NEW SEISMIC ZONING MAPS OF CANADA

by

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EXTENDED ABSTRACT

General developments in seismology in the past decade have made it desirable and feasible to derive new seismic zoning maps to replace the 1970 zoning map used for current National Building Code applications. More than 15 years of low magnitude earthquake monitoring and research on seismotectonics has improved the delineation of earthquake source zones in most regions of the country. Development of methods of earthquake risk analysis and improvement of estimates of strong seismic ground motion have made possible lower probability ground motion estimates over a broader frequency range of building response.

The 1970 seismic zoning map was developed using extreme-value statistics applied to the catalog of known earthquakes (between 1899 and 1963) to compute probabilities of peak acceleration exceedence throughout Canada. The new zoning maps, shown as Figures 1 and 2, have been prepared by applying the Cornell-McGuire method of risk estimation to a model that defines Canadian seismicity in 32 earthquake source zones (1). New peak horizontal acceleration and peak horizontal velocity attenuation relations permit computation of two parameters that are representative of seismic ground motion in the frequency ranges near 5 Hz and near 1 Hz, respectively. The probability of exceedence of the seismic ground motion has been reduced from 0.01 per annum (40% probability of exceedence in 50 years) on the 1970 map to 10% probability of exceedence in 50 years on the new maps, in order that the ground motion probability be more appropriate to the design levels achieved by the application of the provisions of the code.

Computed peak accelerations and velocities have been contoured to produce the seven seismic zones (0-6) shown in Figures 1 and 2. The contour levels have been adopted following trials to determine in which resulting zones various cities in western and eastern Canada would fall with different choices of contours. This involved perceptions of relative levels of risk among various large cities and, where possible, the avoidance of contours which become zone boundaries bisecting large urban areas. The resulting maps with seven zones provide a more detailed subdivision of risk in moderate risk areas and additional zones in high risk areas, compared to the 1970 zoning map. Zone 6, the region of highest risk on the new maps, has no upper-bound on the ground motion parameters. The proposed National Building Code formula for base shear is related to zonal velocities (v) shown in the legend of Figure 2 (2).

The choice of the same numerical values for the acceleration contours (in g) and velocity contours (in m/s) is convenient, but it is also appropriate. When converted to common units, the numerically equivalent contours in Figures 1 and 2 imply the same corner period as that of the acceleration-and velocity-flat levels in average ground motion bounds employed for development of response spectra. However, the relative levels of acceleration and velocity do vary considerably across Canada; the ratio of the two parameters varies from about 0.5 to 2.5. If the relative levels did not vary, a separate velocity map would not be needed; it could be simply scaled from the acceleration map. The different levels of acceleration and velocity at various locations in Figures 1 and 2 result from the nature of the earthquakes contributing to the risk. Acceleration tends to be high, i.e., the higher frequencies are dominant, at sites influenced by nearby moderate-sized earthquakes; velocity tends to be high, i.e., the lower frequencies are dominant, at sites influenced by large earthquakes at a distance.

The change of the probability of exceedence of the seismic ground motion from that employed for the 1970 zoning map has produced higher ground motion levels; in addition, velocity has been added as a new zoning parameter. These changes are accommodated in National Building Code provisions as decribed in (2) and summarized elsewhere in these Proceedings.

The seismic ground motions computed to produce Figures 1 and 2 are considered to be current best estimates for National Building Code purposes, but research on all aspects of this subject is continuing. From the seismological viewpoint there are two aspects for which increased knowledge will lead to improved estimates of earthquake risk in future: the nature and extent of earthquake source zones and the excitation and propagation of strong seismic ground motion from large earthquakes. Changes will be made to the model of earthquake source zones as more knowledge is gained from studies of seismotectonics; changes may also be required if a large earthquake occurs in an unexpected location. Over the longer term, it may become possible to introduce temporal changes in earthquake risk estimates. If the spatial and temporal sequences of large earthquakes in certain source zones can be well-defined, it will be possible to assign high risk to locations near imminent large earthquakes.

A degree of uncertainty is introduced into the seismic risk calculations by the lack of definitive strong ground motion attenuation relations, particularly for the near-field effects of large earthquakes, and particularly for the eastern region of Canada. Although additional strong motion data have been collected from recent moderate-sized earthquakes in the western United States, which are generally applicable to western Canada, a significant improvement in the relations for eastern Canada must await the capture of strong motion data from moderate to large eastern earthquakes. As significant advances in knowledge are made in these areas, changes can be made to the zoning maps.

REFERENCES

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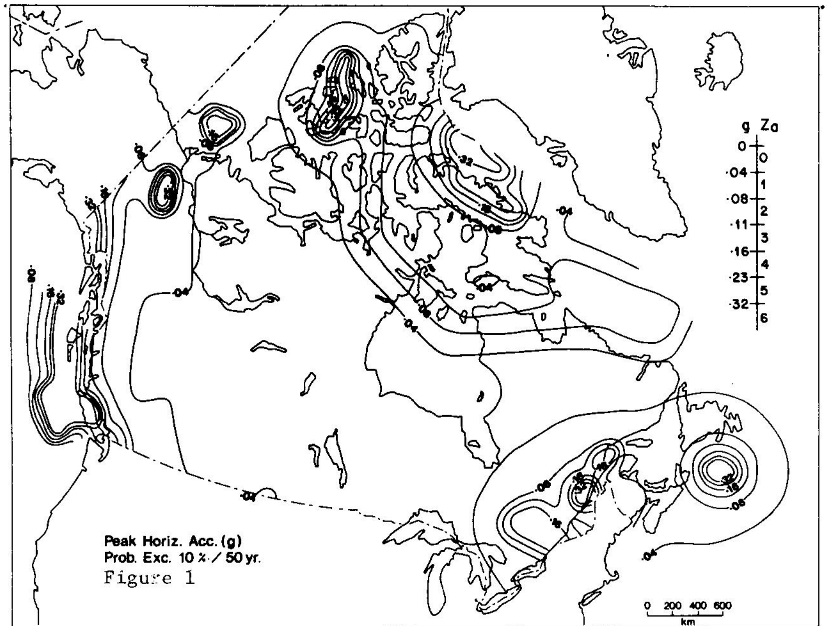

Figure 1

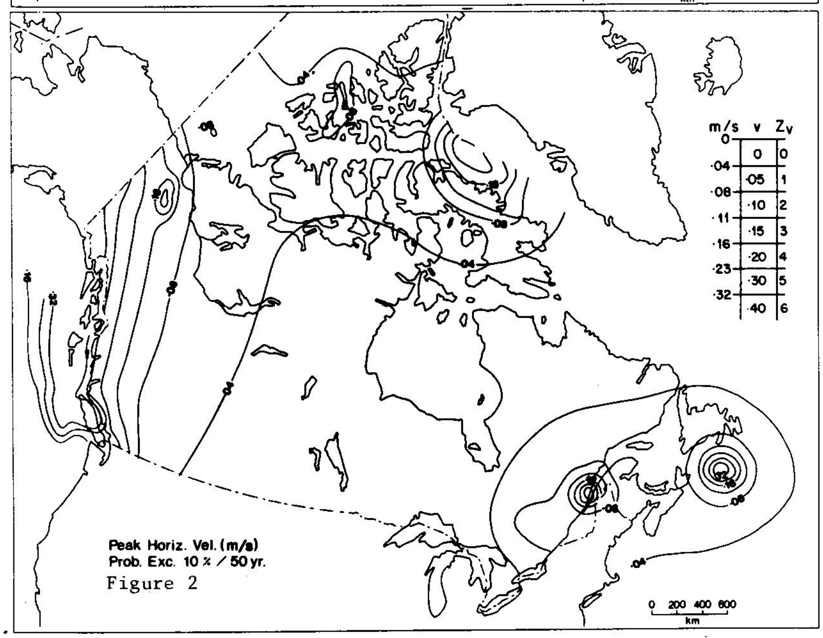

Figure 2