Site effects in strong-impedance environments and the importance of f_0: Lessons learned in Boston, Massachusetts

BAISE, Laurie G., Department of Civil and Environmental Engineering,
Tufts University, Medford, MA, laurie.baise@tufts.edu

KAKLAMANOS, James, Department of Civil Engineering,
Merrimack College, North Andover, MA, KaklamanosJ@merrimack.edu

EBEL, John E., Department of Earth and Environmental Sciences,
Boston College, Chestnut Hill, MA, john.ebel@bc.edu

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ABSTRACT:

In environments with strong impedance contrasts, soil amplification can be significant. Ground motions recorded at the surface and at depth in bedrock during the 2011 Mineral earthquake at a soil site in Boston, Massachusetts, exhibited an amplification ratio of 10 at the fundamental site period (0.7 s). The vertical seismometer array at Northeastern University consists of 51 m of sediments (V_S ~ 200-400 m/s) overlying hard bedrock (V_S ~ 2000 m/s). To test whether these amplifications persist for design-level ground motions, we performed a series of site-specific ground response studies for typical sites with varying bedrock depth in Boston. The results show that when bedrock depth is near 30 m, the mean short-period and intermediate-period NEHRP site coefficients (F_a and F_v, respectively) are consistent with the results of the site-specific ground response study. However, if bedrock depths are less than 30 m, the NEHRP F_a significantly underpredicts the soil amplification, and the NEHRP F_v significantly overpredicts the soil amplification. For bedrock depths greater than 30 m, the NEHRP F_a and F_v both underpredict the soil amplification. We conclude that modifications to NEHRP site coefficients are needed for strong-impedance environments. Because the soil response in strong-impedance environments is driven by bedrock depth, microtremor studies can be used to identify the fundamental site frequency, f_o. By combining local information on soil profiles and soil velocities in Boston, f_o can be used to adequately predict soil amplification in Boston.