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Long human habitation amplifies earthquake shaking and susceptibility to landsliding in ancient cities; Example from the last centuries repeated destruction of the city of Zefat (N. Israel)

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This work studies the effects of long human habitation on site geotechnical conditions. It focuses on the city of Zefat that is located on the borders of the tectonically active Dead Sea Transform in northern Israel. The city of Zefat, hosts unique eminent synagogues and cultural heritage, suffered repeated severe damage and loss of life in historical earthquakes, mainly as a consequence of earthquake induced landslides (EILS). In this work we evaluate the causes for the past and current high EILS hazard in the city of Zefat as an example for the geotechnical conditions exists in modern cities with millennial long habitation history.

We found that the core city of Zefat is built on a layered anthropogenic dirt material, up to 10 meters deep which, was deposited on the bed-rock as a result of more than 2000 years of human habitation with cycles of city-devastation and rebuilding. The anthropogenic material is mechanically weak, thus susceptible to slope failure and amplifies seismic-shaking. Traditionally, until very recently, the city houses and other structures were founded on the anthropogenic material and not on the underlying bed-rock.

The anthropogenic material is apparently responsible for the city's devastation in historical earthquakes and it is the source for the current high seismic hazard as well. Cities in the Eastern Mediterranean with comparable long habitation histories and evidence of earthquake induced sever damage (e.g., Jerusalem, Tiberias, Nablus, Amman) are expected to have similar geotechnical problems in their old sections. As a consequence severe damage and loss of life are expected there in future earthquakes, unless major engineering efforts are made.

In addition considering the above, evaluation of historical earthquake magnitudes based on reported local-damage (e.g. Modified Mercalli Intensity scale) may, however, lead to overestimated magnitudes where the damaged sites are built on anthropogenic strata which amplifies seismic shaking and landsliding (a common setting in the vicinity of the Dead Sea Transform).