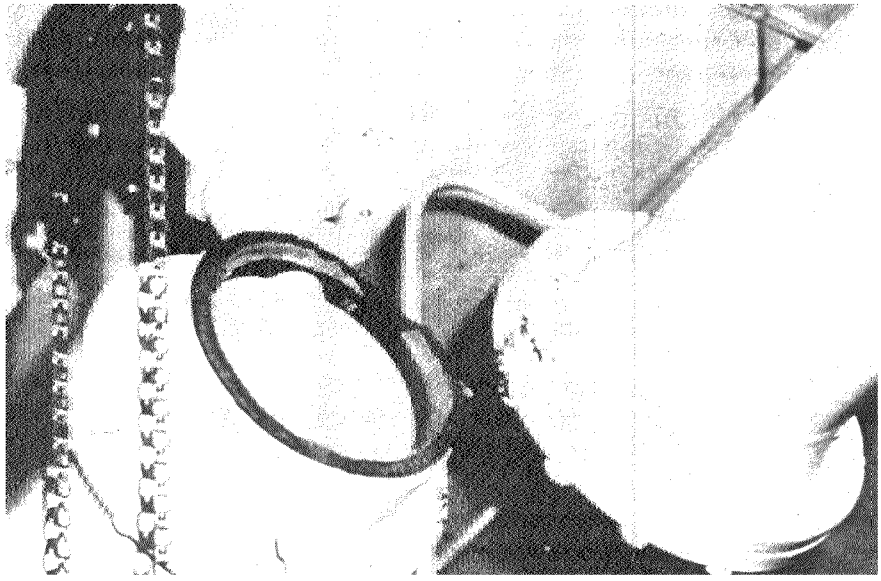


Figure 3-2 Pipeline broken in Olive View Hospital in the 1971 San Fernando, Calif., earthquake

offices, storage tanks, vehicle storage buildings, and material warehouses. Hazards from earthquakes, floods, hurricanes, fires, transportation accidents, and intentional acts are particularly likely to damage structures. Both dams and storage tanks are very vulnerable to earthquake hazards. Dam failures have been caused by liquefaction, internal soil piping, and overtopping. Storage tanks may suffer the following types of damage in earthquakes.

All tanks

- foundation and soil failure
- roof damage from sloshing
- connecting pipe damage

Wire-wrapped concrete tanks (prestressed or post-tensioned)

- failure of corroded wire wrapping
- wall/foundation separation (particularly in pre-1970s tanks)

Steel standpipes and ground storage tanks

- sliding
- elephant's-foot buckling
- splitting bottom or wall seam

Elevated tanks

- collapse of supports (Figure 1-1)

Nonreinforced masonry and steel-frame buildings that have had structural members removed or weakened are particularly vulnerable to earthquake hazards. For earthquake, hurricane, and flooding hazards, proper roof/wall and wall/foundation connections are critical to structure survivability. Fires can cause reinforcement failure.

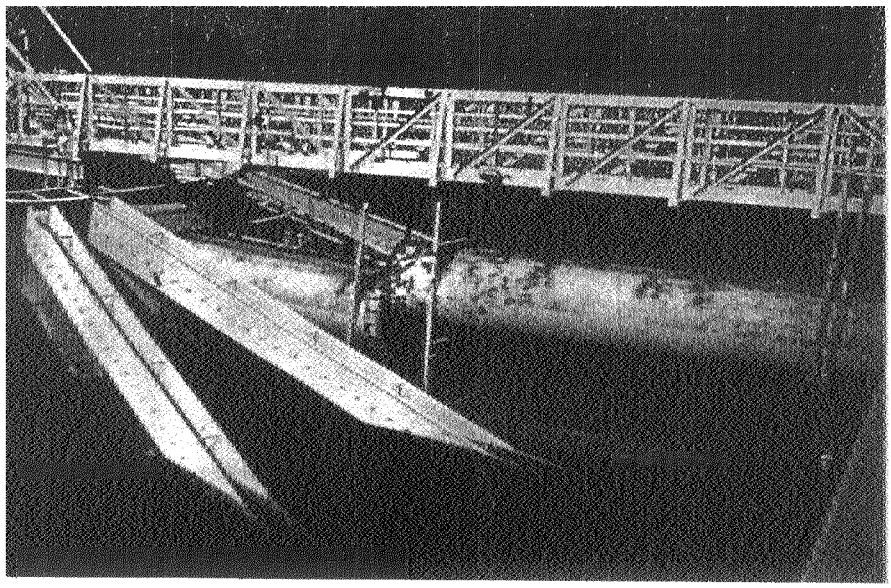
Equipment and material damage or loss. Water system equipment, such as computers, tools, vehicles, and laboratory equipment, can be destroyed, damaged,

lost, or inaccessible due to most disaster hazards. Materials such as chemicals, pipe, valves, and hydrants can also be damaged or lost due to many disaster hazards. Equipment that is not anchored properly will slide or fall in earthquakes and hurricanes. Also vulnerable to hazards are chlorine tanks and containers, which can be damaged by toppling, rolling, and sliding. Connector pipes between pieces of equipment can also break.

Process tank or basin damage. Submerged elements and baffles can break from large hydraulic loading due to sloshing in earthquakes (Figures 3-3 and 3-4). Cast in-place concrete tanks are susceptible to structural failure due to sloshing, ground shaking, soil failure, and structure flotation. High winds may also damage tank roofs (Figure 3-5)

Electric power outage. Many system components, such as pumps and computers, depend on electrical power to operate. Electrical power components, especially aboveground lines (Figure 3-6) and transformers (Figure 3-7), are particularly vulnerable to hurricanes, earthquakes, tornados, and floods. Voltage and phase fluctuations may damage motors. Downed power lines create access problems.

Communications disruption. Communication failures fall into two categories: failure of automatic signal equipment and associated telemetry, and failure of communications that link people, such as telephones and two-way radio. Mass media -- television, AM/FM radio, and newspapers -- are also important communication channels, particularly for informing the public of the disaster effects. The communication system is particularly vulnerable to hurricanes, earthquakes, floods, and tornados. Disruption can be caused by physical damage or too many people using the lines at once. Usually, the telephone system goes out before other communication systems, but there have been cases where radio communication failed but telephones were still working. Communication systems usually depend on electric power to function and can be affected by power outages. Cable wire for telemetry systems will break in earthquake and other disaster hazards. During the 1989 Loma Prieta



Source: D B. Ballantyne

Figure 3-3 Flocculator/clarifier center mechanism damage from sloshing water in 1989 Loma Prieta earthquake. Rinconada Water Treatment Plant, San Jose, Calif.