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Geofacts

SEISMIC HAZARD CALCULATION

The damage potential of an earthquake is determined by how the ground moves and how the buildings within the affected region are constructed. Ground motion can be predicted on the basis of probability, which is referred to as seismic hazard.

In Canada, the evaluation of regional seismic hazard for the purposes of the National Building Code is the responsibility of the Geological Survey of Canada. The seismic zoning maps prepared by the Geological Survey are derived from statistical analysis of past earthquakes and from advancing knowledge of Canada's tectonic and geological structure. On the maps, seismic hazard is expressed as the most powerful ground motion that is expected to occur in an area with a given probability. Contours delineate zones likely to experience similar intensities of ground motion.

The seismic zoning maps and earthquake load guidelines included in the National Building Code are used to design and construct buildings as earthquake proof as possible. The provisions of the building code are intended as a minimum standard. They are meant to prevent structural collapse during major earthquakes and thereby to protect human life. The provisions may not, however, prevent serious damage to individual structures.

Seismic Hazard Information in the National Building Code

Building design for various earthquake loads is addressed in sections 4.1.9, 9.20.17 and 9.24.1.5 of the National Building Code of Canada. The seismic zoning maps are found in Chapter 4, Commentary J, Figures J-1 and J-2 of the Supplement to the 1985 edition. In addition, a table in Chapter 1 starting on page 11 of the Supplement provides ground motion design values for some communities across Canada. The National Building Code applies also to existing buildings (Subsection 1.2.1). Annex A (Section A-1.2.1) outlines the principles by which the code should be applied to the use and modification of existing buildings.

The two seismic zoning maps each divide Canada into seven zones of ground motion, one map on the basis of probable ground velocity and the other according to acceleration. Velocity is given in metres per second; acceleration is expressed as a fraction of gravity.

Ground motion probability values are given in terms of probable exceedence, that is the likelihood of a given horizontal acceleration or velocity being exceeded during a particular period. The probability used in the National Building Code is 0.0021 per annum, equivalent to a 10-per-cent probability of exceedence over 50 years. This means that over a 50-year period there is a 10-per-cent chance of an earthquake causing ground motion greater than the given expected value.

Most buildings are well designed for withstanding vertical forces, but the horizontal component of ground motion is critical to earthquake-resistant building design. In the urban areas of coastal British Columbia, for example, 20-per-cent gravity is a typical seismic load at an acceptable probability. A building should be designed to tolerate a sideward pushing force equal to 20 per cent of its own weight.

Calculation of Seismic Hazard

The seismic hazard at a given site is determined from numerous factors.

Canada has been divided into earthquake source regions based on past earthquake activity and tectonic structure. The relation between earthquake magnitude and the

Canada

SEISMIC HAZARD CALCULATION

REQUESTED BY: John Doe
ABC Engineering Ltd.

SITE: XYZ Building,
Masset, B.C.

LOCATED AT: 54.00 north, 132.15 west

Probability of exceedence per annum	0.010	0.005	0.0021	0.001
Probability of exceedence in 50 years	40%	22%	10%	5%
Peak horizontal ground acceleration (g)	0.170	0.240	0.344	0.471
Peak horizontal ground velocity (m/sec)	0.245	0.361	0.570	0.733

average rate of occurrence for each region is weighed, along with variations in the attenuation of ground motion with distance. In calculating seismic hazard, scientists consider all earthquake source regions within a relevant distance of the proposed site.

The acceleration and velocity seismic zoning maps show levels of ground shaking over different frequency ranges: centred near 5 hertz (oscillations per second) for the acceleration map and near 1 hertz for the velocity map. This is important because different buildings are susceptible to different frequencies of earth motion, and damage is frequently associated with a resonance between earthquake ground motion and the building's own natural frequency. A high-rise of ten stories or more may sway with a natural period of 1 or 2 seconds, whereas in response to the same ground motion a brick bungalow across the street may vibrate at nearly 10 hertz.

Consequently, low brick buildings can be severely damaged by a moderate (magnitude 5.5) local earthquake that has most of its energy in the high-frequency range. High-rises may be affected more acutely by larger, more distant events. In the Mexican earthquake of 1985, most of the severe damage in Mexico City, 400 kilometres from the earthquake's epicentre, occurred in high-rise buildings with natural periods near 2 seconds.

In building construction and design, not only the size of a probable earthquake should be considered, but also the nature of the ground motion most likely to occur at the site. Seismic hazard calculations provide part of this information. As our understanding of earthquakes and of their effects on engineered structures continues to develop, the seismic provisions of the National Building Code will be revised to enhance public safety and minimize earthquake losses.

Availability of Seismic Hazard Information

Seismic hazard calculations for sites in Canada are available for $50 per site from the Geological Survey. The peak horizontal ground acceleration and velocity are given for exceedence probabilities of 5, 10, 22 and 40 per cent over 50 years (see example). Requests should provide the latitude and longitude of the site and, if applicable, the name of the construction project.

A detailed discussion of the application of the seismic zoning maps may be found in the article "Engineering Applications of New Probabilistic Seismic Ground-Motion Maps of Canada", by A.C. Heidebrecht, P.W. Basham, J.H. Rainer and M.J. Berry, published in 1983 in the *Canadian Journal of Civil Engineering*, Vol. 10, pages 670 - 680.

For further information, or to request a seismic hazard calculation, please contact:

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