Engineers and Earthquakes

Caltech engineers develop a simple new instrument which should provide valuable information on the effects of strong earthquakes

"Earthquakes, we will grant, can be disastrous, but who's going to sit around and worry about something when you don't know when or where it will happen — or *even if* it will come in your lifetime?"

This is the kind of reasoning behind the apathy of the public toward the dangers of earthquakes to life and property. And this public apathy is evidenced every time a County Grand Jury proposes to reduce earthquake requirements for buildings. As recently as 1955, such proposals were made in Ventura and Marin counties in regard to school buildings.

The proposals were promptly criticized by the Earthquake Engineering Research Institute of California. George W. Housner, Caltech professor of civil engineering and applied mechanics, and president of the E.E.E.I., pointed out that the destructive California earthquakes of 1906, 1925, 1933, 1934, 1940, and 1952 had amply demonstrated the fact that school buildings not designed to resist earthquakes constituted a serious danger to the lives of school children. Buildings designed according to the minimum requirements of the state law, he noted, were safe for occupancy during earthquakes—even though the buildings might suffer minor damage.

Interest in earthquake technology is much greater in Japan than it is in the United States. In addition to regular university research, the Japanese government supports earthquake study institutes at Tokyo and Kyoto. In the United States, the government supports only the work of the limited number of men who are working with the U.S. Coast and Geodetic Survey, collecting data on destructive earthquakes.

One compelling reason for Japan's interest in this research is its memory of the earthquake of 1923 which took more than 100,000 lives. California's last truly disastrous earthquake was that in San Francisco in 1906 — so long ago that it arouses little concern.

In the past a number of potentially destructive earthquakes occurred in California without being near heavily populated areas, but in recent years the growth of California's population accentuates the danger of earthquakes.

Caltech's Engineering Division has recently launched a major program in earthquake research, with the ultimate objective of preventing disasters such as accompanied the 1906 San Francisco and 1933 Long Beach earthquakes.

One of the major stumbling blocks in the study of the effects of strong earthquakes has always been a lack of good data. More information is needed on the effect of ground tremors on different structural designs, and on the part that the particular geological makeup of the surrounding area plays in the effect of an earthquake on a building. With this kind of data, it might, for example, be possible to correlate soil conditions with earthquake damage.

Some of this data can be acquired in laboratories; some can be obtained by studying the effects of blasting on nearby buildings; but much of the required data can only come from direct study of actual earthquakes.

To provide information for engineering studies, the U.S. Coast and Geodetic Survey maintains a number of strong-motion accelerometers to record the

ground motion during strong earthquakes. The table below shows the Pacific Coast strong-motion earthquakes for which there are recorded accelerograms of ground motion sufficiently strong to be of engineering interest.

Earthquake	*Strong-motion accelerometer station*
March 10, 1933	Vernon
October 2, 1933	Vernon
December 30, 1934	El Centro
October 21, 1935	Helena, Montana
September 11, 1938	Ferndale
May 18, 1940	El Centro
February 9, 1941	Ferndale
June 30, 1941	Santa Barbara
October 3, 1941	Ferndale
March 9, 1949	Hollister
April 13, 1949	Seattle, Washington
	Olympia, Washington
July 21, 1952	Taft
March 22, 1957	State Building, San Francisco
	Alexander Building, San Francisco
	Golden Gate Park, San Francisco
	Southern Pacific Building, San Francisco
	Oakland City Hall

The 1957 tremor is particularly valuable for engineering studies since it was the first earthquake that provided good records at more than two strong-motion accelerometer stations in the epicentral region.

One reason earthquake data has been so hard to come by (outside of the infrequency of the earthquakes themselves) has been the prohibitive cost of the instruments used to record the tremors. So, in recent years, Donald E. Hudson, professor of engineering at Caltech, and Prof. George W. Housner have been actively engaged in developing a simplified instrument that could be produced at a low enough cost to permit large numbers of them to be distributed in important areas. The project is sponsored by the National Science Foundation, and the first batch of instruments has been constructed by the Wilmot Engineering Company of Pasadena. A second batch is now being made by the Sprengnether Instrument Company of St. Louis for the U.S. Coast and Geodetic Survey.

The Wilmot Survey Type Strong-Motion Earthquake Recorder, as the one presently designed is called, is an instrument which measures directly one point on the relative velocity response spectrum curves. It lacks the time-recording advantage of the larger, more complex, and expensive accelerometers, but only costs one-fiftieth as much. Whereas the seismographs operated by seismologists are able to measure small, distant quakes, the strong-motion accelerometers and the new instruments are designed to record only earth motions in the immediate vicinity of the epicenter that are strong enough to be of engineering significance.

The instrument itself is essentially a free conical pendulum, with a period of 0.75 second and 10 percent of critical damping, which is capable of swinging in all directions. The pendulum is topped with an inverted smoked water glass. The motions of the earth cause the glass to move against the point of a needle, which etches a pattern into the smoked coating, tracing the motion of the pendulum and indicating the intensity of the earth movement. The glass can then be removed and dipped in lacquer to make the record permanent.

The particular design parameters for the instrument were selected after a careful study of the complete response curves for past earthquakes, and of the dynamic characteristics of typical building structures. The results of the analysis of strong-motion accelerometer data obtained for the San Francisco earthquake of March 22, 1957 were particularly useful in this respect.

The entire eight-by-twelve-inch instrument weighs eight pounds. Once bolted to a basement floor or to a rock it requires no maintenance.

At a cost of about $100 each, one hundred of these earthquake recorders are now being installed in the Los Angeles and San Francisco metropolitan areas. Dr. Cinna Lomnitz of the University of Chile (Caltech PhD '55) is constructing some of the recorders for use in his country. One of the Caltech instruments is being sent to India to serve as a model. When the strong earthquakes that seismologists anticipate for California do occur, this new instrument program is expected to provide valuable information.

But the engineers who are working to decrease the dangers of earthquakes to life and property realize that they have another problem to overcome – which is to get the results of their work out into practice. Drs. Hudson and Housner are now in India at the University of Roorkee, helping to set up a research laboratory for the study of strong earthquakes and their effects. They report that it will probably be easier to set up the laboratory and to make the studies than to induce the country to make full use of the results.

As noted, our own country is not entirely free of inertia in this respect – even though the larger cities in California do make good use of preventive measures against earthquake damage. But it is better to rely on the adage, "God helps those who help themselves" rather than to rely on the prayer recommended by the author of a booklet published in Naples after the destructive earthquake of 20 March 1730:

> *The Lord bless you and keep you and show you His face, and have mercy on you, and may He turn His countenance to you and give you peace and health. The Lord bless this house and the occupants in it, and liberate it from the onset of earthquakes.*