EDITORIAL

Towards the end of last year, one of my colleagues who was on leave in the United States sent back a cutting from the New York Times (8 August 1995) containing an article by Sandra Blakeslee entitled "Hopes for predicting earthquakes once so bright, are growing dim". The article was based on the views of a number of U.S. seismologists and geophysicists and describes how the science of earthquake prediction has fallen on hard times with some experts viewing earthquakes as a classic example of a chaotic system. Many U.S. seismologists are now reported to think that earthquakes are inherently unpredictable. They say that the search for ways to warn people days, hours, or minutes before an earthquake appears to be futile.

Currently, a third of the US$100 million now spent on earthquake research and reducing hazards in the U.S. is spent on ways to construct safer buildings, bridges and highways. The rest is spent on basic research on understanding earthquakes and looking for ways to predict them. If earthquakes cannot be predicted, it is not surprising that some U.S. scientists think that much more of the money should be spent on reducing the hazards.

Whatever the outcome, the article reports that earthquake prediction has undergone a reversal of fortune from the belief of many scientists during the 1960s through to the mid-1980s that it was possible. Two scientific models drove this optimism. One, called dilatancy theory, is similar to what happens when people at a beach step on wet sand and the sand dries out around their feet. It was thought that the same phenomena would occur in earthquake faults before their failure, as stressed rocks deformed in a characteristic way and released water that could be detected. A second related idea, called the seismic gap hypothesis, says that earthquakes tend to repeat along known fault zones. After an earthquake, stress is released over time - perhaps several hundred years - strain reaccumulates and the fault is destined to break again in a more or less characteristic pattern.

The likelihood of earthquakes reoccurring along several segments of the San Andreas fault have been predicted using this latter model. Instruments were set up along one segment of the fault near Parkfield, about halfway between San Francisco and Los Angeles, where the seismic gap hypothesis predicted another earthquake should occur. The instruments are designed to find precursors, like subtle motions in the earth's crust, so that people can be warned shortly before an earthquake strikes. Unfortunately, the predictions have not been going as planned for the Parkfield earthquake is overdue, having been predicted to occur before 1992! Also, the most recent damaging earthquakes in North America and Japan - Loma Prieta, Northridge and Kobe - struck without any precursory signals.

More importantly, there seems to have been a shift in thinking about the dynamics of earthquakes. The idea that big stresses build up along fault zones and then have to be released in a characteristic manner is no longer considered to make as much sense as it once did. Since actual measurements deep in the ground indicate that stresses within faults are actually very weak, the mystery is why earthquakes occur at all with such small stresses. Apparently, clues to this mystery are now being found in the new science of chaos and complexity with earthquakes being a classic example of a chaotic system.

In this view, the earth's crust is prone to constant shifting, particularly along fault lines. Tiny earthquakes are occurring all the time. In major seismic regions of the world, thousands of earthquakes may be detected each year, though most are not felt. However, for reasons not understood, some of these small earthquakes do not stop. Local rock conditions or other geologic factors allow a magnitude one earthquake to expand into a magnitude two earthquake involving a larger region. Less commonly, a magnitude two earthquake develops into or sets off a magnitude three earthquake, and so on. According to this view, a big earthquake can be thought off as a small one that has run away. The problem in earthquake prediction lies in being able to predict in sufficient detail just which of the small earthquakes will become large.

However, not all scientists share this pessimism and a number of geophysicists have recently proposed an earthquake model that might help to determine which earthquakes could become large. This involves measuring the slow, steady slip that occurs along fault before they undergo high speed slipping that gives rise to an earthquake. One of the problems is how to detect slow slippage (so slow that it doesn't generate seismic waves) over sufficiently large areas.

According to the article, the recent large earthquakes in California and Japan have had the effect of bringing the debate about earthquake prediction to public notice rather than letting it remain in more academic circles. Now some people are calling for the Government to stop spending money on earthquake research and put it all into reducing earthquake hazards. As a seismologist at the United States Geological Survey says, that would be foolish as faults could interact in complex ways and not understanding them could be more costly in the long run.

Nevertheless, there are suggestions that more could be spent on engineering research as there is serious under-investment in our knowledge of how buildings work in earthquakes, how the ground moves and how buildings react. The recent large earthquakes have shown that tall structures in our cities are likely to suffer severe damage. After the Northridge earthquake for instance, it was found that about 100 steel-framed buildings were damaged, and they had been considered to be one of the better type of earthquake resistant structure. As the Californian Seismic Safety Commission says in its report on the Northridge earthquake: "Despite our codes and world-renowned expertise, too many of our buildings and other structures remain vulnerable to earthquake damage. There are significant weaknesses in the way we exercise land use planning laws and design and construct buildings and lifelines". One solution offered is for a moratorium on building any new structures over six stories high in the Los Angeles area until engineers know how to build tall structures that can withstand moderate and severe shaking!

If nothing else, it looks as though the debate about earthquake prediction and how best to spend funds to improve seismic safety will go on for some time yet, not only in the United States but also in New Zealand, Japan and other countries in the highly seismic regions of the world.