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Seismic Loss Estimation of Buildings

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Severe damage of structures due to infrequent and large earthquakes causes direct physical and financial distress to a great number of households and companies, and induces indirect ripple effects across regional and national economies (e.g. 2004 Sumatra, 2008 Sichuan, and 2010 Haiti earthquakes). To make efficient and informed decisions for catastrophic earthquake risk mitigation, it is essential to develop a viable seismic loss estimation tool for multiple buildings. The developed model can be used to tackle a wide range of problems, including life-cycle cost-benefit analysis of risk mitigation measures (e.g. seismic isolation), emergency preparedness planning, and earthquake insurance.

Seismic Loss Model for Multiple Buildings

- A probabilistic seismic loss estimation framework for spatially distributed buildings has been developed by incorporating (i) seismic hazard analysis, (ii) realistic spatial correlation of ground motions, (iii) structural vulnerability assessment, and (iv) seismic loss estimation (Fig 1).
- The model generates random samples of seismic damage costs for multiple buildings due to numerous earthquakes. The samples can be used: to construct a seismic loss curve; to identify scenario events; and to carry out earthquake insurance portfolio analysis.

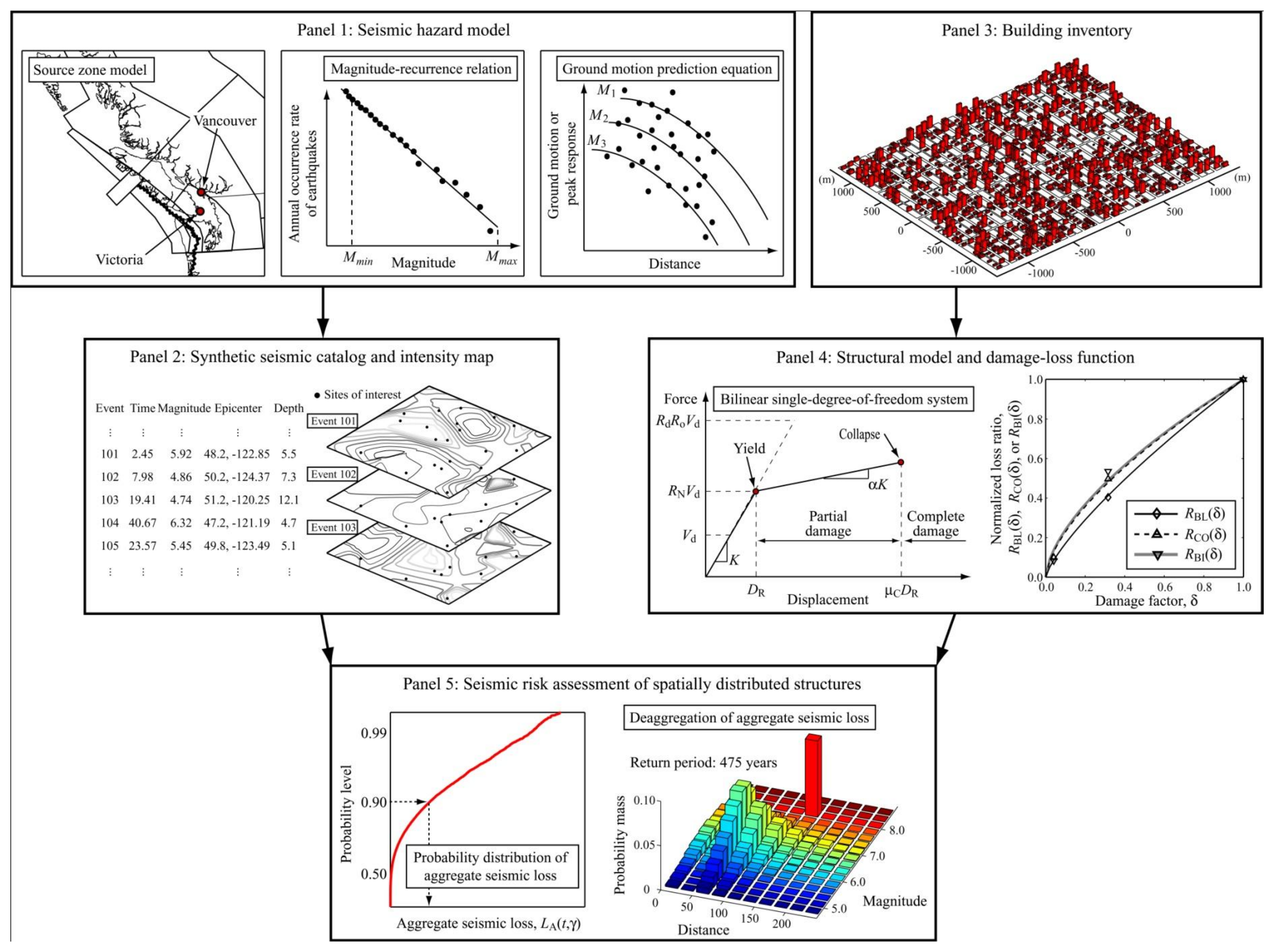


Fig1. Seismic loss estimation framework

Case Study for Wood-frame Buildings in Vancouver, Canada

- Building inventory information of 1415 existing wood-frame houses in Vancouver was collected from the City of Richmond, British Columbia, Canada. Local soil information in term of average shear-wave velocity and aerial photo of a city section are shown in Fig 2. A structural model of a typical wood-frame house is illustrated in Fig 3.
- Sensitivity analyses were carried out to identify key parameters for seismic loss estimation. Results indicate that impacts of seismic rates, ground motion prediction equations, and spatial correlations of seismic effects are significant (Fig 4). Such information is valuable for enhancing accuracy and confidence in the assessment.
- Moreover, the seismic loss model was applied to evaluate an insurer's earthquake risk exposure (Fig 5). An insurer's net worth is modelled as a diffusion-jump process. The spatial correlation of ground motions affects insurer's 10-year ruin probability significantly. Another key parameter is the initial asset of an insurer.

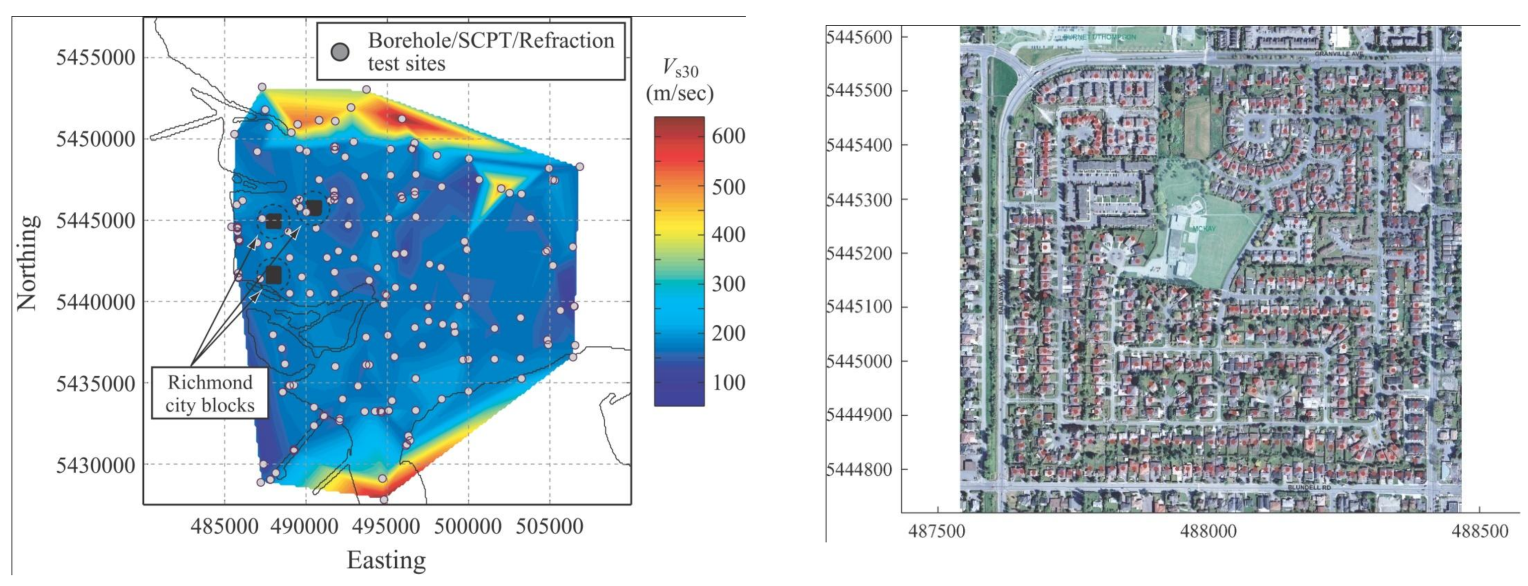


Fig2. Shear-wave velocity map & aerial photo of the study region

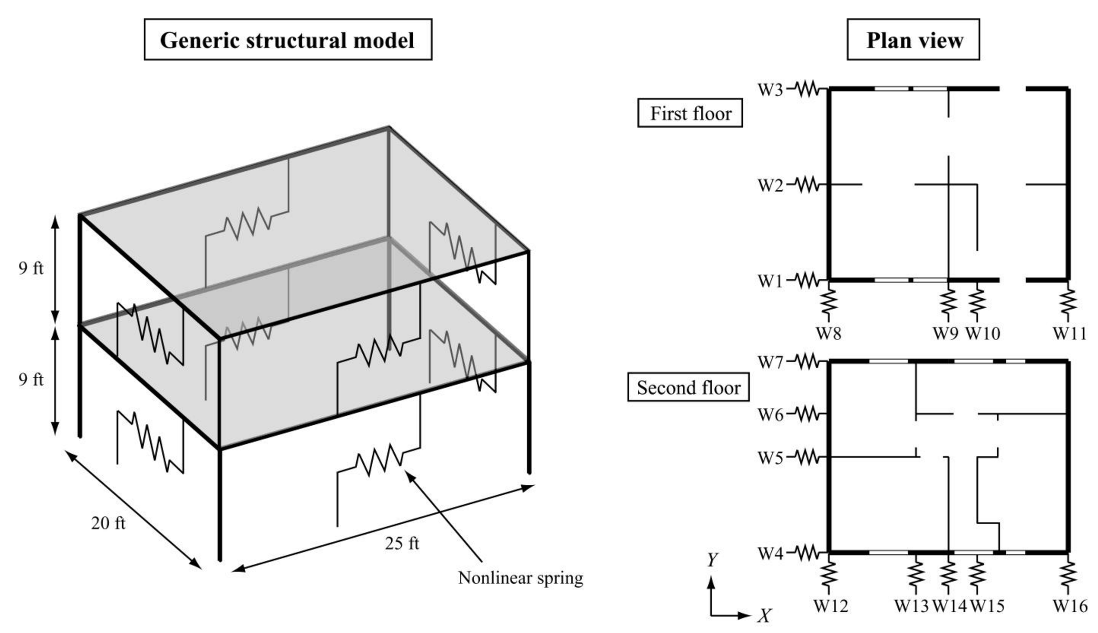
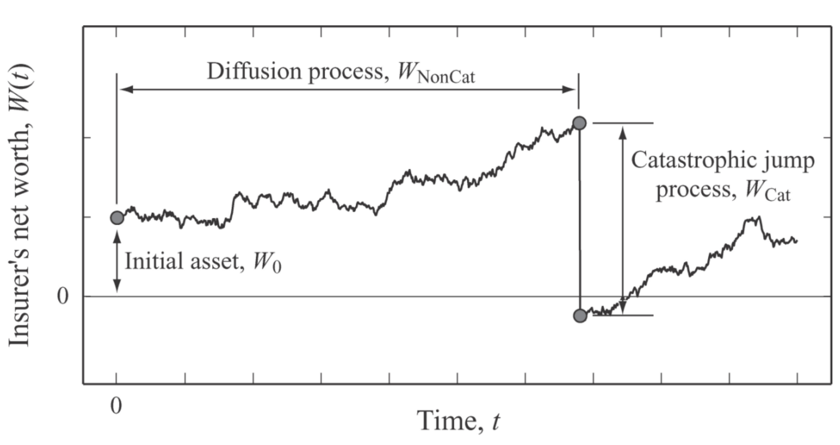


Fig3. Structural model of a typical wood-frame house

An insurer undertakes both usual risk (e.g. car insurance) and catastrophic earthquake risk.
The usual risk is modelled as a diffusion process, while the earthquake risk is modelled as a jump process.



Insurer's ruin: $W(t) < 0$

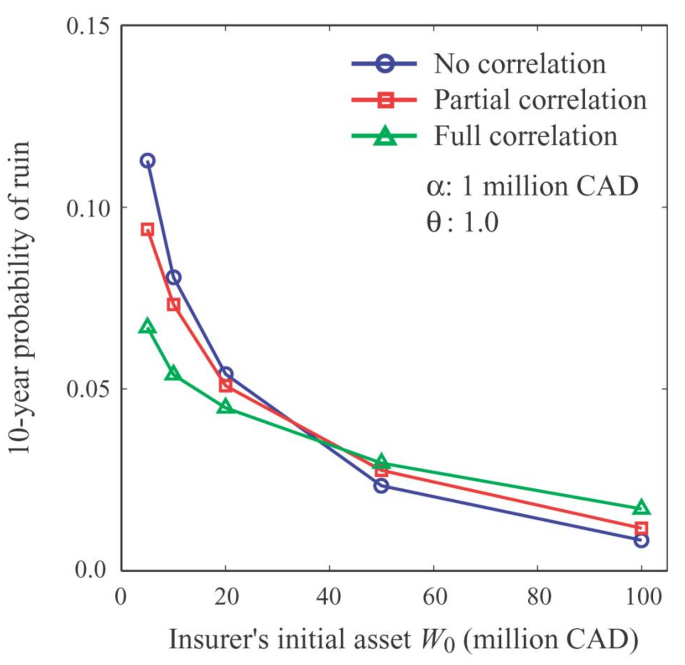


Fig5. Stochastic process of an insurer's net worth (left) & insurer's 10-year ruin probability using different spatial correlation models of seismic excitations as a function of insurer's initial asset

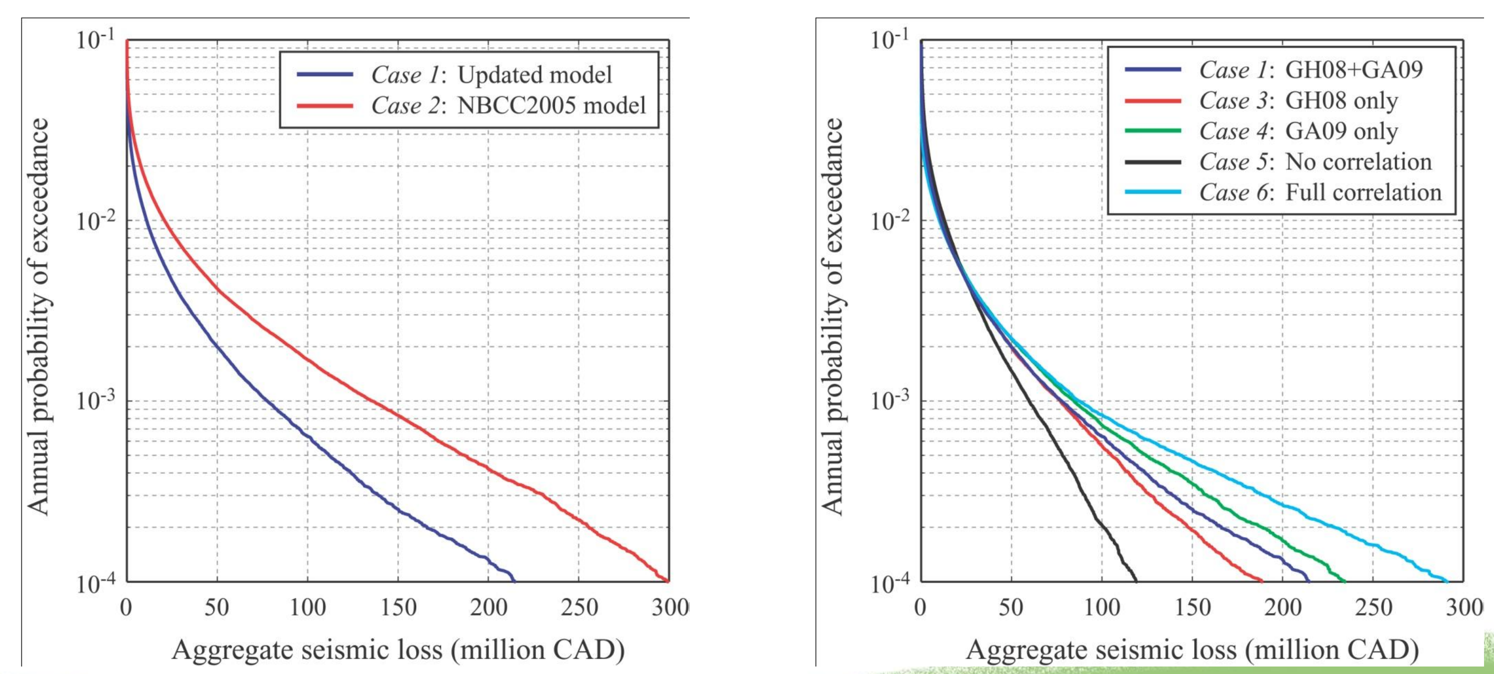


Fig4. Sensitivity of seismic loss curves: impact of seismic hazard models (left) & impact of spatial correlation (right) – Case 1 is the base case for comparison

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