AN APPROACH FOR DEVELOPING RISK-CONSISTENT VERTICAL GROUND MOTION SPECTRA

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The design basis earthquake (DBE) for design of commercial NPPs is developed based on seismic hazard curves and uniform hazard response spectra (UHRS) that are obtained from a probabilistic seismic hazard assessment (PSHA). In the U.S., the input ground motions are determined following ASCE/SEI 4-16 (ASCE, 2017) and ASCE/SEI 43-19[1] (ASCE, 2019). ASCE/SEI 43-19 outlines an approach for developing risk-consistent seismic design criteria for different sites with varying hazard curve slopes. In the approach provided by ASCE/SEI 43-19, the DBE ground motion for horizontal shaking is defined based on target performance goal in terms of the design response spectra (DRS) that is obtained by scaling UHRS at a specific mean annual frequency of exceedance (MAFE). The scaling is performed using frequency-dependent scale factors that are dependent on the slope of hazard. These scale factors account for the slope of seismic hazard curves and are key elements in achieving the target performance goal. This process is typically applied to the horizontal UHRS to develop the DRS. It is common practice to either (1) develop the vertical DRS by applying vertical-to-horizontal (V/H) ratios to the horizontal DRS; or (2) apply the same frequency-dependent scale factors calculated for the horizontal DRS to develop the vertical DRS. Both methods result, essentially, in a vertical DRS hazard consistent with the horizontal DRS. The development of risk-consistent vertical ground motions for design requires (3) applying the V/H ratios to the horizontal UHRS at MAFE thresholds above and below the horizontal DRS, then using the DRS calculation process to interpolate between the resulting vertical UHRS independently. While the ASCE standards do not explicitly specify one method or prohibit the other, the authors' experience indicates that one of the first two procedures is typically followed, not the third one. The process of developing risk-consistent vertical ground motion to be used in pair with the horizontal ground motion, applicable in design practice, is outlined in this presentation.

[1] ASCE/SEI 43-19 contains the latest guidance from ASCE and is a major update from ASCE 4-98. It has been approved for publication by the ASCE Nuclear Standards Committee and is going through the copy-editing process.