Outdoor Safety

Modern Seismic Codes Make Buildings Safer

By John Henry, Principal Staff Engineer, ICC

View of damage to a frame house in San Francisco as a result of the earthquake of 1906.
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On the morning of April 18, 1906, one of the most significant earthquakes in history ripped through San Francisco. At 5:12 a.m., a foreshock was felt throughout the San Francisco Bay area, and about 20 seconds later, one of the greatest quakes in U.S. history produced violent, 45-second shocks felt from southern Oregon to Los Angeles. Estimated to be between 7.7 and 8.3 on the Richter scale, the San Francisco earthquake caused more than 3,000 fatalities, destroyed an estimated 28,000 buildings and left more than 225,000 people homeless. This tells a sad story of the devastation and fatalities resulting from earthquakes that pre-date modern model building codes.

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In 1989, a 7.1-magnitude earthquake struck the Loma Prieta area of California. Sixty miles away, in downtown San Francisco, the 49-story Transamerica building shook for more than a minute, with the top story swaying more than a foot. Yet the building was undamaged, and no one was seriously injured. All told, the Loma Prieta earthquake resulted in 62 fatalities.

Five years later, southern California was rocked by a magnitude 6.7 earthquake that struck near Northridge in the densely populated San Fernando Valley area. Although the epicenter was located near a densely populated area, the quake resulted in 57 deaths. Experts concluded that, because the Northridge earthquake occurred in the early morning hours and on a holiday, the number of fatalities was reduced considerably.

And on Dec. 22, 2003, a magnitude 6.5 earthquake struck San Simeon in central California, killing two, injuring 47 and damaging approximately 500 structures in a two-county area.

In stark contrast to these recent earthquakes in California, a magnitude 6.6 quake hit close to the ancient city of Bam, Iran, four days after the San Simeon quake, killing an estimated 43,000 people and injuring another 30,000. The quake damaged or destroyed up to 85 percent of the city's buildings and infrastructure.

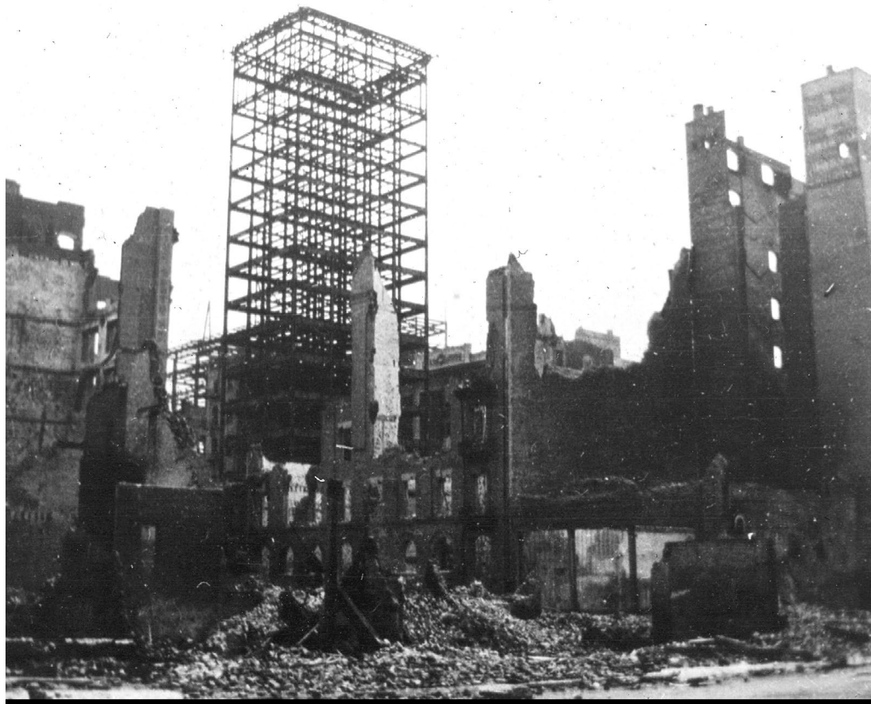
These examples illustrate that modern building codes are important tools to minimize loss of life, reduce serious injuries and prevent structural collapse from earthquakes. Through a continuing Code Development Process, the hard lessons learned from past earthquakes and knowledge gained from research are transformed into technical advances and improvements in our design and construction practices aimed at reducing fatalities from earthquakes. The International Code Council (ICC), through a thorough Code Development Process, works with its many partners to make sure buildings are designed, constructed and inspected according to the latest seismic codes.

Keeping Up with Changing Codes

Advances in earthquake engineering and the subsequent code changes are as dynamic as the world we live in. To guarantee the highest level of safety, it is imperative that building code officials and design and construction communities use the most current codes and standards.

Adopting the most current codes is key, but to get the full benefit, you need proper enforcement. Design and construction teams must diligently follow the current provisions, and building departments must enforce them. If design, construction or inspection fail, buildings and their occupants could be in danger.

Enforcement during the construction phase takes place through regular inspections, as well as through the Special Inspection and Structural Observation provisions of the *International Building Code*® (IBC) Chapter 17. A tremendous amount of resources and the efforts of many dedicated people are necessary to develop National Earthquake Hazards Reduction Program (NEHRP) seismic provisions, and process them into the ASCE 7 stan-



View of damage from the 1906 San Francisco earthquake to the Shreve Building, which was constructed using a steel frame.

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dard for the IBC through the Code Council's public hearings and Code Development Process. If jurisdictions do not adequately enforce the seismic requirements, a lot of time and talent have been wasted, in addition to adding to possible dangers. To make sure building department staff can do their best work, they need to be trained in the most up-to-date codes. There is a need to expand and improve training materials available for both building inspectors and trades workers, especially where earthquake-resistant construction is concerned. A more educated construction workforce — be it designers, contractors or code professionals — will result in safer buildings.

***Loma Prieta, California, earthquake, Oct. 17, 1989, San Francisco*. An automobile lies crushed under the third story of this apartment building in the Marina District. The ground levels are no longer visible because of structural failure and sinking due to liquefaction.**
PHOTO COURTESY OF U.S. GEOLOGICAL SURVEY

The manufacturing industry also plays a big role in providing safe construction. The equipment, tools, devices and building components that connect buildings safely and must resist seismic forces play an increasingly important role. To ensure that such devices and building components comply with the building code and its referenced standards, the ICC Evaluation Service (ICC-ES) establishes Acceptance Criteria (AC) and provides evaluation reports to validate the performance of products as established by the manufacturers. Two examples of such components and related ICC-ES Approved Criteria are Mechanical Anchors in Concrete Elements (AC193) and Post-Installed Adhesive Anchors in Concrete Elements (AC308).

It Takes a Team

The bottom line: When such disasters as earthquakes strike, design, construction and enforcement — using the most up-to-date codes — all are key in preventing loss of life and home. A growing number of people look to the ICC for the most up-to-date solutions. Knowing this, Code Council officials rely heavily on their close partnership with structural engineering organizations — now more than ever — in the development of international codes and associated structural standards. Developed through the governmental consensus process, the ICC family of codes incorporates the latest scientifically based requirements and industry standards from the American Society of Civil Engineers (ASCE), the American Forest & Paper Association (AF&PA), the American Institute of Steel Construction (AISC), the American Concrete Institute (ACI), the American Iron and Steel Institute (AISI), ASTM International and many others. Because it is essential that the design community be well trained and current on the latest code provisions, the Code Council works closely with the engineering and seismic design community, such as the National Council of Structural Engineers Associations (NCSEA), the Structural Engineers Association of California (SEAOC), the American Forest & Paper Association (AF&PA), the Masonry Institute of America (MIA) and many others, to ensure structural engineers have the most current technical publications and resources they need to properly apply the codes. Publications, such as SEAOC's Structural/Seismic Design Manuals and ICC's IBC Code Application Q&A co-branded and partnered with NCSEA, are just two examples of this commitment to serve the engineering community.

Visibility and Vision

Together, ICC structural engineers and other building safety professionals can continue to create the foundation for effective codes and standards. However, this part-

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nership is much more than a technical endeavor; it is a collaborative vehicle for legislative change.

First established in 1994 by the nation's three regional model code organizations, the ICC delivered on the promise to bring more consistency and uniformity to the U.S. building safety codes and standards. In 2000, the Code Council completed its development of a single set of comprehensive and coordinated national model construction codes (*I-Codes*), including the IBC. Twelve years later, 50 states and the District of Columbia have adopted the *I-Codes* at the state or jurisdictional level. Federal agencies, including the Architect of the Capitol, General Services Administration, National Park Service, Department of State, U.S. Forest Service and the Veterans Administration, also enforce the *I-Codes* for the facilities they own or manage. The Department of Defense references the IBC for constructing military facilities, including those housing U.S. troops domestically and abroad. Puerto Rico and the U.S. Virgin Islands enforce one or more of the *I-Codes*.

The Code Council also works with local, state and federal officials on new policy initiatives. On the 100th anniversary of the San Francisco earthquake, ICC CEO Rick Weiland traveled to San Francisco, where he gave a presentation to the Western States Seismic Policy Council (WSSPC) Board of Directors. The Code Council shares its goal of promoting earthquake safety by developing seismic policies and promoting programs to reduce earthquake-related losses. The Code Council also seeks to enhance earthquake preparedness to reduce or eliminate deaths, injuries and property damage. Weiland noted, "Structural engineers are part of the best code design and implementation system in the world — a system as important to public safety as other essential services. The more the public understands what the structural engineering profession has done to make communities safer, the more support there will be for still greater advancements. Many people don't realize that for every dollar spent building safer and stronger, four to six dollars are saved in reduced disaster loss."

***Loma Prieta, California, earthquake, Oct. 17, 1989*. Roadbed collapse near the interface of the cantilever and truss sections of the San Francisco-Oakland Bay Bridge. View is northwest.**
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A Global Ideal

"The ICC's mission is to focus on enhancing building safety in the United States, while also looking at ways to export that system to the rest of the world as the basis for truly global standards," said Weiland.

Collectively, the Code Council and its partners in the building construction community have the ability to lessen human suffering and fundamentally improve the lives of millions of people. Nature always has been an unpredictable and uncontrollable part of the human experience. And looking back at the last decade, there appears to be a new intensity in the global storm systems we are seeing, culminating in the devastation of Hurricane Katrina and the tsunamis in southern Asia and Japan to tornadoes in the Midwest and South. **bsj**

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