Analysis of Q-factor's parameters of Los Angeles through Simulation and Artificial Intelligence

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Abstract

The accurate solution of wave propagation problems requires the appropriate representation of energy losses due to internal friction. These losses are important because their mischaracterization can lead to over- or under-estimation of amplitudes and duration of ground motions. Recent studies show that synthetics from physics-based simulations tend to attenuate at different rates than observations, suggesting that current modeling approaches need to be revised. In physic-based simulation, attenuation is commonly introduced by means of viscoelastic models. Internally, the properties of these models are set based on the material's quality factor, Q. The value of Q for shear waves, Qs, is usually defined according to empirical rules that depend on the shear wave velocity, Vs. Typical Qs-Vs relationships are (piecewise) linear or polynomial functions. Several relationships have been tried in the past, but there is no consensus about what is the most appropriate one. Identifying the parameters that define these relationships through the solution of inverse problems is non-trivial, requires considerable computational resources, and may not lead to a unique solution. In this study we investigate the effectiveness of an approach that combines the use of an artificial neural network (ANN) and a genetic algorithm (GA) to predict ground motion amplitudes and identify the optimal parameters in Qs-Vs relationships. We use direct S-waves as a proxy to evaluate attenuation over distance. First, we train the ANN to predict peak S-wave amplitudes based on a series of simulations with an ample selection of parameters. Then, we use the ANN as a fitness function of the GA, and use the latter to find the optimal parameters based on comparisons between predictions and data. As a proof-of-concept, we test the performance of the proposed approach for the case of the 2008 Mw 5.4 Chino Hills, California, earthquake. Using this approach we find the parameters that lead to the best fit with data. The results include the mean and standard deviation of Qs for each value of Vs. Our initial results for a limited number of stations scattered throughout the simulation domain and for numerical models with a maximum frequency of 0.5 Hz show good promise. We recognize, however, that Q parameters may depend on additional factors such as frequency, depth, path and site effects, and the nature of the traveling waves. Future work will test the method for multiple events and higher frequencies.

Key words: Earthquake Ground Motions, Numerical Solutions, Anelastic Attenuation, Artificial Intelligence