

The Great 1906 San Francisco Earthquake

The worst natural disaster in U.S. history

by Chris Frantz



San Francisco,
California,
April 1906

At 5:12 a.m. on April 18, 1906, the people of San Francisco were awakened by an earthquake that would devastate the city. The main temblor, having a 7.7–7.9 magnitude, lasted about one minute and was the result of the rupturing of the northernmost 296 miles of the 800-mile San Andreas fault. But when calculating destruction, the earthquake took second place to the great fire that followed. The fire, lasting four days, most likely started with broken gas lines (and, in some cases, was helped along by people hoping to collect insurance for their property—they were covered for fire, but not earthquake, damage). With water mains broken, fighting the fires was almost impossible, and about 500 city blocks were destroyed. The damages were estimated at about \$400,000,000 in 1906 dollars, which would translate to about \$8.2 billion today.

Uncertain Death Toll

In 1906 San Francisco was the ninth largest U.S. city with a population of 400,000, and over 225,000 were left homeless by the disaster. The death toll is uncertain. City officials estimated the casualties at 700 but more modern calculations say about 3,000 lost their lives. The lowballing city figures may have been a public relations ploy to downplay the disaster with an eye on rebuilding the city. On April 20, the U.S.S. *Chicago* rescued 20,000 victims, one of the largest sea evacuations in history, rivaling Dunkirk in World War II. Martial law was not declared, but some 500 looters were shot by police and the military.

Shifting Seismologic Knowledge

The epicenter of this earthquake has moved around in the past 100 years, as advances in seismology have been made. It was first thought to have been in Marin County, then northwest of the Golden Gate, and most recently, in the Pacific Ocean about two miles west of San Francisco. The plate-tectonics theory that would shed some light on the quake wasn't formulated until the 1920s and not embraced until some three decades later. The San Andreas fault is on the boundary between the Pacific plate and the North American plate. During the earthquake, the ground west of the fault tended to move northward and, in the most extreme instance, a 21-foot shift was measured. Earthquake ruptures are fast movers—seismologists estimated the average speed of this rupture to have been 8,300 mi/hr going north, and 6,300 mi/hr traveling south. The quake was felt from southern Oregon to south of Los Angeles and inland as far as central Nevada.

Magnitude

Charles Richter developed his scale in 1935 to measure the amount of seismic energy released, the magnitude, of an earthquake. Seismologists found the Richter scale fine for lower magnitude quakes, but inaccurate for higher magnitude ones. The 1906 earthquake was assigned a Richter rating of 8.3, but on the newer moment magnitude scale it has been demoted to one measuring 7.8 or 7.9.

"The Big One"

On Oct. 17, 1989, at 5:04 p.m., at the height of the rush hour, Bay Area residents thought the "big one" had struck. The 7.1 Richter scale (6.9 moment magnitude) Loma Prieta earthquake, with its epicenter about 60 miles from San Francisco, was the largest one to hit the region since 1906. Sixty to 70 deaths were reported, freeways and bridges were damaged,

and the World Series between the Oakland and San Francisco teams was postponed for 10 days. Property damage was estimated at \$6 billion dollars, making this the costliest natural disaster to that date. But seismologists said this was not the major earthquake feared by all. That one is still in the future.

In 1906 there were only about 650,000 people living in the area, but today more than 7 million people make their homes in the San Francisco Bay region. Scientists in 2003 estimated that there is a 62% probability of a 6.7 magnitude or larger earthquake hitting the Bay Area in the next 30 years and Californians live in the shadow of "the big one."

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The Great 1906 San Francisco Earthquake

5:12 AM - April 18, 1906



San Francisco City Hall after the 1906 Earthquake. (from [Steinbrugge Collection of the UC Berkeley Earthquake Engineering Research Center](#))

The California earthquake of April 18, 1906 ranks as one of the most significant earthquakes of all time. Today, its importance comes more from the wealth of scientific knowledge derived from it than from its sheer size. Rupturing the northernmost 296 miles (477 kilometers) of the San Andreas fault from northwest of San Juan Bautista to the triple junction at Cape Mendocino, the earthquake confounded contemporary geologists with its large, horizontal displacements and great rupture length. Indeed, the significance of the fault and recognition of its large cumulative offset would not be fully appreciated until the advent of plate tectonics more than half a century later. Analysis of the 1906 displacements and strain in the surrounding crust led Reid (1910) to formulate his elastic-rebound theory of the earthquake source, which remains today the principal model of the earthquake cycle.

At almost precisely 5:12 a.m., local time, a foreshock occurred with sufficient force to be felt widely throughout the San Francisco Bay area. The great earthquake broke loose some 20 to 25 seconds later, with an epicenter near San Francisco. Violent shocks punctuated the strong shaking which lasted some 45 to 60 seconds. The earthquake was felt from southern Oregon to south of Los Angeles and inland as far as central Nevada. The highest Modified Mercalli Intensities (MMI's) of VII to IX paralleled the length of the rupture, extending as far as 80 kilometers inland from the fault trace. One important characteristic of the shaking intensity noted in Lawson's (1908) report was the clear correlation of intensity with underlying geologic conditions. Areas situated in sediment-filled valleys sustained stronger shaking than nearby bedrock sites, and the strongest shaking occurred in areas where ground reclaimed from San

Francisco Bay failed in the earthquake. Modern seismic-zonation practice accounts for the differences in seismic hazard posed by varying geologic conditions.

As a basic reference about the earthquake and the damage it caused, geologic observations of the fault rupture and shaking effects, and other consequences of the earthquake, the Lawson (1908) report remains the authoritative work, as well as arguably the most important study of a single earthquake. In the public's mind, this earthquake is perhaps remembered most for the fire it spawned in San Francisco, giving it the somewhat misleading appellation of the "San Francisco earthquake". Shaking damage, however, was equally severe in many other places along the fault rupture. The frequently quoted value of 700 deaths caused by the earthquake and fire is now believed to underestimate the total loss of life by a factor of 3 or 4. Most of the fatalities occurred in San Francisco, and 189 were reported elsewhere.



This photograph by Arnold Genthe shows Sacramento Street and approaching fire. (from [Steinbrugge Collection of the UC Berkeley Earthquake Engineering Research Center](#))

When will it happen again? Another Large Quake in the next 100 years? Maybe, but..."

Based on [models](#) taking into account the long-term rate of slip on the San Andreas fault and the amount of offset that occurred on the fault in 1906, the best guess is that 1906-type earthquakes occur at intervals of about 200 years. Because of the time needed to accumulate slip equal to a 20 ft offset, there is only a small chance (about 2 percent) that such an earthquake could occur in the next 30 years, according to the [report of the Working Group on California Earthquake Probabilities](#).

The real threat to the San Francisco Bay region over the next 30 years comes not from a 1906-type earthquake, but from smaller (magnitude about 7) earthquakes occurring on the Hayward fault, the Peninsula segment of the San Andreas fault, or the Rodgers Creek fault.