EGU25-21168, updated on 18 May 2025
https://doi.org/10.5194/egusphere-egu25-21168
EGU General Assembly 2025

Numerical modeling approach to support the future seismic microzonation of Dushanbe, Tajikistan

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This study presents an integrated approach to seismic microzonation in urban environments, emphasizing the importance of dynamic numerical modeling in enhancing earthquake hazard assessments. Our goal was to deepen the understanding of seismic wave behavior in the soils of the city of Dushanbe by combining extensive geological, geophysical, and engineering datasets. These datasets include macroseismic data, local geological observations, and detailed geophysical surveys conducted between 2019 and 2020. The surveys consisted of five Microtremor Array Measurements (MAM), nine Seismic Refraction Tomography (SRT) lines, five temporary Standard Spectral Ratio (SSR) seismic stations, 60 borehole logs, and 175 Horizontal-to-Vertical Spectral Ratio (HVSR) measurements.

Using this comprehensive database, we constructed a consistent 2.5D geological model of the soil strata in Dushanbe, covering an area of 12×12 km2. The borehole data were calibrated against geophysical methods to accurately delineate lithological boundaries. Leapfrog Works software was employed to create the 2.5D geomodel, from which six 12-km-long 2D cross-sections were extracted. Subsequently, 2D dynamic numerical modeling was performed to examine seismic wave propagation under varying lithological and topographic conditions.

The results of the 2D dynamic modeling were compared with fundamental frequency (f0) values derived from ambient noise measurements and SSR data. Our analysis confirms the significant influence of local topography and soil conditions on ground motions, leading to pronounced seismic amplification effects in certain areas. By integrating these approaches, the 2D dynamic numerical modeling allowed for a more precise evaluation of local site effects, improving seismic microzonation and refining estimates of peak ground acceleration in conjunction with regional

seismic hazard maps. Furthermore, these findings corroborate earlier indications of notable seismic amplification attributed to local topographic and subsurface features influencing ground motions.