Identification of Critical Ground-Motion and Bridge Features for Performance Assessment of Regional Transportation Networks

Marc Eberhard

Jeffrey Berman

Brett Maurer

University of Washington

Nasser Marafi
RMS

Acknowledgments

Goals

➢ Compare contributions of sources of uncertainty to estimates of the seismic performance of individual bridges and transportation networks.

➢ Select Key Parameters based on:

   ▪ Impact of Uncertainties in Parameters on Performance,

   ▪ Effort Required to Collect Information

   ▪ Effort required to Incorporate Information

➢ Serve as laboratory to help develop/evaluate NHERI SimCenter Tools (e.g., R2D).
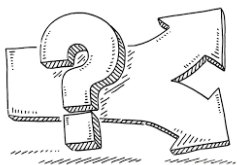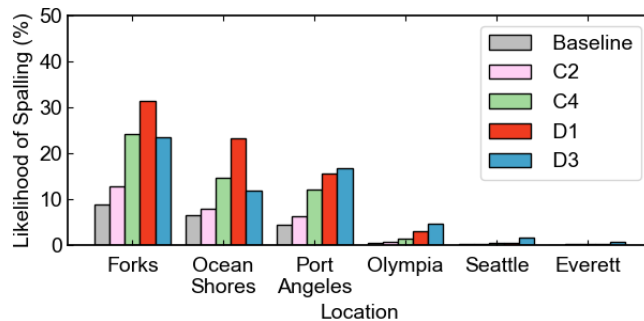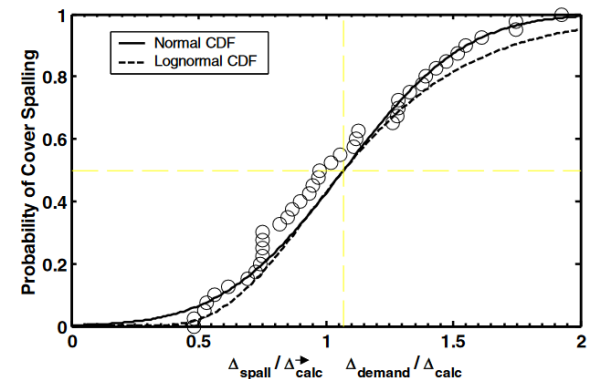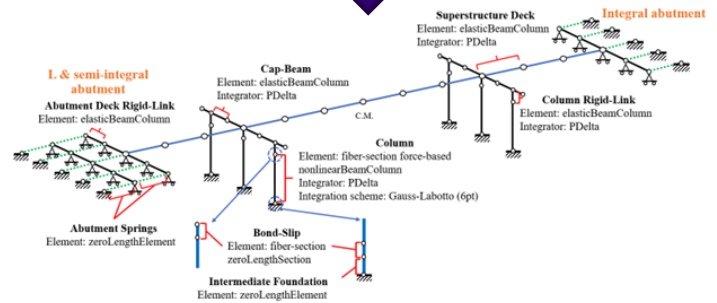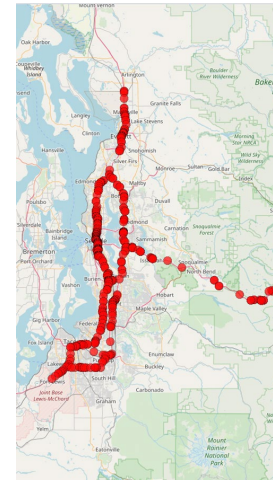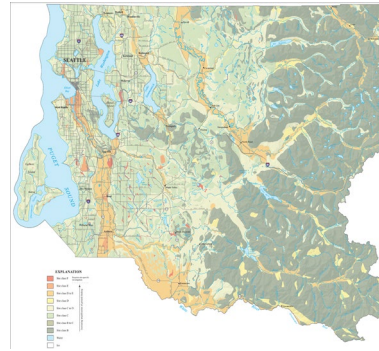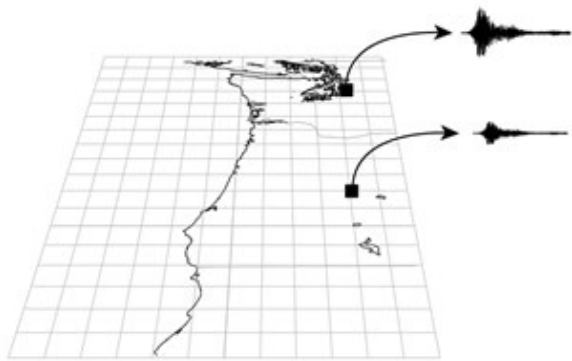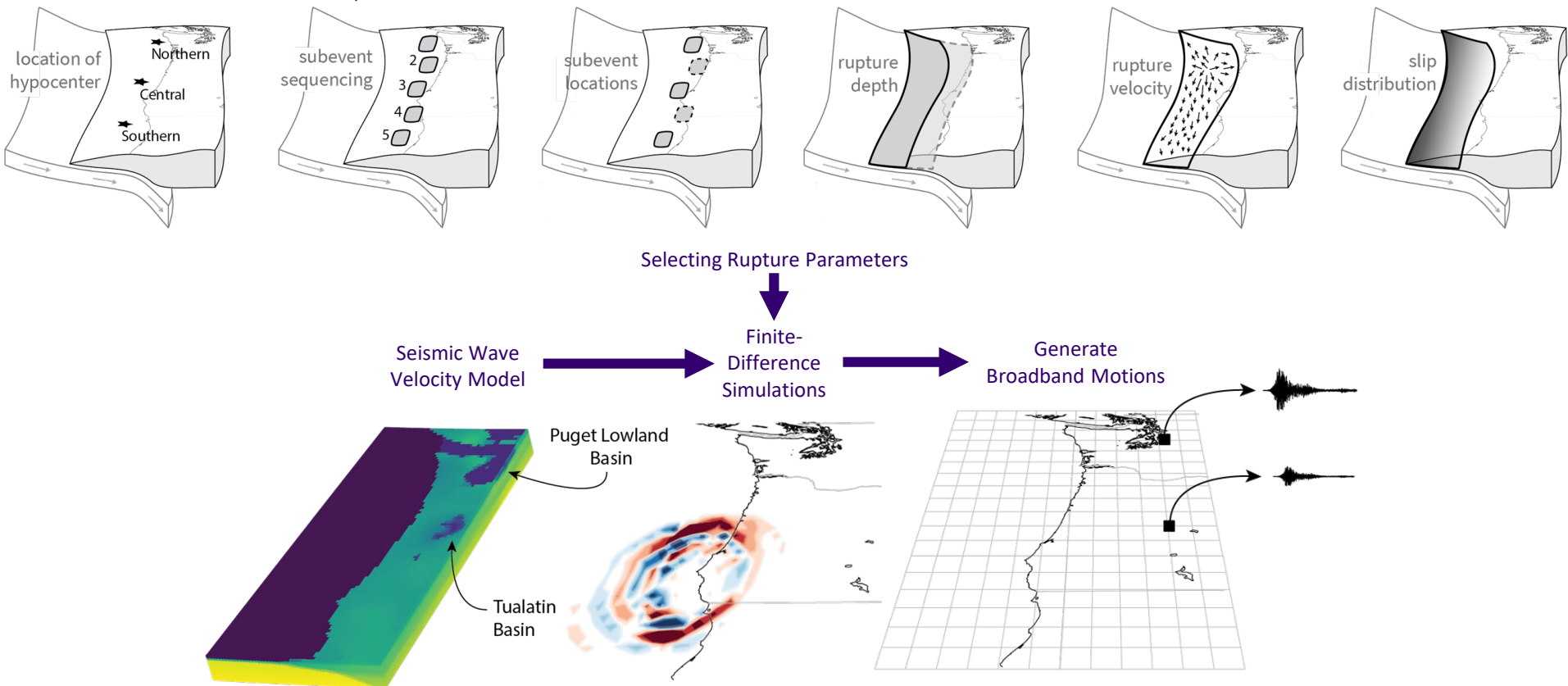
Improved Earthquake Resilience?

Impacts
- Bridge Closures/Restrictions of Individual Bridges
- Network Connectivity
- Pre-tsunami evacuation
- Health care system operation and access
- Disparate impacts

30 M9 CSZ Simulations

location of hypocenter — Northern, Central, Southern

subevent sequencing — 2, 3, 4, 5

subevent locations

rupture depth

rupture velocity

slip distribution

Selecting Rupture Parameters

Seismic Wave Velocity Model → Finite-Difference Simulations → Generate Broadband Motions
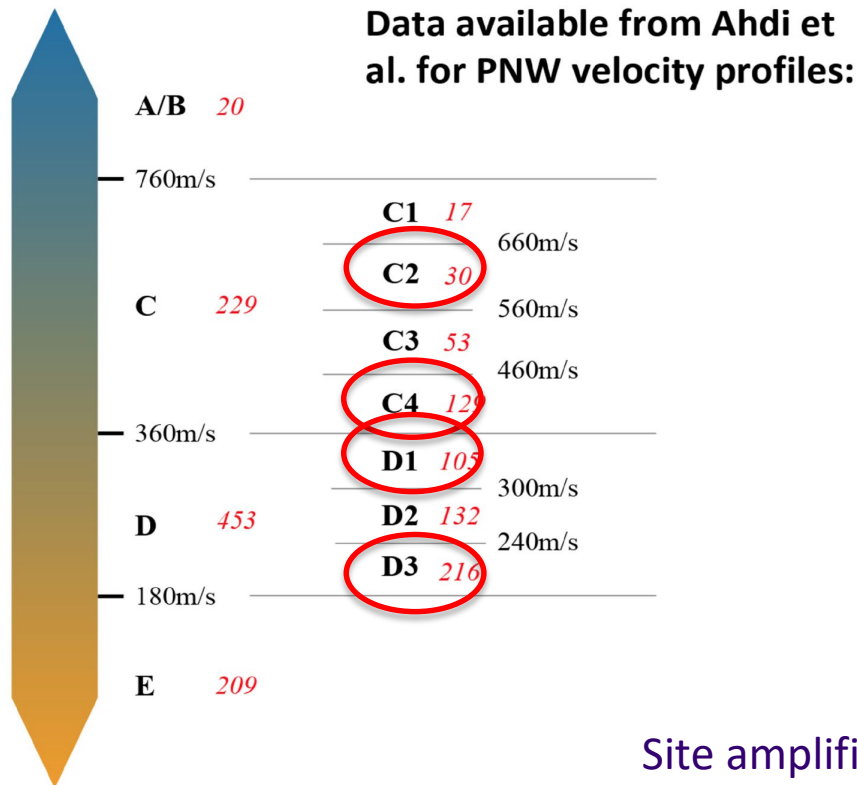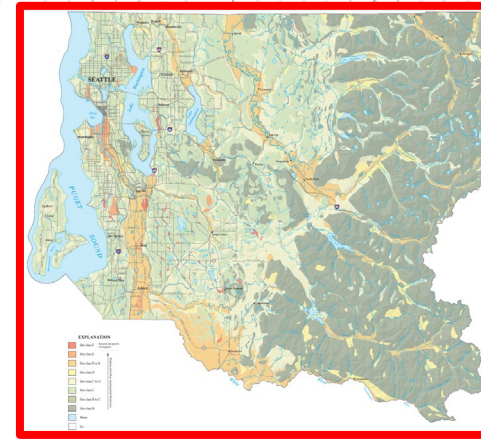
Puget Lowland Basin

Tualatin Basin

Reference: Frankel, A., Wirth, E., Marafi, N, Vidale, J., Stephenson., W. "Broadband Synthetic Seismograms for Magnitude 9 Earthquakes on the Cascadia Megathrust Based on 3D Simulations and Stochastic Synthetics", BSSA, 2018

USGS
science for a changing world

Site Conditions

➢ Simulation: Vs = 600 m/s

➢ Profiles for Ahdi et al. (2017)

Data available from Ahdi et al. for PNW velocity profiles:

A/B	20
760m/s	
C1	17
660m/s	
C2	30
C	229
560m/s	
C3	53
460m/s	
C4	12
360m/s	
D1	105
300m/s	
D2	132
D	453
240m/s	
D3	216
180m/s	
E	209

10 soil profiles for
each site class

Site amplification modeled by Alex Grant, USGS

Bridge Inventories

NBI
Bridge Database

WSDOT-UW Bridge
Database
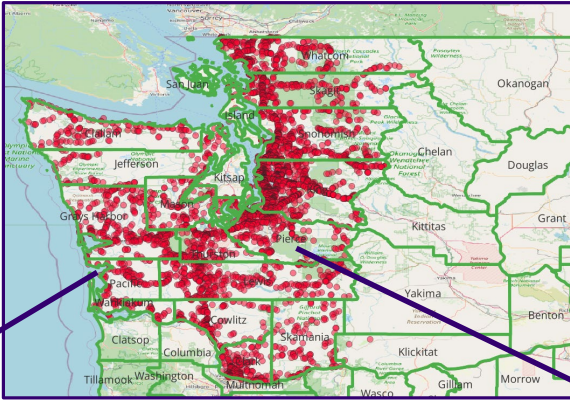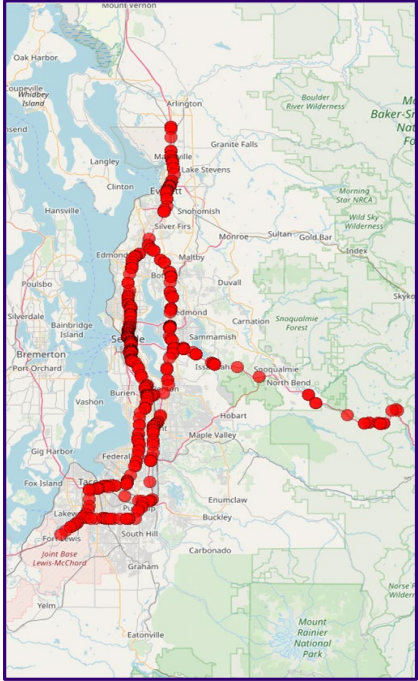
Olympic Peninsula
Bridge Database
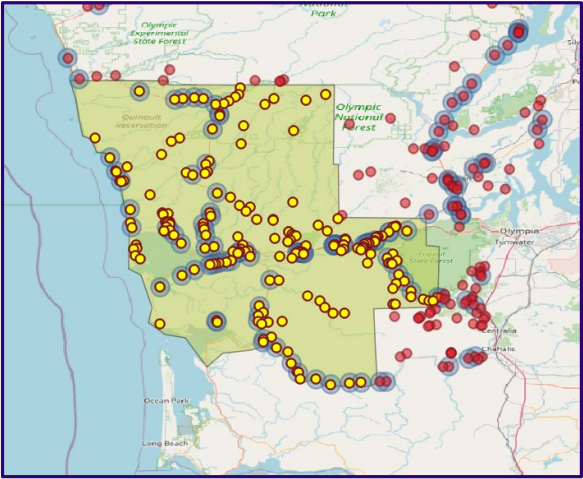
Current Activity

Documented detailed
properties for ~750 Bridges

Upcoming Activity

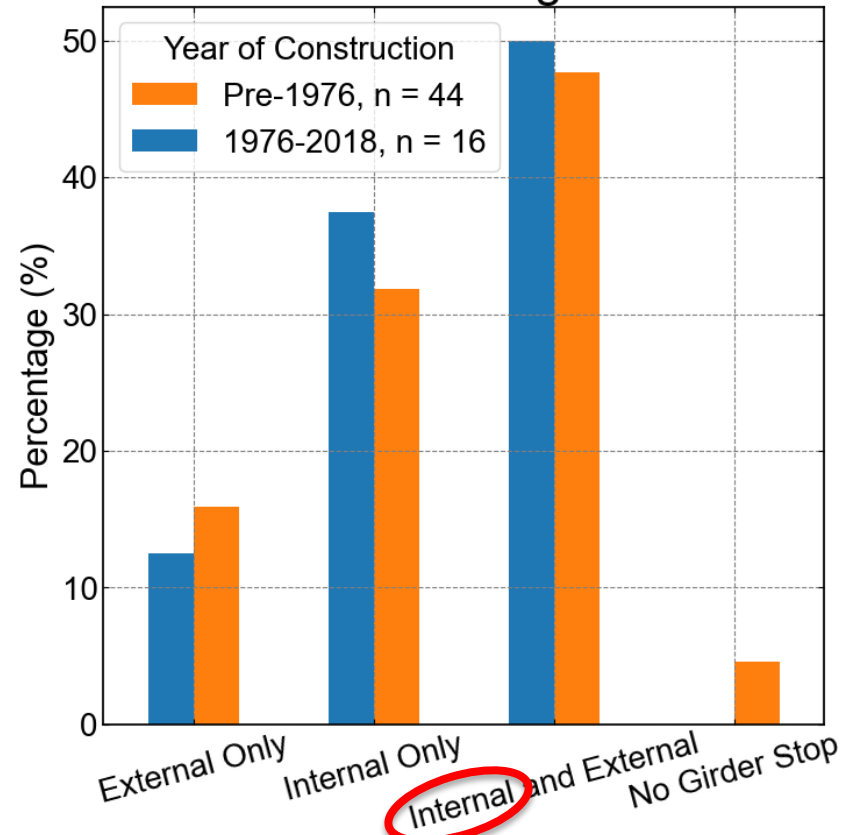Extrapolating from NBI data to
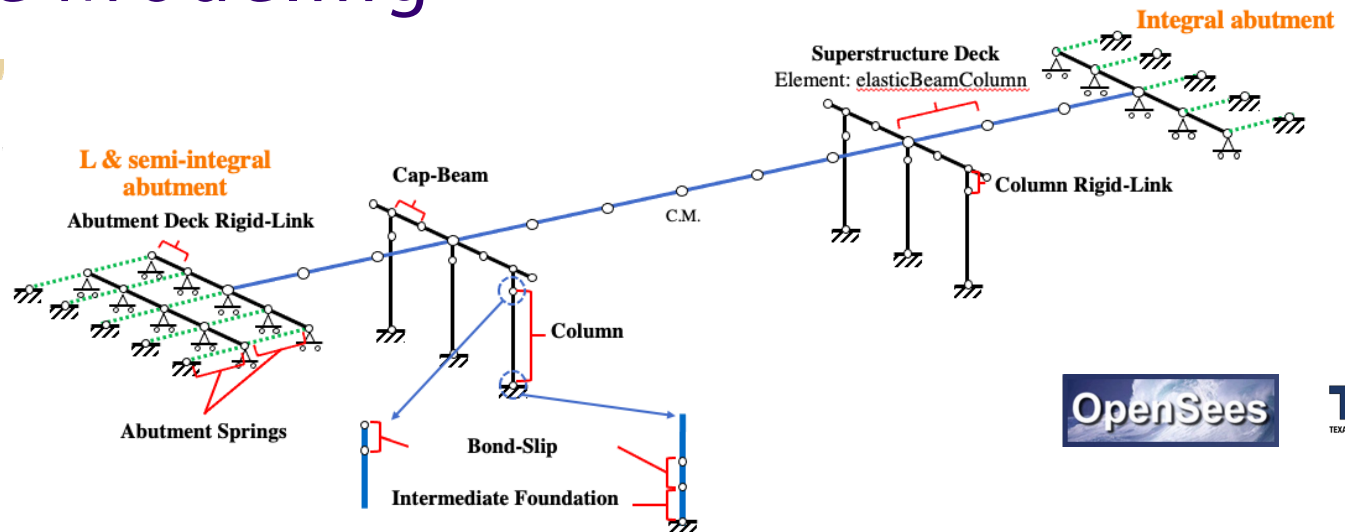detailed data (probabilistically)
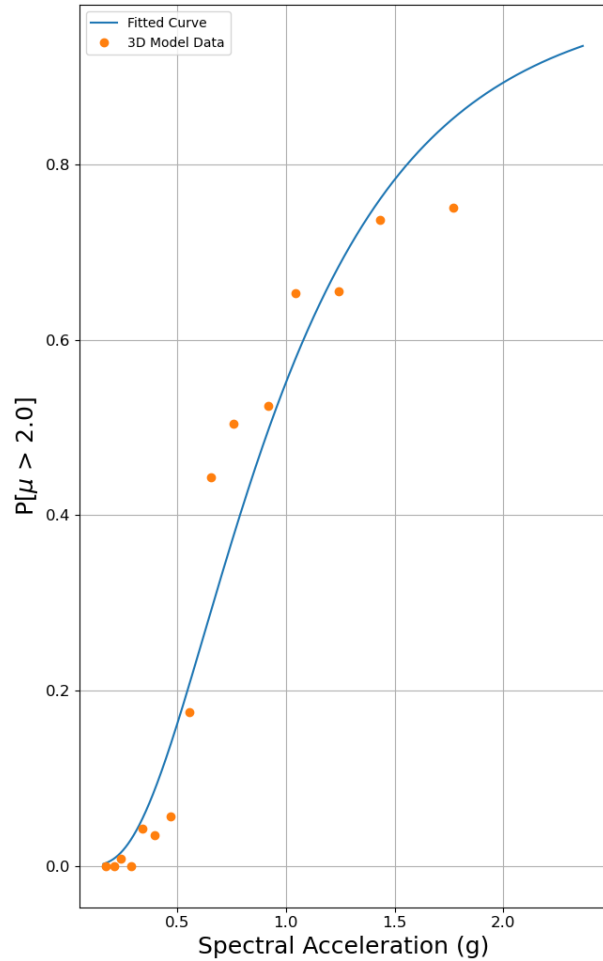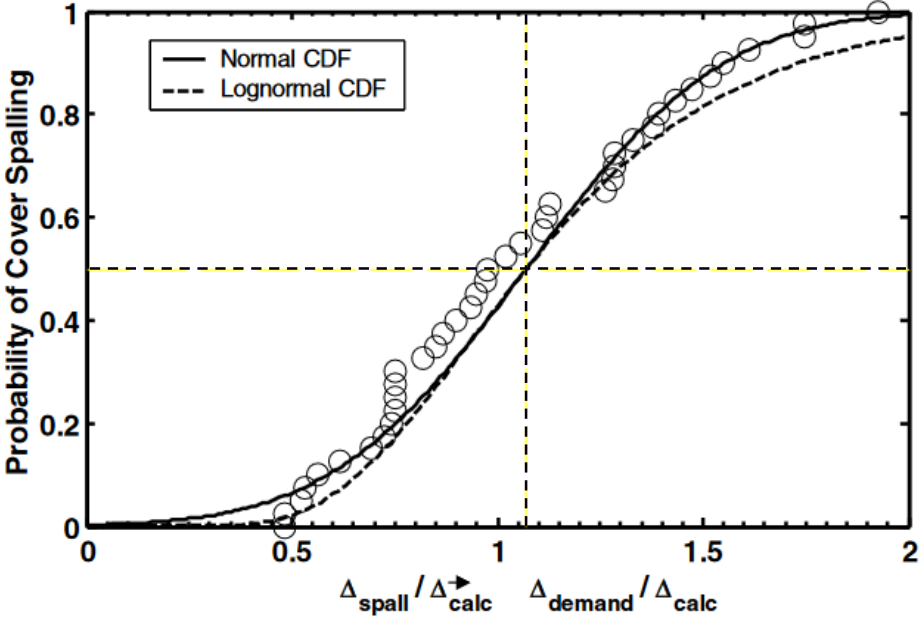
Shear Keys

Bridge Modeling

- ➢ Reference Bridge
- ➢ Changes to abutment properties
  - Shear keys
  - Abutment continuity
  - Foundation types
  - Bearing pads
- ➢ Changes to column height
  - Doubled
  - Halved
- ➢ Changes to transverse reinforcement

- ➢ 30 earthquake scenarios
- ➢ Location
  - Port Angeles
  - Ocean Shores
  - Seattle
- ➢ Site Classes
  - C2
  - C4
  - D1
  - D3
- ➢ 10 profiles for each site class
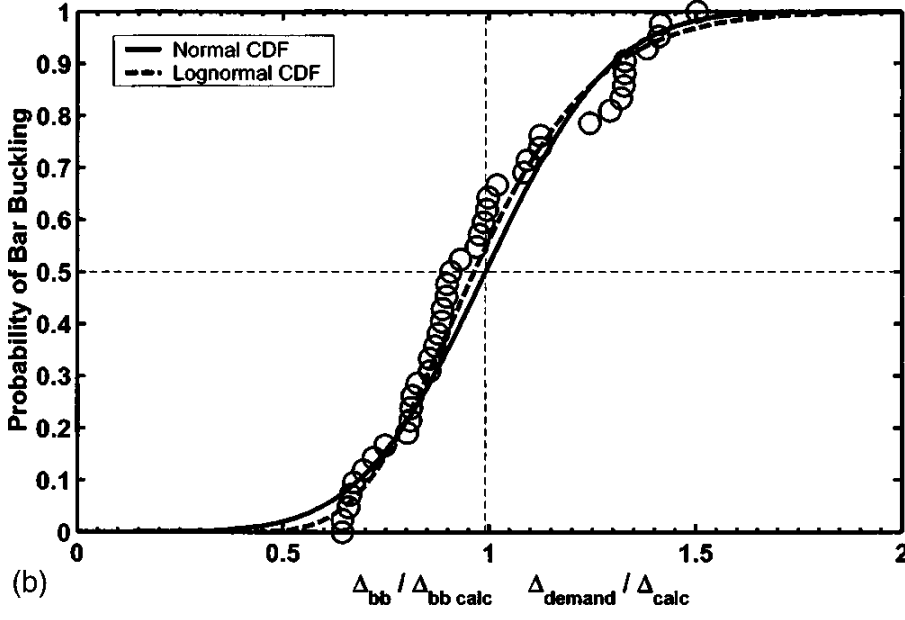
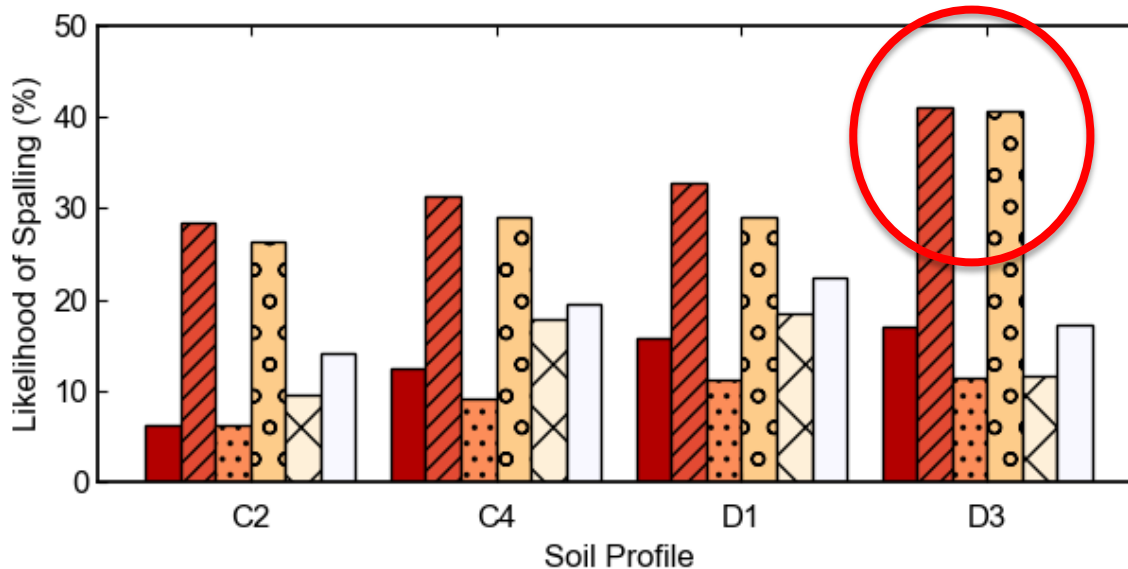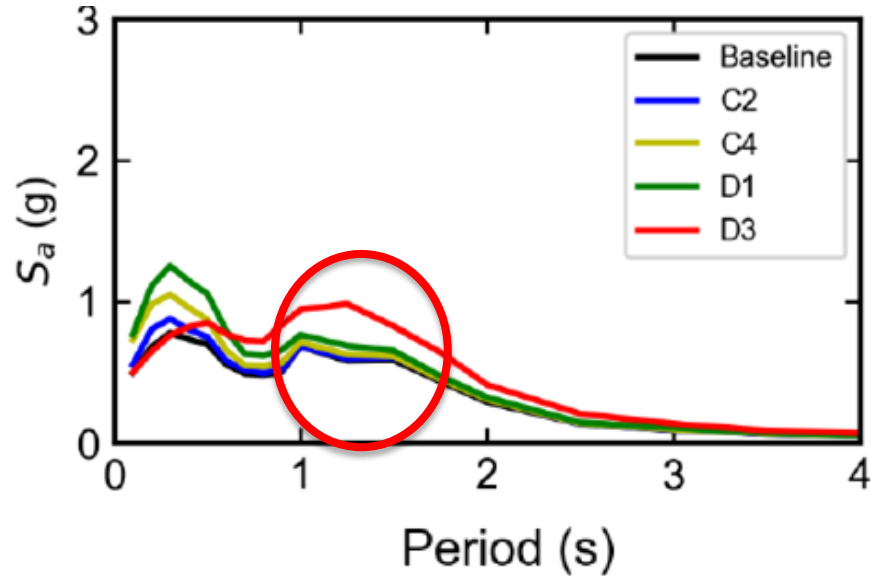# Structural Demands (EDPs)
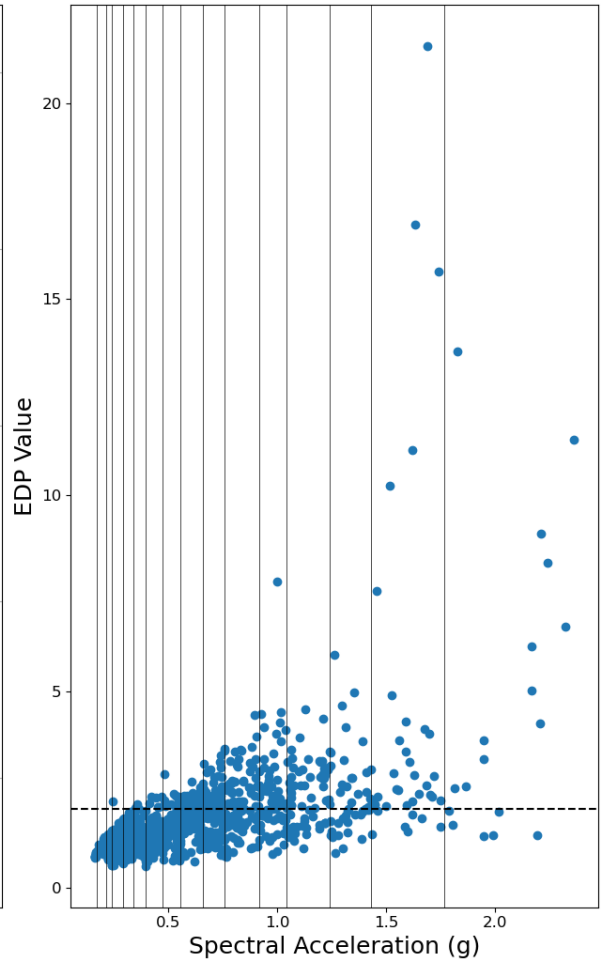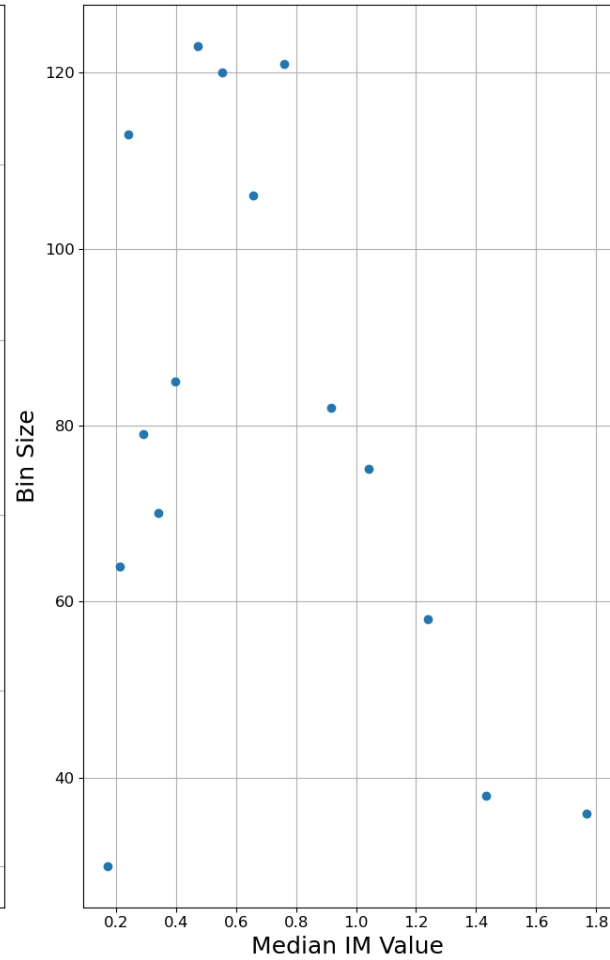
Damage Fragility Curves

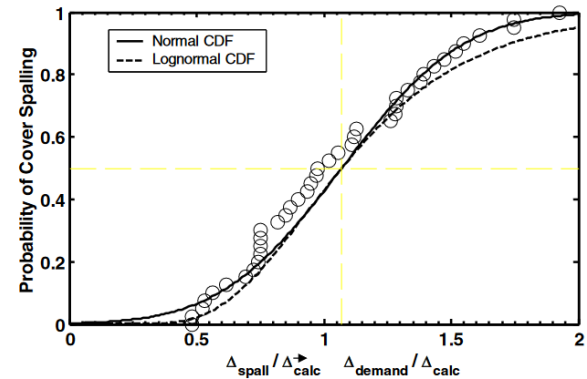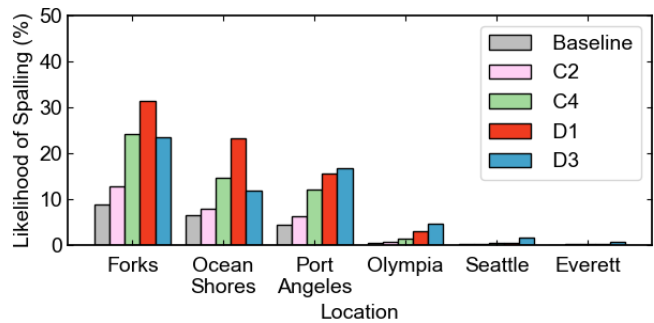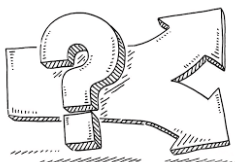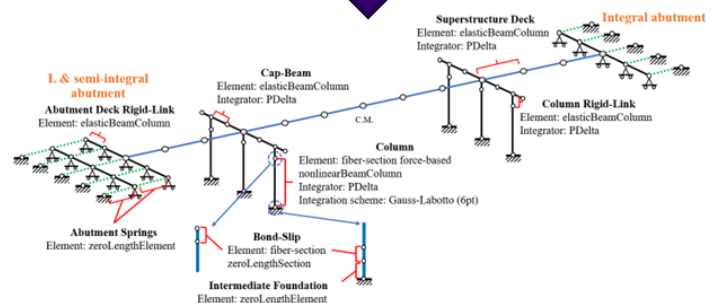# Effect of Column Height and Shear Key

Port Angeles

- **Soft Soils**
- **Tall Columns**
- **No Shear Key**
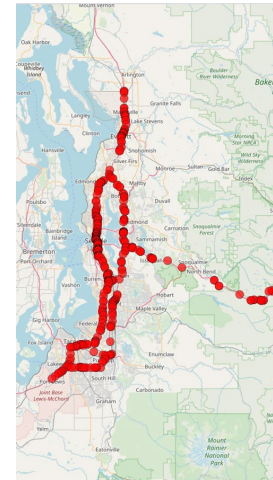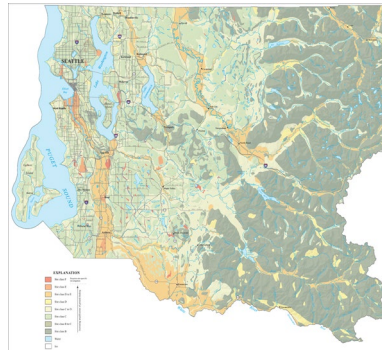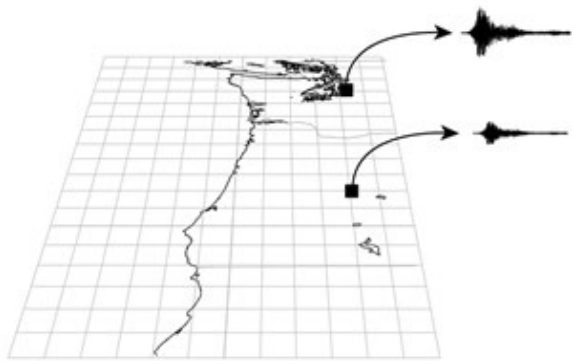
Improved Earthquake Resilience?

Impacts
- Bridge Closures/Restrictions of Individual Bridges
- Network Connectivity
- Pre-tsunami evacuation
- Health care system operation and access
- Disparate impacts

Next Steps

➢ **Predicting Bridge Properties**
  - Expected/Observed Correlations
  - Machine Learning   (ABC-IBT UTC)

➢ **Fragility Curves for Less Common Bridges**
  - Timber Bridges Superstructures and Substructures
  - Moveable Bridges

➢ **Liquefaction and Landslides**
  - Triggering
  - Impact

➢ **Social Impacts (CoPes)**
  - Post-event decision making
  - Health care system operation and access
  - Disparate impacts

➢ **Implementation in R2D**

Thank you