DEPLOYMENT OF STRONG MOTION SEISMOGRAPHS IN WESTERN CANADA

by

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SYNOPSIS

A network of strong motion seismographs has been set out in the seismically active zones of western Canada. The network is being developed to provide a tool for investigating soil response and for investigating the attenuation of strong seismic motion with distance. In a few of the more densely populated areas, accelerographs and seismoscopes are set out in an array to provide data from a number of general soil types. Results from 3 Canadian accelerograms, and 3 accelerograms collected in the United States close to the Canadian border are compared with the attenuation curves used in calculating Canada's present seismic zoning map.

NETWORK DESCRIPTION

A program to establish a network of strong motion seismographs in the seismically active regions in western Canada was begun in 1963 (1). The network of government and privately owned instruments has expanded steadily to where now, 10 years later, it is composed of twenty-four accelerographs, sixty-three seismoscopes, and seven peak recording accelerographs. The objective of the program is to acquire records of the amplitudes and frequencies of local earthquakes on a variety of foundation materials in western Canada. The distribution of the instruments is a compromise between nearness to epicentres of recent major earthquakes and nearness to present population centres where the information gained has a practical application. In four districts of western Canada seismoscopes and accelerographs have been concentrated in arrays to study the response of local soils. In each district one seismoscope is placed next to each accelerograph, and the remaining seismoscopes are located on various typical foundation materials, including rock. Low mass structures are used as sites whenever possible to minimize the amplitude of the feedback of the building into the ground during a large earthquake. The records of local earthquakes are used to study variation in soil response and to obtain acceleration attenuation curves for statistical studies of the regional earthquake risk. Single accelerographs have been deployed in less populated areas along the Pacific coast, for the purposes of investigating acceleration attenuation and of recording near to a large earthquake. One accelerograph has been placed upon permanently frozen soil in an active seismic zone near the Mackenzie Delta in the Arctic.

There are several privately owned strong motion seismographs affiliated with the network. They are all located within specific structures, but are installed and maintained by members of the Seismology Division of the Earth Physics Branch with the provision that any records obtained are to remain in the public domain. The Earth

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Physics Branch encourages the deployment of private instruments in structures of special interest. Records at these sites may be compared with the records of free field instruments from the government network.

The array of strong motion seismographs in the metropolitan area along the lower Fraser River valley can be used to illustrate the objectives of the program. This region is within zone 3 of the Canadian seismic zoning map and can therefore expect to be shaken with at least an intensity of VI on the modified Mercalli intensity scale within the lifetime of most buildings. Previously damaging earthquakes have been to the south and to the northwest of this region. The axes of the array of instruments are aimed in these directions. At least one instrument has been placed on each general soil type (figure 1) and instruments have been placed only at sites where some foundation data are available. Careful attention has also been paid to the proximity of major structures and proposed community development so that the information gained can be put to the best of use.

Three earthquakes have produced accelerograms in western Canada, all at low amplitudes. Two of these (a magnitude 6.5 earthquake in 1965 at a distance of 140 km and near Seattle, Washington; and a magnitude 4.2 earthquake in 1969 at a distance of 45 km and near Bellingham, Washington) were recorded on an accelerograph located on a deep soil deposit at the University of Victoria (UV). The other event (a magnitude 7.0 earthquake in 1970 at a distance of 165 km and south of the Queen Charlotte Islands) was recorded on an accelerograph at Sandspit (SS). These records were digitized at Victoria on an equal time interval digitizer (2). Data on each accelerogram have been reduced by procedures developed by the California Institute of Technology (3) and modified for use on the digitizer and computer available at Victoria. Velocity, displacement, velocity response curves, Fourier analysis curves, and power spectral density curves have been produced for each acceleration trace. All these data along with available site information will be published as records are obtained.

DATA OBTAINED

The 1969 earthquake was recorded on one accelerograph and several seismoscopes at a distance of 45 km. The results, although near the lower limit of sensitivity of the instruments, showed that over a small range of distances within Victoria there can be considerable variation in soil response due to even a moderate earthquake. The data from these records have been published previously (4).

The data from the strong motion program are used to check the acceleration attenuation curves employed in the derivation of Canada's present seismic zoning map. The seismic zones are defined from a statistical analysis of observations of current earthquakes, and one of the basic parameters in the analysis is the maximum acceleration amplitude of each catalogued earthquake at any site. These amplitudes are obtained from acceleration attenuation curves developed by Milne and Davenport (5). For western Canada, these curves were obtained from accelerograms of California earthquakes. There were no indications that these data were not valid in western Canada.

In figure 2, attenuation curves used for western Canada have been plotted using the Milne-Davenport formula (5) for the three earthquakes which have been recorded (1965, M = 6.5; 1969, M = 4.2; 1970, M = 7.0). Peak horizontal accelerations have been obtained from the three Canadian accelerograms. Accelerograms for three United States sites in northern Washington near the Canadian border have been obtained for the 1965 earthquake, and peak horizontal accelerations have been calculated from each. The locations of all the stations used are shown in figure 3. Table Ia lists the peak accelerations obtained at each site. These peak accelerations are plotted on figure 2 at their appropriate distances. The distances for the 1969 and 1970 events are epicentral distances, but hypocentral distances are used for the 1965 earthquake since it had a depth of 60 km. Also plotted on the graph are the accelerations corresponding to the average maximum observed distance of different levels of intensity for the 1965 and 1969 earthquakes. The data are listed in table Ib. As expected, because of local soil conditions, the peak acceleration at UV, OL, and SS are above the attenuation curves for their respective magnitudes. The fact that OL is markedly above the curve needs further investigation. The maximum distances of the intensities however correspond more closely to the curves than do accelerations because they are an averaged value by the nature of their compilation (6). The reason that the 1969 event lies above the attenuation curve cannot yet be resolved. Possibly the location of the epicentre is in error, or the site is anomalous because of the soil type, or the attenuation curves for small earthquakes at short distances need to be modified. These few data suggest that there is yet no apparent need to modify the attenuation curves used in the calculation of the seismic zoning map.

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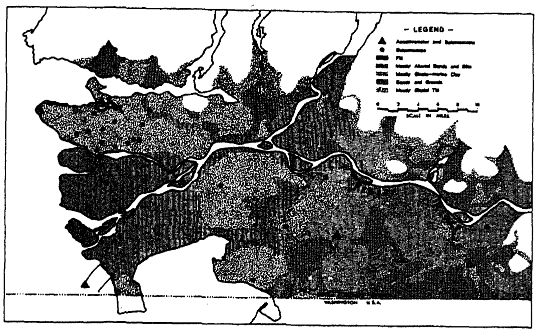

FIGURE 1. SEISMOGRAPH ARRAY IN FRASER RIVER VALLEY

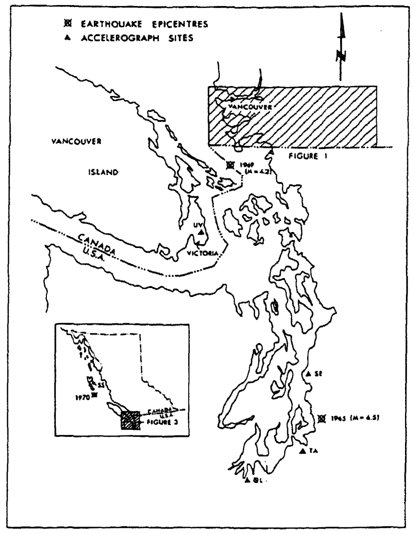

FIGURE 3. EARTHQUAKE EPICENTRES, AND ACCELEROMETER SITES

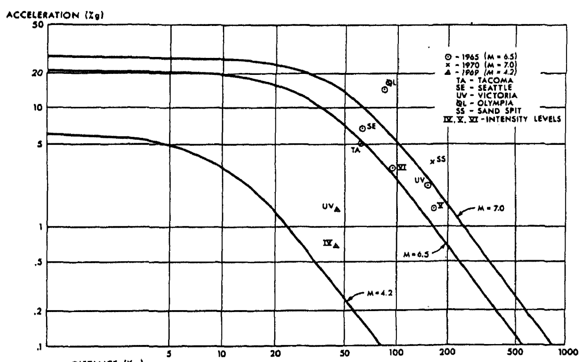

FIGURE 2. ACCELERATION ATTENUATION CURVES

(a) Peak Acceleration (%g)

Station	Date	Distance Km	Average Peak Horizontal Acceleration (%g)
Seattle (SE)	1965	64	6.7
Tacoma (TA)	1965	63	5.0
Olympia (OL)	1965	86	14.7
Victoria (UV)	1965	152	2.2
Victoria (UV)	1969	45	1.4
Sandspit (SS)	1970	165	3.6

(b) Average Maximum Limits of Intensity Levels

Date	Intensity Level	Acceleration (%g)	Distance (km)
1965	V	1.5	163
1965	VI	3.2	94
1969	IV	0.7	45

TABLE 1