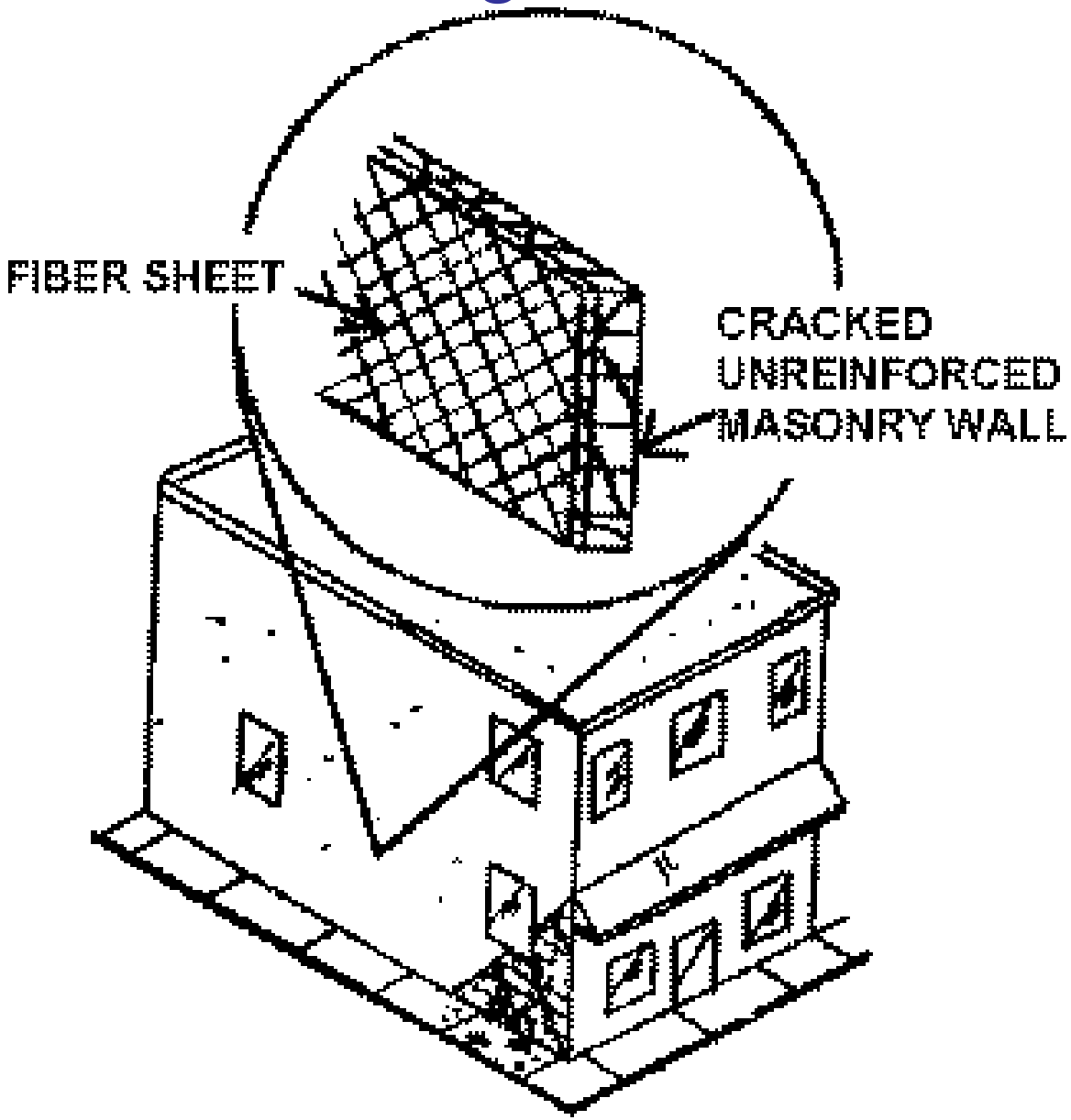


Column wrapped with carbon fiber in a reinforced concrete building

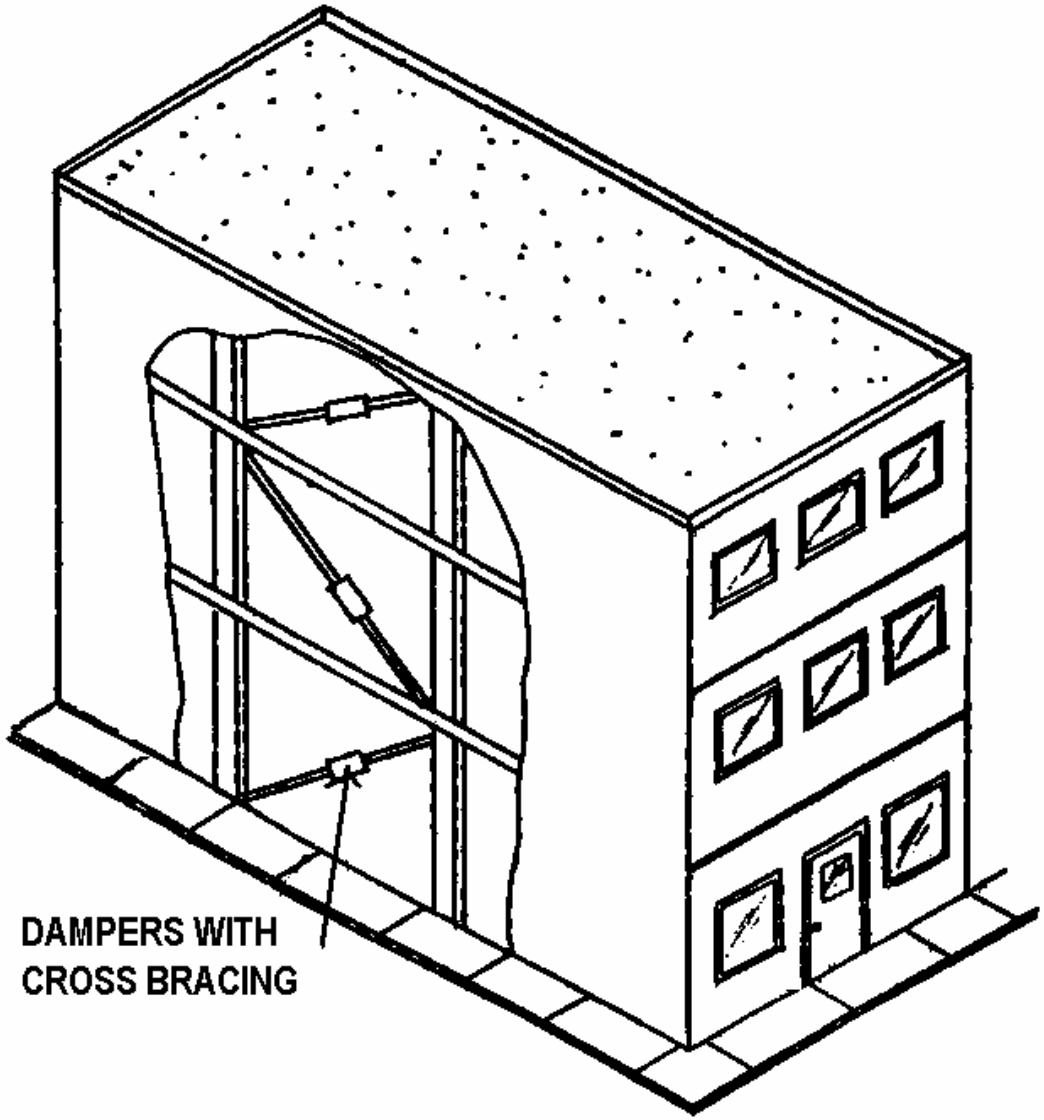


Failure of an unreinforced masonry structure during the 1989 Loma Prieta Earthquake

Wall strengthened in an unreinforced masonry (URM) structure using a fiber-reinforced sheet



Dampers added to reduce shaking of URM building during earthquake.

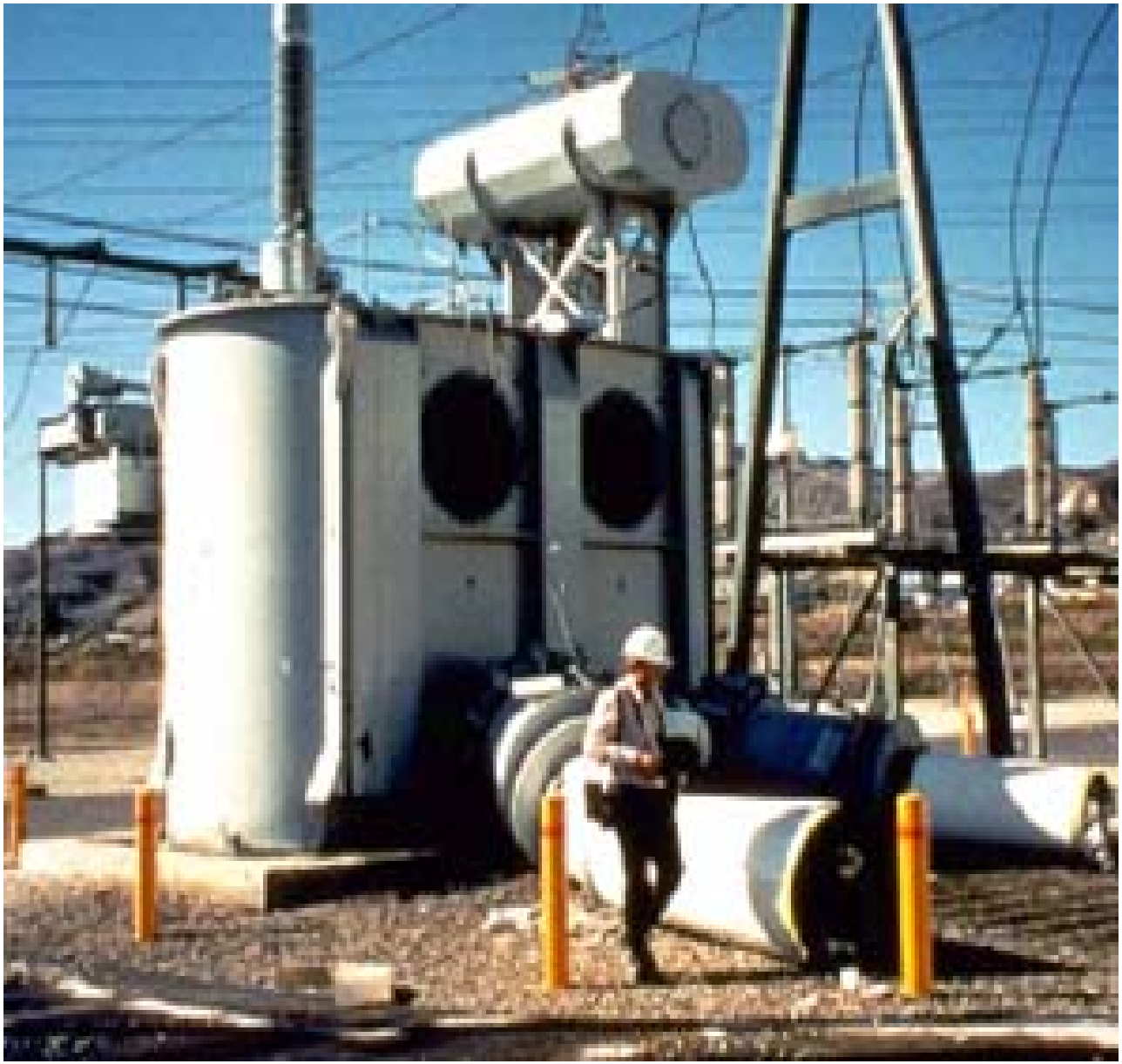


Dampers (four diagonal large “shock absorbers”) being installed in San Francisco

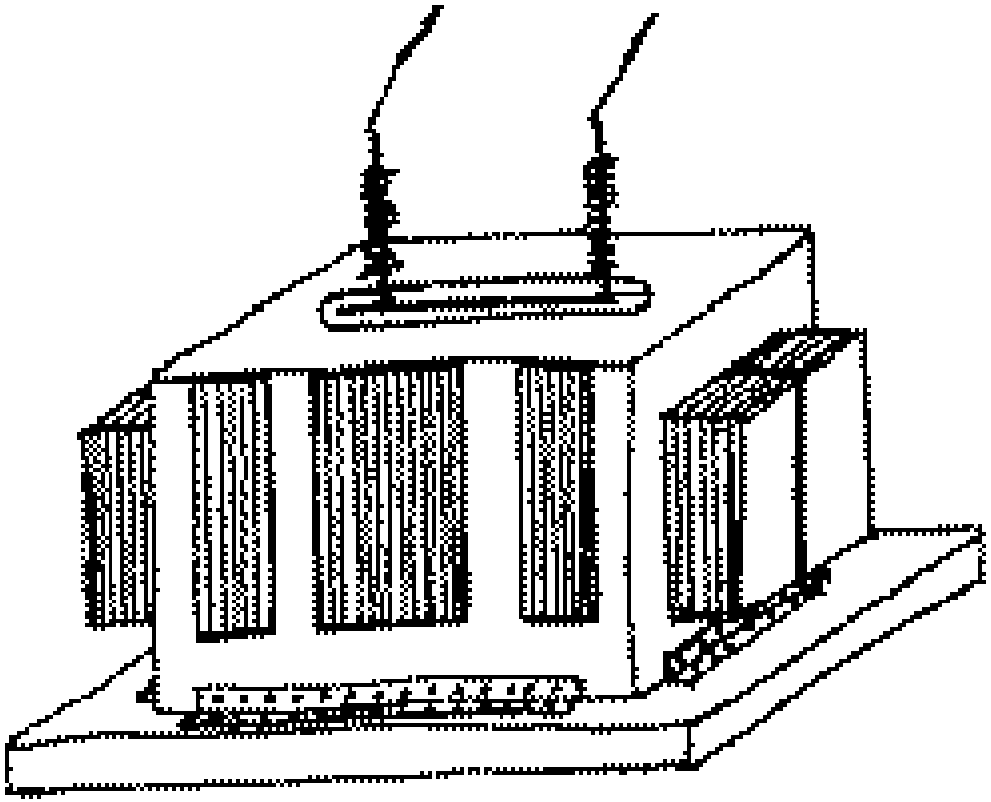
Base isolation bearing installed to support building columns

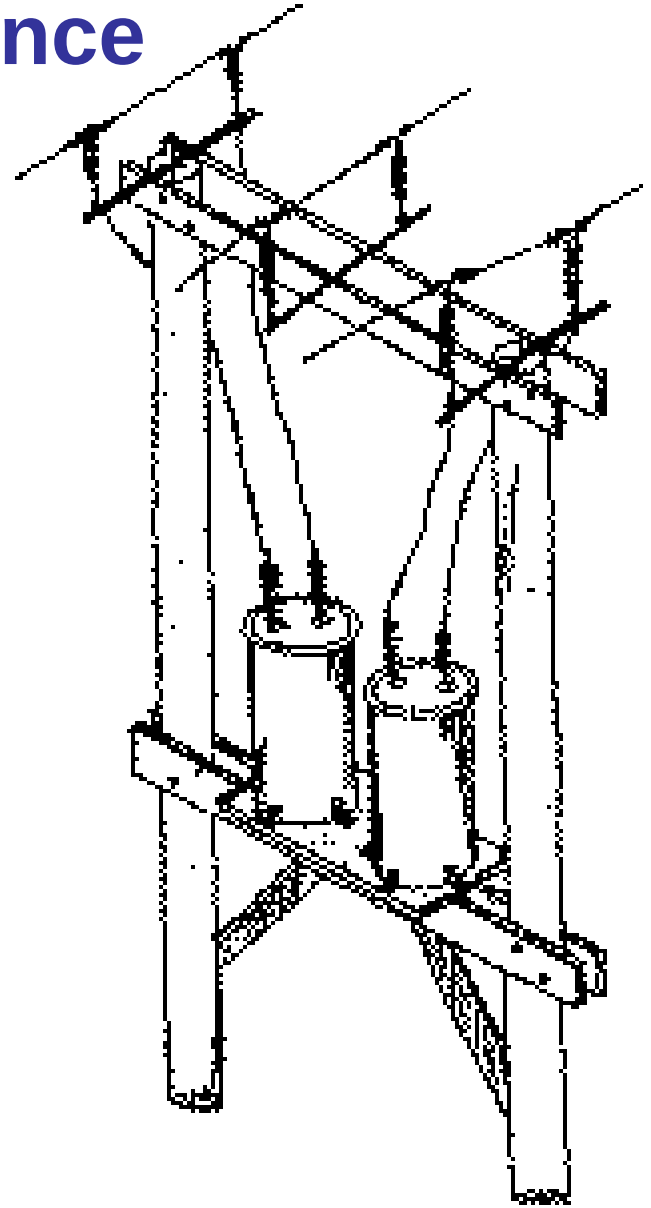
Credit: G. W. Clough

Transformer at power substation damaged during 1994 Northridge, EQ



Anchorage of transformers for increased seismic resistance





Fire in 1906 & 1989 San Francisco EQs

1906 San Francisco, EQ

1989 Loma Prieta, EQ

Broken gas line due to ground movements during 1994 Northridge Earthquake

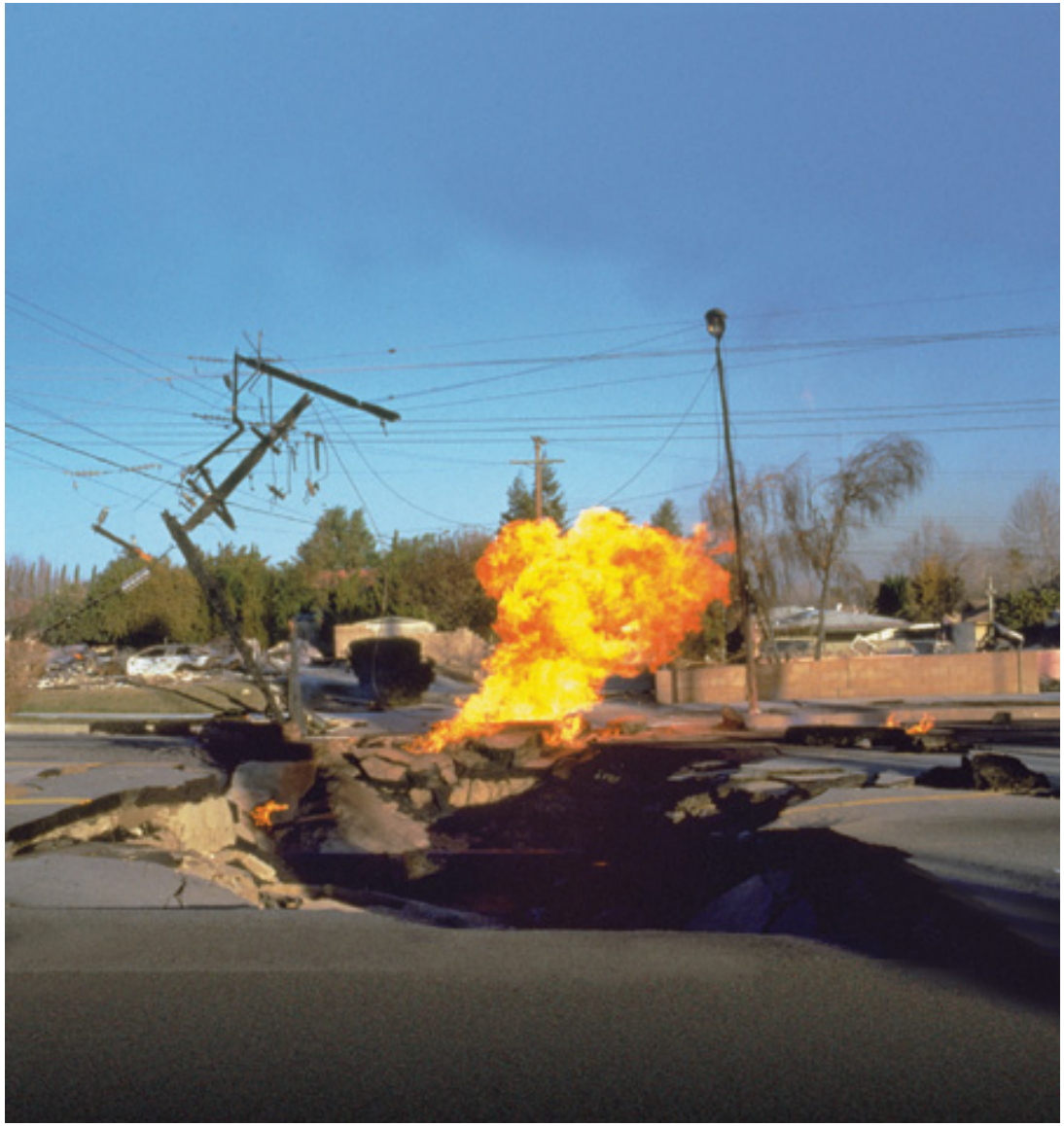
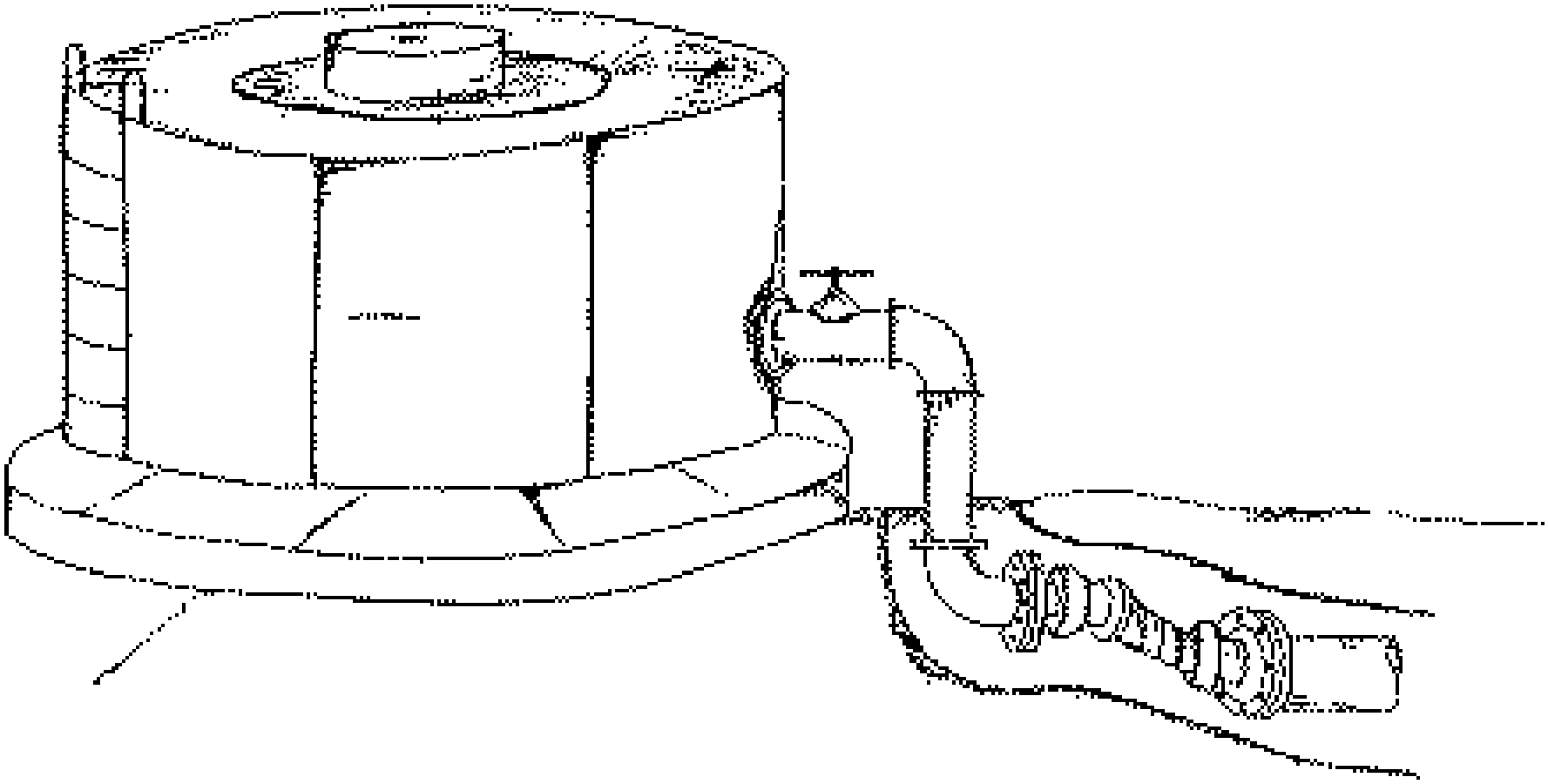
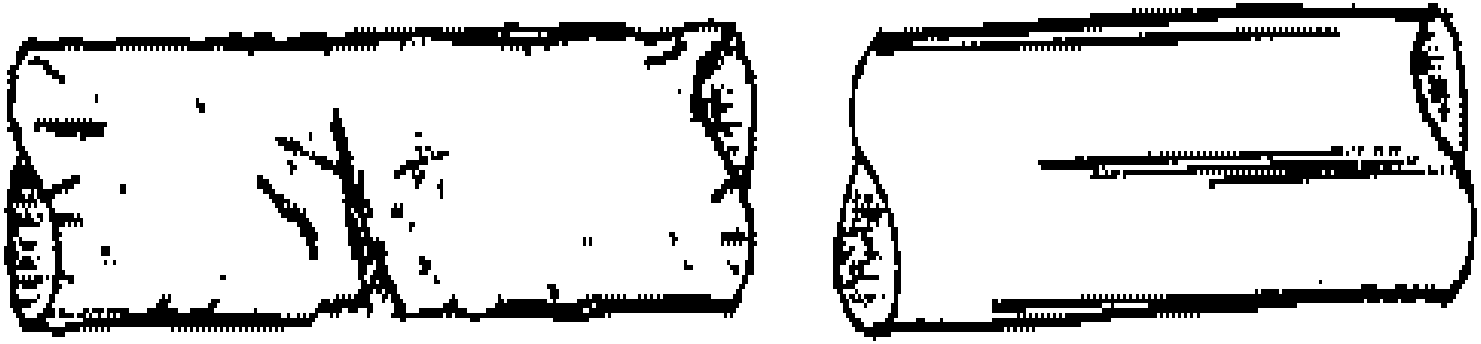


Illustration of flexible joint being used for connection to tank



Use of High Strength Steel Pipe Improves Performance



CAST IRON PIPE

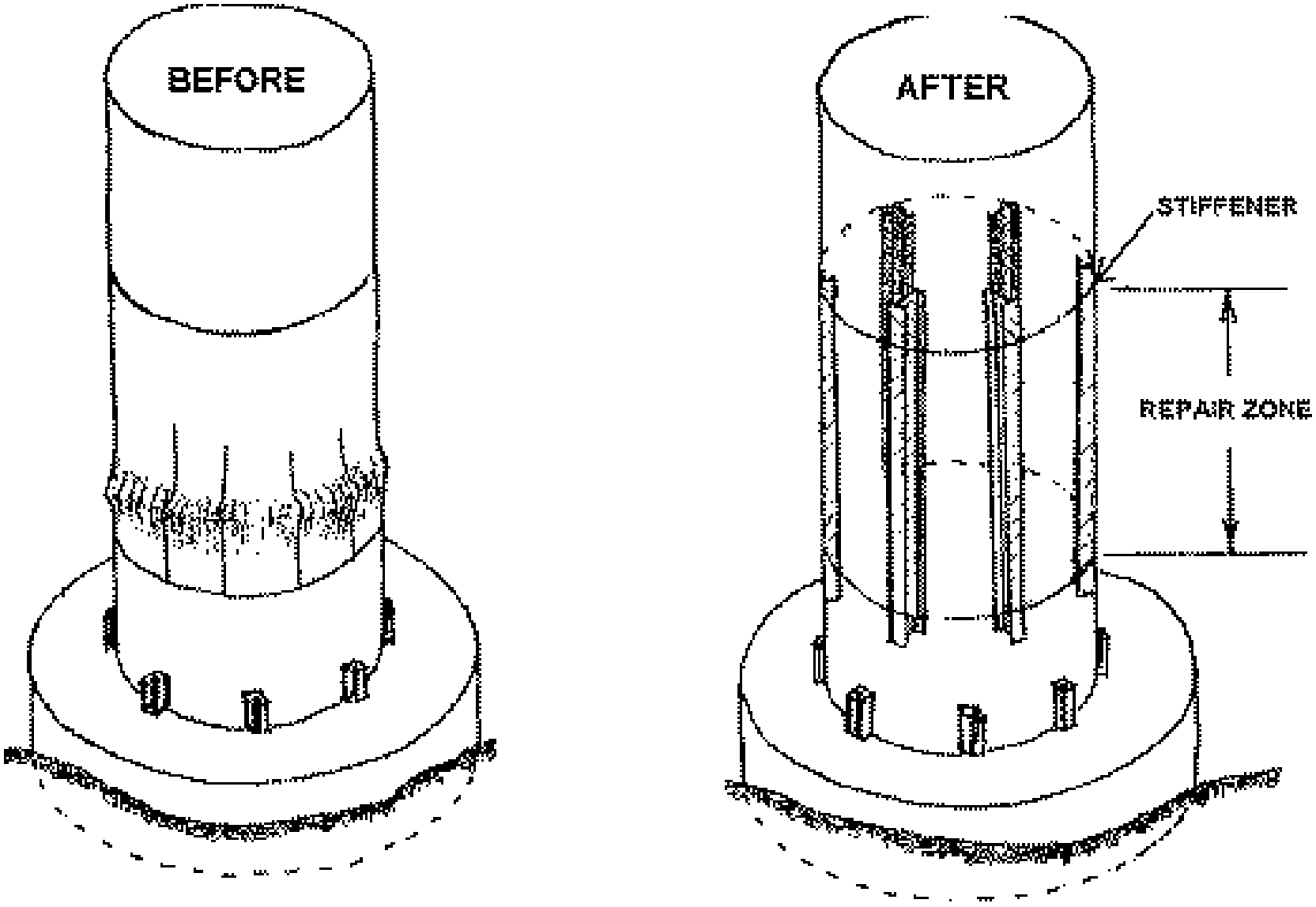
STEEL PIPE

The Alaskan oil pipeline is designed to withstand seismic forces

Tank damage (bulging at the bottom) following earthquake

Tank damage (bulging at the bottom) following earthquake

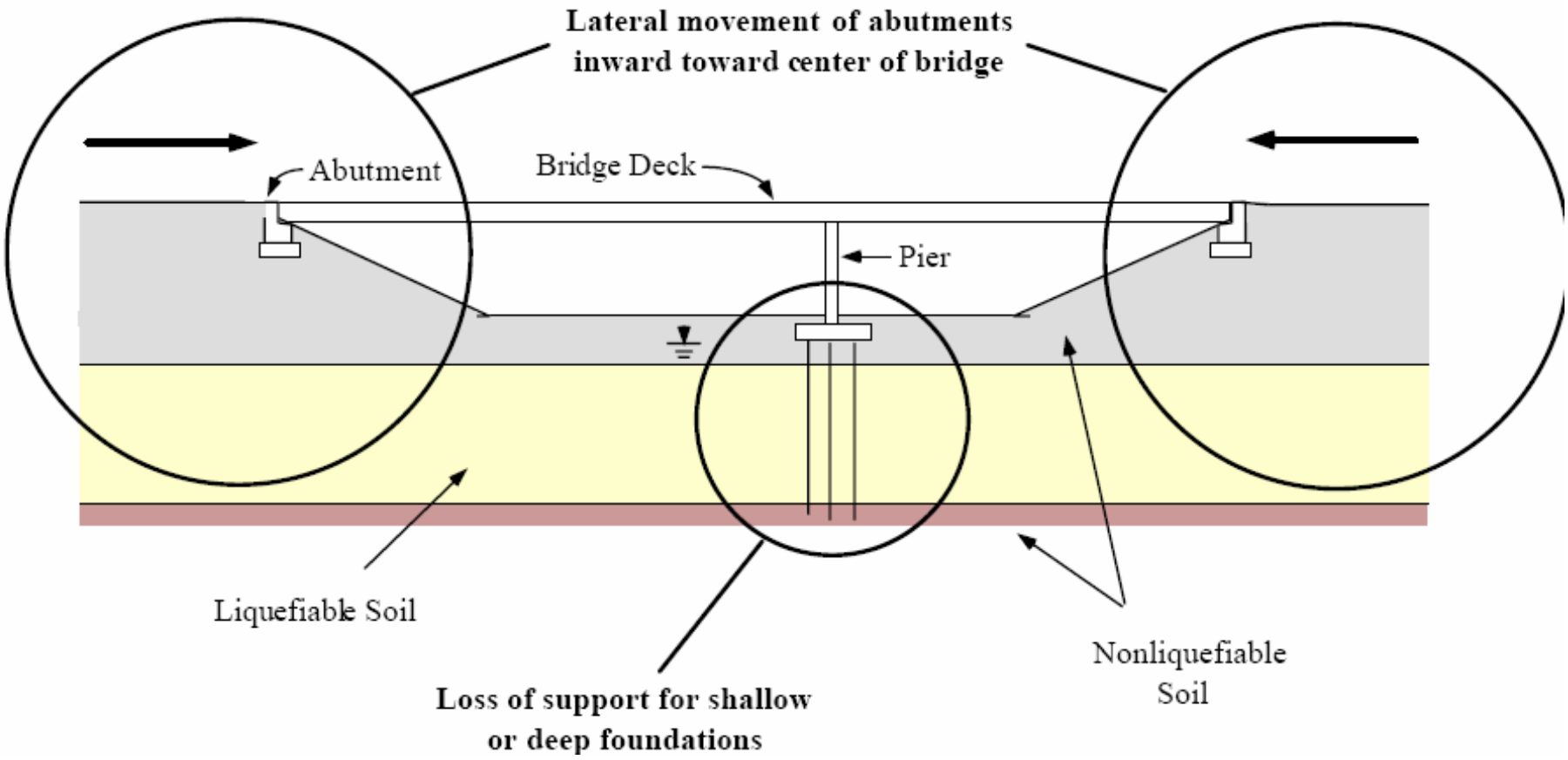
Illustration of damaged tank (left) and stiffening of tank walls (right) to mitigate earthquake shaking



Collapse of the Cypress Overpass During the 1989 Loma Prieta Earthquake

Steel jackets installed on LA highway columns

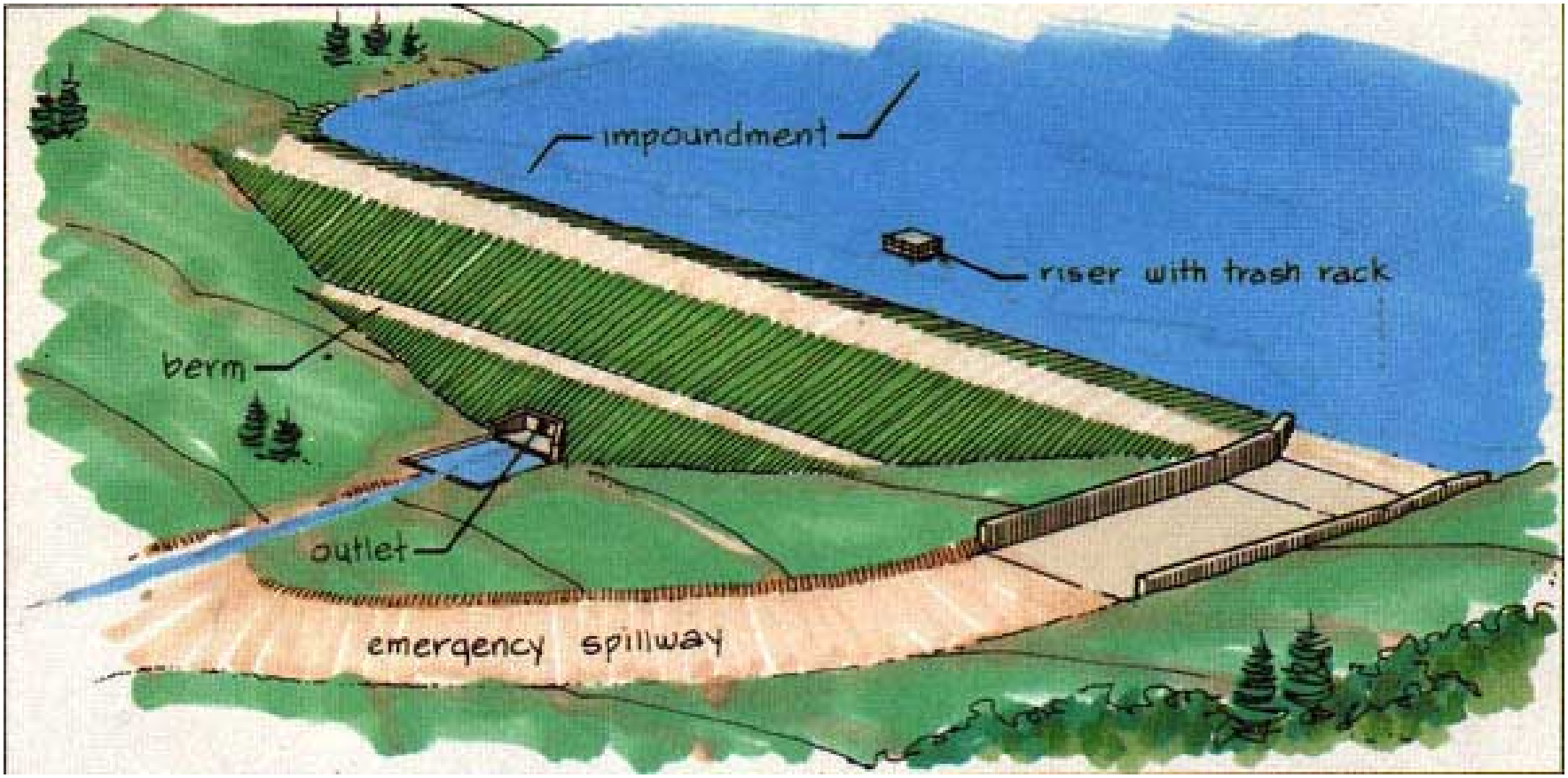
Critical areas where the presence of weak, liquefiable soil is particularly threatening to bridges



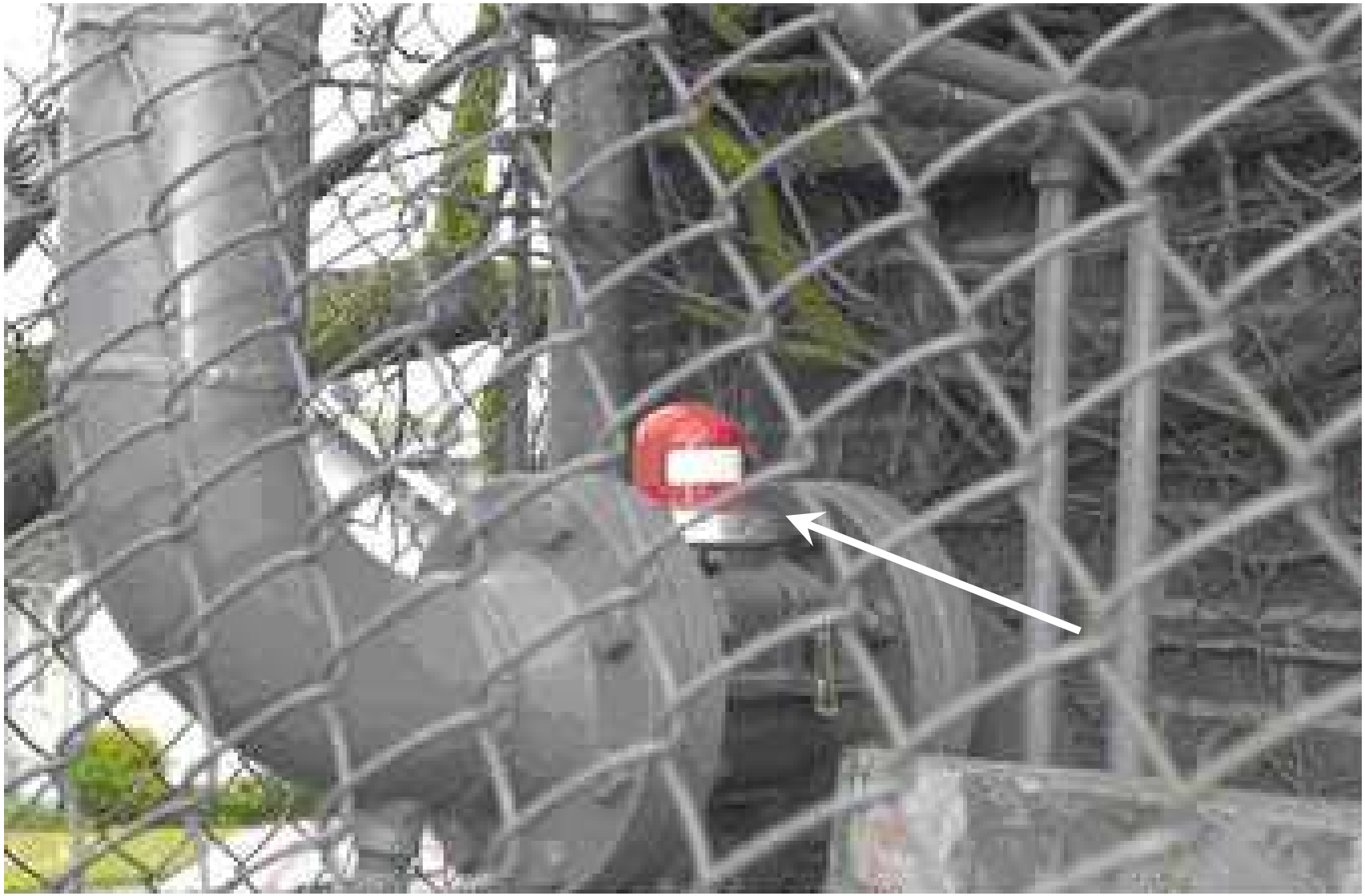
Soil being densified to prevent liquefaction

Failure of upstream embankment of Van Norman Dam following the 1971 San Fernando Earthquake

Schematic showing berm placed down stream to increase dam stability



Special gas valve designed to automatically shut off during an earthquake



Computers strapped down to table to prevent overturning during an earthquake

Bookcases strapped to wall to prevent overturning during and earthquake