

SEISMIC-ENVIRONMENT-BASED SIMULATION OF NEAR-FAULT GROUND MOTIONS

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Based on observations that the critical structural response resulting from the fault-normal component of near-fault ground motions is often strongly influenced by the presence of a velocity pulse, there is an increasing demand from the professional practice for accelerograms that can be used as input to nonlinear time-history analyses of structures located in near-fault environments. A procedure for simulating fault-normal near-fault ground motions for a specified seismic environment (i.e., the magnitude, distance and faulting mechanism of an earthquake and the soil conditions at the site) has been developed in response to this demand.

The proposed model combines an analytical velocity pulse with a realization of a stochastic process that represents the high frequency content of a ground motion. The shape and magnitude of the velocity pulse is defined by four parameters that, for a specified near-fault record, are determined by a nonlinear regression. Predictive relationships for these parameters have been derived from a series of regression analyses performed on an ensemble of recorded fault-normal near-fault ground motions. Due to the inability of velocity pulse model to reproduce the high frequency content of the recorded ground motions, a procedure for superimposing a realization of nonstationary high frequency accelerations on to the acceleration time-history associated with the velocity pulse has also been developed. Readily available attenuation relationships for response spectrum ordinates and Arias duration are used to calibrate the parameters of the stochastic model used to generate the high frequency component of a simulation.

The suitability of the proposed simulation procedure for structural analyses has been evaluated by the comparing the response of linear and nonlinear SDOF systems that are subjected to an ensemble of recorded near-fault ground motions and their idealizations. The results of these time-history analyses indicate that the proposed simulation procedure generates acceleration time histories that, on average, predict the displacement demands at all periods and ductility demand levels with sufficient accuracy for earthquake engineering applications.

An important observation made with time-history analyses mentioned above is that the ratio, Δ_i/Δ_e , of maximum inelastic displacement to maximum elastic displacement of SDOF systems for fault-normal near-fault ground motions is significantly different from the conventional inelastic displacement ratio observed for structures with periods around $T_p/2$, where T_p is the period of the velocity pulse present in the record. An examination of the time history results reveals that the difference is due to the velocity pulse present in the fault-normal near-fault ground motions and it increases with increasing ductility.

The advantages of the proposed near-fault ground motion simulation procedure are three-fold. First, unlike equivalent static force and response-spectrum-based procedures specified by building codes, the proposed velocity pulse model and simulation procedure explicitly accounts for the temporal characteristics of near-fault ground motions, which are known to be important to the structural response. Second, use of the simulation procedure with appropriate attenuation relationships for its parameters can improve the efficiency of time-history-based analyses by providing engineers with a simple means of generating idealized ground motions for near-fault environments. Finally, the analytical nature of the velocity pulse model makes it well suited for use in structural-reliability-based performance assessments.