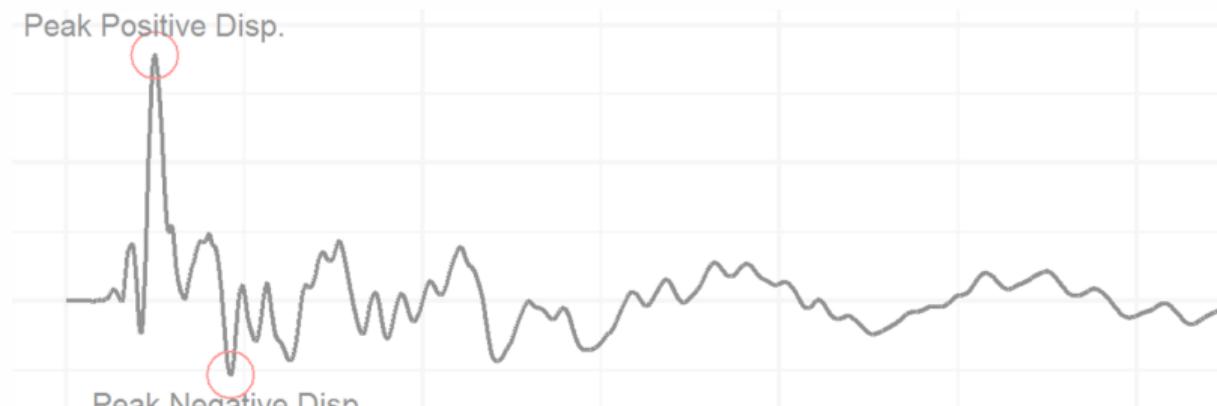


Characterizing Seismic Load History for Performance Based Design

Arjun Jayaprakash and Mervyn Kowalsky



Performance Based Seismic Design

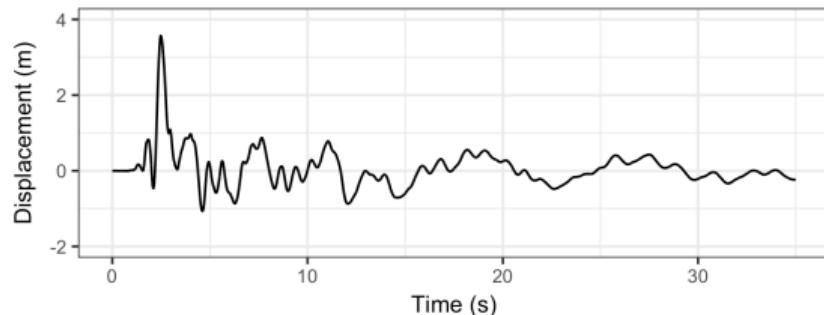
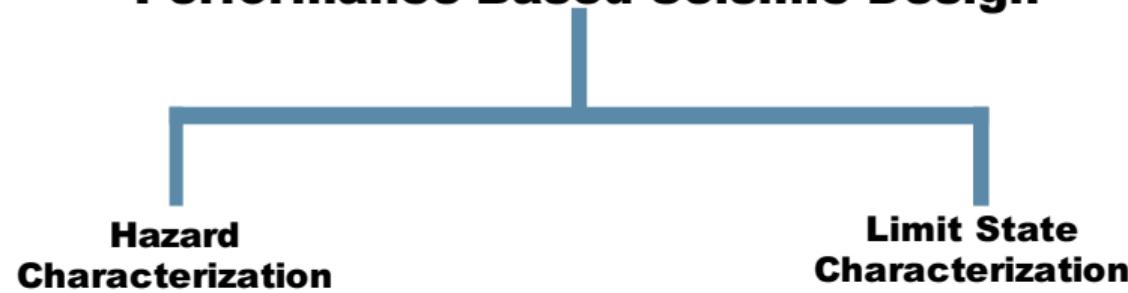


Performance Based Seismic Design



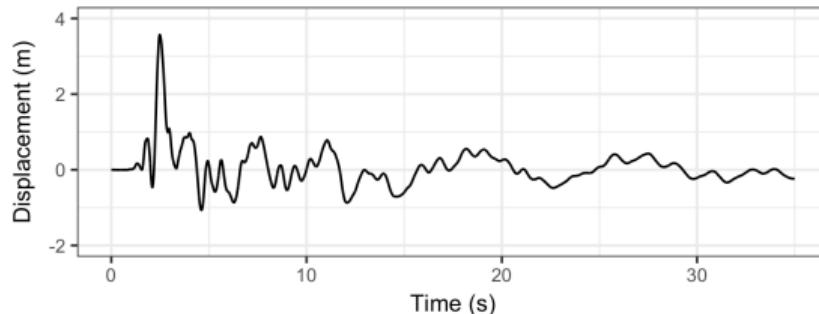
**Hazard
Characterization** **Limit State
Characterization**

Performance Based Seismic Design



Performance Based Seismic Design

**Hazard
Characterization**

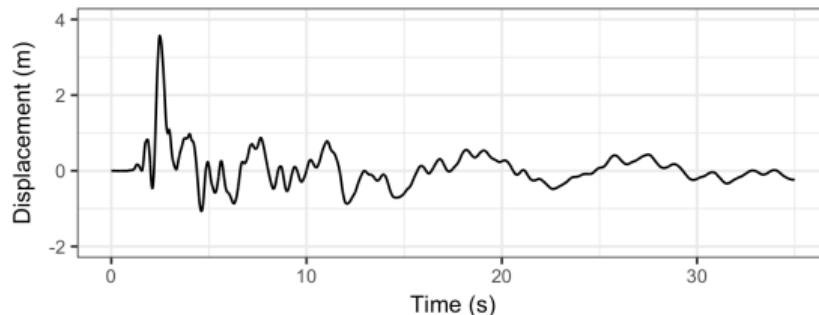


**Limit State
Characterization**

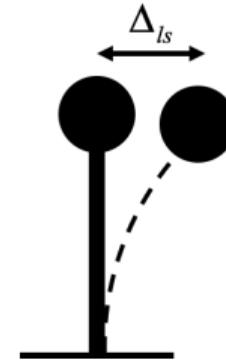


Performance Based Seismic Design

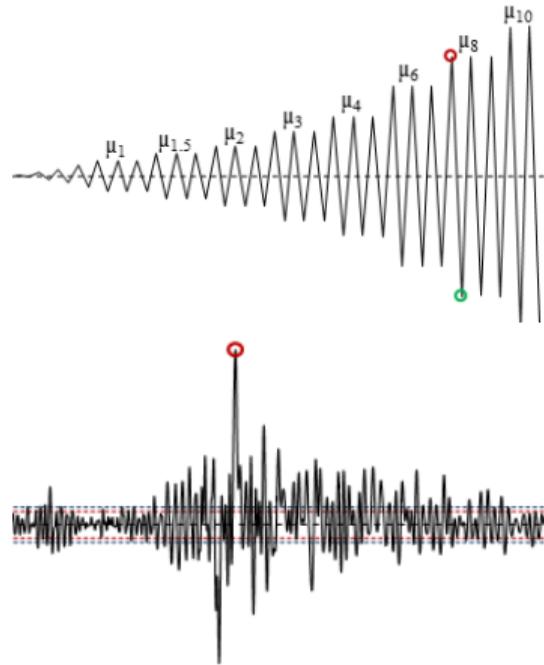
Hazard Characterization



Limit State Characterization



Consider a very specific example



Goodnight et al. (2013) "Effect of load history on performance limit states of circular bridge columns." *Journal of Bridge Engineering*

As a result

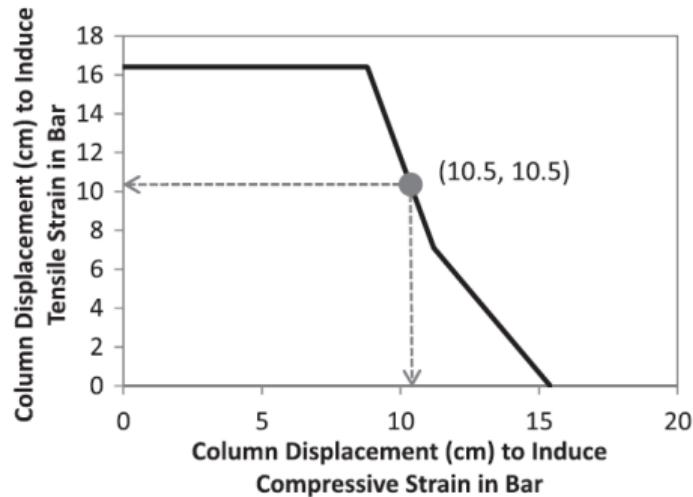
Strain Limits for Bar Buckling

$$\epsilon_{tension} = f(\text{Transverse reinforcement}) + f(\epsilon_{max-compression})$$

Feng et al. (2014) "Effect of seismic load history on deformation limit states for longitudinal bar buckling in RC circular columns." *Journal of Structural Engineering*

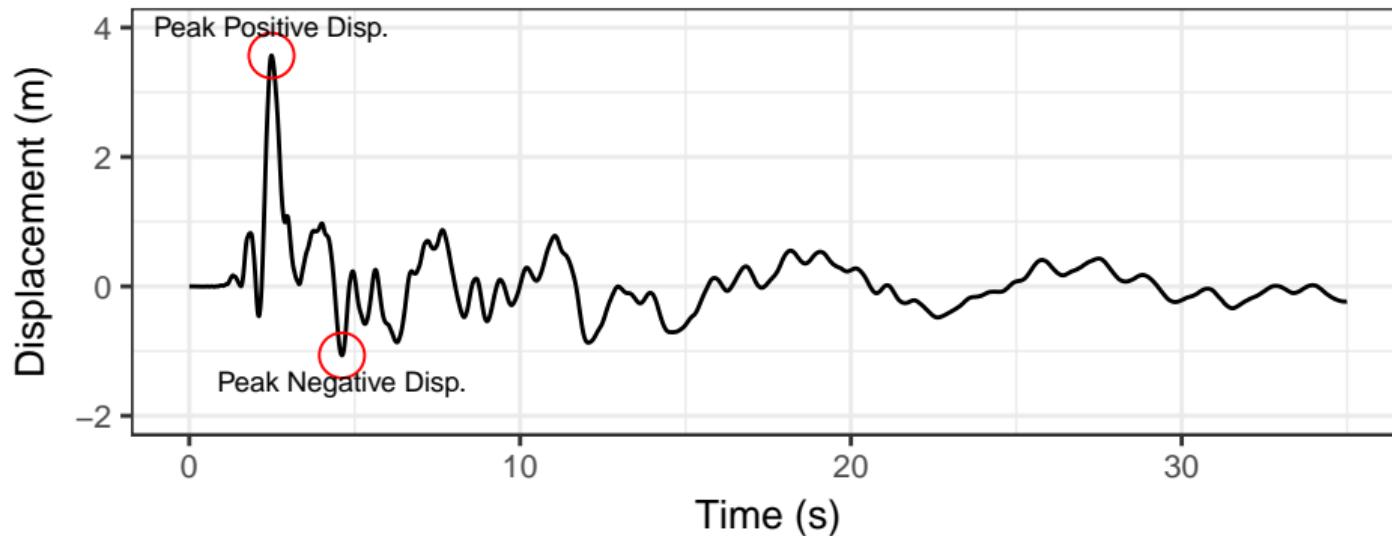
Strain Limits for Bar Buckling

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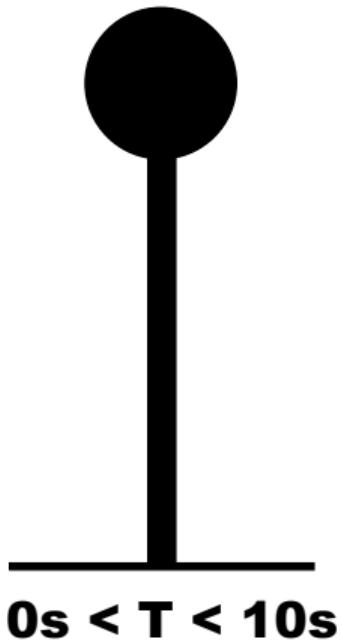


Feng et al. (2014) "Effect of seismic load history on deformation limit states for longitudinal bar buckling in RC circular columns." *Journal of Structural Engineering*

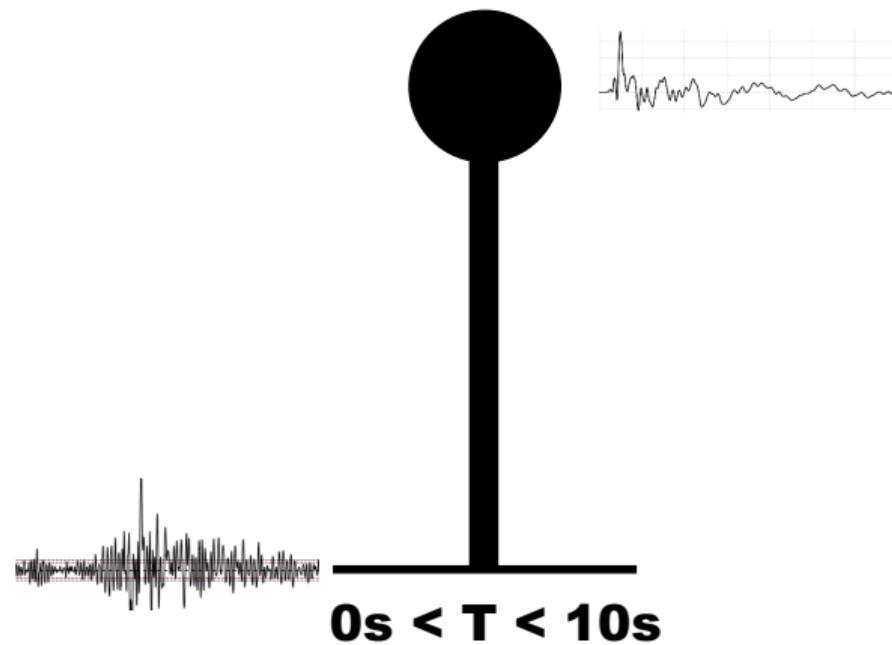
Introducing Balance Ratio (R_b)



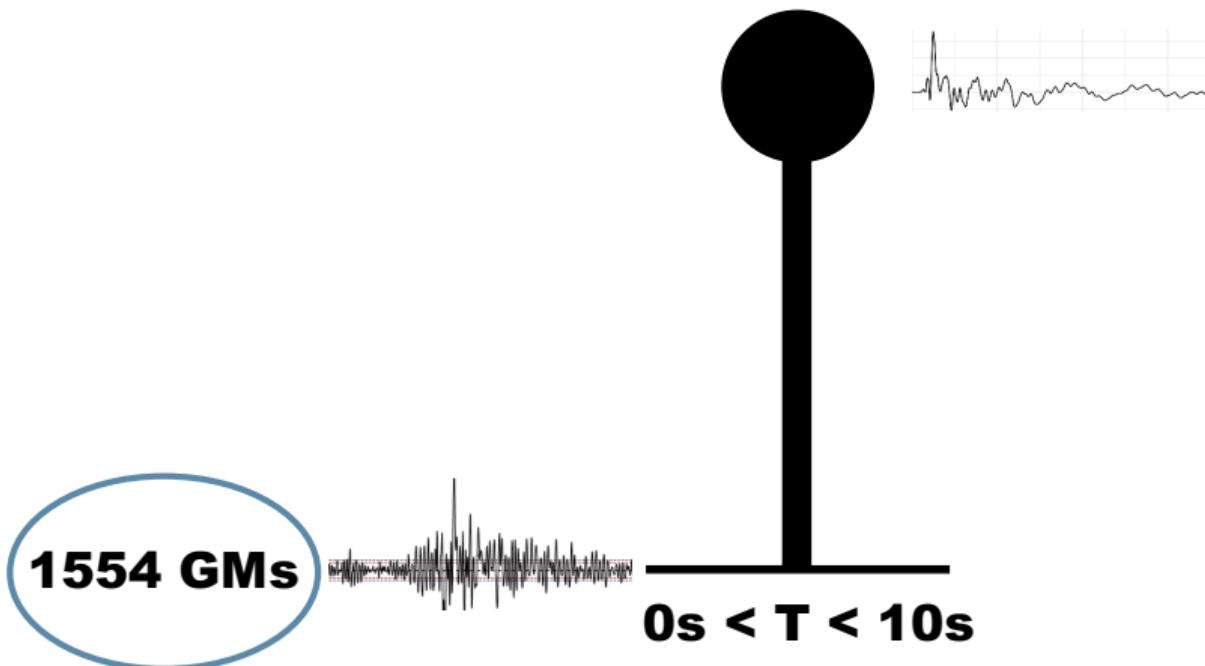
What was our approach?



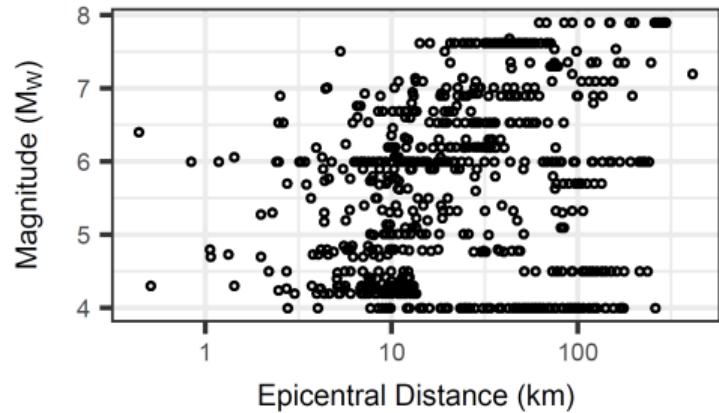
What was our approach?



What was our approach?

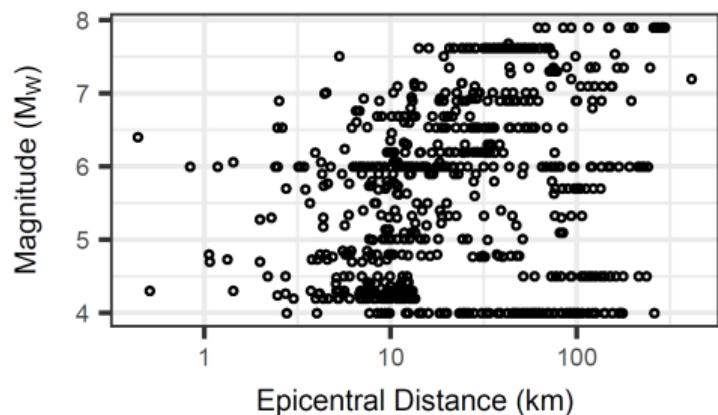


Elastic Analysis

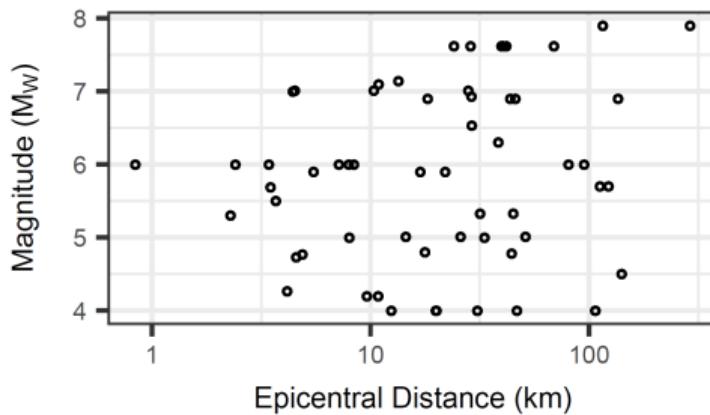


What GM dataset did we use?

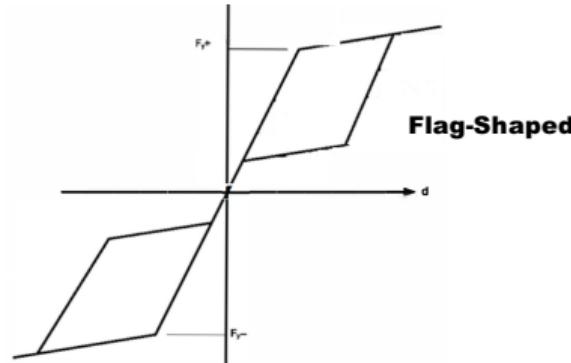
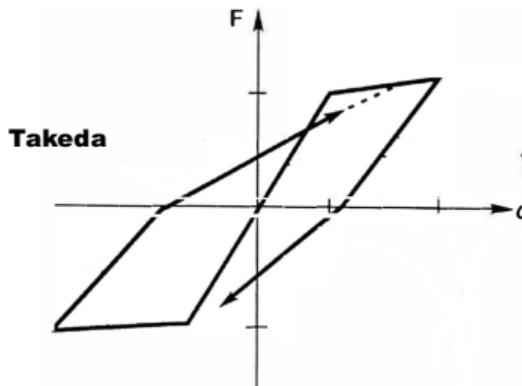
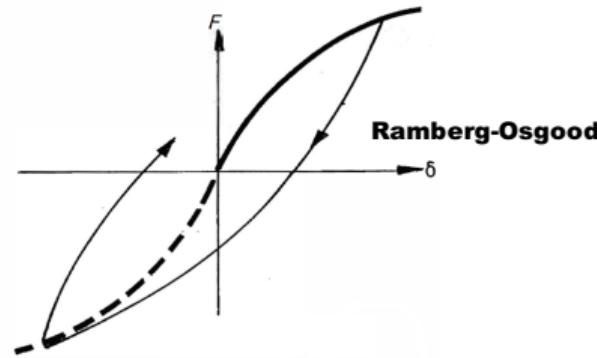
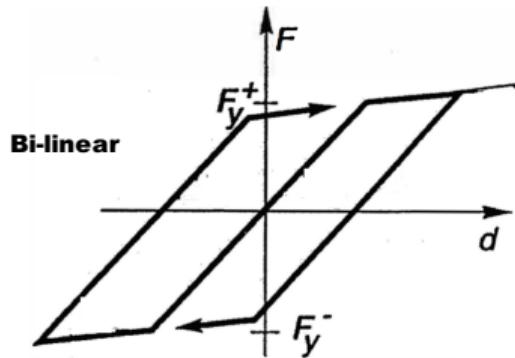
Elastic Analysis



Inelastic Analysis



Inelastic in what way?



Data processing

Ground Motion	Magnitude	Distance	SDOF Period

Data processing

Ground Motion	Magnitude	Distance	SDOF Period	SDOF Ductility	Hysteresis Rule

Data processing

Ground Motion	Magnitude	Distance	SDOF Period	SDOF Ductility	Hysteresis Rule	R _b

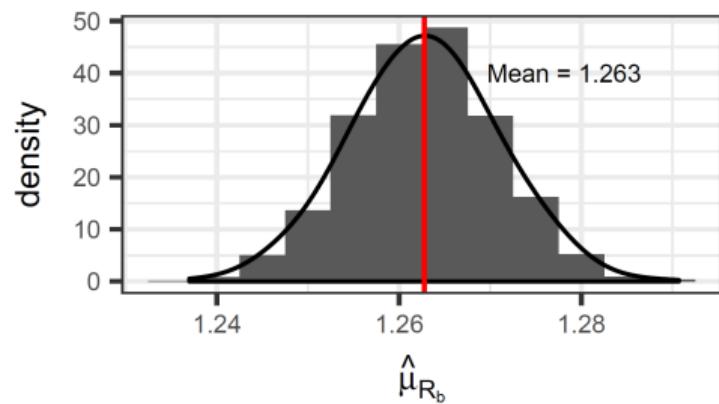
Data processing

Ground Motion	Magnitude	Distance	SDOF Period	SDOF Ductility	Hysteresis Rule	R _b

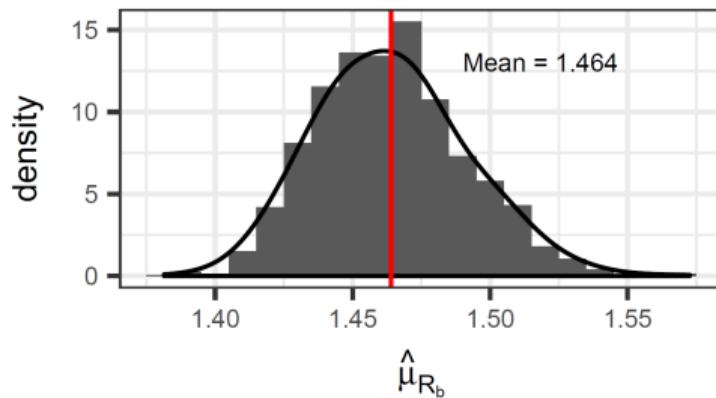
2000 random samples of size, n = 2000

Around 160,000 observations

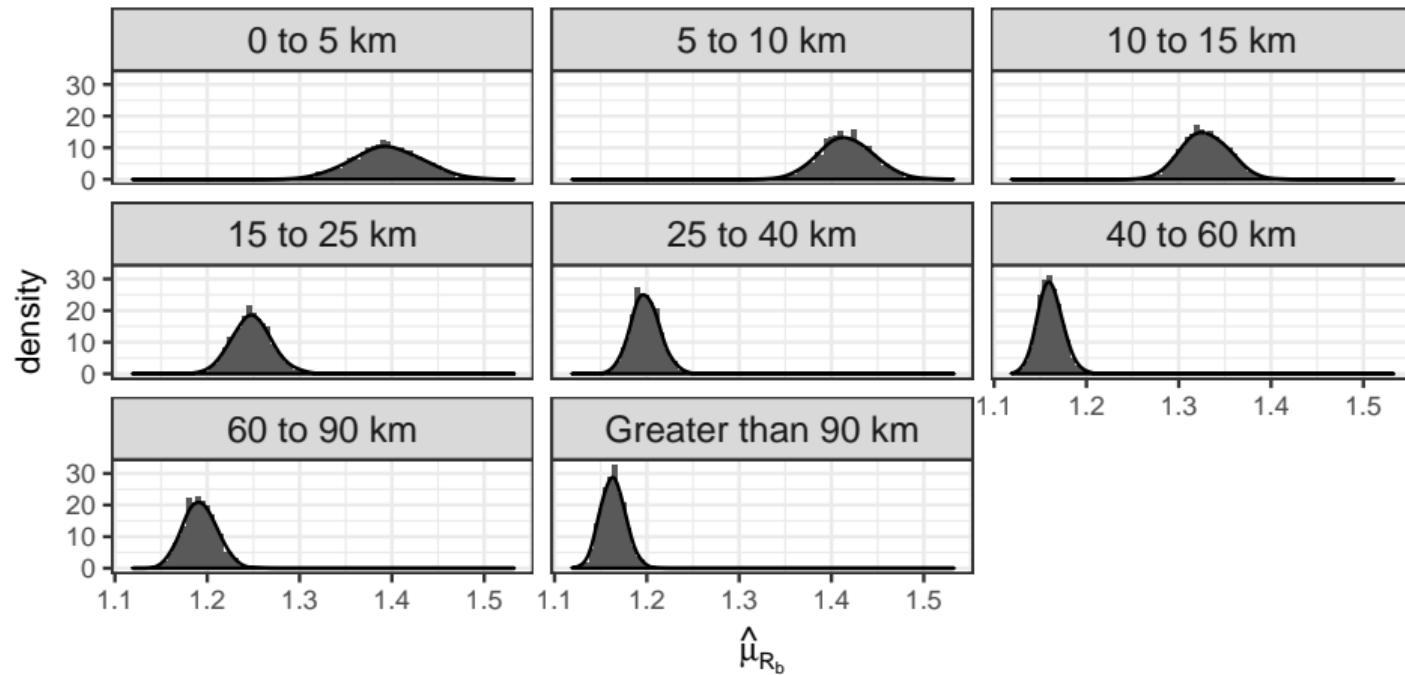
Elastic Analysis



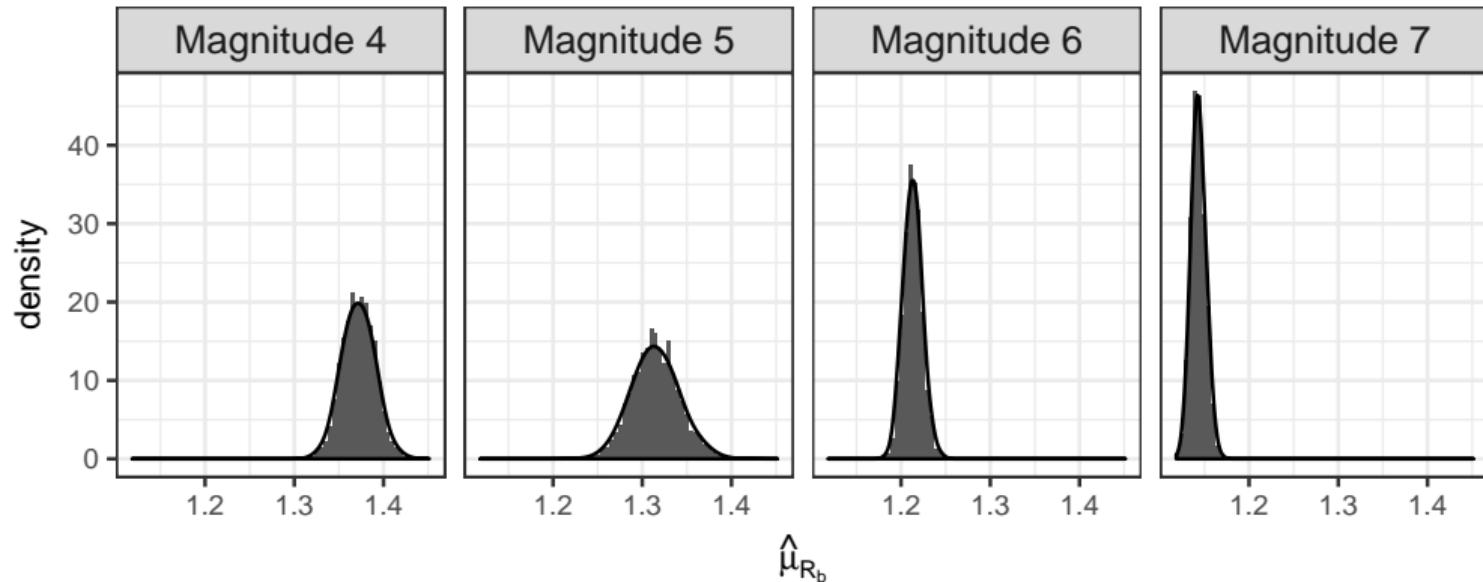
Inelastic Analysis



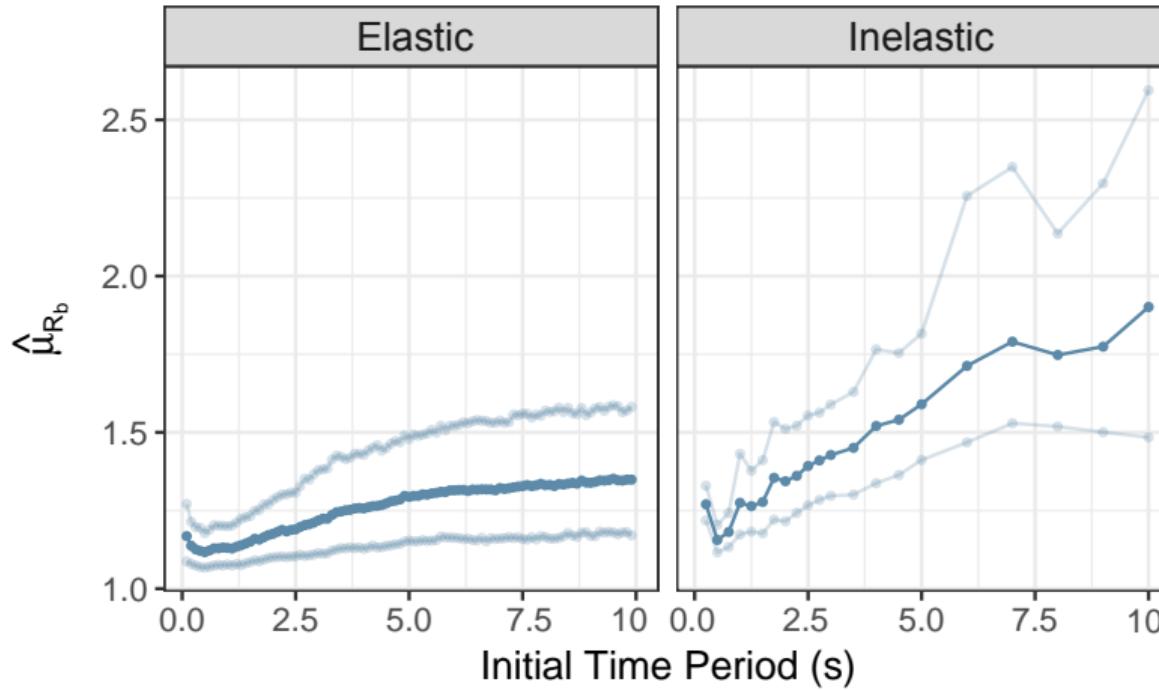
Effect of Epicentral Distance



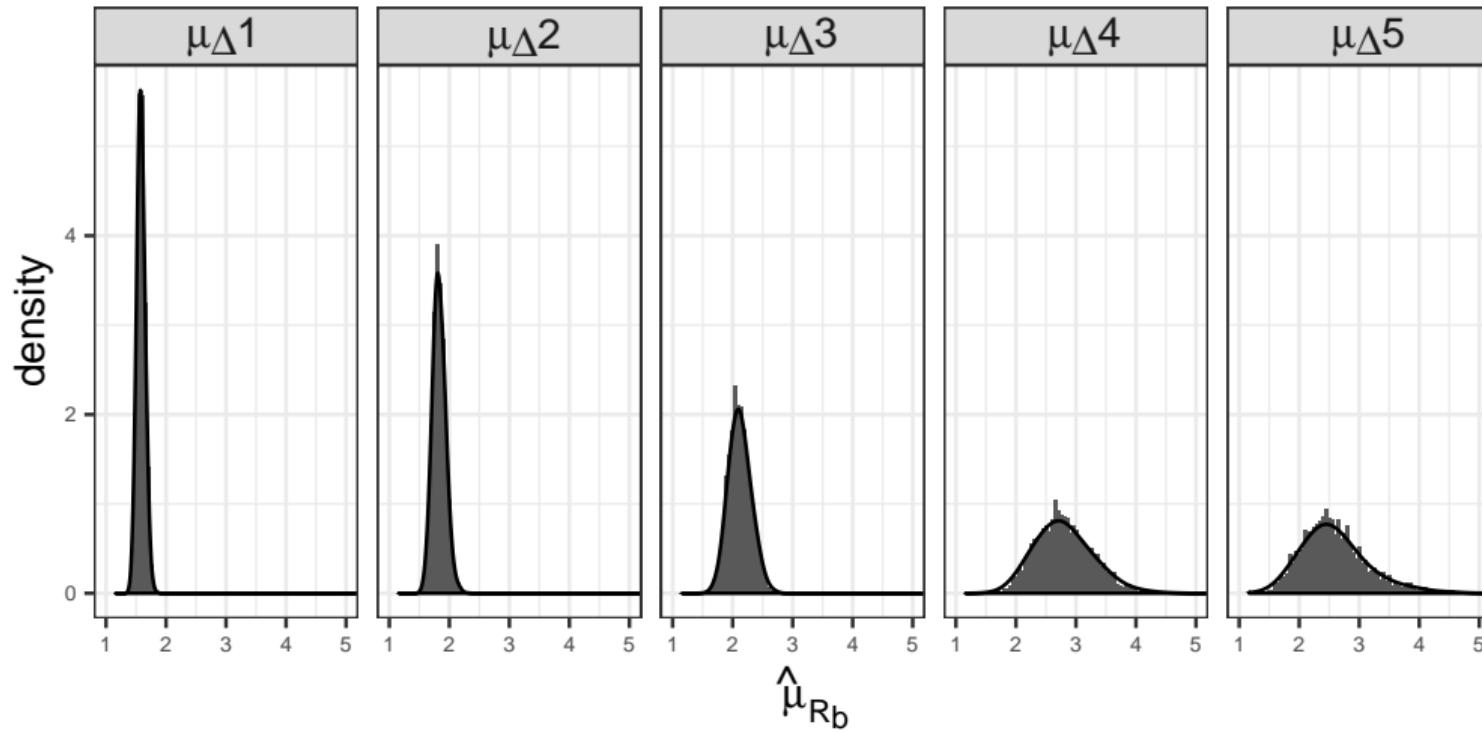
Effect of Event Magnitude



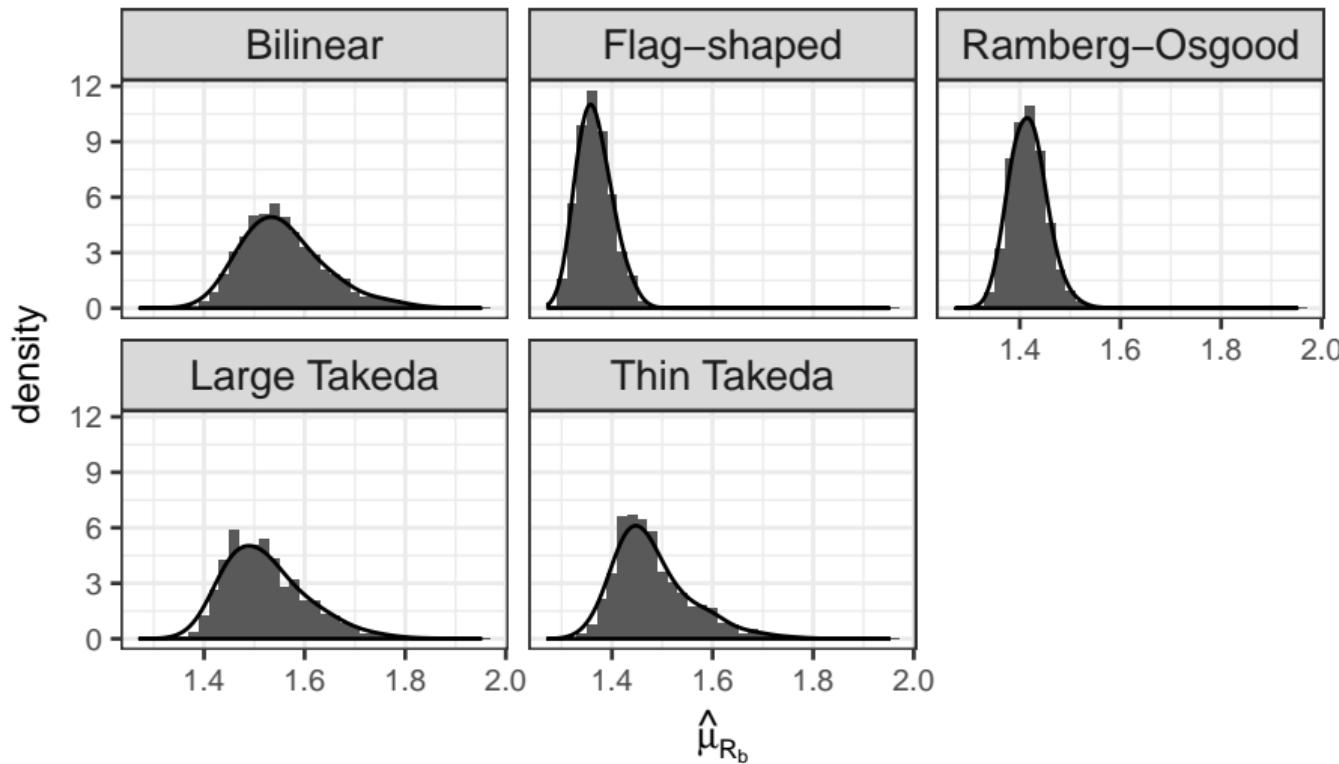
Effect of SDOF Period



Effect of SDOF Ductility



Effect of SDOF Hysteresis Rule



What does all of this mean?

- Structural response to ground motions are not “balanced”, especially in the inelastic range.
- Expressions providing R_b likelihood are desirable.
- Impact of R_b on Direct Displacement Based Design needs to be studied.

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NC STATE
UNIVERSITY

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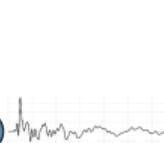
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Thank you!

A small icon of a seismogram or signal waveform is positioned to the right of the exclamation mark in the "Thank you!" text.