Performance-Based Seismic Design Guidelines for Tall Buildings

Ch. 5: Seismic Input (Ground Motion)

TBI Committee Members

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Presentation

1. Seismic Hazard Analysis (SHA)
   - Probabilistic
   - Deterministic
   - Site-Response Analysis
2. Soil-Foundation-Structure Interaction
   - Kinematic
   - Inertial
   - Input Motion

Presentation (cont.)

3. Selection and Scaling of Accelerograms
   - Identification of Controlling Seismic Sources
   - Accelerogram Selection Guidelines
   - Accelerogram Modifications

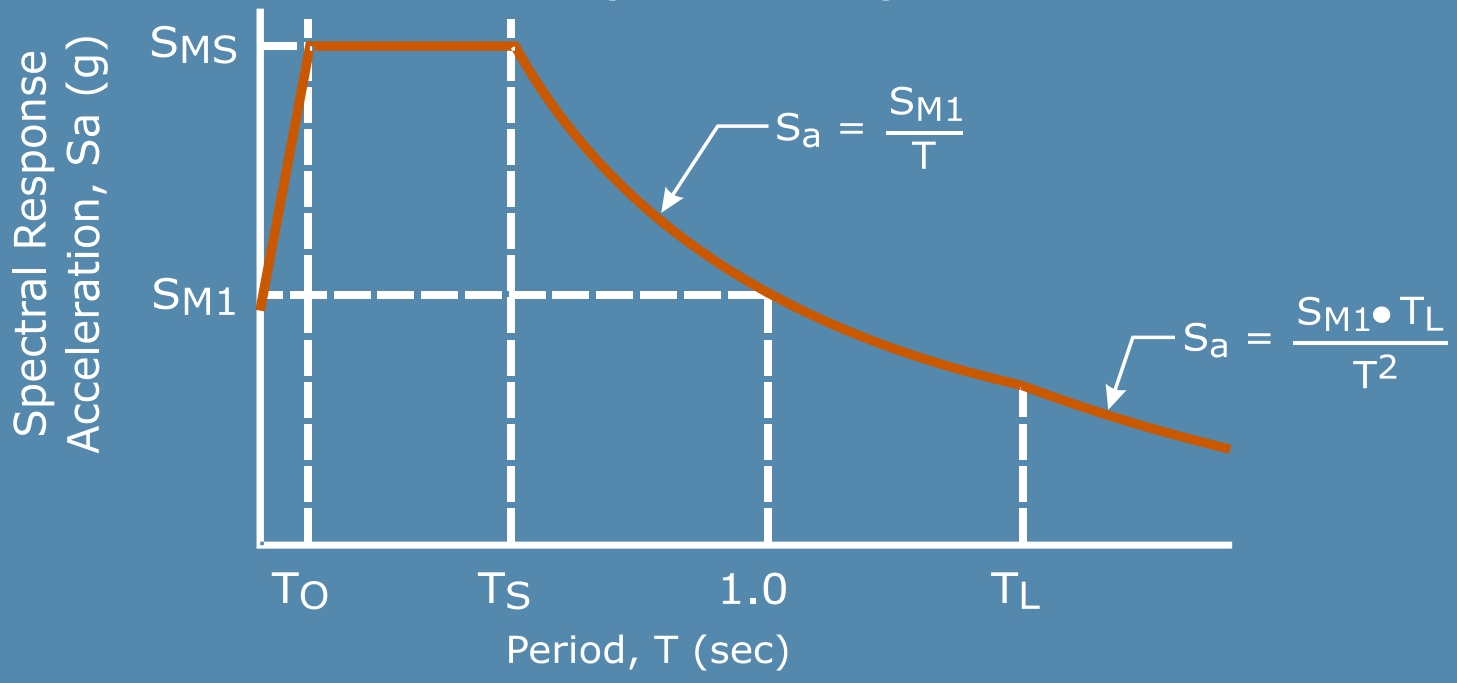
Two SHA Approaches

1. General Procedure - Ch. 11 of ASCE 7-05

USGS MCE Maps & Site Coefficients

S_S, S_1, T_L $\qquad$ F_a, F_v

MCE Response Spectrum



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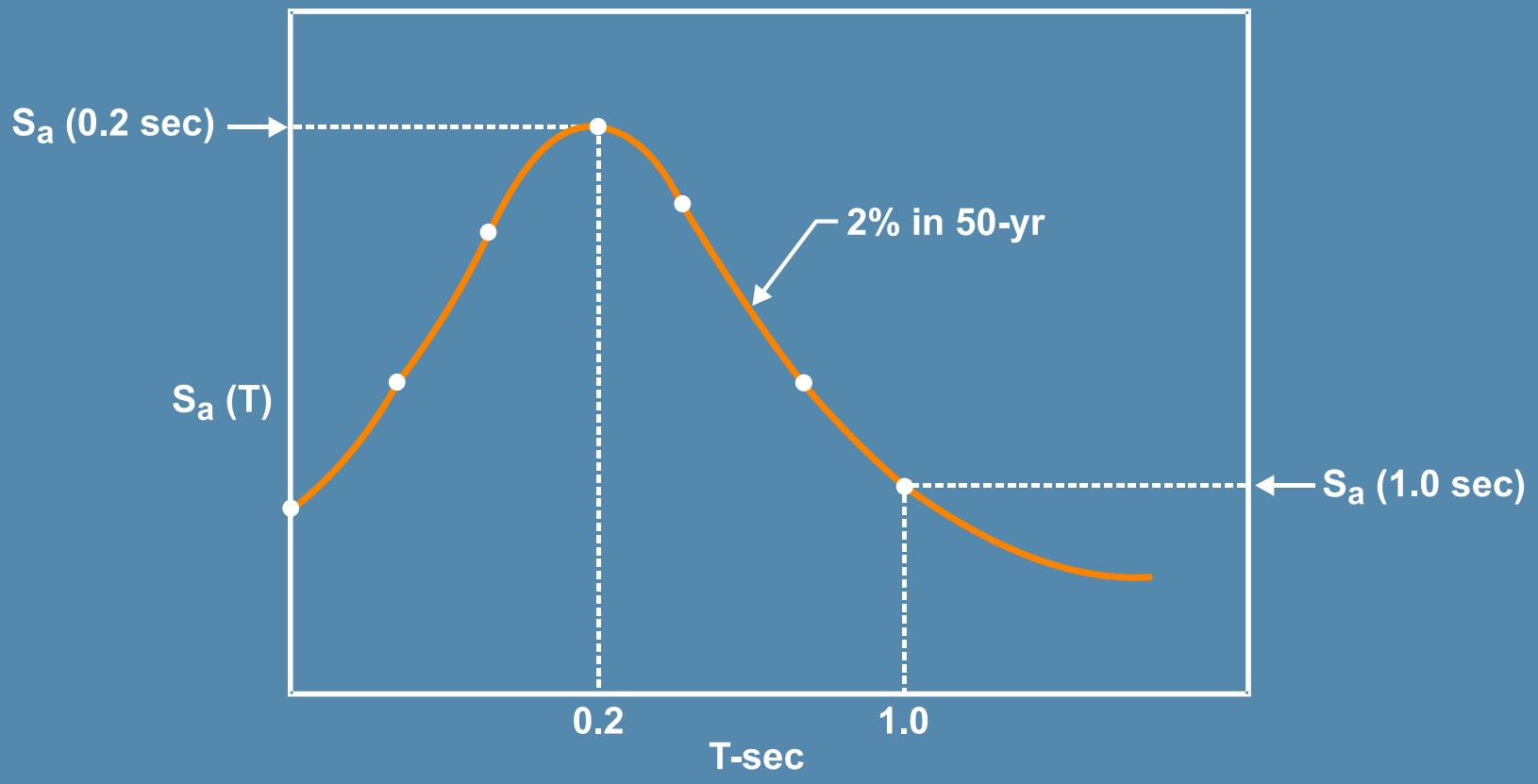
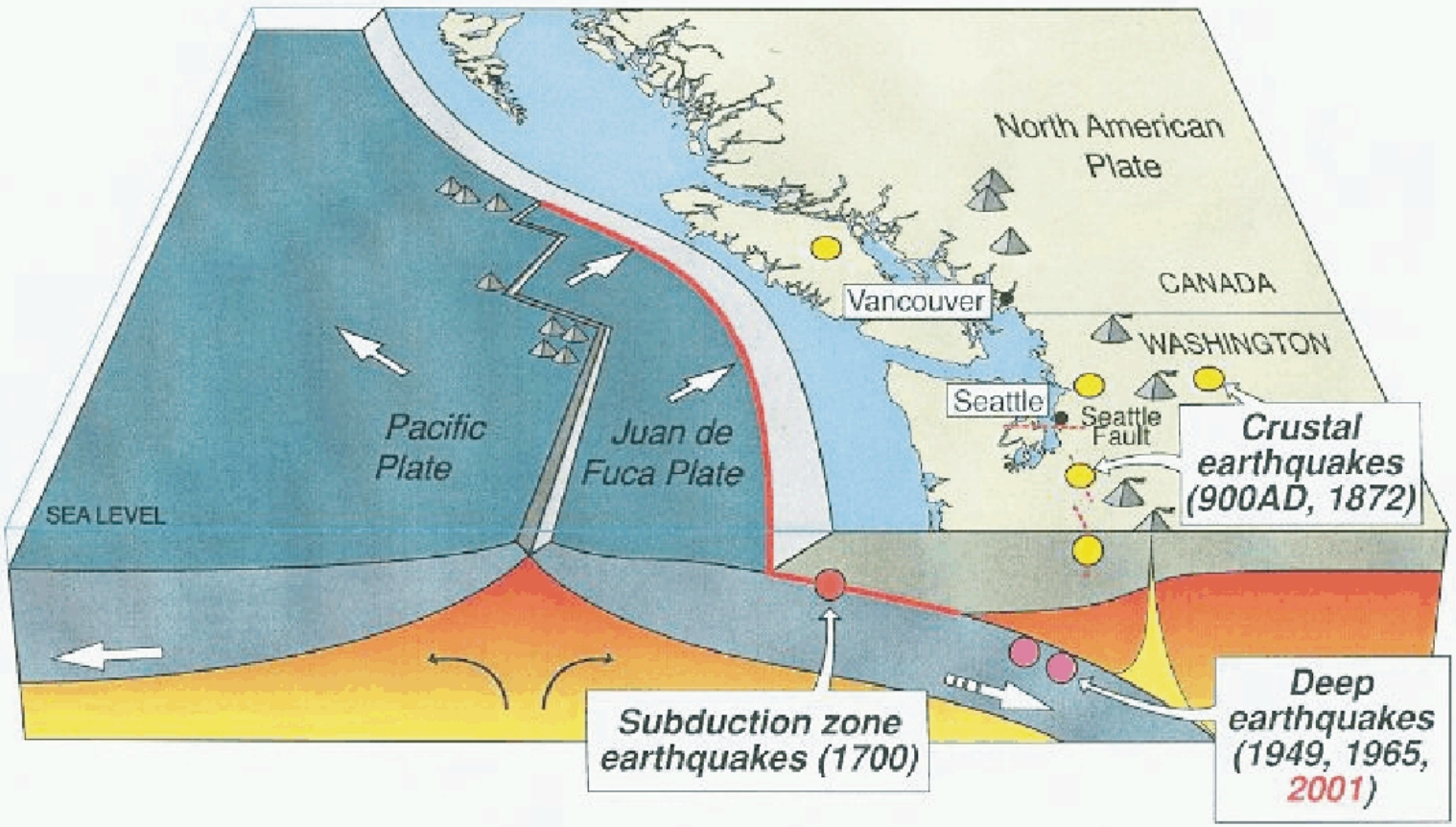
Two SHA Approaches (cont.)

2. Site-Specific (Preferred)
   - Probabilistic
   - Deterministic

Uniform Hazard Spectrum



Cascadia Earthquake Sources



Source	Affected area	Max. Size	Recurrence
Subduction Zone	W.WA, OR, CA	M 9	500-600 yr
Deep Juan de Fuca plate	W.WA, OR,	M 7+	30-50 yr
Crustal faults	WA, OR, CA	M 7+	Hundreds of yr?

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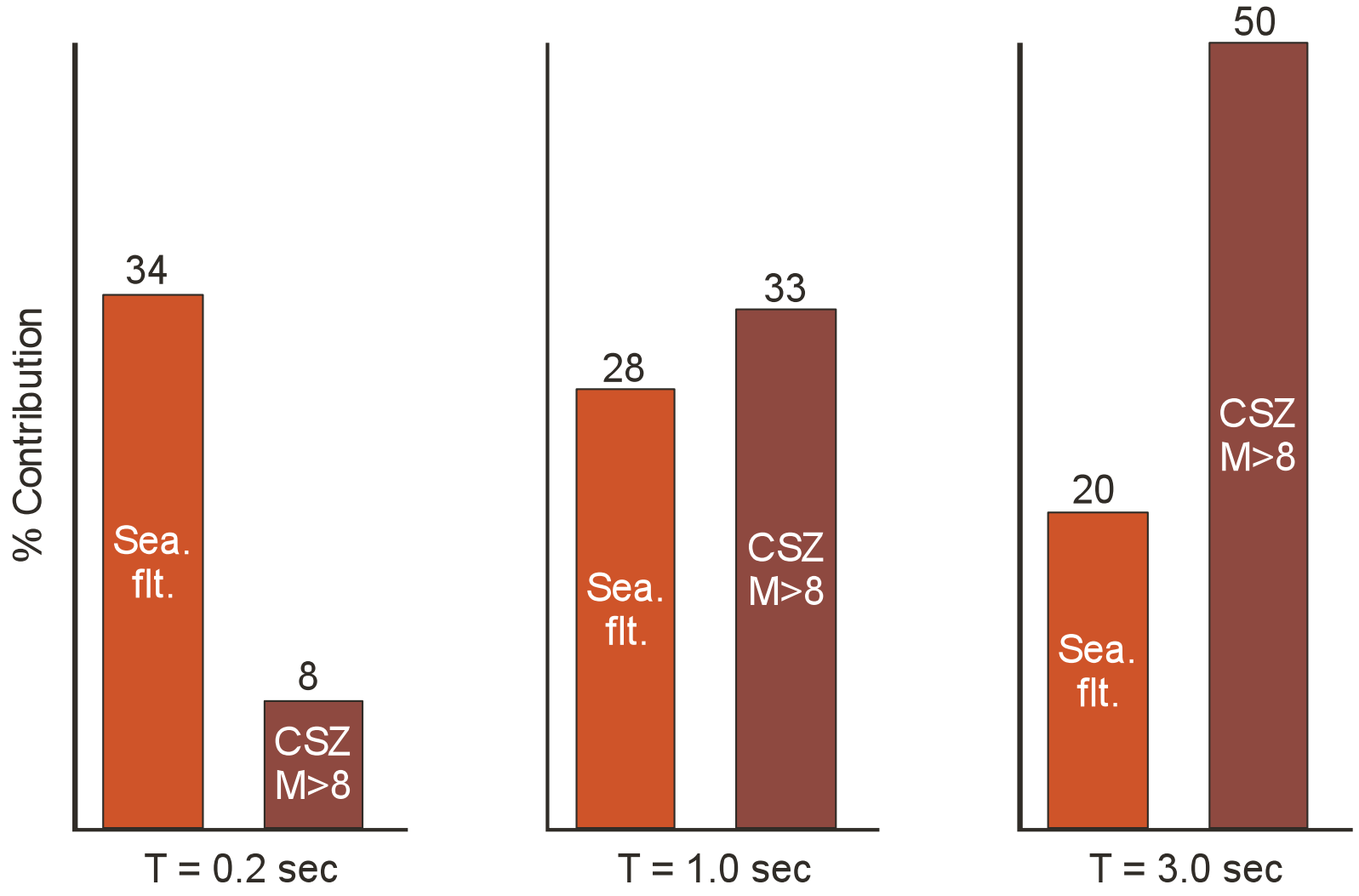
Contribution to 2475-yr Ground Motion Hazard

Lavizzo Park, Seattle (47.6° N, 122.3° W)
2008 USGS PSHA



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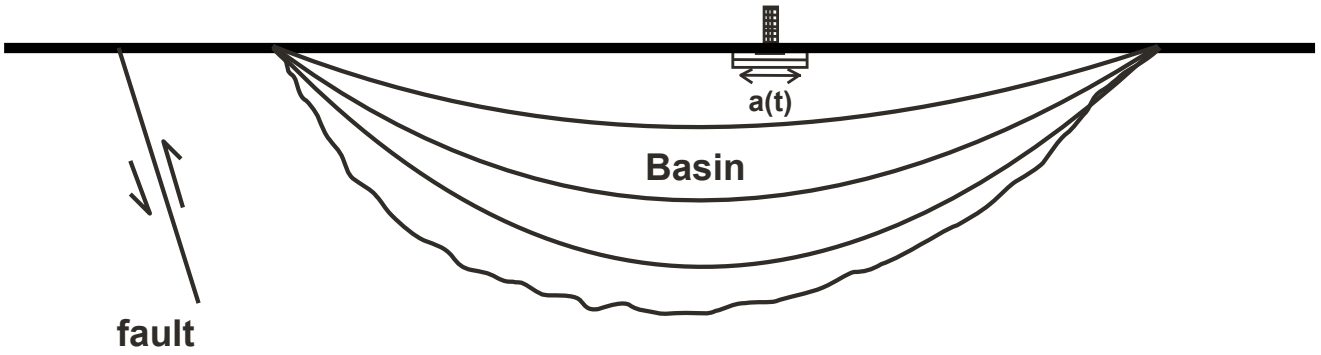
Basin Effects



- Amplify long period motions
- Increase duration

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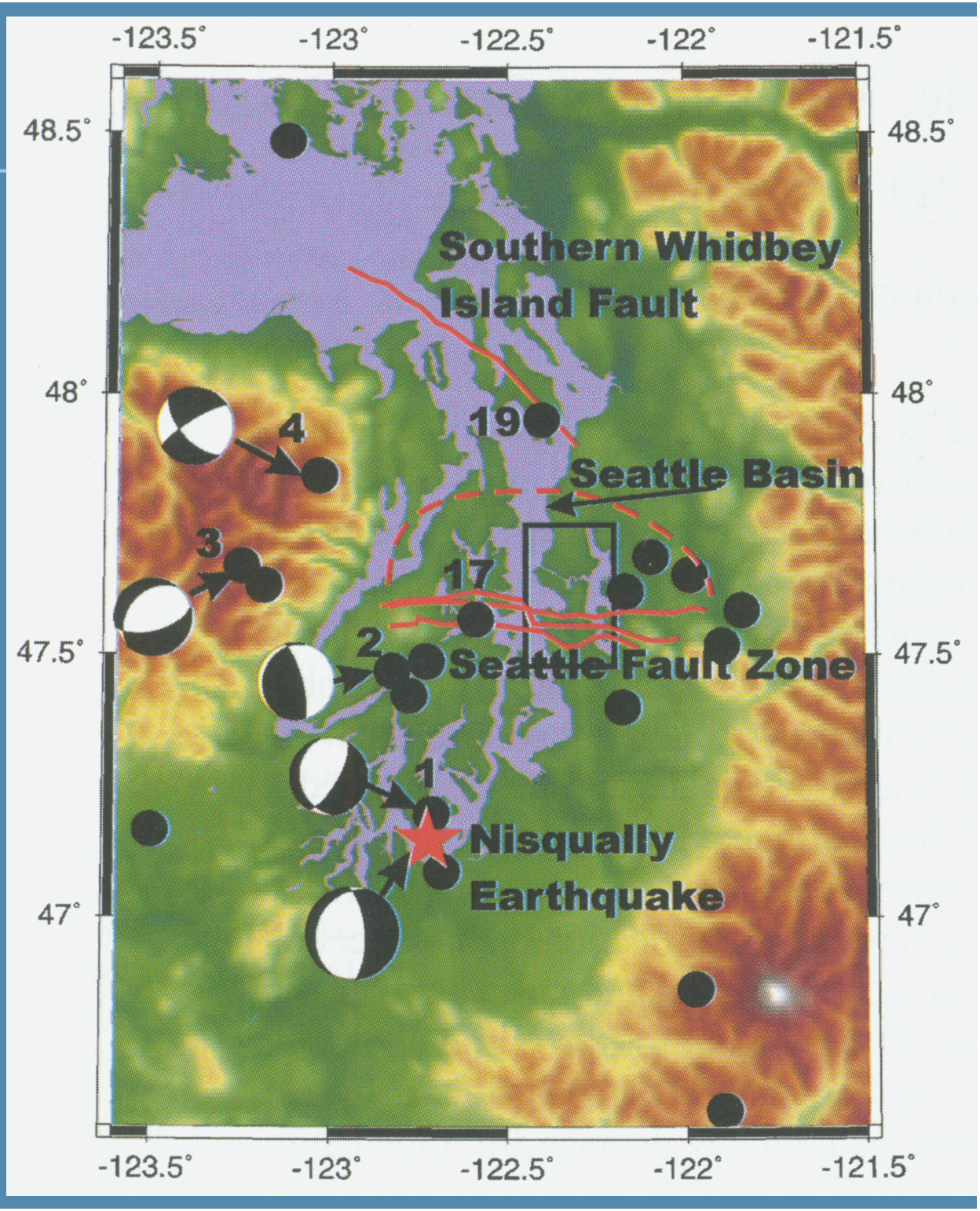
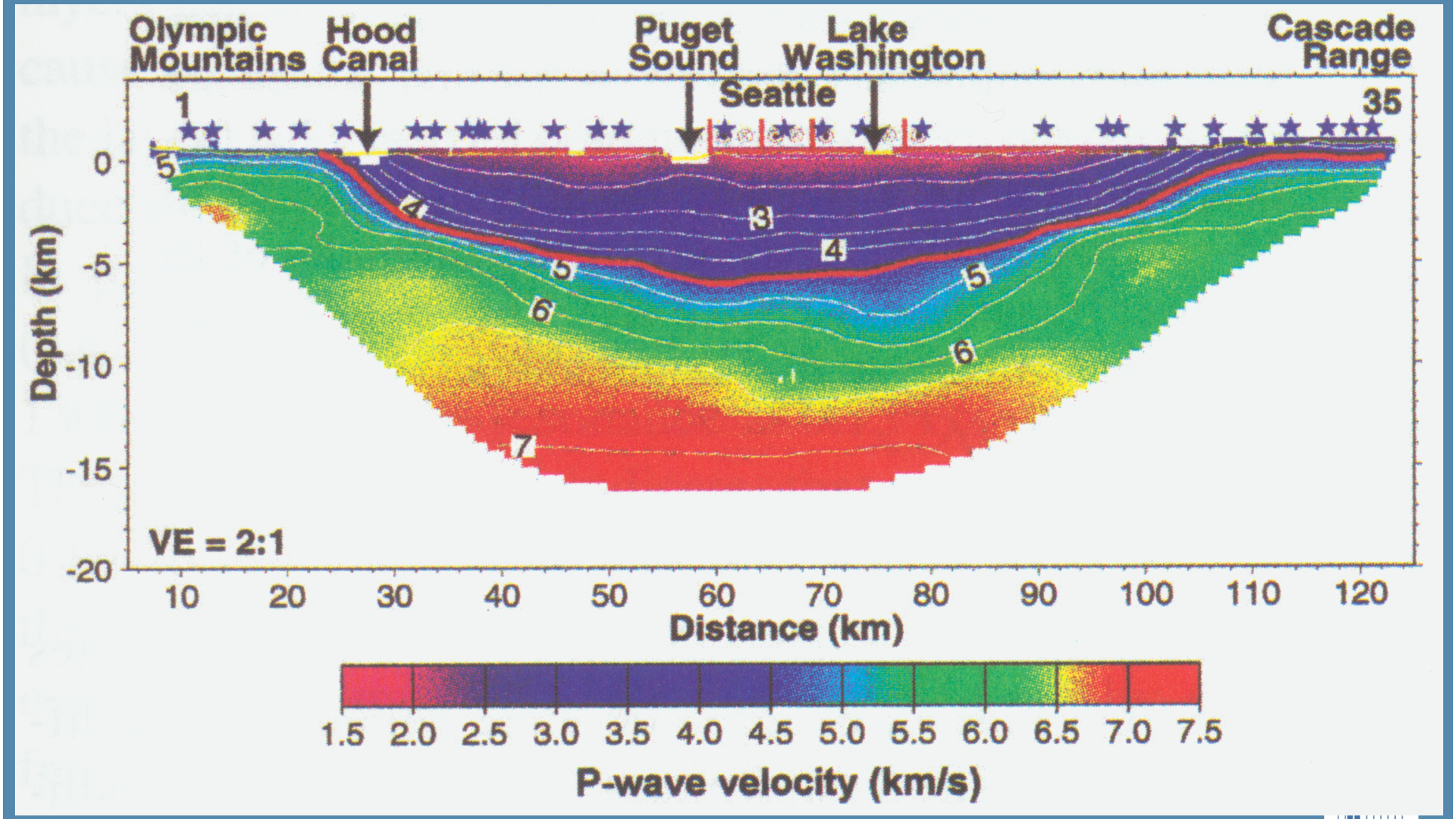
Seattle Basin



Ref.: Frankel et al. (2009)

Seattle Basin – EW Profile



Ref.: Pratt et al. (2003)

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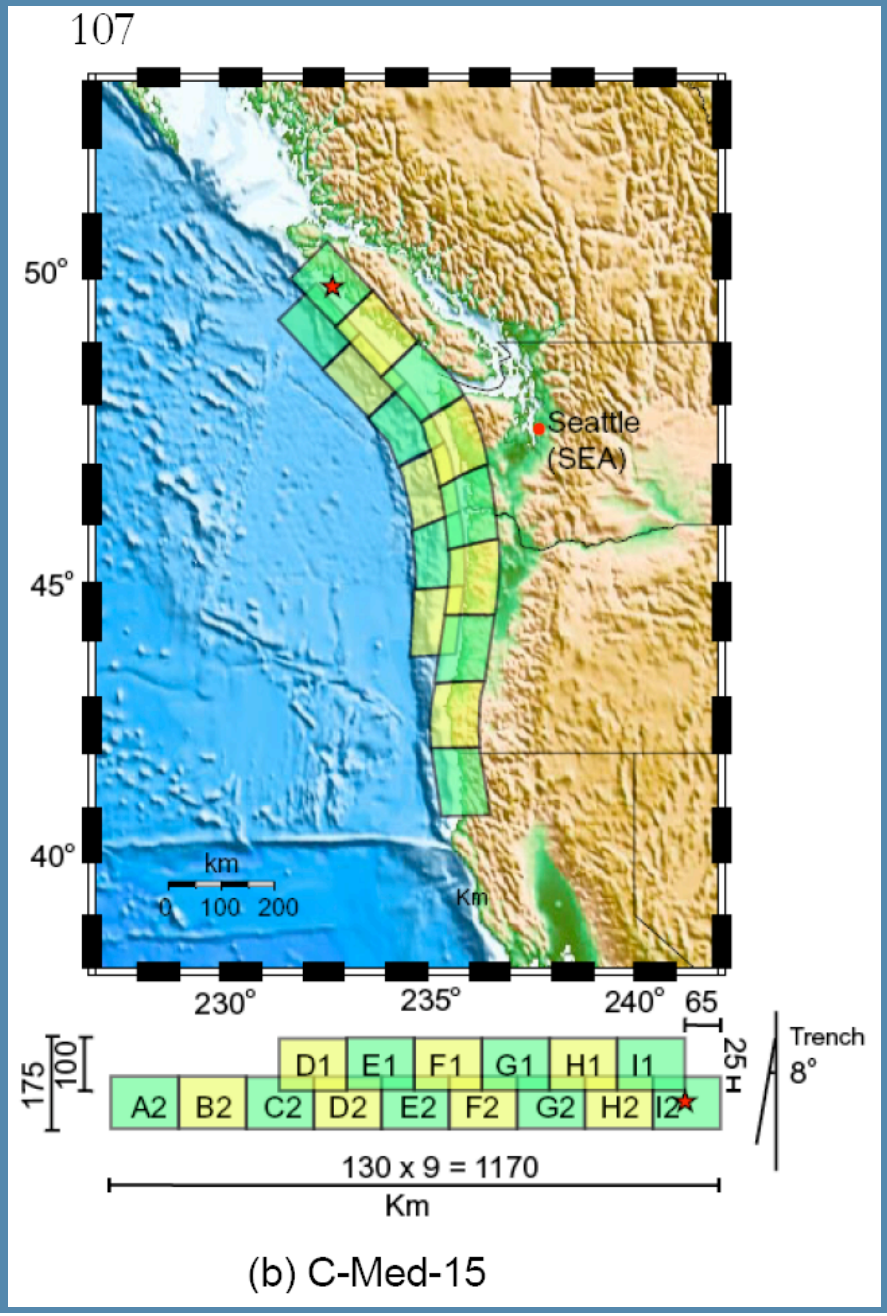
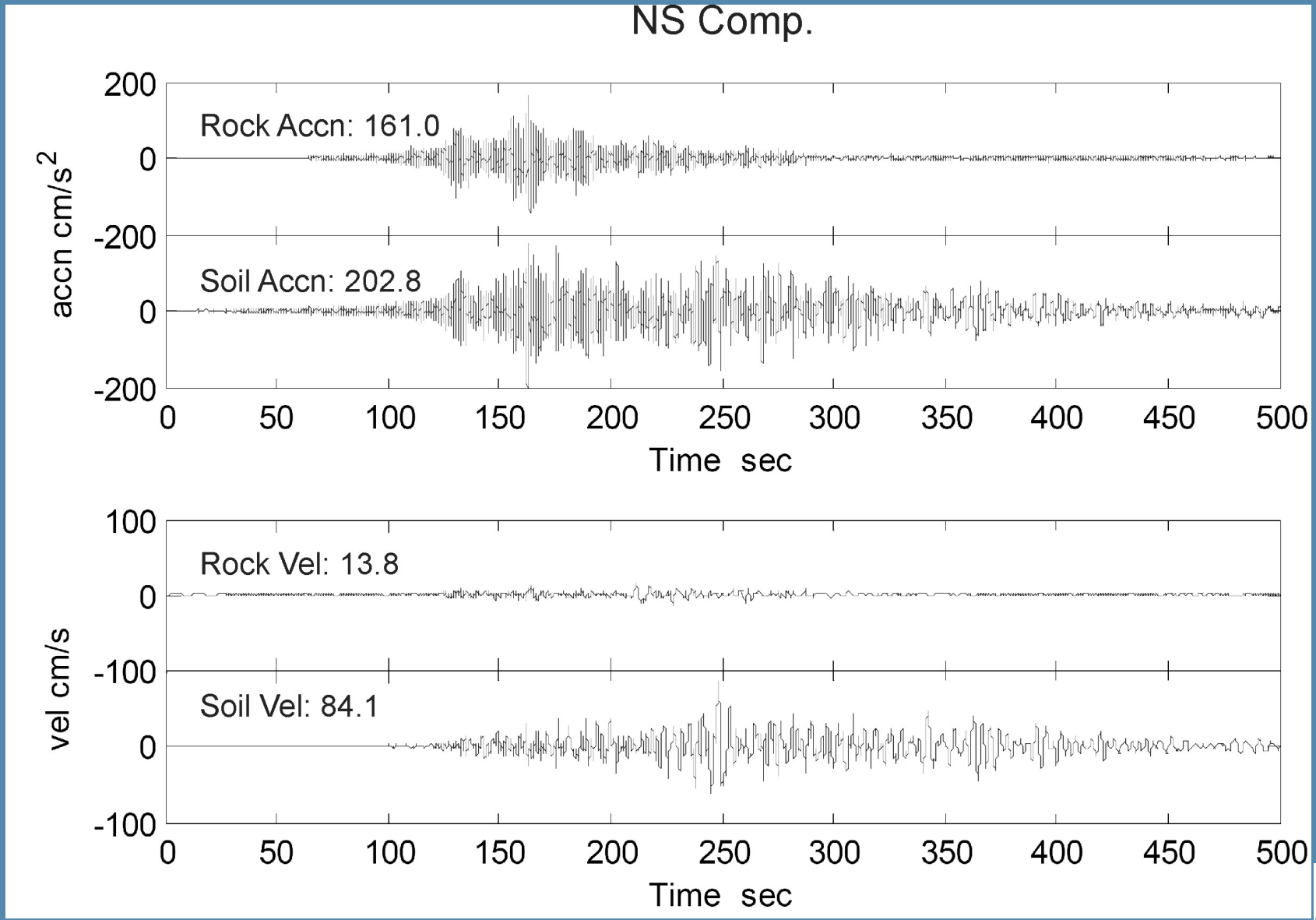
CSZ M 9.2 Scenario (Yang, 2009)

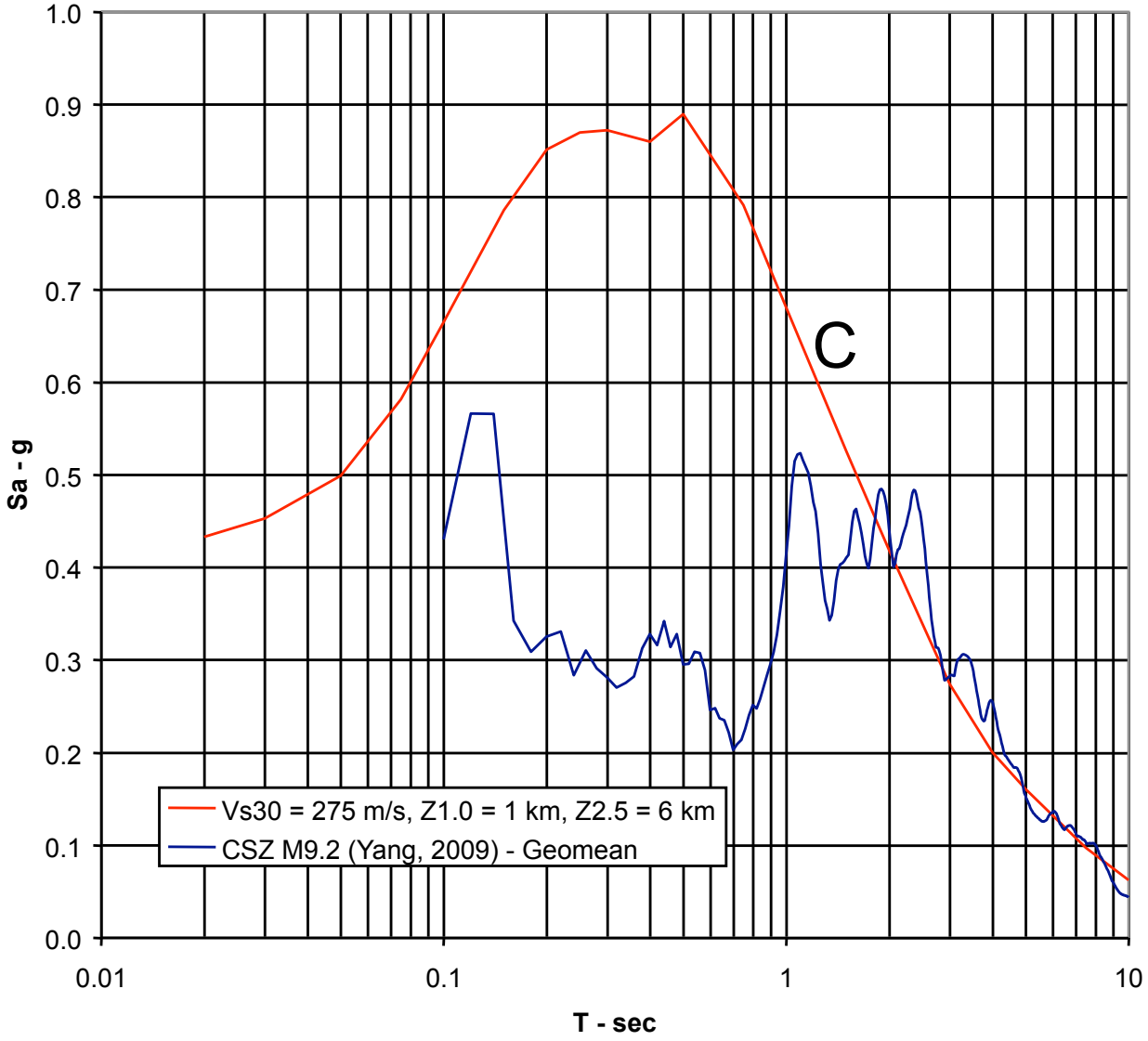


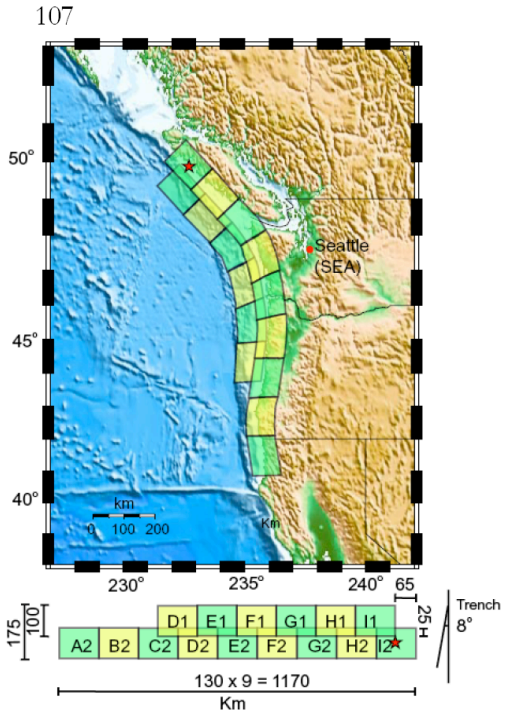
Simulated CSZ M 9.2 Rock & Soil (Basin) Ground Motions for Seattle



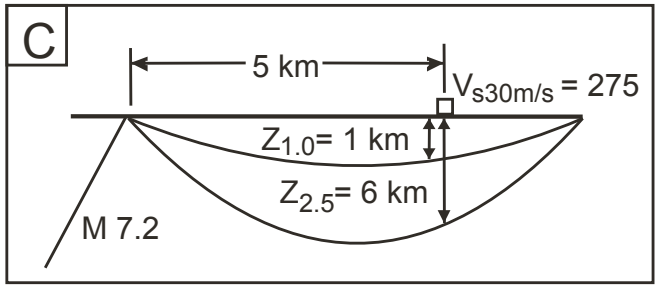
Ref.: Yang (2009)

Response Spectra for Seattle Fault & CSZ Scenarios





(b) C-Med-15



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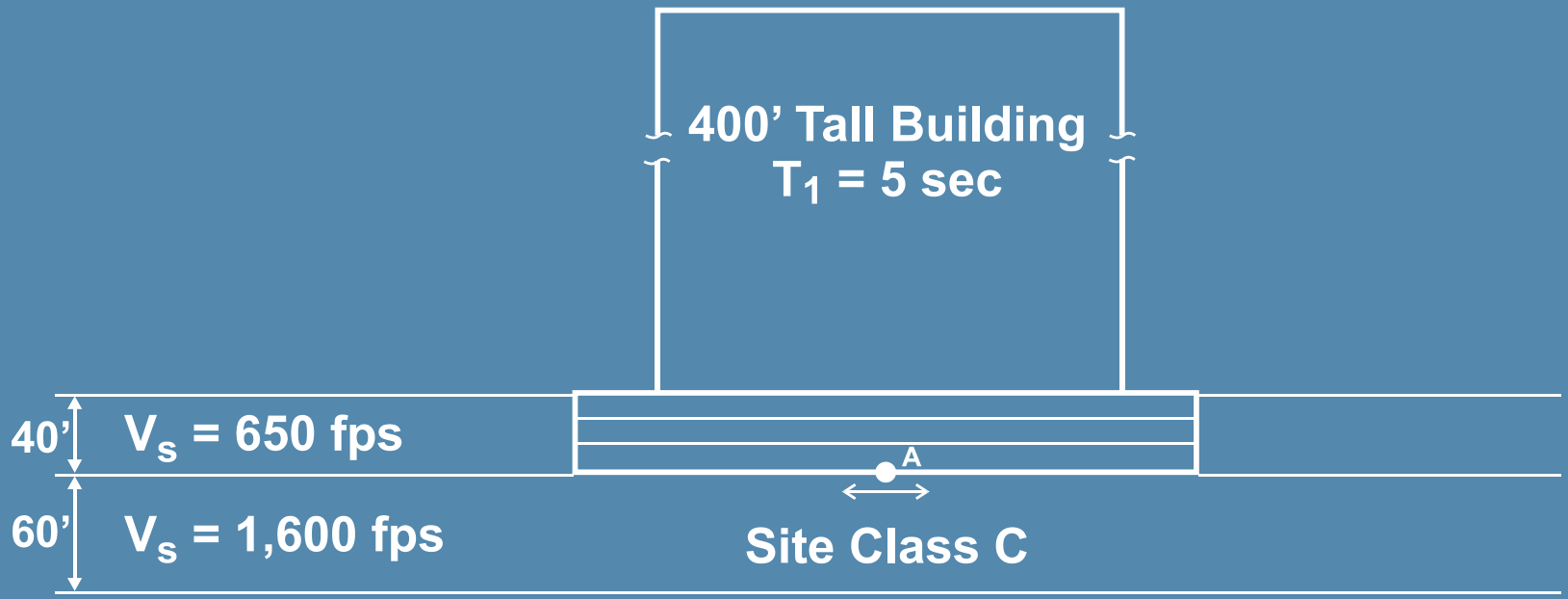
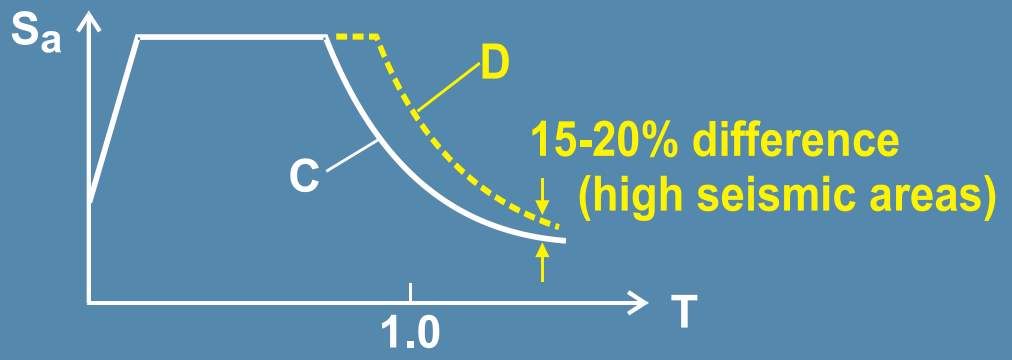
Building Input Motion

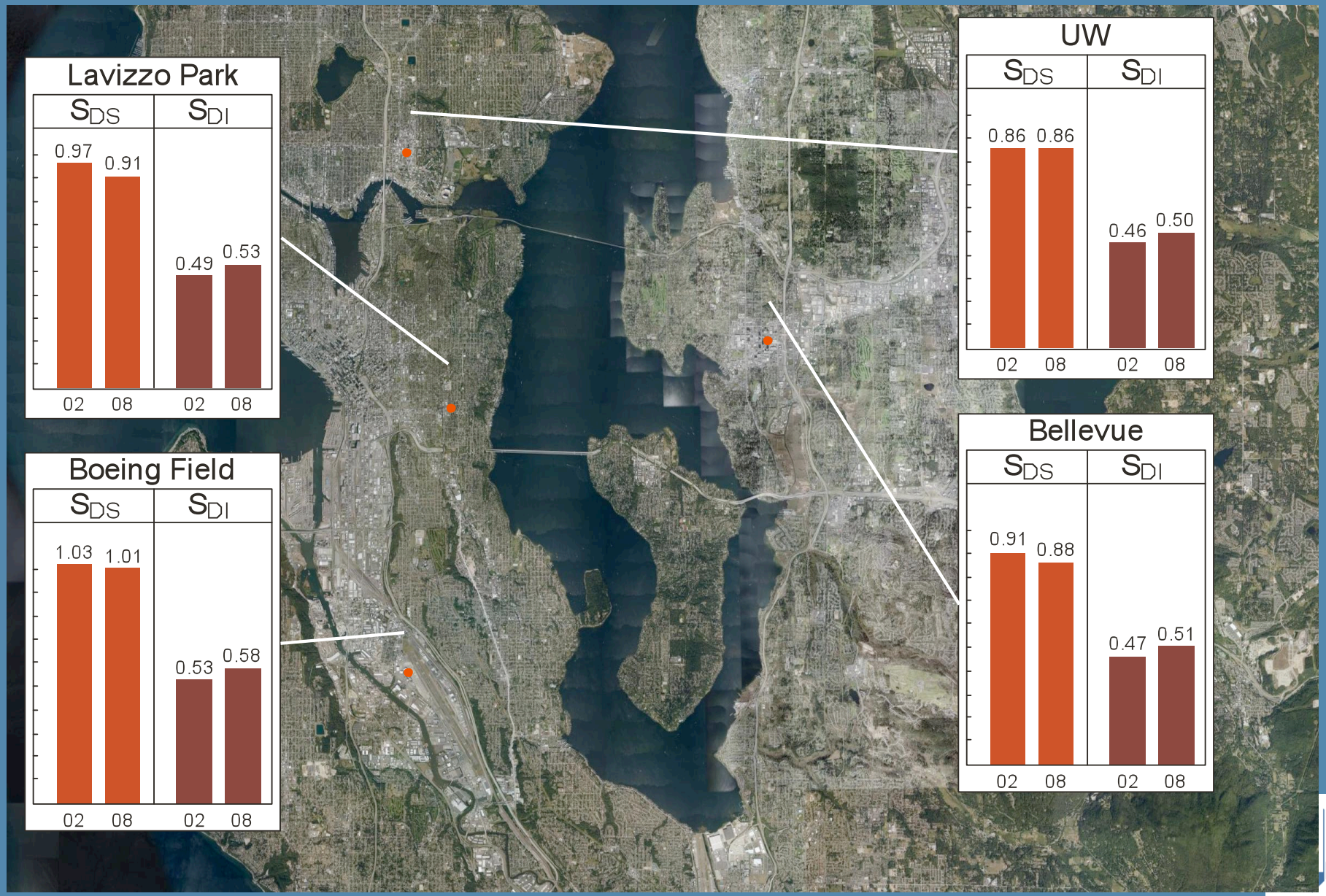


$\bar{V}_s^{30}$ = 1,010 fps

Site Class D



2002 & 2008 USGS S_{DS} & S_{DI}, Site Class D, Seattle



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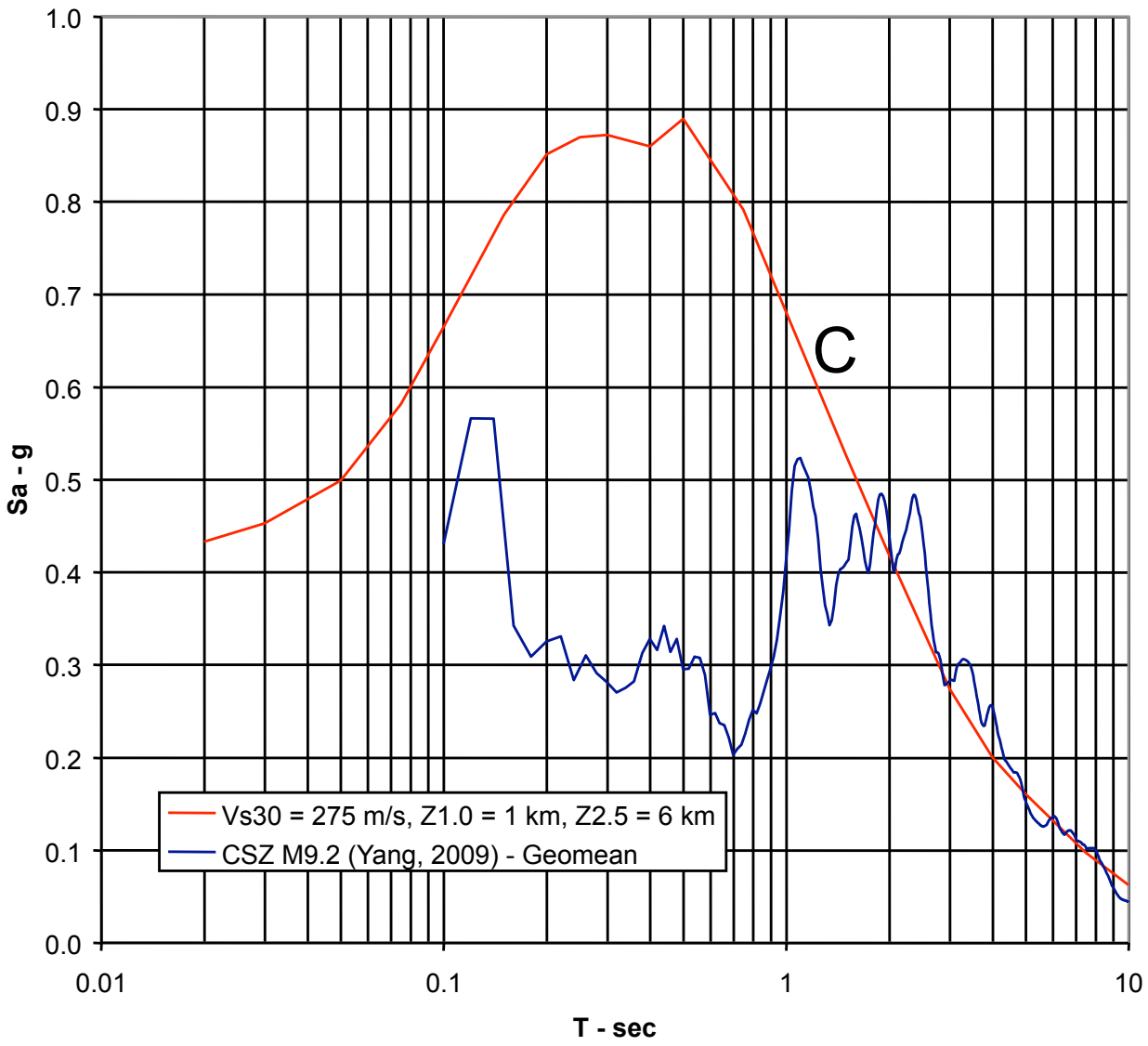
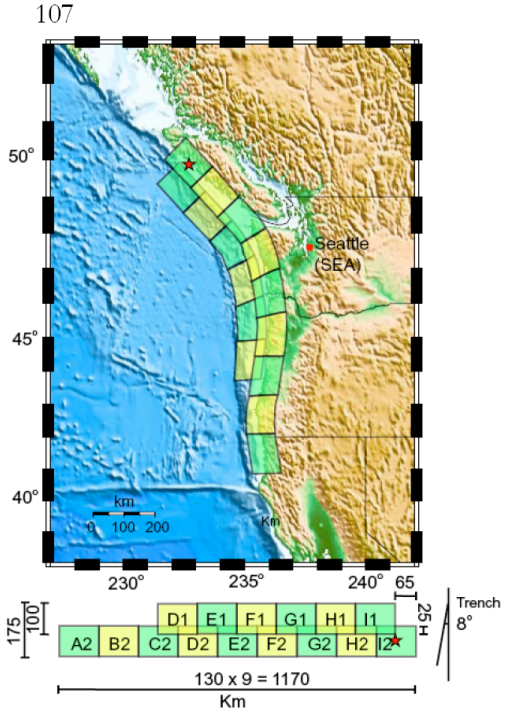
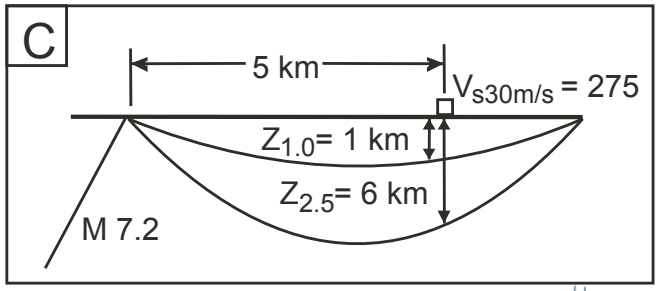
Response Spectra for Seattle Fault & CSZ Scenarios





(b) C-Med-15



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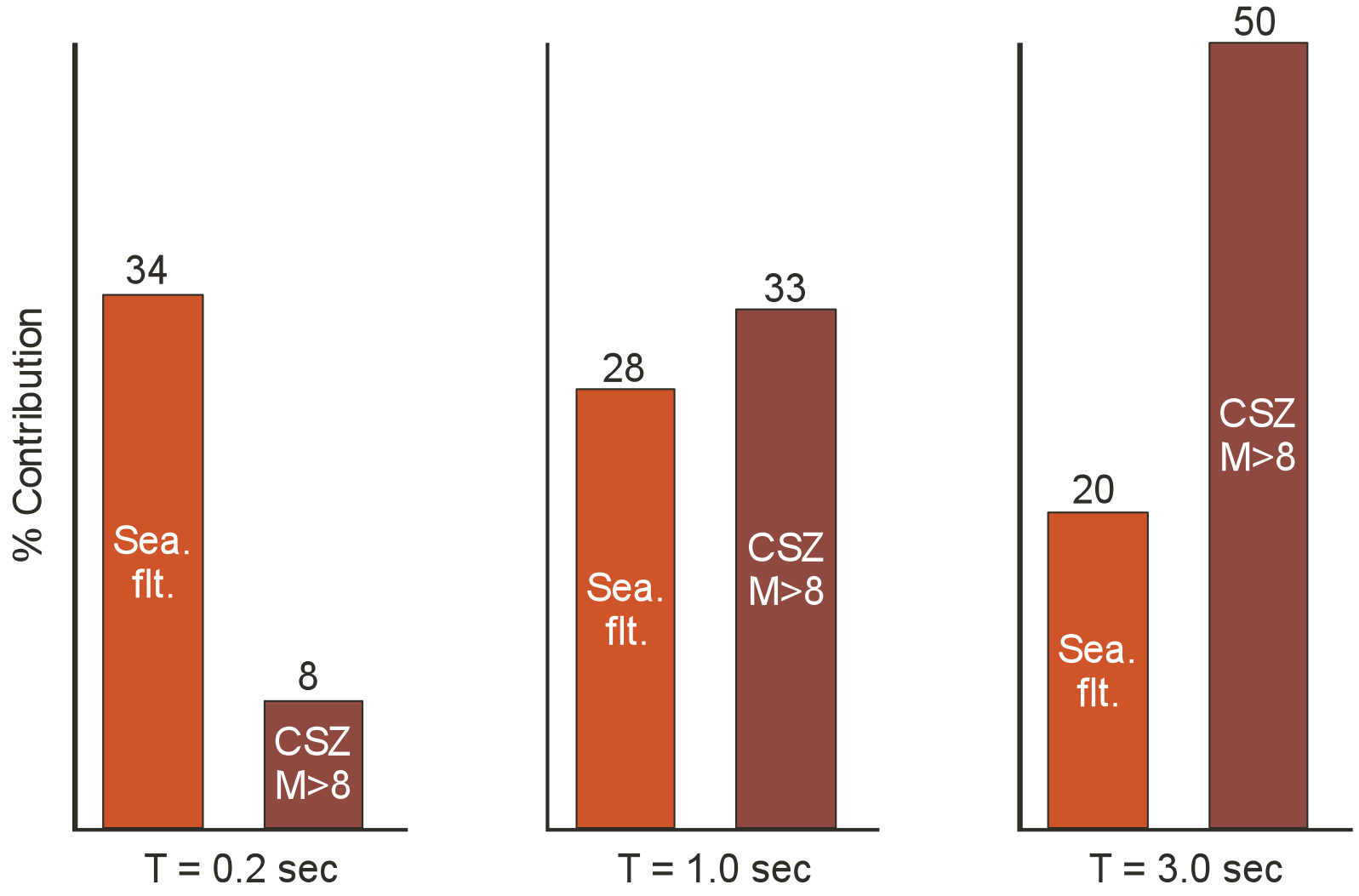
Accelerogram Selection and Scaling

- Identify controlling earthquakes
- Select representative accelerograms
- Modify accelerograms to match target Sa

Contribution to 2475-yr Ground Motion Hazard

Lavizzo Park, Seattle (47.6° N, 122.3° W)
2008 USGS PSHA



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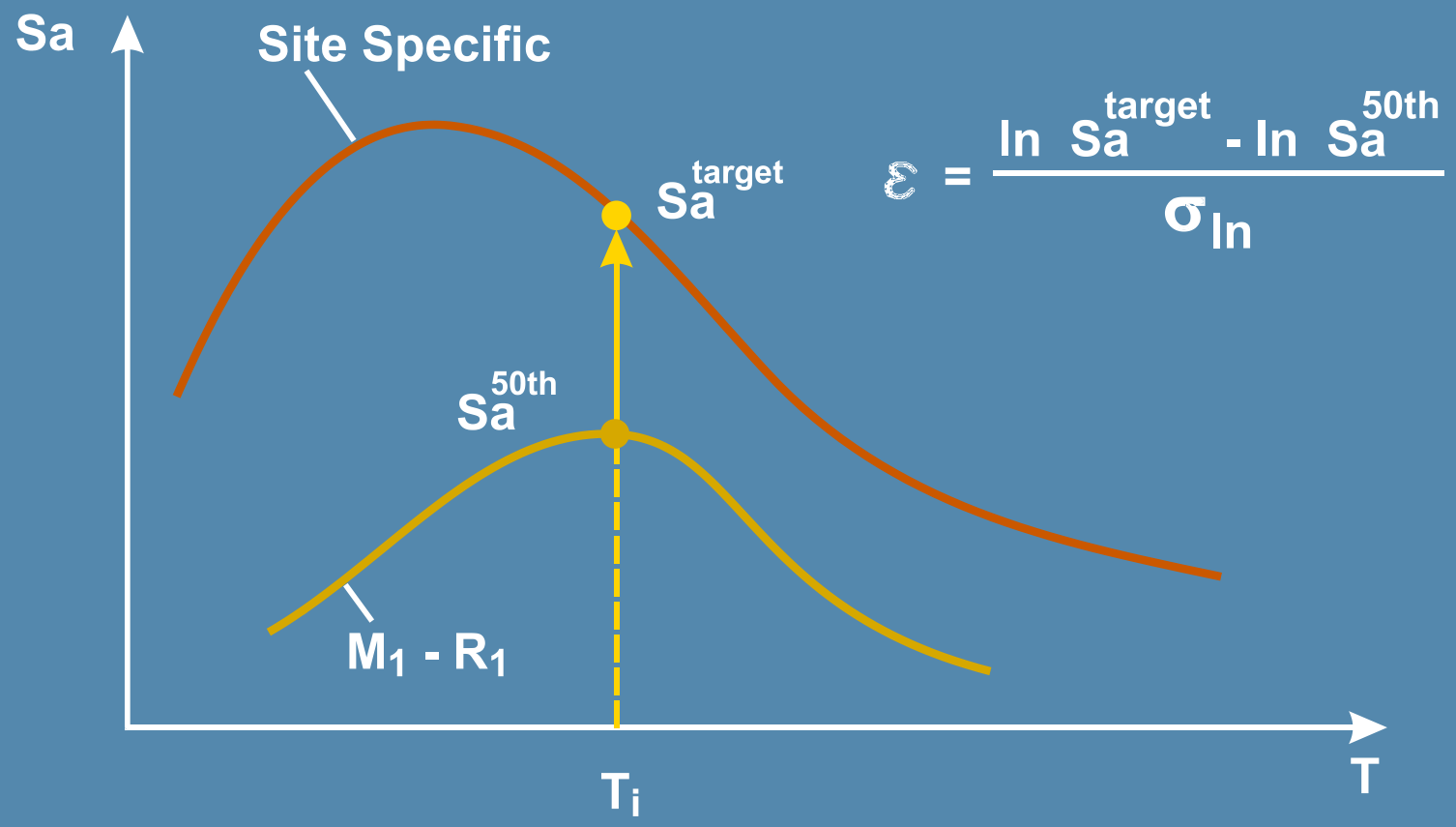
CMS – ε Parameter



M_1 , R_1 , ε ⟶ select accelerograms

Baker and Cornell (WUS shallow crustal EQ's)

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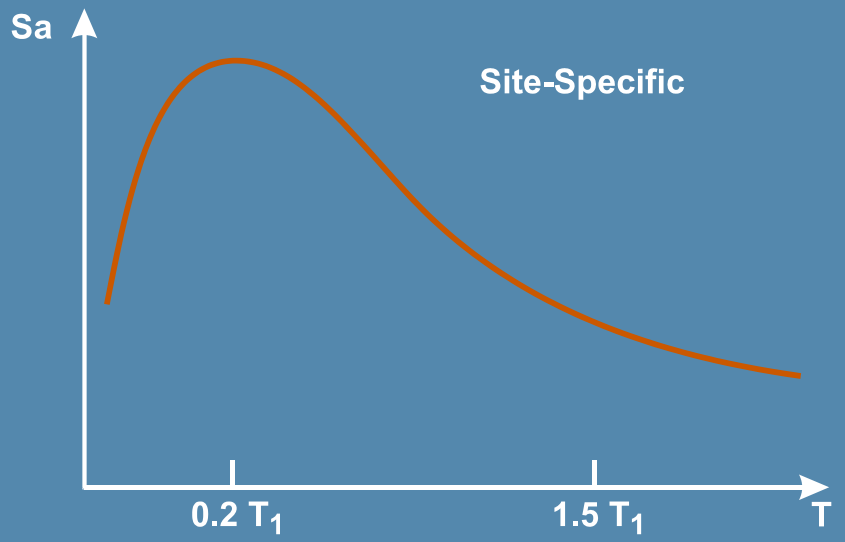
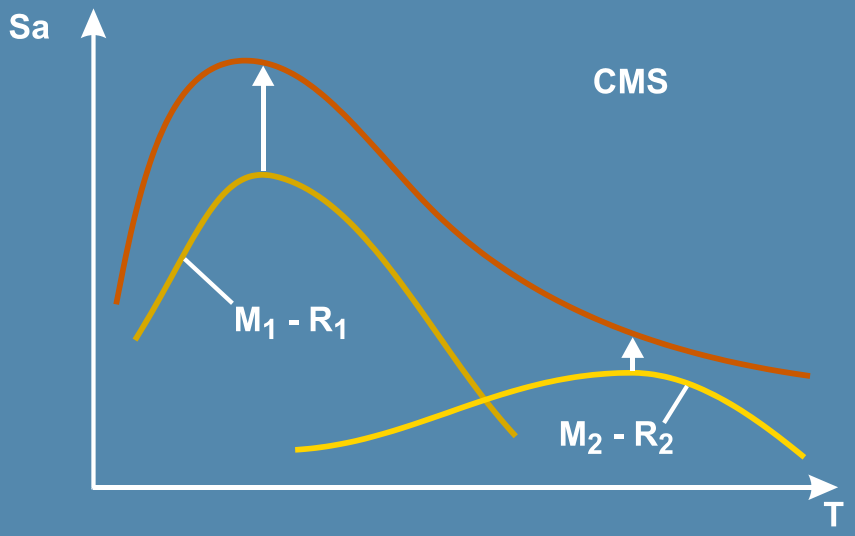
Number of Accelerograms - N

- 7 (minimum)
- Maximum number
  - SE and GE decision

N depends on:

- # controlling earthquakes
- Median/mean or maximum structural response
- Target Sa





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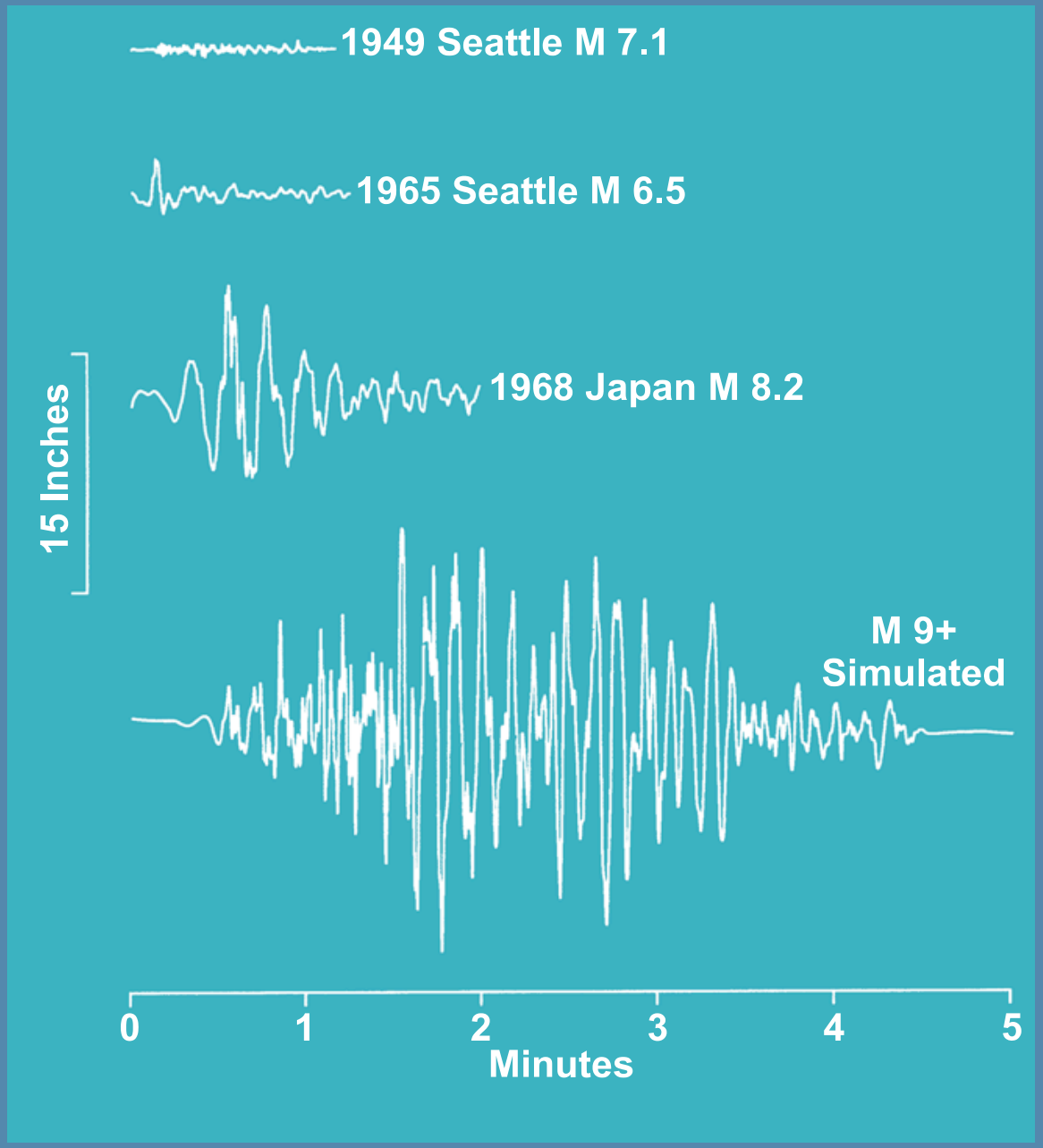
M ≥ ~ 8, Long Duration Motion

- San Andreas fault M ~ 8
- Cascadia and S. Alaska subduction zone M 9+

Past and Future Seattle Ground Motions



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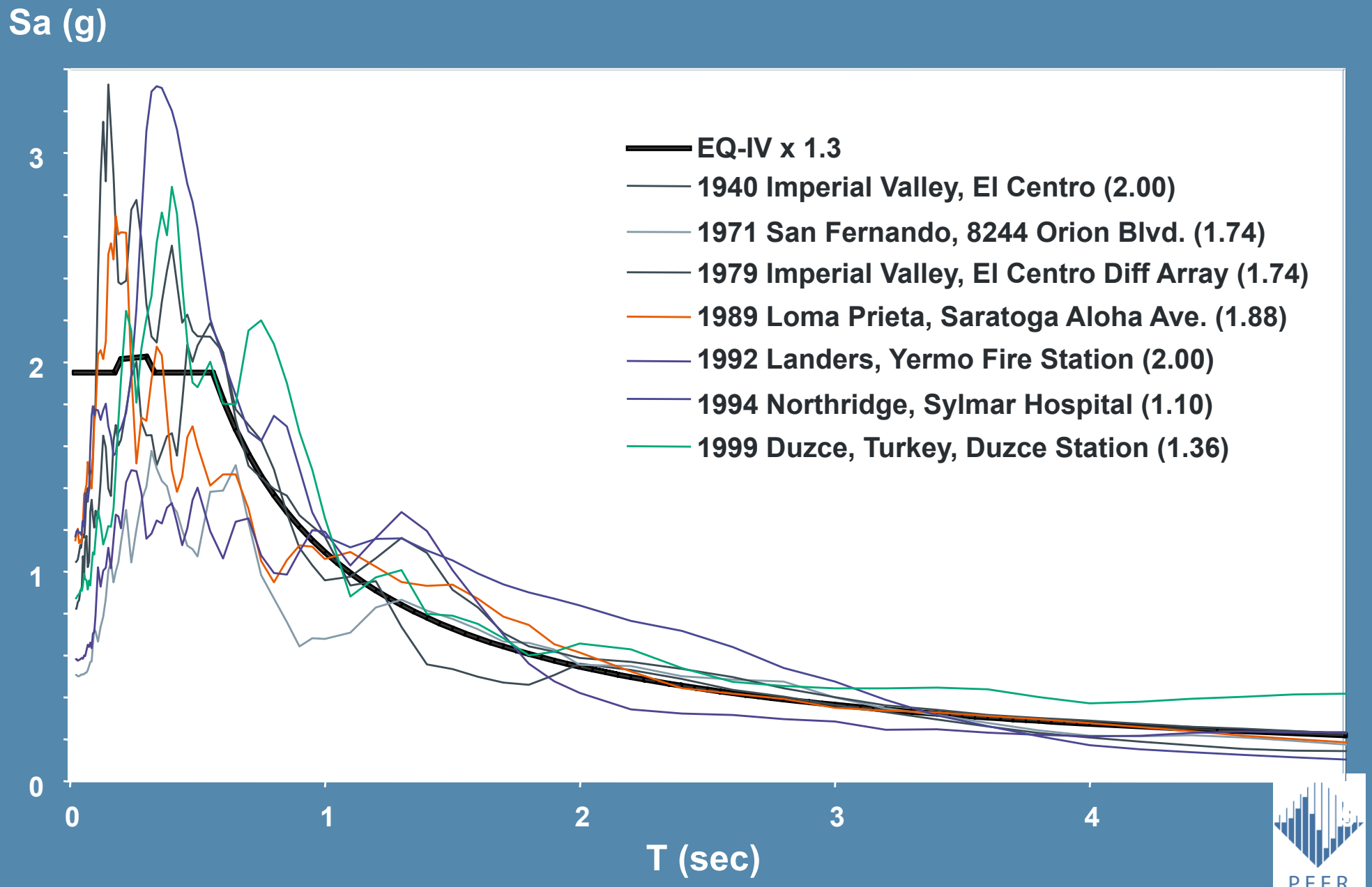
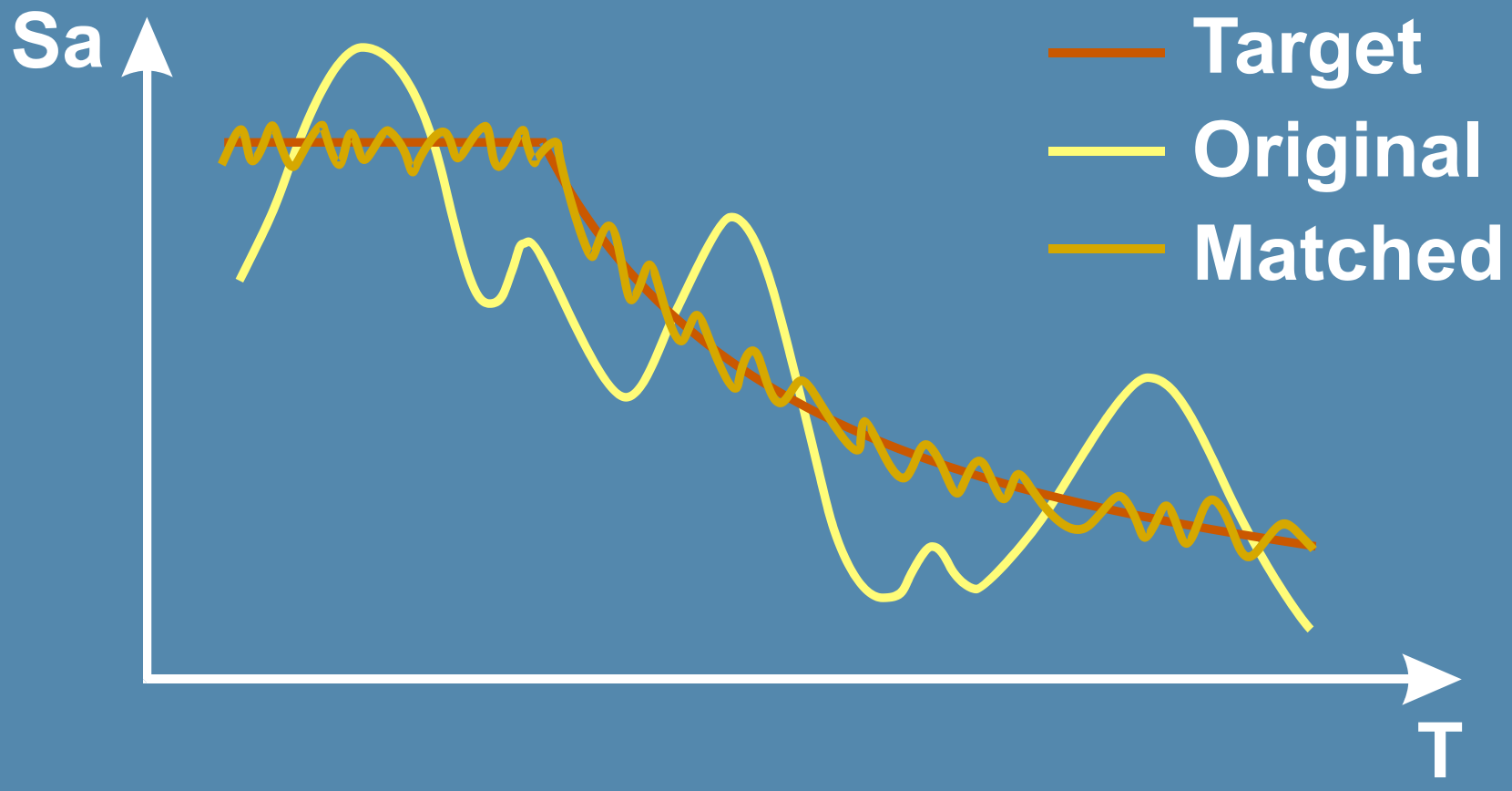
Accelerogram Modification

- Constant Scaling
- Spectral Matching

Constant Scaling Method



Spectral Matching



Accelerogram Selection and Scaling Recommendations

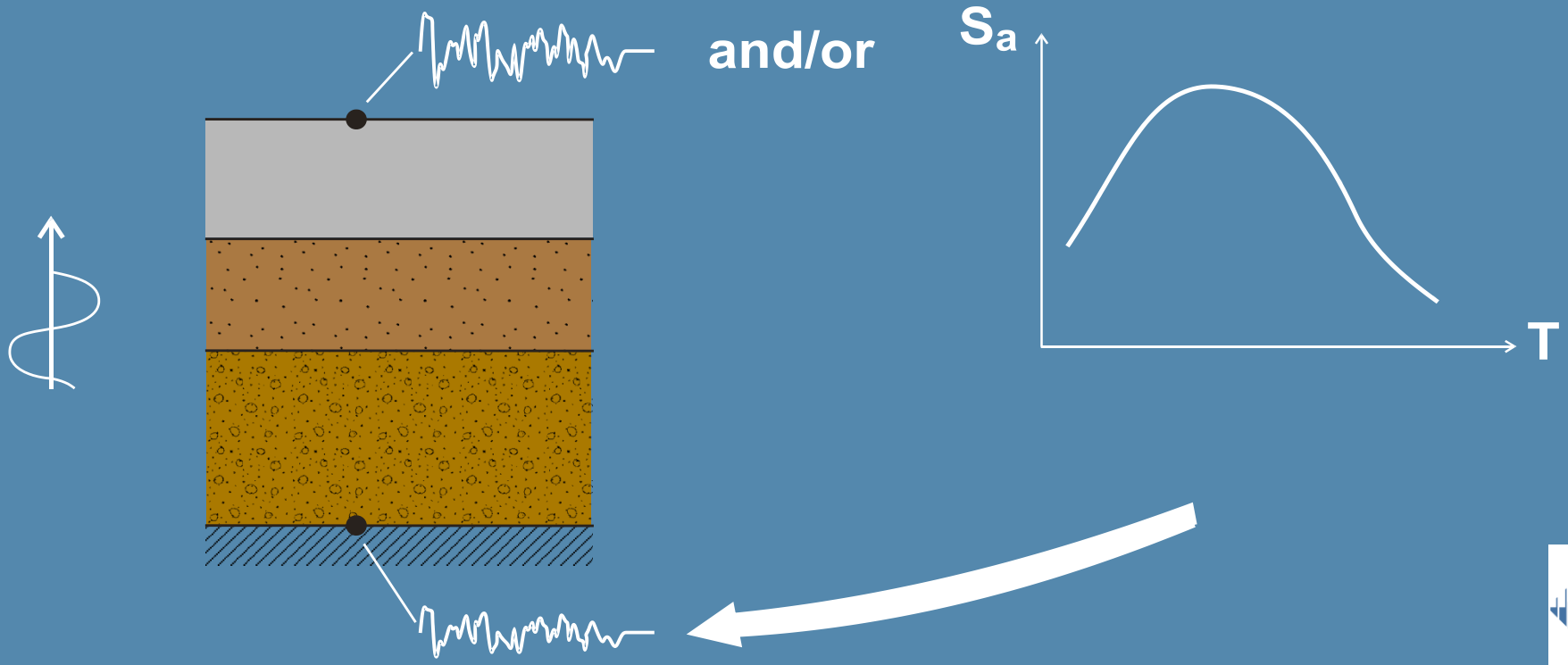
- N $\geq$ 7 (max N limited by $ and time)
- Use M-R deaggregations → controlling EQs
- CMS – use for multiple M-R → different Sa shapes
- Scaling (constant or spectral matching) SE's decision
- Simulated Accelerograms (M $\geq$ ~ 8)
  + - long duration and basin effects
  - - - very limited no. qualified providers
- Peer Review – Extremely Important

Site Response Analysis

ASCE 7-05; Ch.21
Site-Specific Ground Motion

SRA

PSHA/DSHA



Recommendations

- Don't do SRA for stiff soil sites; account for local geology through GMPE (i.e., select stiff soil GMPE or appropriate site terms in GMPE)

Possible Exceptions

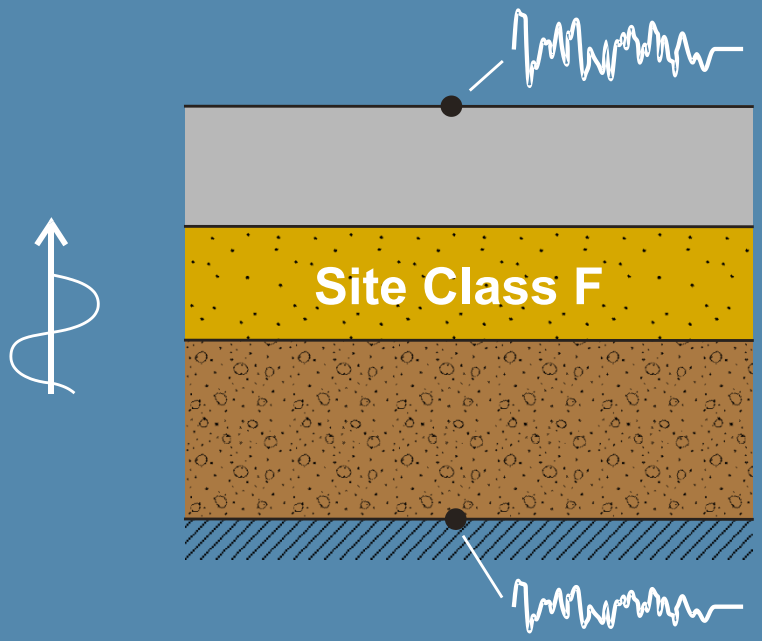
Required in ASCE 7-05

$V_{s,rock} >> V_{s,soil}$

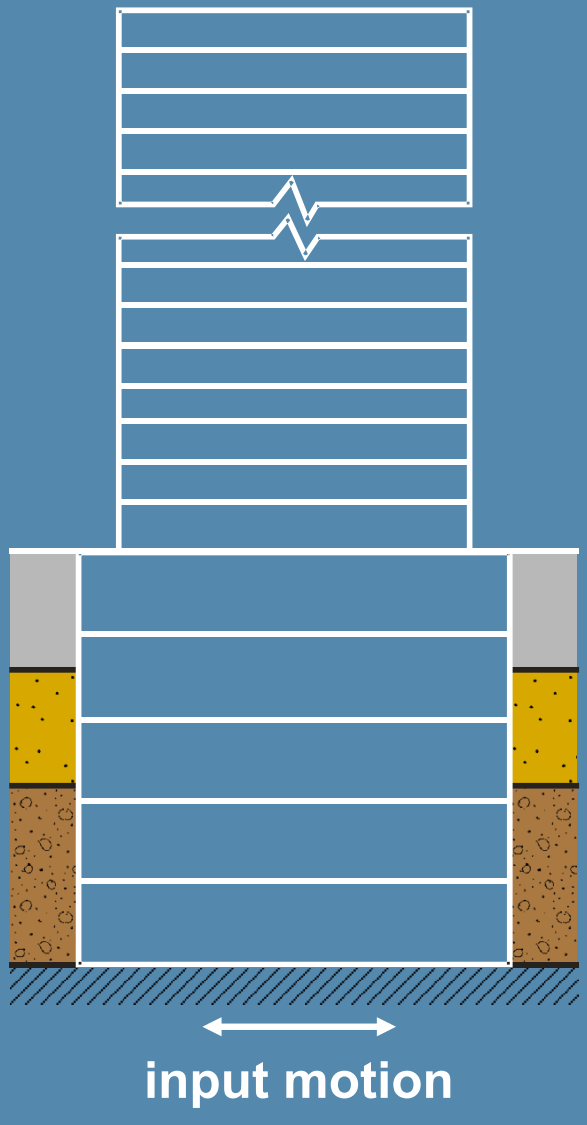
SRA (cont.)

Site Response Analysis

(may not be necessary)



Tall Embedded Building



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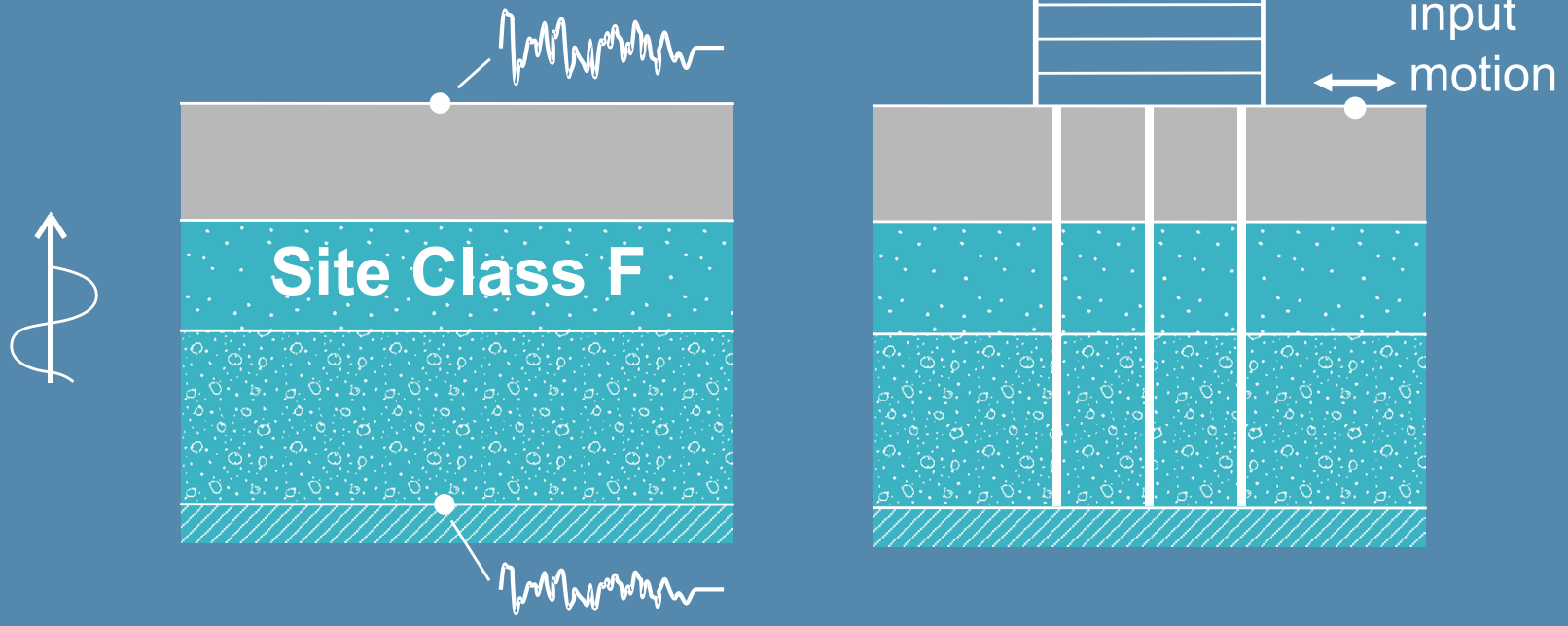
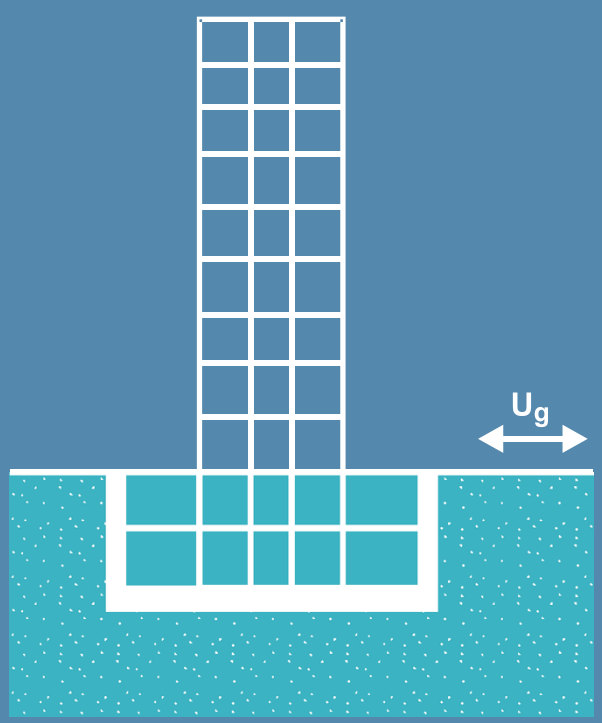
SRA (cont.)

Tall Building on Piles

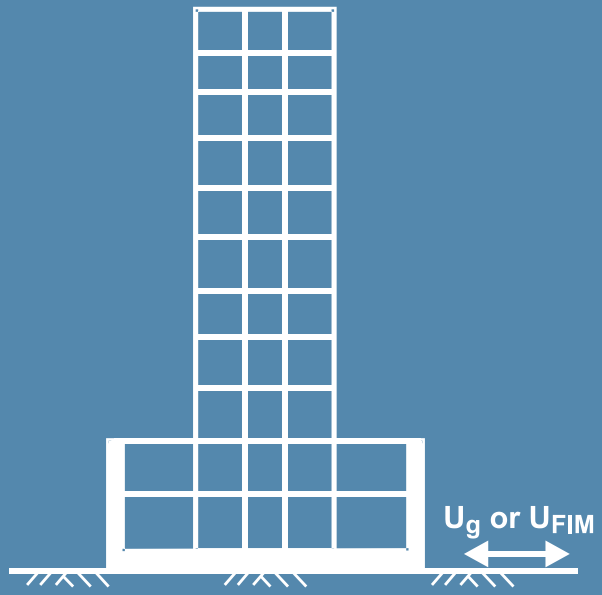
Site Response Analysis (necessary)



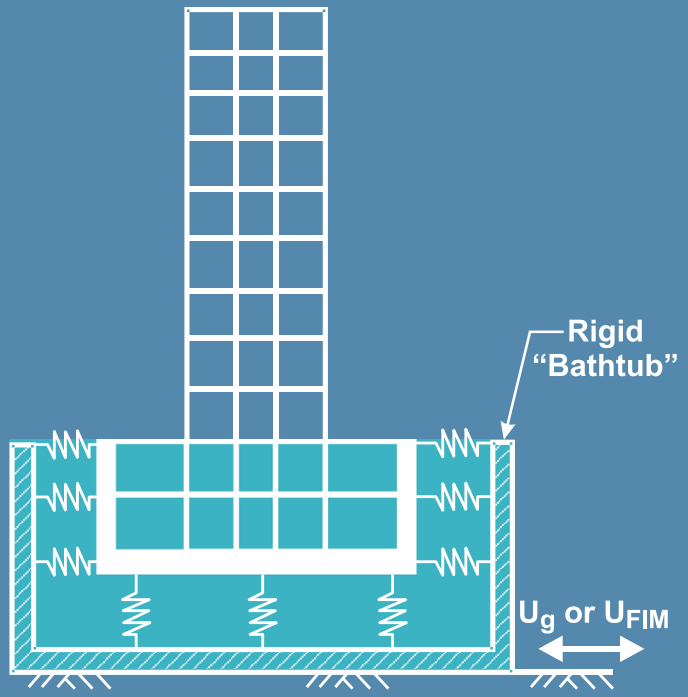
Soil-Foundation-Structure Interaction (SFSI)



(a) Complete System



(b) Model for service-level earthquake



(c) Model for maximum-considered earthquake

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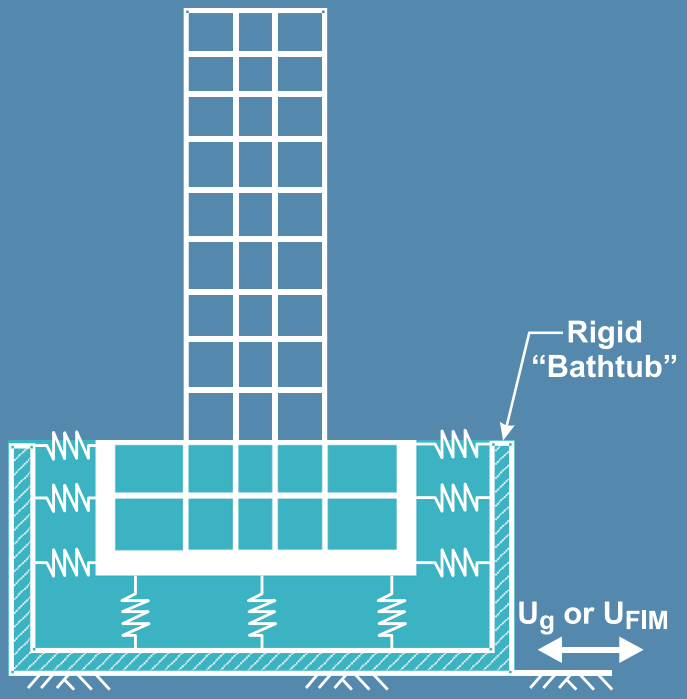
SFSI for MCE



(c) Model for maximum-considered earthquake

- Linear springs and dashpots model soil -foundation interaction
- Input motion same at all points along foundation
- See FEMA 356 and 440, ASCE 41-06, ATC 40, and other references for details

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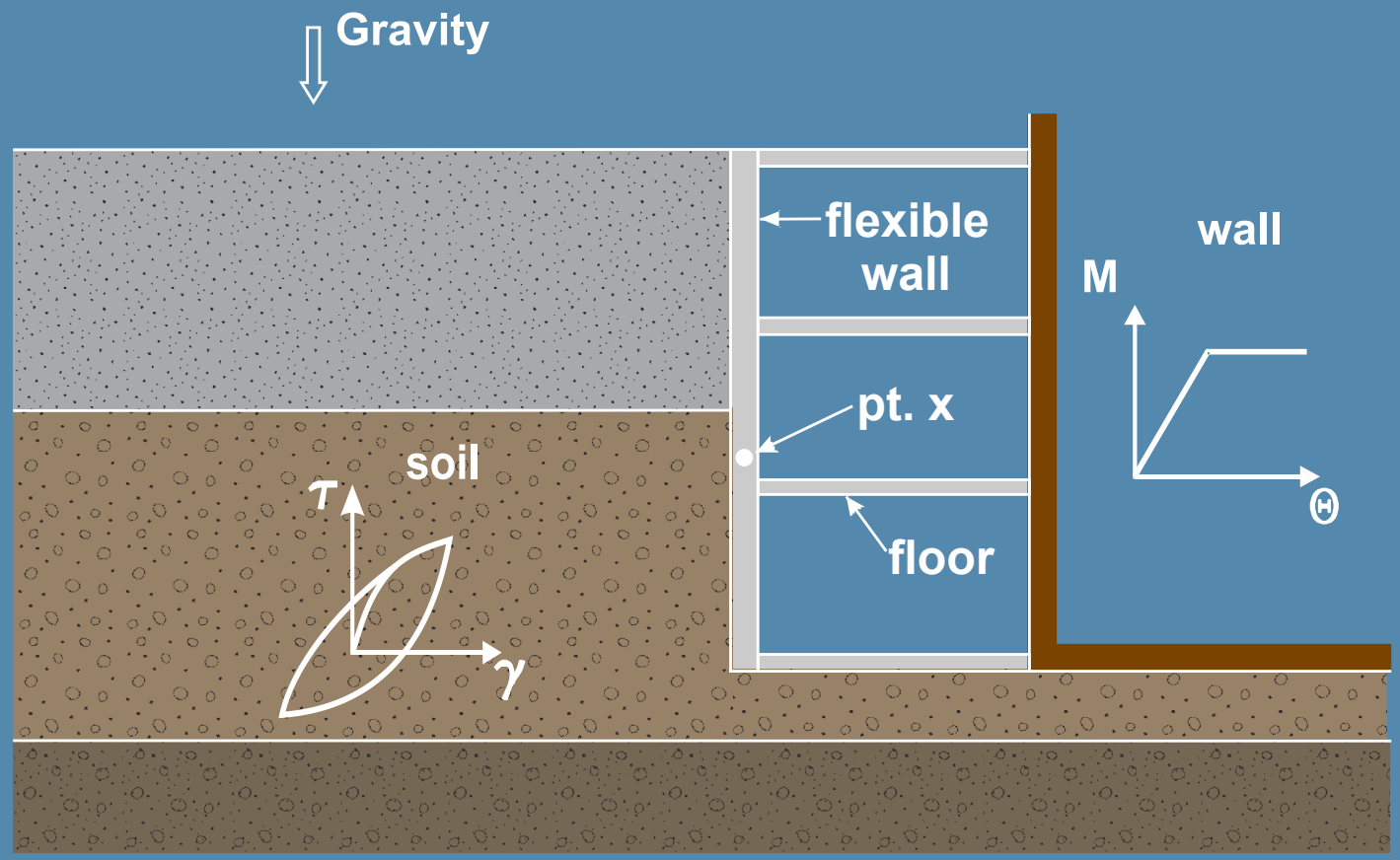
Basement Wall – Soil Interaction



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