

Lifelines Performance, Long Beach Earthquake, March 10, 1933

By Le Val Lund, P.E., M. ASCE-TCLEE

This article was prepared on lifeline utilities for the annual conference of the Earthquake Engineering Research Institute, February 7-9, 2002 in Long Beach, CA. The conference commemorated the March 10, 1933 earthquake in Long Beach with a number of speakers discussing the seismology, geology and the performance of lifelines, buildings and schools. Le Val Lund made the presentation on lifelines.

A Historical Perspective

Introduction

In the number of lives lost and the amount of property damage, the Long Beach earthquake, some times is referred to as the Southern California earthquake, of March 10, 1933 was one of the most disastrous of any that occurred in the United States in the first quarter of the Twentieth century. The number of deaths was reported as 120, of which 52 were in Long Beach and 17 in Compton. Probably two thirds of the loss of life was by persons being struck by falling debris from buildings.

The M 6.3 earthquake struck at 5:54 pm, Pacific standard time, on March 10, 1933 on the Newport-Inglewood fault, the epicenter was located 2-miles west of Newport Beach in the Pacific Ocean. The area seriously shaken was a north south line extending from Long Beach to Vernon with a number of small cities in between and estimated population of 300,000. The most pronounced damage occurred in Compton and vicinity. The total property loss in the shaken area was early on estimated to be \$141,000,000.

Emergency Response

An early development of a emergency response organization was developed in 1926 prior to the Long Beach earthquake by Chief R. J. Scott, Los Angeles Fire Department, various city officials and executives of power, gas and oil companies and others had the foresight in preparing a plan in anticipation of a major disaster, particularly designed for use in the event of an earthquake. Briefly this included safely stored maps, diagrams and data concerning water mains and valves, gas, electric and oil lines, supplies of explosives and a list of outside mutual aid available. Consideration was given to the use of motorcycles, airplanes and radio communication, establishment of temporary headquarters, shutting off gas, electric, ammonia and oil lines. Detailing men for rescue work and using tank wagons, emergency water storage and wells for water supply.

Electric Power

The Southern California Edison Company (SCE) supplied electric power in Long Beach from an interconnected system of to large steam electric generating

plants and a series of hydroelectric generating stations. Power interruption ranged from momentary to 7-hours in duration. Power lines failed due to broken guy wires, swinging crossed wires and damaged pole top transformers. Following failure of the supply transmission lines a standby steam electric generating station quickly picked up the Long Beach load.

The Los Angeles electric supply was provided by the Los Angeles Bureau of Power and Light (LABP&L) and the LAG&E and to a lesser extent by SCE, who also sold power to LABP&L. Minor damage occurred to the LABP&L system at its connection to the SCE system and anchorage of batteries used to operate switches. LAG&E had two steam electric generating stations, one in Los Angeles and the other in Seal Beach. The Los Angeles plant was able to operate fully, while the Seal Beach plant was not able to because of the arching of the switches shaken open while carrying current were destroyed. No power could be supplied to the system until temporary repairs were made. The overloaded condition of the Los Angeles plant prevented synchronizing with the Southern Sierra Power company supply.

Gas

The Long Beach Municipal Gas Department purchased gas from the Southern California Gas Company (SCG) and distributed gas to the citizens of the city. SCG supplied gas at 30-psi pressure through nine service connections; Long Beach through 24 regulating stations reduced the pressure to 4-psi for distribution. The system included two large gasholders with a total capacity of 12,500,000-cubic feet. As a result of the first shock numerous breaks in the high and low-pressure systems reduced the gas pressure service quickly. After field inspection closing valves isolated breaks. In areas outside of Long Beach gas service was provided by SCG and the LAG&E were similar breaks occurred and the closing of valves prior to restoring the system isolated the breaks.

Harbor

At Los Angeles harbor, damage was confined mainly to the breakage of some oil and water lines and moderate damage to brick buildings. Long Beach harbor was very small at this time.

Petroleum

Los Angeles Basin was the largest concentration of oil storage in the world, about 75,000,000 barrels and 60 percent of this was in the area severely shaken. Some of the oil tank farms and refineries were close to the Newport-Inglewood fault and were on damp swampy ground on which maximum damage would normally be expected. In spite of these unfavorable conditions, the loss to oil properties was a very slight percentage of the total investment in the industry. Oil is stored in large earthen reservoirs or steel tanks. No damage was reported to the earthen reservoirs, but it is possible cracks may have occurred in the concrete lining. Tanks shifted on their foundations with breakage of some pipe connections. Retaining walls or dykes proved of value, leakage through tank connections largely being retained by such enclosures. At Signal Hill oil field, many

small field tanks were damaged, mainly through broken connections. Three wooden oil well rigs were destroyed, when boilers set fire to crude oil escaping from the damaged field tanks.

Telephone

In Long Beach, the Associated Telephone Company served about 30,000 stations through four automatically operated exchanges. Two exchanges in buildings of modern construction passed through the earthquake without damage to the equipment; the other two buildings suffered considerable damage. One of these was removed from service for 72 hours. Within a few minutes after the event automatic equipment became dangerously overloaded, therefore all telephone service was shutdown, except the Long Beach Fire Department private system. Telephone service was restored on a priority basis as the system was restored.

Water

Prior to the earthquake the National Board of Fire Underwriters (NBFU) issued reports on the potential for earthquake performance on nine cities in the impact area. Probably because of the NBFU initiative the water systems supplying Santa Monica, Glendale, Pasadena, Alhambra, Pomona and a major part of Los Angeles were unharmed. Systems supplying Huntington Park and Santa Ana received only slight damage. Long Beach and the harbor district of Los Angeles were kept in water with some difficulty.

Long Beach most serious damage was from 127 breaks in cast iron distribution mains, ranging in diameter from 4- to 12-inches. Three distribution-pumping stations were placed out of service leaving the Alamitos Reservoir to supply the demand by gravity. The reservoir was replaced in 1931 with six steel tanks to withstand earthquakes with a total capacity of 20,000,000 gallons. They were undamaged, although there were some cracks on the ground surrounding the tanks. The pumping plants had structural damage in the earthquake. Groundwater well pumps were available as soon as power was restored. The Los Angeles Bureau of Water and Supply supplied mutual aid. The Long Beach Public Utilities Building a 3-story reinforced concrete structure performed very well. The structure with gypsum block partitions, suffered only a few plaster cracks.

In the harbor district of Los Angeles, which includes San Pedro, Terminal Island and Willington was maintained with difficulty because of a broken 12-inch submarine pipeline from Wilmington to Terminal Island. The main pulled 3 1/2 to 4-inches from the rigid concrete abutments and had 21 leaks in the under water portion. The other 16-inch main was found intact to the island. Since the 1929 NBFU report a 557,000-gallon elevated steel tank has been placed on the island, the tank was full at the time of the earthquake and was only slightly damaged. Number of the automatic sprinkler connections to the warehouses sheared off and the tank drained in 1 1/2 hours. When these connections were shut off, low-pressure water service was restored to the island system from the 16-inch main.

There was no reported well casing damaged or pump shaft misalignments in the area. Virtually all well pumping stations were available to operate when electric power was restored. The event was particularly hard on large brick stations housing steam-operated pumps. There was no material damage to concrete ground level reservoirs. Significant damaged occurred to a 7 1/2 million gallon riveted steel tank in southwest Los Angeles, due to wave action on the tank shell. Twenty-five elevated steel tanks on steel legs were used by the cities in the area, two collapsed and two others were placed out of service because of broken risers. About one-third of the 25 elevated wooden tanks were destroyed. He limited number of concrete water mains perform well, but wood stave pipe and riveted steel pipe performance depended on the quality, age, banding, etc, of the pipe.

Lifelines

Some of the lessons learned from the Long Beach earthquake have been remedied by modern design, materials and construction. Some of the lessons learned are still prominent because the older lifeline infrastructure that still exists in some areas. The Long Beach event was certainly before C. Martin Duke, Professor of Civil Engineering, UCLA, brought forth the importance of lifeline concept in earthquake engineering following the 1971 San Fernando earthquake and the forming of the ASCE Technical council on lifeline Earthquake Engineering (TCLEE). Lifelines (water, power, communication, gas, liquid fuels and transportation systems) are necessary for the restoration of a community after a disaster such as an earthquake. Also, lifelines are necessary for the normal existence of community by providing essential services.

LL 12-30-01 Rev 05-03-02

Le Val Lund, PE, M EERI, M ASCE-TCLEE

Civil Engineer,

Water resources and lifeline earthquake engineering

Past Chair, Executive Committee, ASCE-Technical Council on Lifeline
Earthquake Engineering

Formerly planning, design, construction operation, maintenance and
management of the Los Angeles Water System

LL 12-30-01