# IDA Demonstrates nSpectra as Valuable New IM

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nSpectra [W. Graf, Y. Lee, C. Goulet, ASCE, 2010] has been suggested as a potential new intensity measure (IM). For a given ground motion time series, nSpectra quantifies the number of response peaks *"n"* for a linear elastic oscillator exceeding a stated threshold as a function of oscillator period, *T*. nSpectra was designed to capture the effects of magnitude and duration on damage and collapse of building structures, to supplement the use of spectral acceleration *(Sa).*

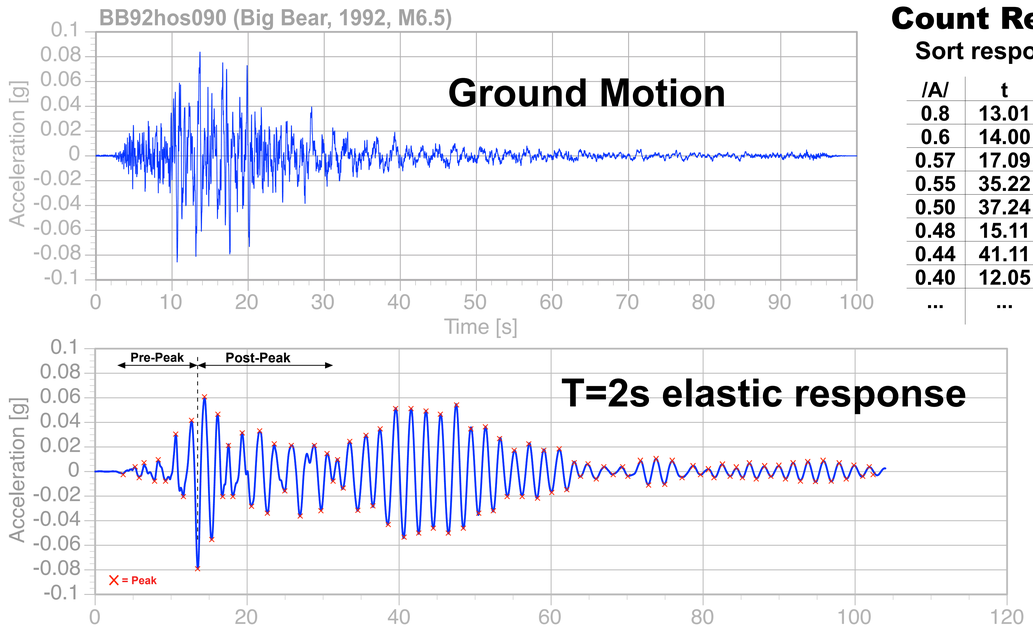
Incremental Dynamic Analysis (IDA) was used to test nSpectra, which is shown to improve the prediction of ductility demand compared to *Sa* alone. For IDA, we selected two oscillators, with *T* = 0.2s and with *T* = 2s (shown). For each oscillator, we assigned hysteretic properties with degrading stiffness and strength, similar to nonductile concrete frame buildings. We also evaluated a non-degrading version of the T=2s oscillator, and elastic-perfectly-plastic versions of the oscillators. To evaluate the nSpectra IM, we computed "n" for each IDA solution point. The results show that the most important part of the response occurs before the elastic response peak, and that, for stiffness and strength-degrading structures, high pre-peak "n" values are associated with higher degradation, and higher ductility demands. This indicates that introducing "n" in predictive models like SPO2IDA will reduce the dispersion, and improve damage and collapse predictions.

## What are n-Spectra?

n-Spectra are a variant of elastic response spectra. For a given excitation, n-Spectra quantify how many times (n) an elastic single-degree-of-freedom (SDOF) oscillator will exceed any given amplitude of response (e.g., Sa).

## How are they computed?

n-Spectra are computed using routines similar to elastic response spectra, except we find and store all response peak amplitudes, not just the single largest response. The list of maxima are sorted, and the number of exceedances are tallied.

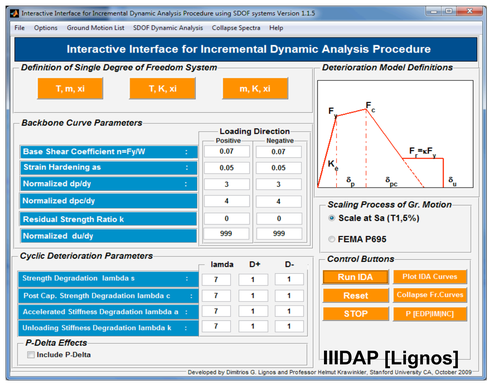


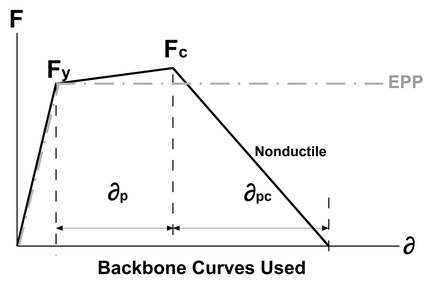

**Count Response Peaks**

Sort responses by amplitude

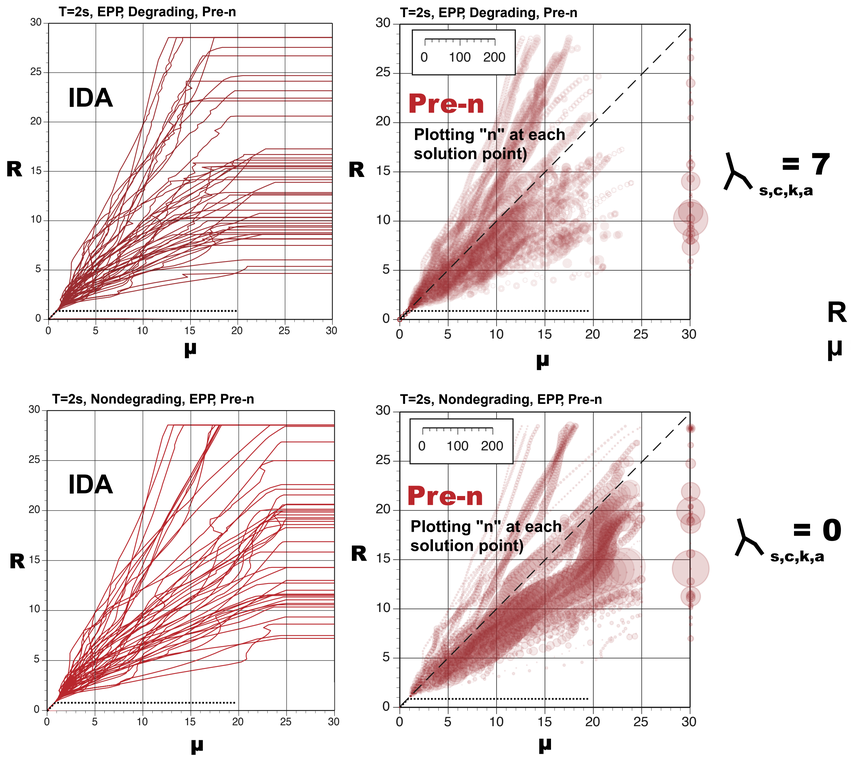
| /A/ | t | "n" | "Pre-n" | "Post-n" |
|---|---|---|---|---|
| 0.8 | 13.01 | 1 | 1 | |
| 0.6 | 14.00 | 2 | | 1 |
| 0.57 | 17.09 | 3 | | 2 |
| 0.55 | 35.22 | 4 | | 3 |
| 0.50 | 37.24 | 5 | | 4 |
| 0.48 | 15.11 | 6 | | 5 |
| 0.44 | 41.11 | 7 | | 6 |
| 0.40 | 12.05 | 8 | 2 | |
| ... | ... | ... | ... | ... |

### Testing with Incremental Dynamic Analysis (IDA)




### Elastic, Perfectly-Plastic Case




### Non-Ductile Case (5% Strain Hardening, ∂p/∂y = 3, ∂pc/∂y = 4)