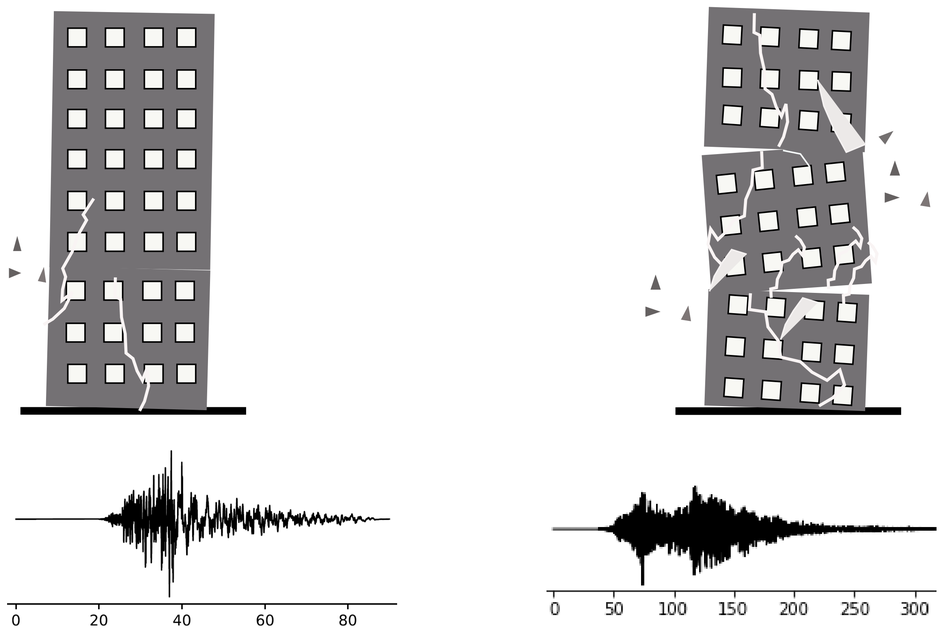
Effect of Ground Motion Duration and Response Spectral Shape on Seismic Performance of Steel Moment Resisting Frame Buildings

Srijana G. Shrestha, Reagan Chandramohan, and Rajesh P. Dhakal

QuakeCore, University of Canterbury

Background and Motivation

- Relying only on intensity of ground motion is not sufficient to predict the seismic response of structures



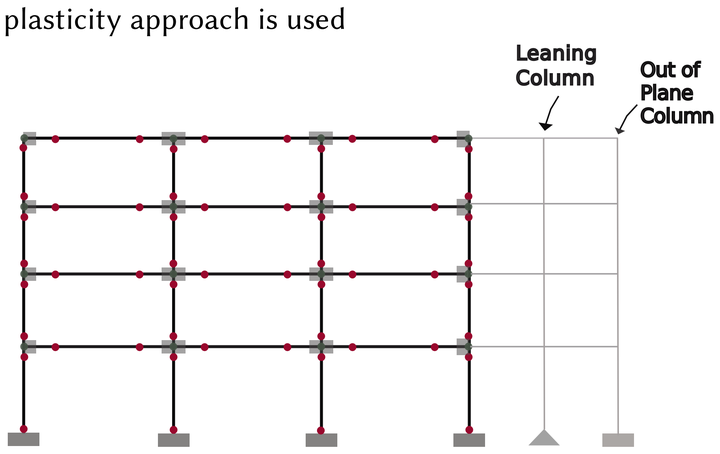
- Ignoring the duration of ground motion overestimates the collapse capacity of structures located on sites susceptible to long duration earthquakes like Wellington and Napier.
- Another important ground motion characteristic is response spectral shape which characterizes spectral acceleration (S_a) at periods above and below the fundamental time period (T_1) of the structure. FEMA P695 reports that neglecting the effect of spectral shape underestimates the collapse capacity by 60%

Objectives

- To adopt a recently developed framework to consider ground motion duration and spectral shape in the US structural design standard to New Zealand practice (Chandramohan et al., 2018)
  - To study the effect of duration of ground motion on mid and high-rise steel moment resisting frame buildings
  - To study the influence of response spectral shape on response of the buildings

Structural Models

- Structural models selected for the study
  - Mid-rise(4 story) typical office building located in Wellington
  - 2D perimeter frames are modeled in OpenSees (Sullivan et al. (submitted))
  - Concentrated plasticity approach is used



- Nonlinear hysteresis response of plastic hinges (located at the ends of beams and columns) is simulated using Modified Ibarra-Krawinkler deterioration model calibrated for steel components

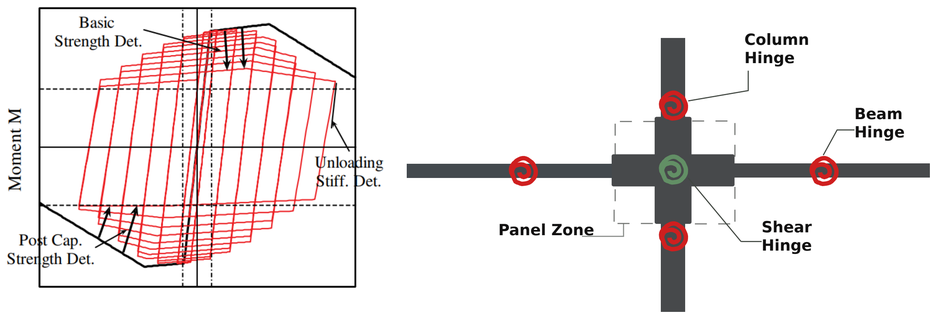


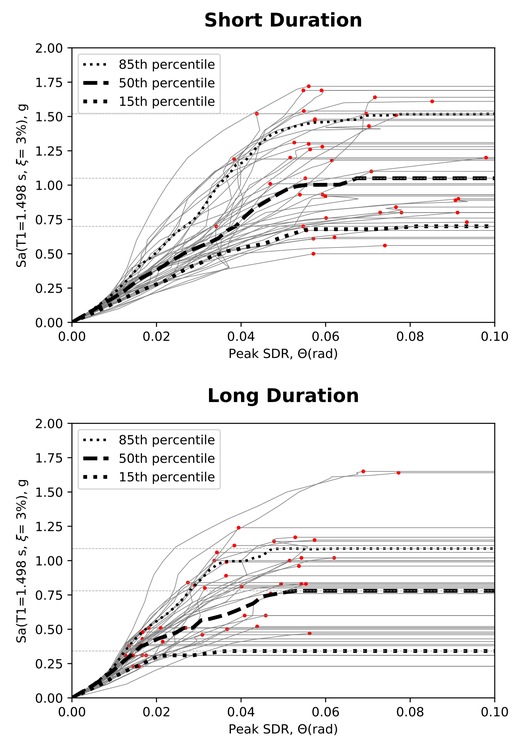
Image source:(Lignos Krawinkler, 2011)

Incremental Dynamic Analysis (IDA)

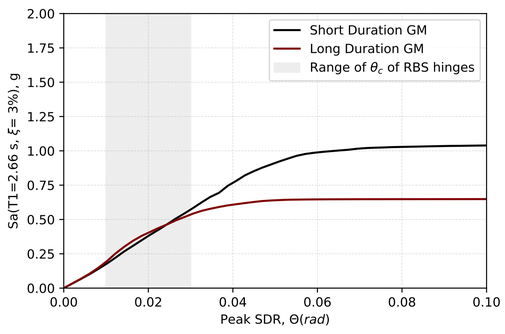
- Two sets of spectrally equivalent short and long duration far-field records were used (FEMA P695)
- Implementation of automated algorithms using parallel processors

IDA Curves

- IDA curves for all the records

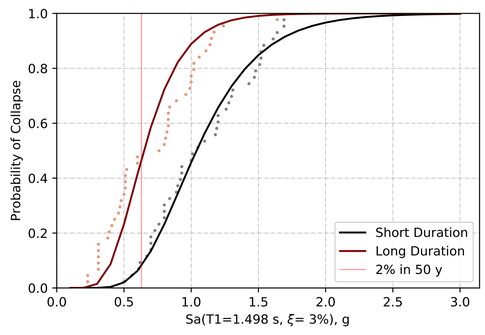


Geometric Mean IDA Curves



- Mean collapse capacity under spectrally equivalent long duration ground motions (GM) is 37% lower than short duration

Collapse Fragility Curves



- Comparison of collapse fragility curves shows that longer duration ground motions have 6 times higher probability of collapse than short duration at MCE level (S_a= 0.63g)

Conclusions and Future Work

- From the analysis of 4 story steel moment frame buildings designed for Wellington, the use of long duration ground motions is observed to decrease it's collapse capacity by 37%. This motivates the need to consider duration in structural design and assessment practice
- Future work will evaluate the influence of response spectral shape on the collapse response of New Zealand steel frame archetypes
- A framework will then be proposed to consider the effects of ground motion duration and response spectral shape in New Zealand structural design and assessment standards