a truly big earthquake is about to occur, or several major ones.

In addition to California, major earthquake are expected to take place in other parts of the world (see box).

Although there are some hopeful lessons from Kobe, most indications are that both Japan and the United States are woefully unprepared for the expected earthquakes.

Some hopeful lessons

One of the hopeful lessons from the Kobe earthquake is that buildings that were built to the latest earthquake-proofing standards survived very well. Unfortunately, buildings built to earlier standards did very poorly.

Another hopeful lesson is that programs to stabilize landfills worked very well. In the past 20 years, more than 200,000 special gravel drains and buried stone columns were installed in certain areas of Kobe. These areas suffered minimal damage.

On the negative side, the amount of devastation caused by the Kobe earthquake was unexpected. This is a serious warning, given the fact that Japan has one of the best earthquake preparation programs in the world. Scores of "earthquake proof" highways, railways, and subways were destroyed. Miles and miles of water, gas, and sewer lines were broken or otherwise damaged. Broken gas lines led to huge fires in several sections of the city.

A great deal of damage was done to the poor suburbs of Kobe, one of the weakest areas in Japanese earthquake damage-prevention efforts. In Kobe, as in many areas of Japan, older homes use a wooden post-and-beam construction style, where vertical posts brace long horizontal roof beams. Moreover, the traditional roofing for these structures in Japan is heavy terra cotta tile. This housing design is excellent for preventing damage from typhoons. However, it makes the structures inflexible and inherently unstable in earthquakes.

The earthquake itself was a surprise. It took place in what was considered a minor fault. The major earthquake, and thus most of the preparations, had been expected near Tokyo, where a major earthquake had killed over 140,000 people in 1923. Still, the Kobe earthquake should not have been unexpected. There was a major earthquake in the Kobe area in 1948, which, however, caused little damage, because most of Kobe had already been destroyed by American bombers.

Thus, that warning went unheeded. This warning now has to be heeded, because many of the world's most important cities sit on top of "minor faults."

Is a major earthquake coming in the Himalayas?

A massive earthquake could hit the central Himalayan region of India at any time, geophysicists are warning. A group of Indian and American geophysicists has been studying historical data and more recent data collected using the latest satellite technology. The data indicate that the central Himalayas in India is due to suffer a major earthquake, of magnitude 8 or 9 on the Richter scale (the Kobe earthquake was magnitude 6.9; since the scale is logarithmic, this quake could be 10 to 100 times greater than the Japanese earthquake). Such an earthquake would devastate a region with a population of more than 200 million and several major dams. "It is like the Sword of Damocles hanging over you," said Roger Bilham of the University of Colorado at Boulder.

The Himalayan range was formed as the Indian subcontinent drifted northward and collided with the Asian continent, a process that began 40 to 50 million years ago. Bilham and his colleagues used the Global Positioning System (GPS), a network of satellites and ground stations, to chart the progress of a set of points on the Indian and Asian tectonic plates between 1991 and 1994. They found that India is still crunching into Asia at a speed of two centimeters per year, the same rate at which the two sides of the San Andreas Fault in California are sliding past each other.

First direct measurement

These are the first direct measurements of the movement of the Indian subcontinent in relation to Asia, according to Vinod Gaur, former director of the Indian Geophysical Institute. Gaur is now based at the Center for Mathematical Modelling and Computer Simulation in Bangalore. Bilham, Gaur, and their colleagues recently presented their data at a meeting of the American Geophysical Union in San Francisco.

The India plate is moving down and under the Asian plate. The GPS data, however, indicate that all along the border with Nepal, the margins of the plates are stuck, according to Roland Burgmann, a geophysicist at Stanford University in California. Instead of one plate sliding smoothly under the other, the plates are colliding, storing energy like a spring. When the plate margins finally slip to release this energy, an earthquake results. How big the earthquake will be depends on how much stress has accumulated along the boundary of the two plates.

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