Risk of a major earthquake in the Bay Area, and Likely Disaster Scenarios

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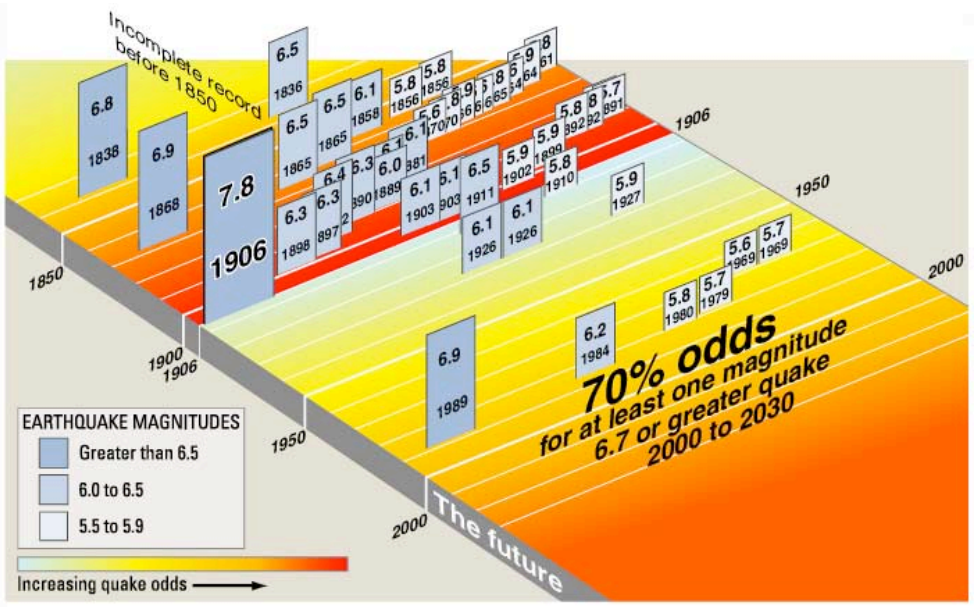
Bay Area Earthquakes

It has been 101 years since the 1906 San Francisco earthquake and fire. That event has endured as one of the most widely known disasters in the world. Almost 300 miles of the San Andreas Fault ruptured shortly after 5 am on April 18, 1906, affecting portions of 19 counties, from Mendocino in the north to Sacramento in the east and Monterey in the south. The ground shaking and ensuing fires caused more than 3,000 deaths, destroyed over 28,000 buildings, and left homeless about 225,000 of Northern California's one million residents.

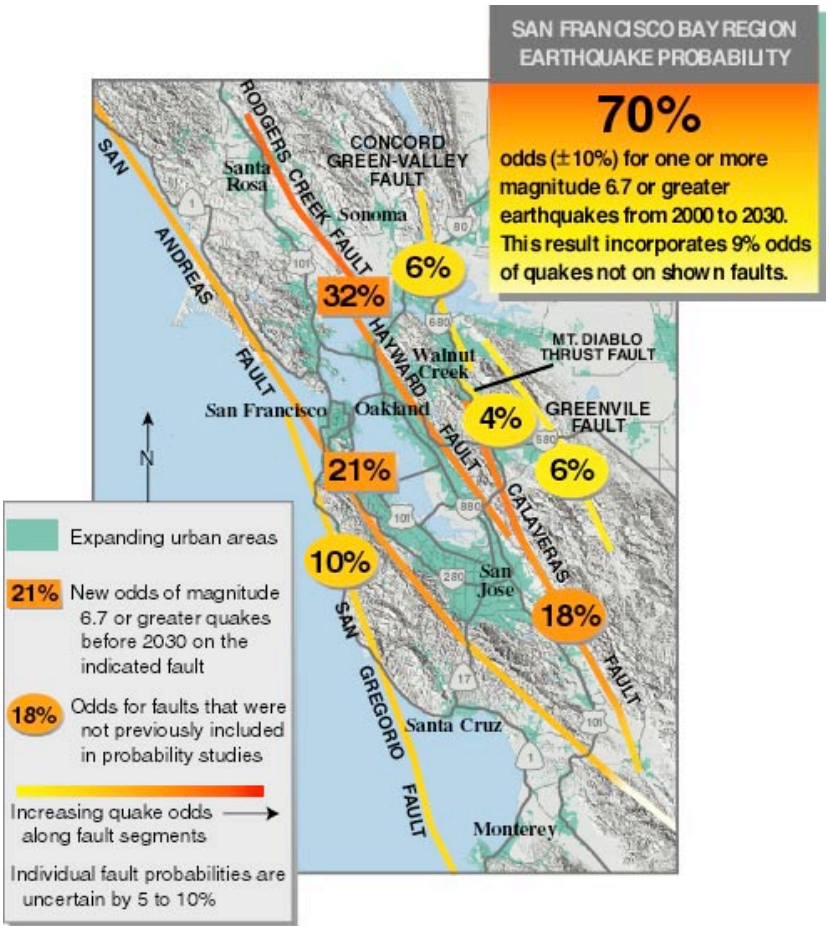
Today the Bay Area is enjoying a long period of relative quiet on the seismic front. Our most recent memory of a major northern California earthquake is the 1989 Loma Prieta earthquake, 18 years ago. The 1989 Loma Prieta earthquake lulled Bay Area residents into thinking they could survive the big one. But the 1989 Loma Prieta earthquake was not the big one, and with epicenter 60 miles away it was not even a Bay Area earthquake.



Source: USGS

What would happen today if the M6.9 Loma Prieta earthquake occurred closer to the Bay Area, on the Hayward fault that slices through the East Bay? The closest comparison we have is the 1995 Kobe Japan earthquake. That temblor, also M6.9, ruptured through the city of Kobe, killed more than 6,000 people, and caused $100 billion in damage. It knocked out elevated expressways, railway systems, highways, ports, and harbors. It could happen to us.

What are the chances of this happening to the Bay Area in the near future? Research by the U.S. Geological Survey (USGS) and other scientists concludes that there is a 70% probability of at least one magnitude 6.7 or greater quake, capable of causing widespread damage, striking the San Francisco Bay region before 2030.



Source: USGS

Likely Disaster Scenarios

In the 101 years since the 1906 San Francisco earthquake, the Bay Area has grown tremendously. The population has increased ten fold. That population has moved into the San Francisco Bay margins, some on reclaimed land, where it is more vulnerable to earthquake effects. And it is more dependent on a complex infrastructure of utilities, roadways, and communications. While we believe we are designing safe structures today, much of the seismic risk we face is a result of the built environment that was put in place before seismic design requirements were well understood. What would happen if there was a repeat of the 1906 earthquake today?

To answer this question, the Earthquake Engineering Research Institute (EERI), Seismological Society of America (SSA), California Governor's Office of Emergency Services (OES), and U.S. Geological Survey (USGS) commissioned teams of experts to conduct a comprehensive simulation and analysis of potential losses due to a repeat of the 1906 earthquake. What follows focus on that occurrences, but a similar scenario is likely for a major earthquake on the Hayward fault.

The report, "When the Big One Strikes Again," found that if the 1906 earthquake were to happen today, it would affect many of Northern California's nearly 10 million residents and cost between $90 and $120 billion to repair or replace the more than 90,000 damaged buildings and their

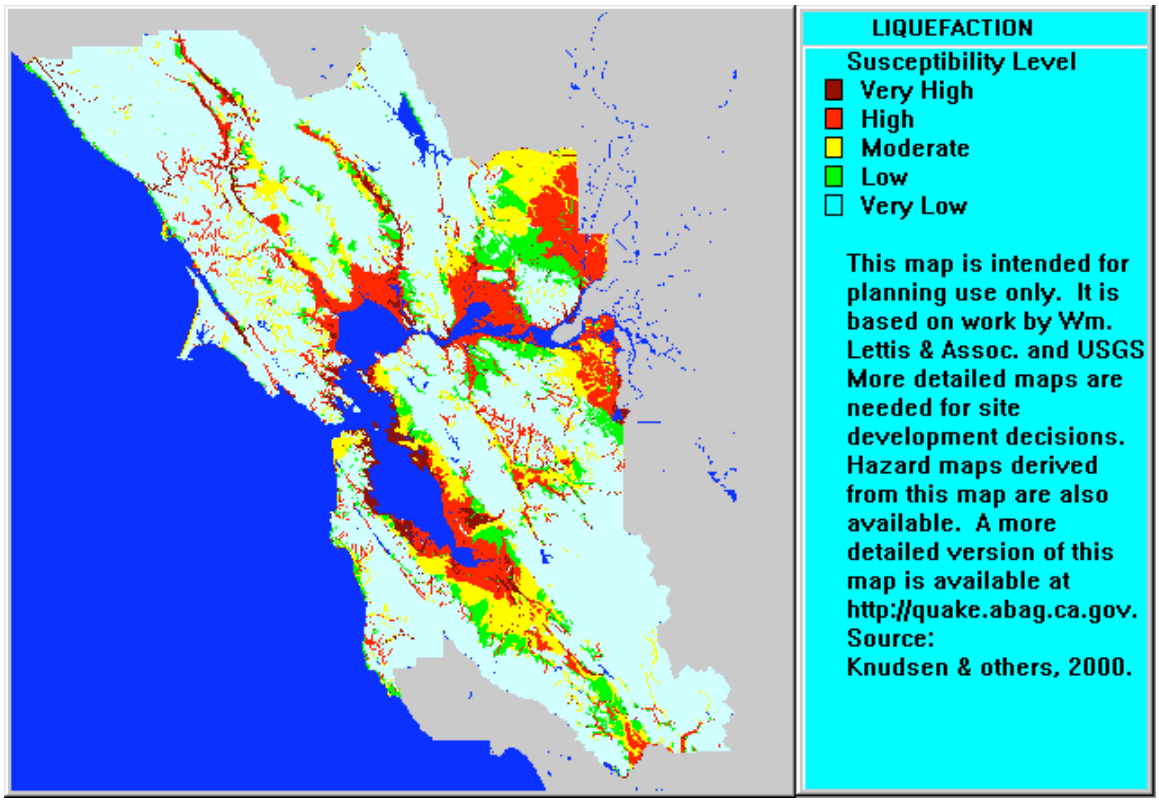
contents. As many as 10,000 commercial buildings would sustain major structural damage and between 160,000 and 250,000 households would be displaced from damaged residences. Depending upon whether the earthquake occurs during the day or night, building collapses would cause 800 to 3,400 deaths. More than half of these deaths would result from the collapse of old concrete, unreinforced masonry, and other vulnerable buildings yet to be strengthened. These older, dangerous structures comprise less than 5% of the region's building stock; structures built after the mid-1970s are generally much safer.

Subsequent individual fire ignitions would damage an additional 5% to 15% of the region's buildings and cause additional deaths. A conflagration similar in scale to the 1906 fire is possible and could cause an immense loss, but is not considered in this scenario. Damage to utilities and transportation systems would increase losses by an additional 5% to 15%, and economic disruption from prolonged outages would cost several times this amount. Considering all loss components, the total price tag for a repeat of the 1906 earthquake is likely to exceed $150 billion.

The 1906 scenario study focused on buildings. What would be the impacts on transportation systems or other infrastructure? Comprehensive studies of these systems have yet to be completed. But one can speculate on likely scenarios.

A major source of damage to transportation systems and other infrastructure will be liquefaction of soils in the San Francisco Bay margins. Liquefaction is a phenomenon whereby loose soil deposits liquefy not unlike quicksand when strongly shaken by an earthquake. When the marshy ground around the San Francisco Bay was filled, it produced land that is now susceptible to liquefaction. What might this impact?

- Utility pipelines – Liquefaction leads to ground movement, which can fail pipelines. The most vulnerable pipelines are typically those carrying sewage because they are made of the most brittle materials and do not have sealed joints. The next most vulnerable are water pipelines. Some pipelines carrying natural gas are also vulnerable, though utilities such as Pacific Gas & Electric are upgrading and replacing vulnerable pipelines.
- Delta levees – The Delta levees are made land that in many cases has not been properly engineered or maintained. The system is highly vulnerable to effects of ground failure. One or more failures could inundate large tracts of land and disrupt water supplies throughout the State of California.
- Highways, roads, airport runways – Many roads and other pavements traverse reclaimed land and will be susceptible to liquefaction damage and closure. Oakland and San Francisco airports are built on non-engineered fill, atop Bay Mud, while San Jose airport crosses series of ancient river channels. Liquefaction at these facilities is likely to require repairs and closures lasting days to weeks. Upgrading of these facilities to prevent liquefaction damage prior to the next earthquake generally is not economically feasible.
- Ports and harbors - In the Bay Area, port and harbor facilities commonly are built on man-made fill typically placed over Bay mud, which amplifies earthquake shaking, and is vulnerable to failure. Ports consist of bulk storage facilities and warehouses, cranes to move large containers, and rail and other facilities that serve to connect the port to the land-side transportation system. The Port of Oakland is taking measures to toughen its facilities, but complete upgrading is not likely to be completed for many years.



Major transportation agencies have taken steps to strengthen their systems against the effects of earthquakes. The California Department of Transportation (Caltrans) has mostly completed its program to strengthen over 2000 bridges statewide, including the Richmond-San Rafael, Benicia-Martinez, San Mateo-Hayward, Carquinez, and parts of the San Francisco-Oakland Bay Bridge (The Golden Gate Bridge under separate authority also has been retrofitted). Until the replacement to the east span of the San Francisco-Oakland Bay Bridge is completed around 2013, it remains vulnerable to the effects of strong earthquake shaking. A major earthquake today could result in heavy damage to the Bay Bridge, leaving it out of service for many weeks. Other bridges spanning the Bay would sustain limited damage to approaches, which likely would affect transportation patterns for days until repairs were completed.

The Bay Area Rapid Transit (BART) system is well along in its Earthquake Safety Program. A system-wide vulnerability study completed in 2002 identified the Transbay Tube, aerial structures, stations, and equipment as being particularly vulnerable to damage. The study concluded that if the BART system is not strengthened, a major earthquake could result in the BART system being out of service for several years. Repair costs could approach $1 billion, and subsequent economic disruption caused by a prolonged BART system outage would be several times this amount. BART has embarked on a seismic retrofit program, with the Transbay Tube retrofit scheduled to be completed at the end of 2010, and the rest of the system completed in 2013, but until then the system is vulnerable.

Earthquake Professionals' Top Ten Actions for Northern California

As part of the preparations for the centennial of the 1906 San Francisco earthquake and fire, earthquake scientists, engineers, and emergency management experts in Northern California developed a top ten list of action items to increase safety, reduce losses, and ensure a speedier recovery from the next major earthquake. Their list follows:

Develop a Culture of Preparedness

1. Every household, government agency, and business must know the seismic risks of the buildings they occupy, the transportation systems they use, and the utilities that serve them, as well as the actions they can take to protect themselves.

2. Every household, government agency, and business needs to be prepared to be self-sufficient for at least three days (72 hours) following a disaster.

3. Citizens and governments need to take steps to ensure adequate response care for special needs and vulnerable populations.

4. Government agencies, the region's major industries, and earthquake professionals have to work together to prepare the region to respond to and recover from major earthquakes. This can be done through region-wide, multi-organizational plans, training, exercises and coordination assessments, as well as continuing improvements in our collective understanding of seismic risks.

Invest in Reducing Losses

5. Building owners, governments, and the earth science and engineering professions must target potential collapse-hazard buildings for seismic mitigation, through retrofit, reduced occupancy, or reconstruction.

6. Governments and other relevant agencies must retrofit or replace all facilities essential for emergency response to ensure that they function following earthquakes. These facilities include fire and police stations, emergency communications centers, medical facilities, schools, shelters, and other community-serving facilities.

7. Governments and other relevant agencies must set priorities and retrofit or replace vulnerable response- and community-serving infrastructure, including cellular communications, airports, ports, roads and bridges, transportation, water, dams and levees, sewage and energy supplies, to ensure that functions can be resumed rapidly after earthquakes.

Ensure Resiliency in Recovery

8. Government agencies, the region's major industries, and earthquake professionals have to plan collaboratively for the housing, both short- and long-term, of residents displaced by potential fires, large numbers of uninhabitable buildings, and widespread economic and infrastructure disruption following a major earthquake.

9. Every household, government agency, and business has to assess and plan for financing the likely repair and recovery costs following a major earthquake.

10. Federal, state and local governments, the insurance industry, and the region's major industries have to collaborate to ensure adequate post-event funding to provide economic relief to individuals and communities after a major earthquake, when resources are most scarce yet crucial for recovery and reconstruction.

The earthquake engineering experts believe that local planning, stronger building codes, and ongoing mitigation have substantially reduced the potential loss of life and property that a major Northern California earthquake could cause. Many areas are better prepared than ever before, yet the region is still not sufficiently ready for the next major earthquake. The social and economic consequences could prove to be long-lasting and ruinous to communities. With these actions and a renewed emphasis on safety, Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake.

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