



Seismic Hazards Mapping Act

Liquefaction Damage in Marina

1989 Loma Prieta Earthquake

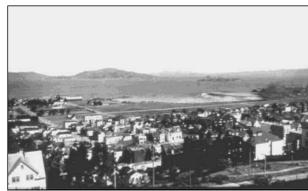
The Environment



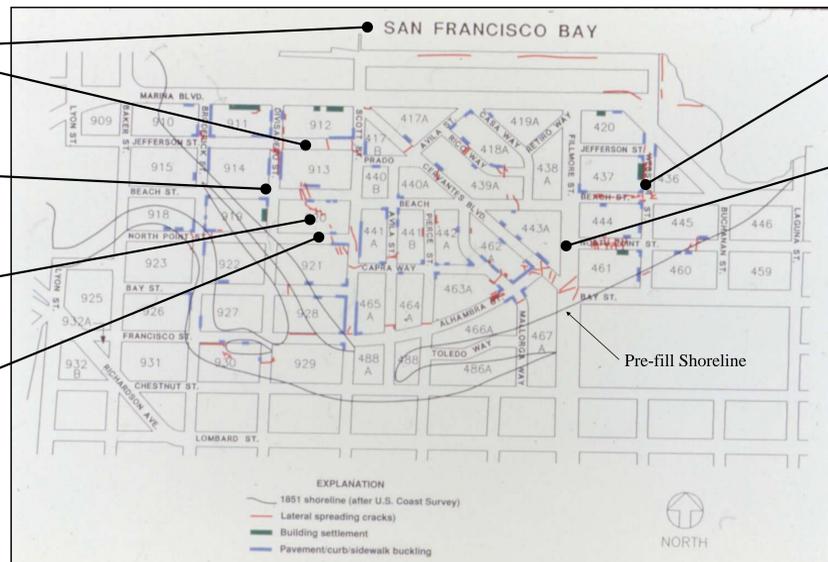
Marina District – Embayment Late 1800's



Pre-fill Shoreline over Today's



Marina District 1912 – Filling Begins



The Damage

Though 50 miles away, the 1989 M7.1 Loma Prieta Earthquake caused complete destruction of 35 buildings in the Marina District. Land in the high-priced Marina District was created when a lagoon was filled with dune sand and building rubble from the Great San Francisco Earthquake



of 1906 – to make fairgrounds for the Panama Pacific International Exposition. The poor soils increased the shaking, and failed as the area liquefied during the 1989 earthquake.



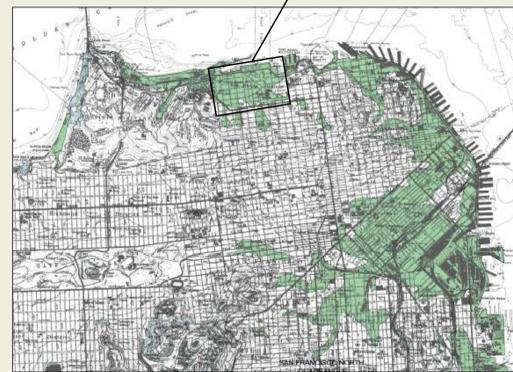
The Damage



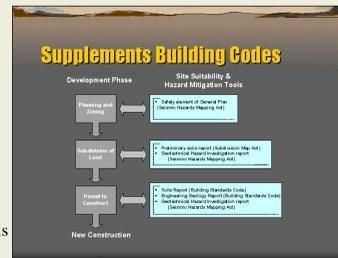
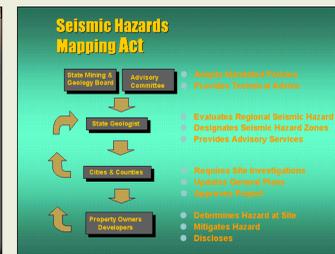
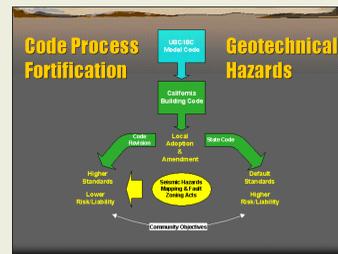
Broken gas lines and connections caused fires – broken waterlines inhibited fire suppression.



The Loss-Reduction Policy

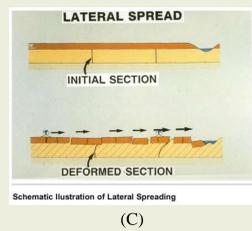
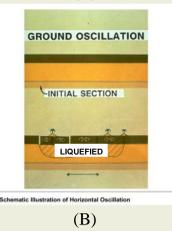


Although the Loma Prieta Earthquake caused only 63 fatalities, the severe economic loss (\$6 billion) was unexpectedly high for a moderate-distant event, initiating a new effort to control building damage through performance-based engineering. Seismic hazard zones identify where hazardous ground conditions are more likely, and trigger a process that leads to fortified construction where it is needed most.



The Cause

Ground failure accompanying liquefaction in the Marina District was caused by A) Loss of bearing strength – caused by fluid-like behavior of loose saturated ground that accompanies liquefaction, B) ground-oscillation – breakup of ground into disrupted blocks, and C) lateral spreading – horizontal movement down a gentle incline.



The Remedy

Stronger Foundations



Post-tensioned Slabs



Pilings

Ground Improvement

