Site-Specific Nonlinear Seismic Response Analysis and Updated Site Coefficients for Islamabad, Pakistan

Muhammad Yasir; Waqas Ahmed;

National Centre of Excellence in Geology, University of Peshawar

Email: myasir6755@uop.edu.pk

Abstract:

The study aimed to enhance understanding of seismic site response in Islamabad, Pakistan, by quantifying local amplification patterns, evaluating the adequacy of BCP-2021 design spectra, and proposing updated site coefficients (F_a and F_v) for BCP -2021 Site Classes C and D. This addresses key gaps in seismic hazard assessment for the region's variable subsurface conditions. A geotechnical database comprising 180 boreholes, including 30 new sites with laboratory testing, was developed to characterize soil stratigraphy. Nine representative profiles were selected, and shear-wave velocity (V_{S30}) was estimated using local SPT–Vs correlations. Fully nonlinear one-dimensional site response analyses were performed in DEEPSOIL using a calibrated hyperbolic soil model. Seven spectrum-matched input motions, representative of design-level earthquakes, were applied to assess ground surface spectra relative to BCP-2021 provisions.

Results showed that stiff soil sites (Class C) amplified short-period motions (around 0.2 s) by 1.5–1.6 times the input motion, exceeding BCP-2021 estimates and highlighting possible underdesign risks for low- to mid-rise buildings. The deep soft site (Class D) exhibited limited amplification at longer periods (>0.5 s), suggesting BCP-2021 may overestimate seismic demands for such sites. Updated site factors were proposed: Fa ≈ 1.6 and Fv ≈ 1.17 for Class C; Fa ≈ 1.6 and Fv ≈ 1.4 for Class D. The study confirms that local soil conditions significantly influence seismic response and that site-specific nonlinear analysis offers more reliable predictions than generic code provisions.