THE NEW ZEALAND STRONG MOTION EARTHQUAKE RECORDER NETWORK

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SYNOPSIS

The network of strong-motion earthquake recorders, maintained throughout New Zealand by the Engineering Seismology Section of the Department of Scientific and Industrial Research, is described. The instruments are either deployed as ground instruments to measure potential earthquake attack on structures, or in structures, e.g. buildings, dams and industrial installations, to record structural response. Details are given of installation of instruments, maintenance, laboratory work, record retrieval and digitisation, costs and staffing for the network. Future developments mooted include an improved digitising system, the introduction of an improved version of the existing mechanical-optical instrument in 1979, and, in the long term, the introduction of an entirely new digital recorder, having an electrical output from its accelerometers, which will make possible the transmission of data by telephone or radio link.

1. INTRODUCTION

The Physics and Engineering Laboratory first became interested in earthquake recording in the 1950s as the result of requests from designers about the effect of earthquakes in New Zealand on engineering structures. Instruments were designed and developed and a network of strong motion recorders has been gradually built up throughout the country. The network was first described in the Bulletin of the New Zealand Society for Earthquake Engineering in 1970[1] when there were 77 three component records and 74 two component (non time-base) recorders. By the end of 1978 the number of three component recorders had risen to 125 while the number of two component records remained the same, the increase in the number of three component recorders resulting mainly from requests for installations in important structures such as power stations, bridges and buildings.

With an increasing number of records accumulating at the Laboratory, emphasis is now being placed on their digitisation and routine analysis, so that they can be used in research and in the computerised design of structures, thereby enabling improvements to be made in earthquake-resistant design.

2.0 THE INSTRUMENTS

2.1 MO2 Accelerograph (Fig. 1)

The primary instrument of the New Zealand network is type MO2 (mechanical-optical) accelerograph, which records accelerations at its location in three orthogonal directions, from the motions of damped pendulums. It records high definition traces on unperforated 35 mm film. Time marks are provided which are controlled either by a tuning fork clock, or more recently by a crystal oscillator, imprinted along the edge of the film at 0.02 second intervals. Starting is initiated by a vertical sensing geophone. For inter-connected accelerographs, any one instrument started by an earthquake acceleration will also start all the others in that system. The film cassette holds sufficient film for nine records, each of 47 seconds duration.

The accelerograph is fully sealed and operates off a 12 volt dry cell power supply. More detailed information on the accelerograph is outlined in the instrument manual[2].

2.2 MO1 Accelerograph

The MO2 was developed from the type MO1 three component accelerograph and 24 of the type MO1 are still in operation in the network. They are gradually being replaced by the type MO2 recorder, as they do not have the facility for inter-connection or time marking, and are not sealed.

These instruments are mainly situated in telephone exchanges as this gives the best environment for successful operation.

2.3 SP2 Accelerograph

The two component SP (scratch plate) accelerographs (Fig. 2), recording accelerations in the horizontal plane only, were the first instruments to be used in the network. Although limited in accuracy and lacking a time base, they have given records at many points where otherwise none would have been available, notably during the Inangahua earthquake. When installed beside a MO2 accelerograph they have provided a valuable back-up.

The accelerograph is based on an inverted pendulum with an undamped period of 0.06 seconds, and a damping factor of about 60% of critical, the damping being provided by silicone oil. The relative displacement of the pendulum weight, with respect to the base, is a measure of the amplitude and direction of the horizontal acceleration of the instrument[2]. The movement of the pendulum weight is amplified by the lightweight extension arm into which is plugged a smoked

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glass disc. A fine line, (about 0.01 mm wide) is inscribed on the smoked surface of the moving disc by a specially sharpened steel needle, this giving the acceleration record. The instrument has proved to be very reliable and the only cause of inoperation has been vandalism.

3. THE NETWORK

3.1 Instrument Distribution

The distribution of MO1 and MO2 recorders throughout the country is illustrated in Figure 3, and the breakdown in terms of buildings, dams and bridges and individual instruments is given in Table 1. The distribution of SP recorders is shown in Figure 4. The build-up of MO instruments since 1965 is shown in Figure 5, the most rapid increase in numbers occurring in the two years following the Inangahua earthquake in 1968. Of the total of 125 three component recorders distributed throughout the country only 15 MO2s and 19 MO1s were purchased by the Laboratory, the remainder either being purchased by government departments or by private building owners on the advice of consulting engineers. Agreement has been obtained for the installation of a further 29 instruments in buildings, bridges and power stations (Table 2).

From Table 1 it is seen that all of the instruments purchased by other authorities have been required for particular structures, while those purchased by PEL have been for ground installation, either to fill gaps in the network (22 instruments) or for micro-zone installations in the Wellington and Hutt Valley areas (12 instruments). All the projected installations listed in Table 2 are for structures, over half of which, 18 instruments, are for the Wellington area.

The instruments in the network have been deployed to gather data of two kinds to promote the design of more efficient and economical earthquake resistant structures. Firstly, ground accelerations are recorded so that designers have a wider data base from which to select the most appropriate earthquake loadings for use in structural design. Secondly, accelerations are recorded at several locations throughout major structures to monitor their performance during strong-motion earthquakes (Fig. 6).

Most ground based instruments are located in areas of highest seismicity, which are indicated by the map prepared by the Seismological Observatory showing the occurrence and distribution of earthquakes in New Zealand since 1840 (Fig. 7). This shows that the major earthquakes occur in a zone which is along a band running roughly between Milford in the south-west to Cape Runaway in the north-east. Although the Laboratory does not intend to increase the total number of instruments in the network, a comparison between this map and the distribution of MO2 instruments (Fig. 3) indicates that more instruments of this type should be added to fill in gaps along this band, particularly in the area north of the Wairarapa through to Napier. Some redistribution is possible, however, e.g. no records have been obtained from Auckland from the time the network was first started and it is less likely that performance data into the ductile range will be obtained from the instrumented tall buildings there. Perhaps therefore the number of instruments in these buildings should be reduced in favour of ground-based instruments only in Auckland. Also, improvements are being carried out by selectively replacing SP instruments by MO2 instruments in preferred locations, the service time for the two instruments being about the same.

3.2 Local Microzone Networks

Two local networks in the Hutt Valley and in the Te Aro district of Wellington City have been set up to study the influence of local geological features and of soil properties on ground motion.

3.3 Networks at Dam Sites

Instrument arrays have been installed at dam sites, either to study local seismicity and microzone effects during a site investigation (e.g. Atene) or to study structural response, as at the earth dams of Matahina and Benmore. One particular use of an array of instruments on a dam is in recording the effect of any local earthquakes which may be caused by filling the lake behind the dam. Improved knowledge of the seismic behaviour of dams is of great importance from the safety aspect.

3.4 Instruments in Industrial Installations

The safety aspect is also of considerable importance in industrial installations. Two MO2 recorders have recently been installed at the Maui A offshore gas rig which will enable the loading on the structure in the event of an earthquake to be assessed. Similar safety aspects apply to the installation of a recorder at the Karioi wood-pulp mill where it will be possible to assess loadings on the machinery and pipework and its fixings. In addition, a request has recently been received for an installation in a thermal power station, together with an earthquake trigger which will give a warning to engineers in noisy areas that an earthquake is taking place, thereby allowing emergency measures to be taken. Such a trigger has already been manufactured for an industrial installation from standard MO parts, and a commercial device should soon be available.

3.5 Instrument Installation

The instruments are normally bolted firmly down to a concrete plinth which can be set conveniently above the normal concrete floor level. In the field the plinth needs to be keyed thoroughly to the surface for which motion is to be recorded. Occasionally instruments may be bolted to a vertical concrete wall in bridge or building applications. They are protected by a padlocked steel case.

3.6 Instrument Siting

Because of the risk of vandalism of field instruments, instruments of the main ground network are normally located in the basements of smaller public buildings such as post offices, telephone exchanges and fire stations. Within multi-storey buildings instruments are located in storerooms or