EARTHQUAKE GROUND MOTION RESPONSE STUDIES; A CONTRIBUTION TO THE OTTAWA VALLEY LANDSLIDE PROJECT

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The Lefaivre area of Ontario has recently been the target of intensive geological and geophysical studies directed at understanding the origin of irregular topography and near-surface disturbed cohesive sediments produced by lateral spreading and surface subsidence of Leda clay. Buried bedrock depressions up to 180 m deep directly correlate with the surface deformation in the study area. In addition, the presence of water-saturated sand units at shallow depth, along with elevated earthquake hazard in the area (West Quebec seismic zone) suggest that liquefaction may be an important factor in the development of the disturbed ground. In order to understand and quantify the influence of local geology, different geophysical approaches have been adopted:

i) Estimates of fundamental resonance periods were obtained (based on one-dimensional models) from shear-wave reflection methods. These values were compared with direct measurements obtained using the Nakamura technique (ambient seismic noise). The resonance periods derived from shear wave velocities are slightly higher than the direct Nakamura measurements, but the two sets are fairly consistent. The maximum period is 2.6 s. Significant variations in fundamental site periods throughout the study area suggest an irregular surface pattern response to ground shaking.

ii) One-dimensional and two-dimensional ground motion modeling of site response of thick sediments overlying bedrock were computed using seismic velocities and layer thicknesses determined from shallow seismic surveys. Comparison of fundamental resonant periods obtained with the Nakamura technique and one-dimensional site-response modeling has delineated geological boundaries that may be key factors in ground motion amplification. Two-dimensional modeling based on the indirect boundary element method (IBEM) revealed strong variation of amplitude as a function of frequency within the basin area. Amplification can be as high as 24 times (without considering attenuation effects. Maximum amplification values are reached at limited areas within the basin and at certain defined frequencies.

This study demonstrates that adverse soft-soil site effects, such as amplified earthquake ground shaking, can trigger liquefaction and subsequent surface disturbance of cohesive sediments. Similar geophysical studies and ground-motion analyses can be applied to site investigations in other areas of similar geology in the Ottawa-St Lawrence seismic zone.