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What Experts Know About Earthquakes

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contributors

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"Earthquakes: What We Know Today and What We Should Do to Minimize Their Impacts"

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feature

Earthquakes

What We Know Today and What We Should Do to Minimize Their Impacts

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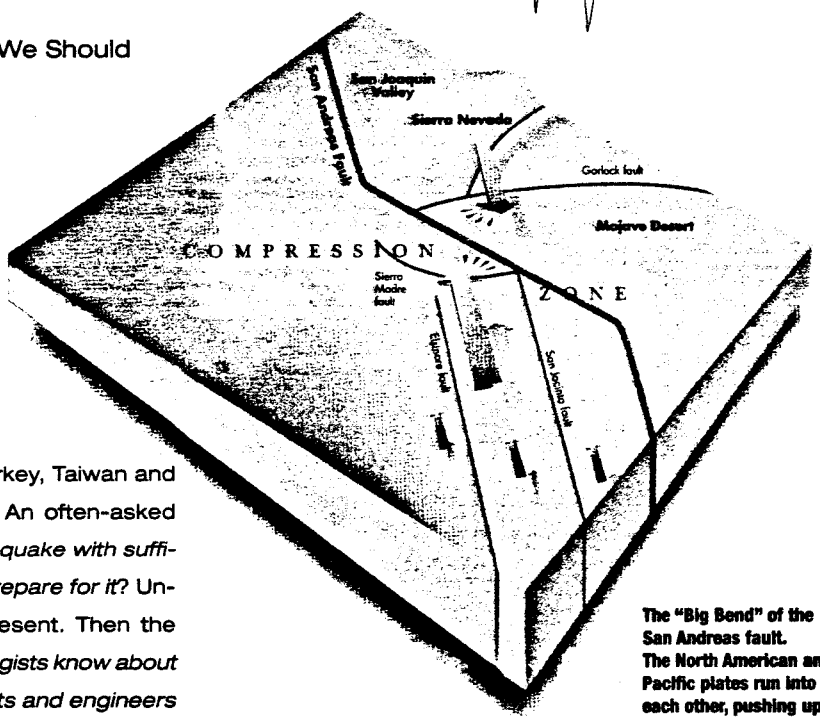

The "Big Bend" of the San Andreas fault. The North American and Pacific plates run into each other, pushing up the mountains of Southern California.

The recent tragic earthquakes in Turkey, Taiwan and India are still fresh in our memory. An often-asked question is: *Can we predict an earthquake with sufficient accuracy to allow citizens to prepare for it*? Unfortunately, the answer is no at present. Then the questions become *What do seismologists know about earthquakes? What are seismologists and engineers doing to minimize the impact of earthquakes?* And *What should citizens know about earthquakes and what should they do to prepare for them?*

How and why do earthquakes occur?

Earthquakes occur due to failure of rocks in the Earth caused by stresses (forces) produced by plate motion. The Earth's surface is covered by about a dozen large tectonic plates that are moving with respect to each other. As they move against one another, strains and forces are produced. If the force at a point exceeds the local strength of the Earth's crust, an earthquake occurs. Most earthquakes occur on or near plate boundaries, but some earthquakes do occur in the interior of plates. It is true that earthquakes are caused by stresses, but it is not necessarily true that they occur at the place where the stress is highest. An important factor is the strength of the Earth's crust. In a way, we can say that earthquakes are more likely to occur where the crust is weak rather than at the place where the stress is high. The crust near plate boundaries is weak and most earthquakes occur there. However, there is stress in the interior of plates and if a weak spot happens to exist in the plate interior earthquakes can occur.

The relative speed of plate motion is as fast as 2 to 3 inches per year in California and Japan. With this rate of plate motion, we expect large earthquakes at a given location about once every 100 to 1,000 years on plate boundaries and every 1,000 to 10,000 years in the plate interior.

After a sudden failure in the crust (*i.e.* an earthquake), the disturbance propagates as seismic waves, which cause damage by ground shaking and other secondary effects such as landslide, liquefaction and fire. Also, the fault displacement itself causes damage by shearing the buildings and structures located directly on it.

What do scientists know?

Plate motion and the resulting strain accumulation rate can be measured accurately with various methods including modern space-based methods, such as the Global Positioning System. Also, seismologists have extensively studied how earthquake slip motion occurs and how seismic waves propagate in the crust. Geologists and seismologists studied the past history of earthquake activity for many faults in the world. Thus, a significant progress has been made in the last decades in understanding the science of

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earthquakes. Then, why cannot seismologists predict earthquakes? In fact, seismologists now can make much more concrete statements (forecasts) regarding earthquakes in the future and their effects on society than they could decades ago. Unfortunately, their forecasts are not precise enough for individual citizens to take quick actions in a way they do with weather forecasts.

Accurate earthquake predictions are difficult for the following reasons: (1) The process leading to an earthquake is a slow geological process with a long time scale, hundreds to thousands years and the forecasts made by seismologists are good only on this long time scale. Thus, if the forecast in time is off by a small fraction, it will involve many years (easily many decades) of uncertainty, which is too large for ordinary citizens to cope with. (2) The occurrence of an earthquake is controlled by many factors and it is not possible to understand every one of them and to predict how these factors interact with each other to cause an earthquake. Technically, this kind of system is called a "Complex System" or "Chaos." This situation is somewhat like a traffic accident on a busy freeway. If a freeway is congested over a long stretch, the probability of a serious accident to occur is high. This is more like a seismologist making a probabilistic forecast on the basis of the past earthquake history and strain accumulation patterns in the area. Then, suppose a minor collision occurred at one location—this corresponds to a small minor earthquake. The collision may result in just a minor two-car accident, or it may lead to a sequence of collisions in a domino fashion ending up with a big pile-up. It would be very difficult to make a precise prediction at the time of the first minor collision of what will eventually happen—because the final outcome is determined by many factors (how alert other drivers are, how good the cars are and how good the road conditions are). This situation is similar to an earthquake occurrence. A large earthquake essentially consists of many small earthquakes. It is difficult to predict what will happen when the first small earthquake occurred. It may stop there, or it may trigger an adjacent earthquake, which in turn triggers many others thereby evolving to a very large earthquake. Exactly what will happen after all depends on many small factors such as whether an area adjacent to the first small earthquake is ready to go or not and how close the entire area is to failure. These details are extremely difficult to determine. An accurate prediction of the time, place and size of an earthquake is difficult despite the good progress in seismology. Even if any prediction can be made at all, it would be subject to large uncertainties.

Thus, seismologists can make some forecasts, on long-term seismic activity in a specific geographical area, like California and Japan. However, they cannot make a precise short-term prediction of an earthquake that would allow citizens to prepare for it quickly.

What should we do as citizens?

As mentioned above, an accurate short-term prediction is not possible at present. Thus, if someone made a short-term prediction of a specific earthquake, we should not unduly worry about it. Such short-term predictions, or something that can be construed as such, have occasionally been made by someone, even by some scientists. Also overly alarming statements are often made by scientists, but we should understand the difference in the language used by scientists. Terms like "soon" or "eminent" used by geologists often mean "many years" and have very different implications from our ordinary language. Also, the uncertainty associated with these statements is generally very large.

However, these statements may have some merit and we should be always aware of potential earthquake hazards, especially in the areas where geological activity is intense, such as California and Japan. Even in areas where normal seismic activity is not very high damaging earthquakes can occur; a good example is the recent earthquake in India. In a way, the force that can generate earthquakes exists everywhere and wherever the earth's crust is weak, an earthquake can occur. Of course, the frequency of earthquakes is in general higher in geologically active areas, but earthquakes do occur in relatively inactive areas, though less frequently.

Given this uncertainty, then, what should we do as citizens? There are a few simple things one can do to effectively minimize the impact of earthquakes. The following are examples: (1) Bolt down the house to foundations; (2) Fasten water-heaters, book-shelves, etc., to the wall; (3) Keep emergency supplies in good order. Of course, there are many other things one can do but these are among the most important.

What can seismologists and engineers do?

Seismologists have made good progress in understanding long-term behavior and the way seismic waves are generated by an earthquake. Engineers understand the effects of earthquakes on buildings and structures, and design and build earthquake-resistant structures. Geologists determine the long-term (*e.g.*, 100 to 1,000 years) behavior of earthquake faults. Thus, the overall process of earthquakes and their effects are understood well these days.

What seismologists, geologists and engineers can do is to assess the long-term seismic hazard in various regions and determine what kind of building and structural designs are needed in the respective regions. Long-term land-use planning and improvement of structures are extremely important for overall reduction of earthquake damage in the future.

New exciting developments include real-time earthquake information system and structural control. A real-time earthquake information system is an automated system that determines earthquake magnitude, location and the distribution of ground motion in real time, and broadcasts this information to various agencies. When a damaging earthquake occurs, it is essential for any emergency services, utility, communication and transportation agencies to know the location and size of the earthquake. Also important is the immediate distribution of ground motion

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in order to minimize the loss of lives and disruption of the city's function. Because of the inherent complexity of its process, an earthquake usually occurs without any warning. Furthermore, the effects of an earthquake can be also unpredictable because of the secondary hazards such as landslide, liquefaction, tsunami, fire and flooding, and the potential chain reactions between them would lead to more unpredictable consequences. Also, any urban area has old structures and defective or untested modern structures, which often fail somewhat unexpectedly. Real-time information system is essential for dealing with these inherently uncertain situations associated with earthquakes.

With the advancement of seismic instrumentation, communication and computer technologies, real-time information system is becoming more rapid and reliable, and is now a standard infrastructure of large metropolitan areas that are prone to seismic hazard. Such a system now exists in California, Japan, Taiwan and Mexico. If the system is fast enough, it is possible to send by radio (or other electronic methods) the information on ground shaking to places some distance away from the epicenter before shaking begins there, because radio waves travel much faster than seismic waves. Then, precautionary measures can be taken before shaking starts to protect lives and properties. This type of system is called an "Early Warning System" and has long been used in the Japanese Bullet Train system. Mexico has a similar system, and an advanced system is now being developed in Japan and California.

Another important engineering development is structural control. As technology develops, it is now possible to install a device that controls the behavior of buildings and structures during seismic shaking so that the effect of shaking can be minimized. Many controlled structures have been built recently in modern cities, especially in Japan. This is an important technological development that will contribute greatly to earthquake damage mitigation in modern urban areas.

A difficult problem is to deal with existing structures, which are not designed properly. There are many such structures, especially in developing countries, but also in modern industrialized countries. Large earthquakes that occur in densely populated areas in developing countries are often extremely devastating. Poor construction of houses and buildings is one of the main causes for such tragic events. Even if modern design practices have been introduced, they are not strictly enforced and the new structures are not rigorously inspected. How do we rectify this situation? It would require more than just science to improve this situation. Financial problem is one thing, but education and proper implementation of modern technology are also important. Efforts at an international level should be strongly encouraged to improve the situation with developing countries. Fortunately, some organizations are working actively in this area. For example, Geohazards International is a nonprofit organization aiming to reduce death and injury caused by earthquakes in the world's most vulnerable communities. Activities of organizations like this would be among the most important for reducing earthquake damage in developing countries.

Conclusion

The earthquake process is very complex and despite the progress in seismology, an accurate short-term prediction is difficult. However, seismologists now understand the basic physics of earthquakes and can make forecasts on the long-term behavior of earthquakes in a specific area. But such a long-term forecast is not directly useful for ordinary citizens because it would be very difficult for them to effectively respond to a vague warning about something that may or may not happen in the next 100 years. The basic understanding of the physics of earthquakes and long-term forecasts are indeed important for land-use planning, earthquake-resistant design of buildings and structures, including modern control system.

No matter how well prepared we are, earthquakes will inevitably strike even in normally seismically quiet areas, though less frequently. The consequence of a large earthquake in modern urban areas can be extremely unpredictable, too. Fires, landslides, disruption of lifelines could affect the function of modern cities in a complex fashion. To deal with this situation effectively at the government level, a real-time information system that helps streamline emergency services would be a key element. At the personal level, the few simple preparedness measures mentioned earlier can be very effective.

Earthquakes in developing countries with large population are often very tragic, mainly because of the poor construction combined with inadequate implementation of modern construction designs. Rectifying this situation would require serious international efforts.

How can we make all this work effectively? In addition to technological advancements in view of the inherently unpredictable nature of earthquakes, good coordination of efforts between scientists, emergency management personnel, utility operators, communication engineers, media, private citizens and others are extremely important. Fortunately, such efforts are now in progress in many parts of the world and the impact of earthquakes will be significantly minimized in the future. ◆

The Tokai Earthquake Prediction

In Japan, a very special program has been in effect for the Tokai area. On the basis of past earthquake activity and various geophysical data currently gathered, a group of scientists may one day advise the government to issue a short-term prediction.

From the present scientific point of view, this prediction will be very uncertain. However, even if the probability is small, if the predicted large earthquake did occur there, its consequence will be extremely serious. Thus, if proper measures were taken against the adverse effects of false alarms, such a prediction can be socially beneficial. This case clearly demonstrates that earthquake damage mitigation is not just a matter of science, but it should involve the entire society. Citizens should be informed of the correct implication of this type of special program.

golfcalendar

July 16
Yonsei Basketball Association Golf Tournament
Candlewood Country Club
Armando Padilla • (310) 327-0343

July 23
Heads Up Youth Foundation
Coto de Caza Country Club
Grace Wakamoto • (310) 768-1553

July 30
Jeff Aiu Memorial Golf Tournament
Industry Hills Golf Course
Richard Sato • (626) 918-3558

August 1
Golf Tournament for Tomohiro in L.A. Exhibition
Green River Golf Club
Tatsuhiko Wakao • (310) 540-5523

August 27
Asian American Christian Counseling Service
Los Verdes Country Club
Pam Fong • (626) 457-2900

August 27
Prime Minister's Cup Golf Tournament
Los Verdes Country Club
Shinji Abe • (213) 626-3067

September 10
Japan America Society
Yorba Linda Country Club
(213) 627-6217

September 17
2nd Annual San Fernando Valley Japanese American Community Center Golf Tournament
Calabasas Golf & Country Club
Hal Suetsugu • (626) 573-3556

September 24
Rafu Shimpo Charity Golf Classic
Dove Canyon
Michael Komai • (213) 629-2231

September 26
75th Anniversary Gardena Buddhist Church Tournament
Rio Hondo Country Club
Ken Inouse • (310) 541-8022

Where to Get More Information

California Department of Conservation, Division of Mines and Geology
(Maps and publications on earthquake faults)

P.O. Box 2980
Sacramento, CA 95812
(916) 445-5716

Federal Emergency Management Agency
(Publications on earthquake preparedness)

FEMA
P.O. Box 70274
Washington, DC 20024

Governor's Office of Emergency Services
(Free catalog, publications and videotapes on earthquake preparedness)

11200 Lexington Drive, Bldg. 283
Los Alamitos, CA 90720
(310) 795-2900

117 W. Micheltorena, Suite D
Santa Barbara, CA 93101
(805) 568-1207

1350 Front St., Suite 2041
San Diego, CA 92101
(619) 525-4287

U.S. Geological Survey
(Maps and publications on earthquake hazards)

Earth Science Information Center
345 Middlefield Road
Menlo Park, CA 94025
(415) 329-4390

Bookmark This!

Are you prepared for a natural disaster? Do you know what to do in a life-threatening emergency? Just what is an earthquake and will you experience one soon? Do you know what to do in its aftermath? We've compiled a list of some helpful Web sites that will provide answers to such important questions.

Surviving the Aftermath
www.redcross.org/services/disaster/afterdis
Preparation is key to surviving a disaster, but what do you do afterwards? Visit this American Red Cross site to get lifesaving information on what to do in the aftermath.
See page 15 for a detailed breakdown.

An Earthquake Information Center for Southern California
www.scec.org
Find extensive information on earthquakes, from its research to education and outreach. Just about everything you need to know about earthquakes is available at this up-to-date site by the Southern California Earthquake Center.

Study Seismology
www.trinet.org/scsn/scsn.html
This Southern California Seismic Network site provides general information, waveform data, outlines of faults in Southern California, shake maps and special reports on earthquakes.

Understanding California's Faults
www.consrv.ca.gov/dmg/pubs/cg/teacher/faults.htm
Created for teachers, but equally informative for parents, this site gives you an educational, easy to glimpse look at earthquake faults and their classifications.

Helping Children Cope with Disaster
www.ag.uiuc.edu/~disaster/teacher/teacher.html
Disasters are especially traumatic for children. Learn more about helping them through it at this site created by the University of Illinois. An effective guide for teachers and youth workers, the information on this site is also indispensable to parents.

Know Your Earthquake
quake.wr.usgs.gov
The Earthquake Hazards Program of Northern California has abundant information on the latest quake news, preparation, research and plenty of resources to keep you in the know.

Protecting Your Pets
www.hsus.org/disaster/index.html
During an earthquake or any other natural disaster, people aren't the only ones who need attention. If you're worried about your pet, visit this informative site. The Humane Society's page gives you tips on how to prepare and care for your pet during a natural disaster. You'll find info on how to evacuate your pet, whether they are domestic or farm animals.

Manage Your Emergency
www.fema.gov
This comprehensive site prepared by the Federal Emergency Management Agency is notable for detailing disaster news and information on emergency management. Also offered are directions for prevention and preparation.