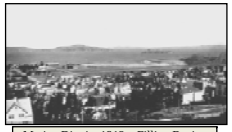
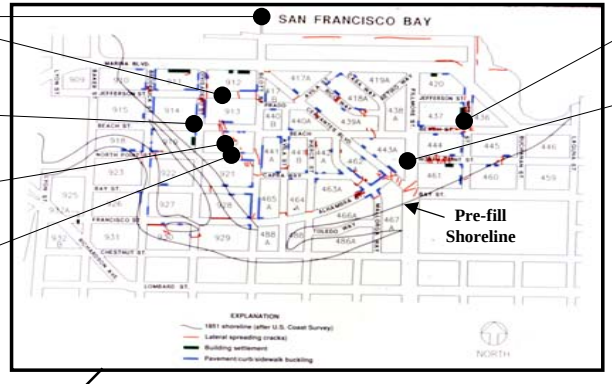
Liquefaction Damage In The Marina District From The 1989 Loma Prieta Earthquake

The Environment


Marina District – Embayment Late 1800's


Pre-fill Shoreline over Modern Shoreline

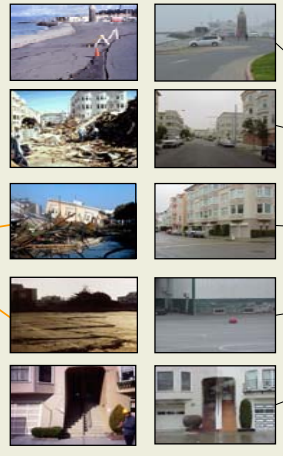

Marina District 1912 – Filling Begins



The Damage

Though centered 50 miles away, the 1989 M7.1 Loma Prieta Earthquake caused complete destruction of 35 buildings in the Marina District. Land in the 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 in 1915. The poor soil conditions (saturated, loose sands) in this area led to amplified shaking and liquefaction during the Loma Prieta Earthquake.

Then Now

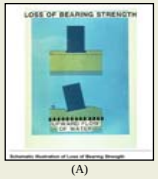


The Damage

Then Now

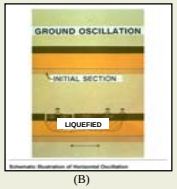
Broken gas lines and connections caused fires and broken waterlines inhibited fire suppression.

The Cause

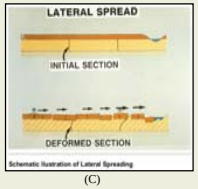


(A)

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



(B)



(C)

The Loss-Reduction Policy – Initiation of the Seismic Hazards Mapping Act and Program

SEISMIC HAZARDS ZONES
(northern portion of San Francisco)

Zones of Required Investigation
Liquefaction Zones
Earthquake-Induced Landslide Zones

In addition to the 63 fatalities from the Loma Prieta Earthquake, the severe economic loss ($6 billion) was unexpectedly high for an earthquake that was a moderate-distant from some of the areas that had damage due to ground failure, like the Marina District. This initiated a new effort to control building damage through performance-based engineering. In 1990, the Seismic Hazards Mapping Act was passed, mandating the California Geological Survey (CGS) to identify where hazardous ground conditions are more likely to occur. The Seismic Hazard Zone maps, like the one of the northern portion of San Francisco shown to the left, trigger a process that leads to fortified construction where it is needed most. For more information about earthquake hazards and CGS earthquake programs, visit the CGS website at **www.conservation.ca.gov/cgs**.

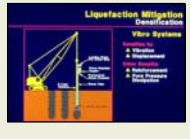
The Remedy

Stronger Foundations


Post-tensioned Slabs


Pilings

Ground Improvement



Note: Sources for photography, maps, and other information are California Geological Survey (CGS) and Earthquake Engineering Research Institute (EERI).