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AN ELABORATE SEISMIC STUDY OF BEIRUT: INTEGRATING 3D MULTIDISCIPLINARY GEOTECHNICAL MODEL DEFINITION, MACHINE LEARNING ENHANCEMENTS, AND NUMERICAL SIMULATIONS

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In seismic hazard assessment, using Vs30 proxies and 1D shear wave velocity profiles often leads to underestimated ground motion, especially in complex geological areas like Greater Beirut (GB). This metropolis, near active seismic faults and with a history of significant earthquakes (551, 1202, 1837), features diverse soil types, necessitating detailed geotechnical subsurface modeling. Our study developed a 3D geotechnical model for GB, using data from around 500 boreholes, 700 geophysical measurements, a refined DEM, and geological insights. The model shows bedrock elevation and geological strata variations, with sediment depths reaching 70 meters. By integrating H/V measurements and borehole data, we estimated the average shear wave velocity (Vs-mean) across GB. To fill data gaps in southern GB, we used a Random Forest machine learning model, trained on interpolated points from Kriging in the central part of the model. This approach ensured a continuous and comprehensive representation of subsurface conditions, even in areas with limited data. Building on this foundation, our ongoing work involves detailed seismic simulations to predict ground motion amplification in Beirut. Using a 3D hexahedral mesh generated via open-source Python code, we will conduct full 3D numerical simulations of seismic wave propagation using the spectral element method (Komatitsch and Tromp, 2002; Komatitsch and Tromp, 2002; Komatitsch et al., 2023). These simulations aim to provide valuable insights into the seismic response of Beirut's subsurface, contributing to the city's earthquake preparedness and risk mitigation strategies. The presentation will showcase the first seismic scenarios based on our 3D geotechnical model.

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