GROUND MOTION PREDICTION OF INELASTIC SPECTRAL DISPLACEMENT

Polsak Tothong and C. Allin Cornell

Introduction

Intensity measures (IMs) are properties of records that may be used as predictors of MDOF nonlinear structural responses. Typical examples are PGA and the first-mode elastic spectral acceleration (S_a). However, the inelastic spectral displacement (S_{di}) of a record can be used to improve the estimation of inter-story drift and other engineering demand parameters (EDPs) of structures, Luco [2002], Jalayer [2003], Bazzurro and Luco [2003] have shown that S_{di} is more efficient than S_a, i.e. requires fewer nonlinear dynamic analyses. S_{di} in place of S_a also leads to an alternative way of performing an Incremental Dynamic Analysis (IDA). Modern PBEE requires an integration of this EDP given IM prediction information with a hazard analysis of the IM. Therefore to incorporate S_{di} into the PBEE methodology, attenuation relationships of S_{di} need to be developed in order to estimate hazard at a given site (via Probabilistic Seismic Hazard Analysis).

Problem Statement

The attenuation laws for S_{di} have been developed along the usual lines of conducting regression analyses of S_{di} (for a given oscillator) versus magnitude (M_w) and distance ($Dist$). The oscillator properties now must include the yield displacement (d_y) in addition to period (T) and damping ratio (ξ). We have chosen to include d_y explicitly in the regression independent variables along with M_w and $Dist$ via the parameter $\hat{R} = \hat{S}_{de} / d_y$. This factor is analogous to the familiar strength reduction factor ($R = F_{el} / F_y$) except, as we do not know (for a given M_w and $Dist$) precisely what S_{de} will be, we must replace by its estimated value ($\hat{S}_{de}$) as predicted by a common elastic S_a attenuation law. The work of others (e.g., Vamvatsikos [2002] and Miranda [2003]) on the dependence of S_{di} / S_{de} versus R has been used to guide the selection of the functional forms used in the empirical regression. The results for non-near source records are available in the form of tables of empirical parameters for the ratio S_{di} / S_{de}. These can be used to supplement the Abrahamson elastic S_a attenuation law to produce an S_{di} attenuation.

Future Research

It is our intention to also construct the S_{di} attenuation for near-source ground motions with forwarded-directivity effects. Analogously, it will be built as a factor on top of the attenuation for the directivity modification factor (Somerville [1997]). Two or more variables (e.g., T/T_p and $X \cos\theta \, or \, Y \cos\phi$) need to be used in order to capture the narrow band frequency content of the pulse-like behavior. Lastly, one may be interested in having an extra indicator variable to say whether or not a ground motion record has a distinct pulse.