Infrastructure Corridor between Ottawa and Québec City

This broad-scale Hazus Canada validation study is conducted in the infrastructure corridor between Ottawa and Québec City.

Study area: The study area covers approximately 65,000 km^2, encompassing the St. Lawrence Lowlands of southern Québec and eastern Ontario. It is bounded to the north by the Canadian Shield and to the south by the American border. With some 7,300,000 inhabitants, this area is one of the most populated regions in Canada and is vibrant industrially and economically. The population is concentrated in large urban centres. Eighteen urban centres are listed among the 100 largest population centres in Canada (2011 census, Statistics Canada): Montréal (population of 3,407,963), Ottawa-Gatineau (933,596), Québec City (696,946), Sherbrooke (140,628), Trois-Rivières (126,460), Saint-Jean-sur-Richelieu (83,053), Châteauguay (70,812), Drummondville (66,314), Saint-Jérôme (65,825), Granby (60,281), Beloeil (50,796), Saint-Hyacinthe (48,576), Shawinigan (47,735), Joliette (42,883), Victoriaville (41,701), Salaberry-de-Valleyfield (39,391), Sorel-Tracy (36,969), and Saint-Georges (25,703).

Seismicity: The study area encompasses parts of two seismic zones: Western Quebec and Charlevoix. In both zones, the seismicity is believed to be primarily caused by a northeast-to-east oriented compressive stress field reactivating zones of crustal weakness in the Grenville Geological Province. Historically, at least three damaging earthquakes occurred in the Western Quebec Seismic Zone: Montreal (M5.8, 1732), Temiscaming (M6.2; 1935) and Cornwall-Massena (M5.6, 1944). Located some 100 km downstream from Quebec City, the Charlevoix Seismic Zone is the most seismically active region of eastern Canada. Historically, the zone has been subject to five earthquakes of magnitude between 6 and 7: the 1663 (M7); 1791 (M6); 1860 (M6); 1870 (M6½); and 1925 (M6.2 ± 0.3). On a yearly basis, both areas are shaken by tens of weaker earthquakes recorded by seismograph stations, including some felt by the local populations.

Soil conditions: To estimate the potential amplification of the seismic shaking, an update of the surficial geology based on existing Quaternary maps was initially produced. A regional 3D stratigraphic model was then generated using the standardized surficial geology along with information provided from the provincial water well databases and available geotechnical measurements, geophysical surveys and oil and gas well logs. The 3 arc-second SRTM – NASA digital elevation model with grid size of approximately 90 m was applied to represent the terrain topography. The final 3D stratigraphic model comprises three major surficial units: stiff glacial and glaciofluvial sediments with earlier Pleistocene sediments; soft postglacial marine muds; and offlap sands of marine lacustrine and alluvial origin. Correlations between average and interval shear-wave velocity and depth, recently developed by the Geological Survey of Canada, were used to assign shear wave velocities to the geological units. These were later transformed into appropriate soil classes according to the specifications of the National Building Code of Canada (NBCC 2010).

Seismic scenarios: The simulated earthquake scenarios consisted of eight probabilistic earthquake scenarios with return periods of: 100, 250, 475, 750, 1000, 1500, 2000 and 2475 years. For a better comprehension of what may occur in a single event, eight deterministic scenarios were also generated. These were based on the 1/2475 year Sa(0.3 sec) mean values. The four cities are all located within the Iapetan Rifted Margin zone of the 4th generation seismic hazard model used in the 2010 NBCC (M = magnitude; D = epicentral distance) : a) Ottawa: M7.25D31 (45.67, -75.50) and M6.0D7 (45.47, -75.63); b) Montreal M7.25D31 (45.78, -73.58) and M6.0D7 (45.45, -73.50); c) Trois-Rivières M7.25D34 (46.13, -72.85) and M6.0D9.0 (46.33, -72.44); and Québec City M7.25D34 (46.98, -70.87) and M6.0D9.0 (46.84, -71.12). Sa(0.3 sec) and Sa(1.0 sec) values for soil class C (average shear wave velocity 360-760 m/s) tabulated on a regular 10 km grid in the case of the probabilistic scenarios, and predicted hard rock values in the case of the deterministic scenarios, were converted for the local soil conditions. The embedded 2010 NBCC Fa and Fv factors were used for that purpose. The PGA values were amplified with the same short period factors as Sa(0.3 sec), whereas PGV used the long period amplification factors for Sa(1.0 sec). In addition to the transitional ground shaking, a landslide susceptibility map was provided to estimate the probability of permanent ground displacement as a result of the considered earthquake scenarios.

Assets at risk: The population and general building stock were aggregated according to the 1,957 census subdivisions and tracts within the study area. The inventory data included residential, industrial and commercial building stock; essential facilities (schools, hospitals, police and fire stations), major transportation infrastructures (roadways, railways, tunnels and bridges), and major utilities (oil and gas pipelines). The building stock was aggregated on a census track level. It was generated using the information provided in Statistics Canada's 2006 Census and standard occupancy mapping schemes. The essential facilities and lifeline infrastructures were derived mostly from NRCan's CanVec reference geodatabases, and then integrated to the model with geographic coordinates using CDMS and ArcGIS tools.

Consequences: Simulations and analyses of the geographic variation of the loss estimates are underway and will be posted on this site by the end of March, 2014.