CHARACTERIZING EXTREME GROUND MOTIONS AT YUCCA MTN

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Characterization of the epistemic uncertainty and aleatory variability of ground motion, as part of the Yucca Mountain nuclear waste repository PSHA (Stepp et al., 2001), results in ground motion values that increase without bound as lower and lower annual probabilities of exceedance are considered. For probabilities of exceedance less than about \(10^{-6}\) (yr\(^{-1}\)), use of these results as input to the site response model leads to ground motion values for the repository that most engineering seismologists feel are not credible.

To provide a defensible technical basis to develop credible emplacement level motions for extreme events, the undeformed nature of the 12.8 million year old lithophysal tuff units at Yucca Mountain provide strong constraints on the level of strain (stress) not experienced by the site since deposition of the tuff. Uniaxial unconfined compressive tests (the only tests available to the project) of the lithophysal tuff indicate axial strains of about 0.3% at fracture, which converts to approximately 0.2% shear-strain. This shear-strain limit (fracture strain), which has not occurred, is used with standard equivalent-linear (and nonlinear) point-source site response analyses to develop corresponding response spectra assuming a controlling earthquake of \(M = 6.5\) at a distance of 5 km, based on the site PSHA.

In addition to the uncertainty in fracture shear-strain resulting from unconfined uniaxial tests, the analyses demonstrate that the uncertainty in nonlinear dynamic material properties of the tuff result in a factor of two uncertainty in extreme response spectra, conditional on a value of 0.2% for the fracture strain. To reduce the large uncertainty in extreme spectra, a high pressure (\(\approx 1,000\) ft), large scale (\(\approx 1\) ft\(^3\)) test device is needed that simulates earthquake loading conditions (cyclic shear strain). The test device would give direct measures of shear fracture strain for the lithophysal tuffs as well as reliable nonlinear dynamic material properties for all tuff units. Such laboratory measurements would represent the only direct measurements of ground motions not experienced by the site over the last 12.8 million years and provide the most defensible and least ambiguous characterization of extreme ground motions over the next 10,000 yrs or longer.

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