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Effects of Rupture Directivity on Earthquake Loss Estimation

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A seismic loss analysis, whether for a single structure or a portfolio of properties, requires a relationship between a chosen ground motion intensity measure, IM, and structural loss. This relationship, called a Loss Function, LF, is developed here by a two–step procedure that combines analytical and empirical data. A suite of ground motions is first run through a structure and the resulting analytical relationship linking losses to IM is obtained via regression. This relationship is then calibrated using loss data from past earthquakes. Typically, the spectral acceleration, S_a, at the structure's fundamental period of vibration, T_1, is used as the IM of choice. Studies have shown, however, that near-source forward-directivity ground motions are, on average, more damaging than other accelerograms with the same $S_a(T_1)$. This is true for moderate to long-period structures and, less intuitively, for stiffer structures whose T_1 value is significantly shorter than the period of velocity pulses observed in fault-normal components of forward-directivity records. This study illustrates the different damageability of near-source accelerograms from both forward and backward directivity regions to stiff woodframe structures from the CUREE-Caltech Woodframe Project. We predict the loss for several woodframes using two-parameter loss surfaces (derived from nonlinear dynamic analysis of about 400 recordings) that incorporate $S_a(T_1)$ and the directivity parameter Xcos(θ) or Ycos(ϕ) introduced by Somerville *et. al*. We also show for a portfolio located close to a fault the differences in probabilistic loss estimates obtained by utilizing a LF based on $S_a(T_1)$ versus a loss surface based on both $S_a(T_1)$ and Xcos(θ).