HOW WELL IS THE INSURANCE INDUSTRY SERVED BY EXISTING RESEARCH AND TECHNOLOGY?

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INTRODUCTION

The question which forms my theme is well posed. When a damaging earthquake occurs, it is left to society to meet the cost, in both human and economic terms. A scientific understanding of the physical process responsible for the devastation is clearly desirable. But does continued study of the earthquake phenomenon help society, and in particular does it help the Insurance Industry?

INSTRUMENTS AND TECHNIQUES

A short description of what the earthquake scientist does, and of what equipment he uses, is in order. There are essentially two kinds of instruments, both of which measure the movement of the ground.

A **SEISMOGRAPH** is an extremely sensitive instrument, which can detect moderate and large earthquakes at great distances (such as the other side of the Earth), or extremely small disturbances nearby which are far too small to be of direct consequence to any structures. There are very many small earthquakes, and much of the seismologist's work is in recording and studying these, for only in this way can an understanding of the whole earthquake phenomenon be gained. Most seismographs in New Zealand are operated by the Geophysics Division of the DSIR.

A **STRONG MOTION RECORDER** is a much more rugged instrument. Its purpose is not so much to study the earthquake source, but rather to examine the detail of the motion which causes damage to structures. If a building fails, it is important to know the severity of the ground motion to which it was subjected. The following questions must then be asked. Was the ground motion more than the building was designed for? If so, should its replacement be designed more strongly? If the ground motion was only moderate, why did the building fail? Because of the engineering applications for this type of recording, most strong motion recorders in New Zealand are operated by the Physics and Engineering Laboratory of the DSIR.

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I should not overlook my geologist colleagues. Large earthquakes commonly distort the ground surface in a permanent way, such as by abrupt break, or rupture, on a geological fault, by uplift or by subsidence. This permanent deformation poses an increased level of hazard, beyond that due to the shaking itself. And because it leaves a permanent record, past earthquakes may be identified. Thus geological investigation can be used to extend our knowledge of our earthquake history, back beyond the time of written records, and this is helpful in ascertaining the level of earthquake hazard.

OBJECTIVES

Scientific work in studying earthquakes has three purposes in view. They are mutually dependent.

(a) To understand the physical process of an earthquake. I here define an earthquake not as the actual shaking but as the disruption that occurs within the Earth. Shock waves travel outwards in all directions and can cause damage to structures.

(b) To describe the geological structure of the Earth, and ascertain its effects on propagating seismic waves. The severity with which any structure is shaken depends not only on the earthquake source and its distance from the site in question, but also on the local site conditions: strong rock, valley sediments, coastal sand dunes, etc. Moreover, the properties of deep geological structures can only be ascertained by studying the passage of earthquake waves through them.

(c) How bad is the risk? How often will I get shaken, and how badly? Will tall buildings be affected? Short buildings? The answers to these questions depend heavily on the knowledge gained in the first two sections of research. Estimates of future shaking can only be made on the basis of recordings made in the past, of our knowledge of the rate of occurrence of earthquakes and of their known effects. The swaying of various types of buildings can be calculated, so that their likely performance in earthquakes can be estimated.

It was in recognition of the fact that these three areas of research overlap that the Commission recently made a substantial grant to the DSIR for the upgrading of the seismograph and strong motion networks. Old recording equipment is being replaced with modern digital recorders which will provide data capable of being subjected to modern computer analysis.

PROGRESS IN RESEARCH

What have we learnt? Seismographs have been operated in New Zealand for about a hundred years, strong motion recorders for the last few decades. As a result, the following are examples of areas where knowledge of the earthquake phenomenon and its effects has advanced.

(a) Geographical variation of earthquake occurrence. Earthquakes occur throughout New Zealand, but most strongly in the main Seismic Region which extends from Coromandel and East Cape to about Greymouth and Christchurch, and also in Fiordland. The physical reasons for this variation are now understood, so that forward projections of future rates of occurrence can be made in a reliable way.

(b) The pattern of damage in strong earthquakes can now be quantified. Why was it that the 1929 Buller earthquake was felt over virtually the whole country, while the 1931 Hawke's Bay earthquake, of about the same Richter magnitude, was not felt north of Auckland? An understanding of the way in which earthquake waves travel, and of how they interact with geological strata, sheds light on this. So the likely effects of a large earthquake anywhere in the country can be estimated, on the basis of past occurrences and knowledge of the behaviour of earthquake shock waves.

(c) Earthquakes are not all the same. Size apart, there are essential differences in the mechanisms of earthquakes. All result from the Earth being deformed under stress, and rupturing, but this can take place in a variety of ways and the resulting patterns of damage differ. This is one of the areas that we know least about in New Zealand, but it is clear that there are characteristic mechanisms in particular parts of the country, and these must be reflected in the severity of the hazard.

(d) For special structures, individual site-specific estimates of the hazard can be made. Recent advances in ways to model the propagation of seismic energy through complex geological structures have resulted in more reliable techniques to assess the likely effects of earthquakes at specific sites. The difference between siting a structure on a hill or in a valley, on firm rock or unconsolidated ground, can now be estimated. Large important structures warrant this kind of analysis.

(e) The characteristics of specific sites can now be measured with portable recorders. One site can be compared with another during small earthquakes, which occur almost every day, and the comparison scaled up to large, damaging shocks.

(f) Structures will respond to earthquakes in ways that can be modelled theoretically. This allows the design of buildings to be checked against likely earthquake motions, and it also allows buildings to be designed to resist such motions. Detailed data from strong motion recorders are used to check the design of buildings, and in the development of design criteria for future structures.

THE IDEAL INFORMATION PACKAGE

It seems to me that the insurance industry should be concerned to know, for actuarial purposes, the likely damage to any given structure at a specified location. To provide this information we will need to know first all the earthquake history in the area, and this is one particular aspect of earthquake research in New Zealand which still needs much work. There has never been a comprehensive examination of all written records (newspapers, diaries, journals, etc) for the period 1855 to 1940, collecting all available information about earthquakes that occurred and their effects. The period before 1855 has been studied, and instrumental records are good since 1940. The fact that the intervening period has never been examined properly is surely a question of resources within the seismological community.

Many of the geological faults in New Zealand will yield a wealth of information if they can be excavated systematically at a few locations. This work would reveal the history of large earthquakes in prehistoric times, and a better understanding of their average rate of occurrence of earthquakes could be built up.

New digitally recording seismographs and strong motion recorders will provide much information about the details of the earthquake source. This is a fundamental research area and important in any hazard study.

Techniques for estimating the likely severity of ground motion at a particular locality have been developed considerably, and this work is still progressing. Seismology is not an exact science. There is still a need for more recordings obtained during large earthquakes. With these, more comparisons with calculations can be made, and more refinements made to mathematical procedures.

Procedures for designing buildings to withstand earthquakes, and for predicting the response of buildings when subjected to strong ground motion, are well established. But these can be refined by experience, and that means good records of buildings in large earthquakes, for comparison with theoretical estimates of how they should perform. It is of course as important economically to avoid gross overdesign of structures as it is to ensure that anti-seismic design measures are adequate.

EARTHQUAKE PREDICTION

I have said nothing about earthquake prediction. The truth is that while this is an issue which attracts a lot of public interest, it is probably the area of seismology about which scientists are least confident of success. Much money has been invested in research into earthquake prediction, particularly in the USA and Japan, with very little success. Detailed experiments are currently underway in those two countries. From an insurance point of view, the question of whether or not an earthquake can be predicted seems to me to be of little consequence. But still the public clamour for a scientific advance which will enable predictions to be made. At the present state of the science, I see a possibility that medium to long-term predictions might one day be feasible (time scale months to years), because there are some indications of changes in the ongoing pattern of small earthquakes, before the large one arrives. But there are no promises in science, and from an insurance perspective that is probably just as well in this case.