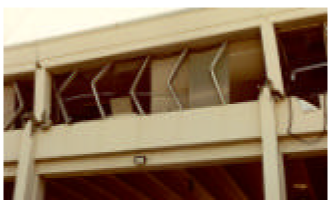
PAST EARTHQUAKES – WHAT HAPPENED LAST TIME?

1989 Loma Prieta Earthquake

The magnitude 6.9 Loma Prieta earthquake occurred in the Santa Cruz mountains near the border of Santa Cruz and Santa Clara counties on October 17, 1989. Because the earthquake source fault was far south of the main urban center of the Bay Area, it only serves as a wake-up call for what might happen in a closer or larger magnitude earthquake. Thus, it is inappropriate to assume that since a problem did not occur in this earthquake, it will not occur in the future.

San Francisco International Airport (SFO) was over 35 miles from the fault source for the Loma Prieta earthquake. Although operations at SFO officially halted for one night, this was not due to any significant damage to the facilities or the runways. The control tower sustained window and non-structural damage, and some unanchored equipment was broken, but this did not prevent the tower from operating. ***The primary reason for the shutting down of flights during that night was that not enough controllers were available to operate the tower safely.*** The runways (built on fill), navigational equipment, runway lights, fuel tanks, and piping were mostly unaffected. However, liquefaction (a process where loose water-saturated sands temporarily behave like a liquid when shaken) shifted some small support structures. Lost power was restored within 3 hours, well before the time the airport was reopened. Non-structural damage occurred in the terminals, but did not cause the airport to be shut down. Damage to an air cargo building was significant, and problems transpired with a power transformer, but these were remedied over time without air operations being affected. ***There were no problems with access road failures or freeway closures within the immediate vicinity of this airport that contributed to closure. However the ability of the controllers to travel to work safely and quickly was an issue*** (EERI, 1990).



source –
SFO – R. Wiggins

Oakland International Airport (OAK) was also affected by the Loma Prieta earthquake, in spite of its location over 40 miles from the fault source for the earthquake. OAK and adjacent Port of Oakland lands, however, experienced peak ground accelerations of almost 0.3 g. These problems affected airport operations. Its main 10,000-foot runway, built on hydraulic fill over Bay mud, was severely damaged by liquefaction; 3,000 feet of the runway sustained cracks, some of them were a foot wide and a foot deep. Spreading of the adjacent unpaved ground resulted in cracks up to 3 feet wide. Large sand boils appeared on the runway and adjacent taxiway, a few as wide as 40 feet (EERI, 1990). As a result, OAK was immediately shut down to evaluate runway damage. A shorter 6,212-foot general aviation runway was used to accommodate diverted air traffic for a couple of hours before the main runway was reopened with a usable length of only 7,000 feet. This shorter runway length impacted cargo loads during takeoff. Over the next 30 days, 1,500 feet of the 3,000 foot damaged section of the runway was repaired using an emergency repair order for resurfacing and crews already present during the earthquake. An adjacent taxiway was also damaged by liquefaction. Repairs of this taxiway segment and the final 1,500 feet of the main

source –
Geomatrix Consultants

runway were completed six months later, after a competitive bidding process (T. LaBasco, S. Kopacz, and J. Serventi, Port of Oakland, personal communications, Sept. 2000). Post-earthquake communications were difficult at OAK, as both telephone service and the usable radio frequency became quickly overloaded, affecting both cleanup crews and the public on-site at the time of the earthquake. Other damage was limited – for example, the control tower lost three windows, a walkway between terminals was damaged, and a water main ruptured causing a service road to collapse (EERI, 1990). Repair costs totaled approximately $6.8 million, including $3.5 million for runway repairs, $2.2 million for taxiway repairs, and $1.1 million for repair of other damage. FAA funded approximately $5.5 million of the repairs, with the remainder funded by OAK (T. LaBasco and I. Osantowski, Port of Oakland, and J. Rodriguez, FAA, personal communications, Sept. 2000).

San Jose International Airport (SJC) was located approximately 15 miles from the fault source of the Loma Prieta earthquake. The airport immediately closed for inspection of runways, taxiways, associated lighting systems, and aircraft parking ramps. The operational status of the Air Traffic Control (ATC) tower, other ATC facilities, and aircraft navigational aids were verified. Both terminals, automobile parking garages, and lots were also inspected. The inspection showed that there was no damage that might affect operations, so the airport reopened and was fully operational 40 minutes after the earthquake. The airport also determined the status of the three principal access routes, as well as of SFO and OAK. The status of the airport was then communicated to the City Emergency Response Center (C. Herrera, SJC, in Perkins and others, 1999b). The control tower lost a window and had non-structural problems; other cosmetic damage occurred at the terminal. Commercial power was lost for over 5 hours, but backup generators worked well. The airport was considered as an alternative airfield if flights needed to be diverted from San Francisco or Oakland. The main reason this did not occur was the lack of refueling capabilities at San Jose (rendering takeoff of most of those planes impossible) rather than damage due to the earthquake. No road failures at or near the airport were reported (EERI, 1990). The emergency plan for natural disasters, in place at the time of the earthquake, clearly spelled out procedures relating to duties, communications and inspection procedures. The airport staff feel that the plan worked well, although the minimal damage did not give the plan a thorough test. The staff, therefore, are continuing to use this plan and procedures (D. Chubbic, SJC, personal communication, Sept. 2000).

source –
J. Bray – University of California, Berkeley and U.S. Geological Survey

Significant damage also occurred to the Alameda Naval Air Station. Substantial liquefaction led to the closure of both the 8,000-ft. and 7,200-ft. runways. The terminal building had structural damage and was closed. Other damage occurred to piers, railroad tracts on piers, and the water- and gas-distribution system. The power was not disrupted. The helicopter pads were not damaged and were used during the emergency operation. The two runways were repaired and reopened (one in December 1989 and the second expected in January 1990) (EERI, 1990). However, the facility was closed in 1995 and is now scheduled for non-airport reuse.

source –
J. Villarin,
for California Pilots Association

The Watsonville airport, with two 4,000-ft. runways, had a loss of power and no emergency generators. Thus, flights could not depart at night due to lack of runway lights. Some hanger doors fell from their support rails. However, this airport became a key player in the emergency relief effort. For example, there was an average of 25 military flights per day. In addition, approximately 300 flights were made by light planes on the weekend of October 28-29 (EERI, 1990). A total of about 300,000 pounds of emergency supplies were flown to Watsonville and Hollister during the week following the earthquake utilizing over a hundred small aircraft (J. White, California Pilots Association, personal communication, 2000).

Because of problems at the three commercial airports, flights were diverted to outside of the Bay Area. Sacramento Airport was notified to expect diversions from the Bay Area. It had 256,000 gallons of jet fuel on hand. An emergency recall of fueling staff was ordered to help facilitate fueling aircraft, escorting of vehicles and handling of paperwork (flight plans and fueling paperwork). The second runway and some taxiways were used to park incoming aircraft. No domestic flights at Sacramento were cancelled. Some international flights landed and fueled, these had to keep people onboard the aircraft due to no international facilities available. The airport accepted a total of 40 diversions in the first five hours, at which time Chevron topped off the jet fuel tank farm. There were later occasional fuel diversions during the following week.(S. Soto, Sacramento County Airport System, personal communication, 2000).

No significant damage was reported at smaller airports in the region. Smaller amounts of damage would be expected because these airfields generally have fewer facilities.

1994 Northridge Earthquake

Van Nuys Control Tower had gashes in its siding caused when ¾" thick windows fell.
source –
A. Schiff, 1995

The magnitude 6.7 Northridge earthquake occurred on a fault buried beneath the San Fernando Valley of Los Angeles on January 17, 1994. The three airports in the area with most severe shaking in the Northridge earthquake were closed for runway and taxiway inspections. However, all three were reopened quickly when the inspections were completed and showed no significant damage.

Van Nuys Airport, the general aviation airport closest to the area of highest shaking intensity, had window glass breakage in the control tower (EERI, 1995a). Equipment in that tower slid up to 4 inches. Damage to FAA facilities at the airport control tower totaled about $160,000 (Schiff, 1995).

Burbank Airport, a commercial airport located just east of the fault source zone, was closed for approximately five minutes while the runways and taxiways were inspected. The terminal building was closed for approximately two hours for inspection and to allow cleanup of fallen ceiling tiles (EERI, 1995a).

The Los Angeles International Airport (LAX), located almost 20 miles south of the fault source zone, was closed down for several hours for inspection. Due to a power loss of approximately one hour, the emergency generator power backup was used and functioned. Some ceiling tiles fell, and there were some water leaks at pipe joints (EERI, 1995a).

1995 Kobe, Japan Earthquake

The magnitude 6.9 Hanshin-Awaji (Kobe) earthquake occurred on January 17, 1995 on a 30 – 50 km segment of the Nojima and associated faults (EERI, 1995b). There were three airports in the region affected by the earthquake: the Osaka International Airport, the Kansai International Airport, and the Yao Airport. The Yao Airport is a small general aviation airport and was undamaged in the earthquake. Both the Osaka and Kansai International Airports were slightly damaged. More importantly, they had a large role in the rescue and emergency response phase of the earthquake, particularly due to damage to the main bullet train connecting eastern and western Japan. The following description is summarized from a report prepared by the Editorial Committee on the Hanshin-Awaji Earthquake Disaster (2000). This Committee consisted of the Architectural Institute of Japan, the Japanese Geotechnical Society, the Japan Society of Civil Engineers, the Japan Society of Mechanical Engineers, and the Seismological Society of Japan.

source – Kansai International Airport Web Site

The Kansai International Airport, completed in 1994, serves the Kobe and Osaka region. It was less than a year old at the time of the earthquake. It lies approximately 19 miles (30 km) from the epicenter on a man-made island. Although there was no damage on the outside levees, some cracks were observed on the apron of the water access base. Runways, access ways, and asphalt maintenance aprons had minor cracks approximately 1/8” (2-3 mm) wide. At the time of the earthquake (5:46 am) there was a plane preparing to land. Immediately, the runway was inspected and determined to be safe in spite of the cracking, so that plane was allowed to land at 6:15 am. The cracks were sealed the following night to prevent rainwater from seeping into them. The fuel supply system is equipped for automatic shutoff when shaking exceeds 80 gal (0.08 g). After inspection confirmed the system was safe, it was restarted. Airport buildings had damage to ceilings, hallways and water lines. The rail of the shuttle in the passenger terminal was slightly bent, but service was quickly restored. Minor damage occurred to terminal walkways, expansion joints, escalators, water tanks and light fixtures.

The Itami (Osaka) Airport, the former international airport for the region, now handles domestic flights. It is approximately 6 miles from the most heavily damaged area. Immediately after the earthquake, runways were inspected and many cracks of less then an inch (a few mm) wide were observed. The airport was not closed; the cracks were sealed the following night to prevent rainwater seepage. The control tower and the fire department and power generation buildings had cracks in glass, as well as other areas. The passenger terminal had fallen concrete panels, broken wall panels, damaged roof and ceiling sections, and broken glass. Water lines, toilets, sprinklers, air conditioners, and boarding bridges were damaged. There was some damage to the runway lighting system, but this system was quickly restored.

Due to damage to the rail lines and roads, the number of flights increased significantly between January 17th and April 14th. Additional flights were added at the Itami Airport until 10 p.m. during this period. (Airport service had stopped at 8 p.m. prior to the earthquake.) Helicopters transported emergency relief goods. Those goods were mainly food and drinking water during the first 4-5 days, followed by tents, portable toilets, blankets and heaters for the next 6-10 days, and then clothes and goods for infants. The Itami Osaka Airport accepted domestic relief goods and distributed them via trucks and helicopters to the disaster area. The Kansai Airport accepted both domestic and international relief goods, which were then distributed via trucks, helicopters and ships to the disaster area. Between January 19th and May 10th, about 1,722 tons of goods were transported. The sky over the disaster area was crowded with airplanes from the Japanese self-defense forces, police, fire fighters, and media groups. NATM was provided to control them. The process of obtaining permits to land in non-equipped areas was simplified in order to speed up the transportation of relief goods by helicopter.

The Kobe report notes that the role of air transportation is to provide emergency and alternate transportation, and to contribute to the recovery of the disaster area. Recommendations included:

- seismic reinforcement of current facilities;
- alternate or redundancy for aircraft control facilities;
- establishment of air emergency response and recovery systems; and
- research on earthquake investigation methods.

1999 Turkey Earthquake

source – Istanbul Ataturk Airport Web Site

The magnitude 7.4 Kocaeli earthquake occurred in northwest Turkey, rupturing an approximately 70 mile (110 km) length of the North Anatolian fault system on August 17, 1999. The epicenter was approximately 60 miles (95 km) from Istanbul and 70 miles (110 km) from the Istanbul Ataturk International Airport (IST). The closest extension of the source fault rupture was approximately 50 miles (80 km) from the city center and 60 miles (95 km) from the airport. The peak ground acceleration at the strong motion station nearest the airport was only 0.09 g (USGS, 2000). Because the earthquake source fault was relatively far away and because IST likely experienced low shaking levels, there was minimal damage. Stronger shaking would have damaged the emergency power system (J. Eidinger, personal commications, Sept. 2000). Thus, one should not assume that since a problem did not occur in this earthquake, problems will not occur in the future.

Airport personnel conducted inspections of all runways and aprons following the earthquake prior to allowing any planes to land. When no damage was found, airport operations continued without major delays (A. Tang, personal communication, Sept. 2000). Although more damage to runways might have occurred with higher shaking levels, the runways are ***not*** located in a general area of high liquefaction susceptibility (unlike the Oakland and San Francisco airports on the margins of San Francisco Bay) (J. Bachhuber, personal communication, Nov. 2000).

IST handled over 14 million passengers in 1998 on over 184 thousand flights. In August 1999, international flights were highest on the 19th and 20th with a smaller rise on the 26th and 27th, probably due to international rescue and relief efforts. Cargo operations were also increased due to the increase in foreign aid (A. Tang, personal communication, Sept. 2000). In addition, during the month following the earthquake, there was a significant drop in inbound passenger arrivals over historical seasonal trends, reflecting the 30% to 50% reduction in tourism for the month following the post-earthquake. Outbound departures may have increased after the earthquake, reflecting the shortened vacation plans of tourists and the departure of displaced people (J. Eidinger, personal communication, Sept. 2000).

A new $305 million terminal was under construction when the earthquake occurred. As a result of the earthquake, the decision was made to review the design for the terminal, although construction was 90% complete at the time of the earthquake. Needed changes were made and it was opened in January 2000 (Eng. News Record, 1-17- 2000).

Much less information is available on the performance of the Cengiz Topel Military Airport in Izmit. It appears that there was significant damage to the control tower rendering it unusable. It was further reported that airport operations were reduced as a result of the damage (A. Tang, personal communication, Sept. 2000).

1999 Taiwan Earthquake

The magnitude 7.6 Chi-Chi earthquake occurred in central Taiwan on September 21, 1999. The international airport is located approximately 75 miles (120 km) from the earthquake epicenter and approximately 50 miles (90 km) from the fault source. It was undamaged and functional following the earthquake, enabling it to serve a critical role in the earthquake response and recovery effort.