Discussion on
Seismic Site Response Characteristics in Korea

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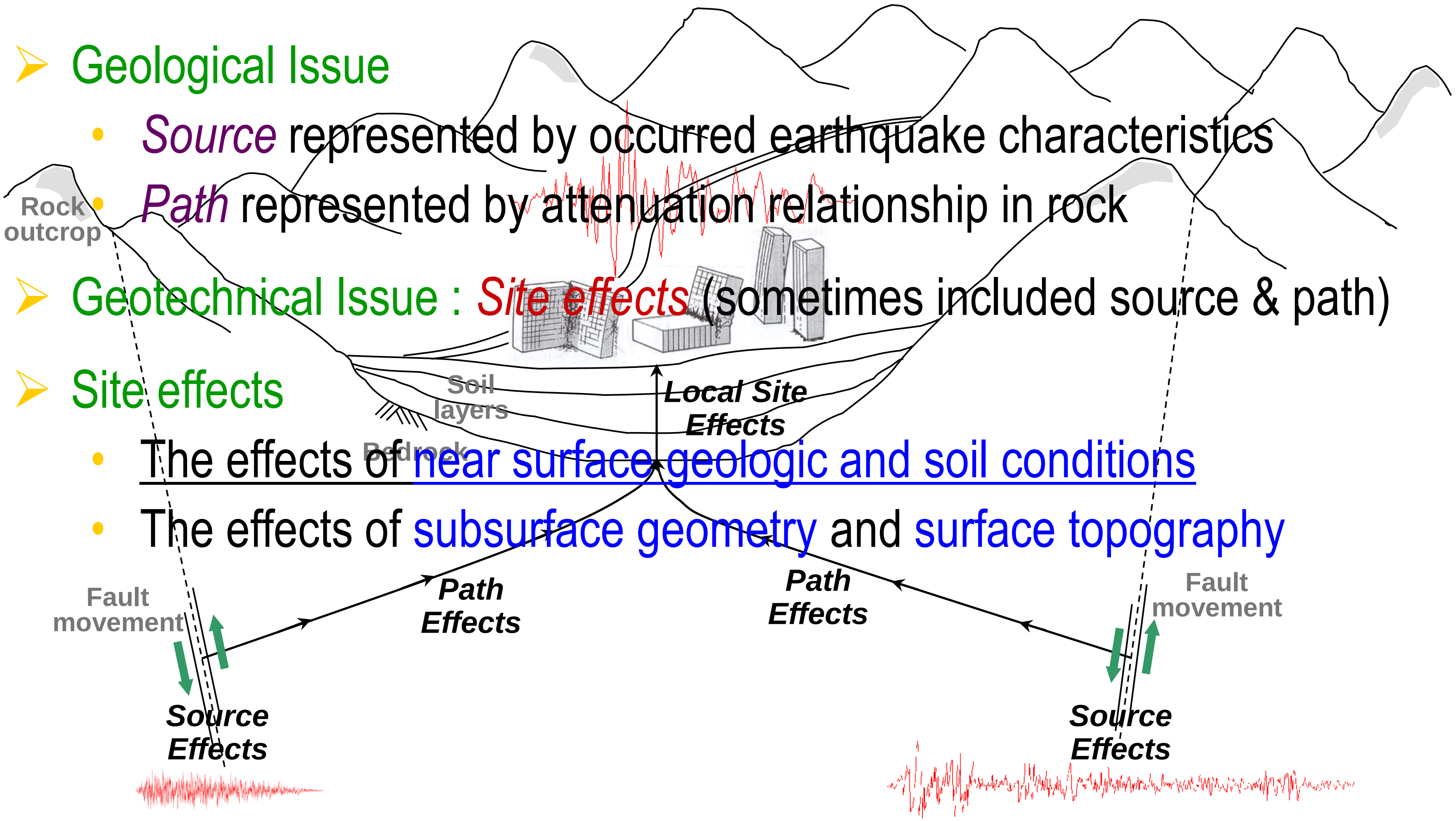
Contents

Site Effects and Site Classification

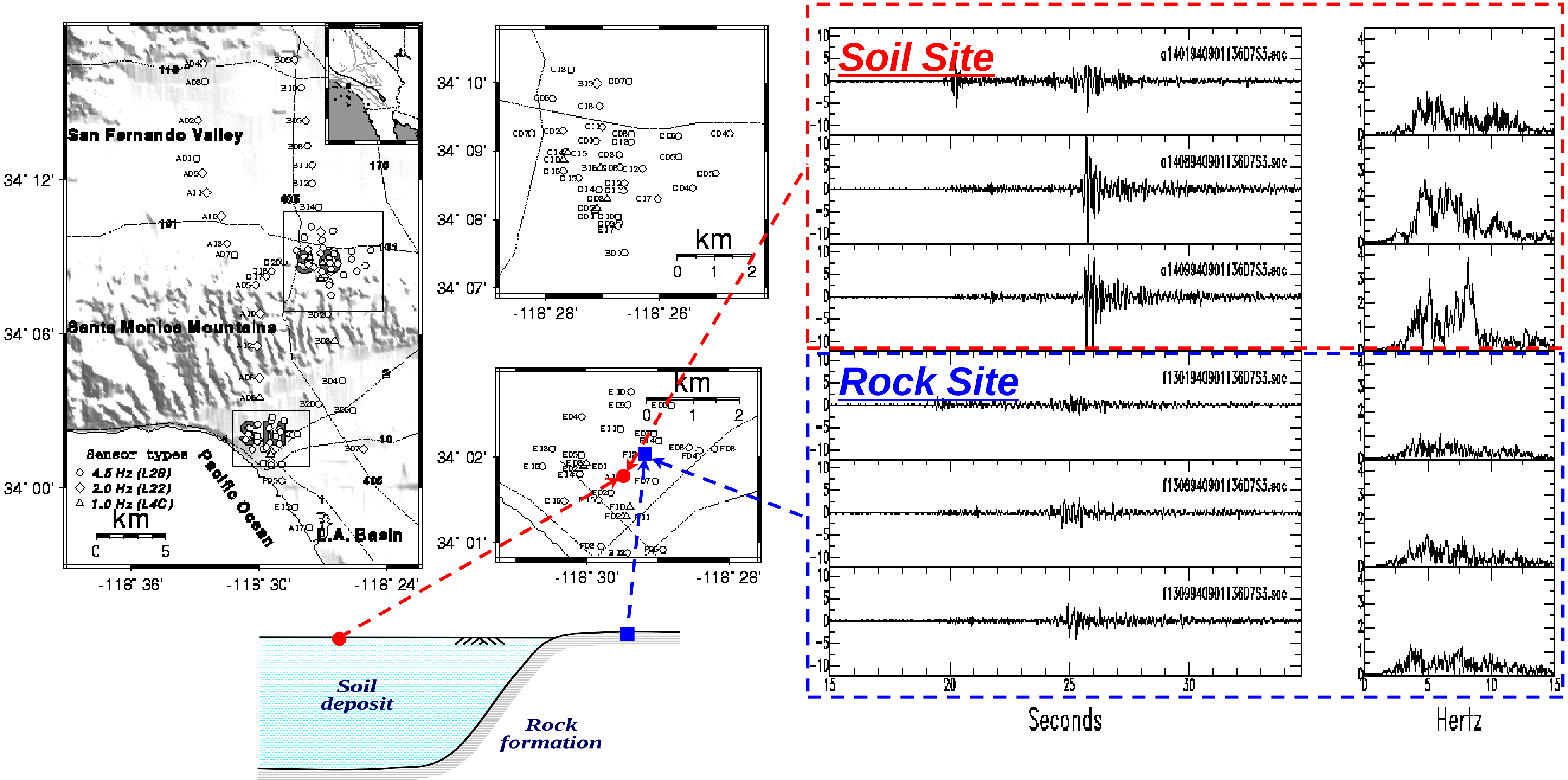
Complexity of Earthquake Ground Motion

- Main Influence Effects
  - Source effects / Path effects / Site effects
- Geological Issue
  - *Source* represented by occurred earthquake characteristics
  - *Path* represented by attenuation relationship in rock
- Geotechnical Issue : *Site effects* (sometimes included source & path)
- Site effects
  - The effects of near surface geologic and soil conditions
  - The effects of subsurface geometry and surface topography



Observational Evidence of Site Effects

- 1994 Northridge Earthquake(Santa Monica; Gao et al., 1996)
  - The amplitudes at soil site are about 4 and 7 times stronger than those at rock site located apart from 650 m



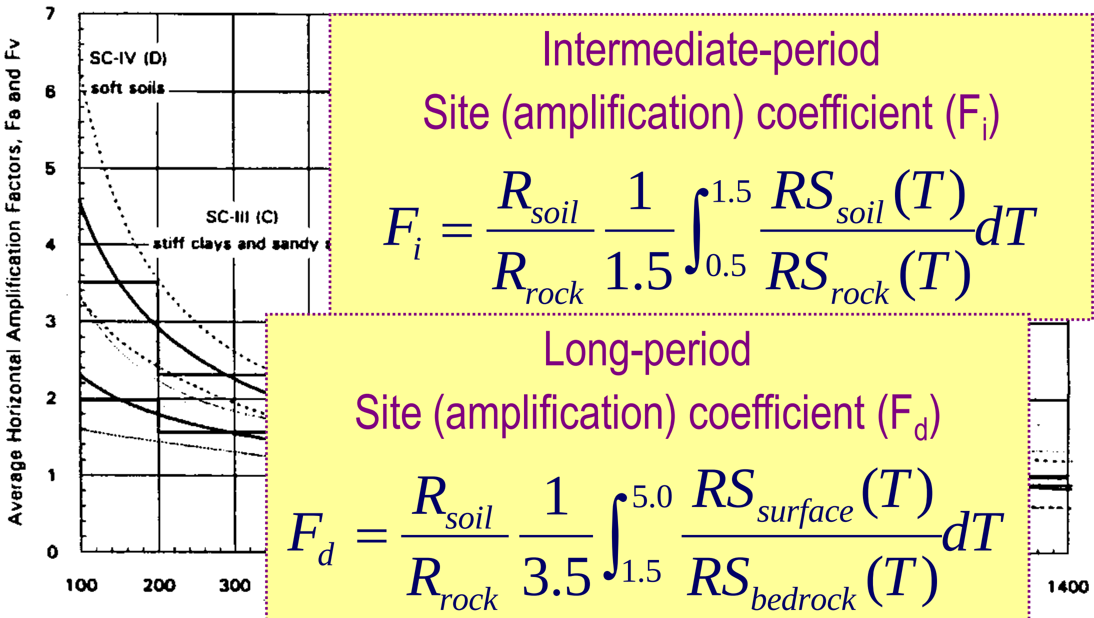
Determination of Site Coefficients, F_a and F_v Based on 1989 Loma Prieta and Other Earthquakes

Short-period
Site (amplification) coefficient (F_a)

$$F_a = \frac{R_{soil}}{R_{rock}} \frac{1}{0.4} \int_{0.1}^{0.5} \frac{RS_{soil}(T)}{RS_{rock}(T)} dT$$

Mid-period
Site (amplification) coefficient (F_v)

$$F_v = \frac{R_{soil}}{R_{rock}} \frac{1}{1.6} \int_{0.4}^{2.0} \frac{RS_{soil}(T)}{RS_{rock}(T)} dT$$



Intermediate-period
Site (amplification) coefficient (F_i)

$$F_i = \frac{R_{soil}}{R_{rock}} \frac{1}{1.5} \int_{0.5}^{1.5} \frac{RS_{soil}(T)}{RS_{rock}(T)} dT$$

Long-period
Site (amplification) coefficient (F_d)

$$F_d = \frac{R_{soil}}{R_{rock}} \frac{1}{3.5} \int_{1.5}^{5.0} \frac{RS_{surface}(T)}{RS_{bedrock}(T)} dT$$

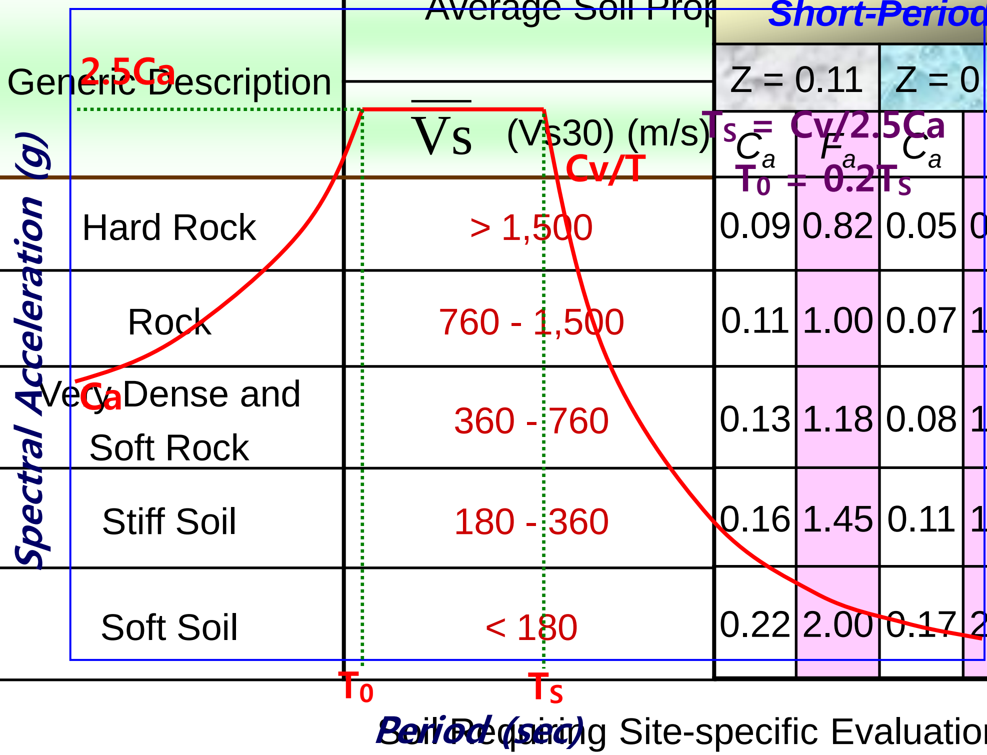
- **Sites were classified based on the mean shear wave velocity of the upper 30m(Vs30; 100ft or 30.48m) depth.**

$$V_S30 = 30 / \sum_{i=1}^{n} \frac{d_i}{V_{Si}}$$

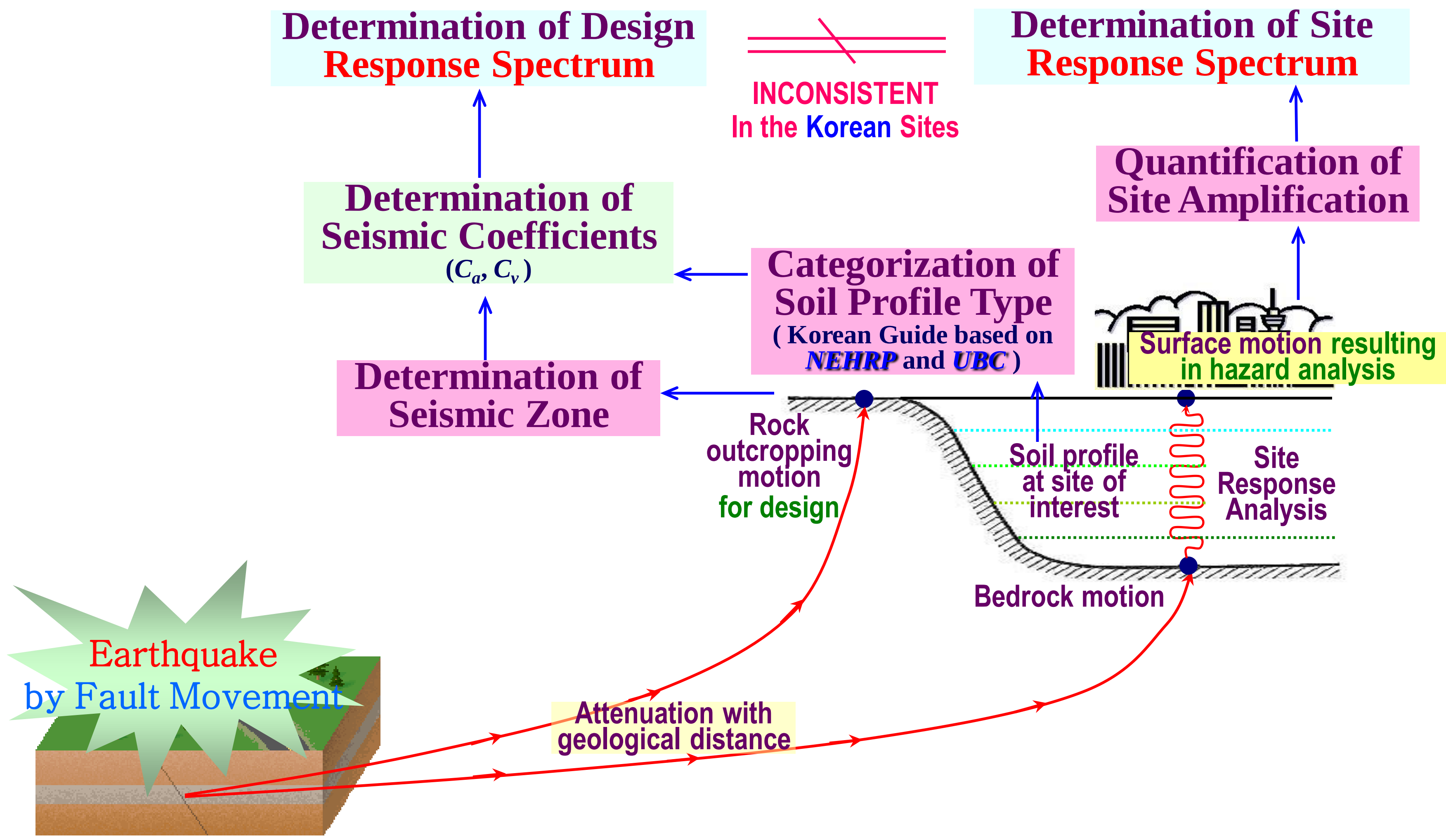
- ***Basis of the Current Site Classification System***

Current Site Classification System for Seismic Design (UBC 1997; NEHRP 1997; 2000)

Soil Profile Type	Generic Description	Average Soil Prop $\overline{V_s}$ (Vs30) (m/s)	Short-Period Z = 0.11 C_a	Short-Period Z = 0.11 F_a	Short-Period Z = 0.07 C_a	Short-Period Z = 0.07 F_a	Mid-Period Z = 0.11 C_v	Mid-Period Z = 0.11 F_v	Mid-Period Z = 0.07 C_v	Mid-Period Z = 0.07 F_v
S_A (Site Class A)	Hard Rock	> 1,500	0.09	0.82	0.05	0.71	0.09	0.82	0.05	0.71
S_B (Site Class B)	Rock	760 - 1,500	0.11	1.00	0.07	1.00	0.11	1.00	0.07	1.00
S_C (Site Class C)	Very Dense and Soft Rock	360 - 760	0.13	1.18	0.08	1.14	0.18	1.64	0.11	1.57
S_D (Site Class D)	Stiff Soil	180 - 360	0.16	1.45	0.11	1.57	0.23	2.09	0.16	2.29
S_E (Site Class E)	Soft Soil	< 180	0.22	2.00	0.17	2.43	0.37	3.36	0.23	3.29
S_F (Site Class F)	Soil Requiring Site-specific Evaluation									

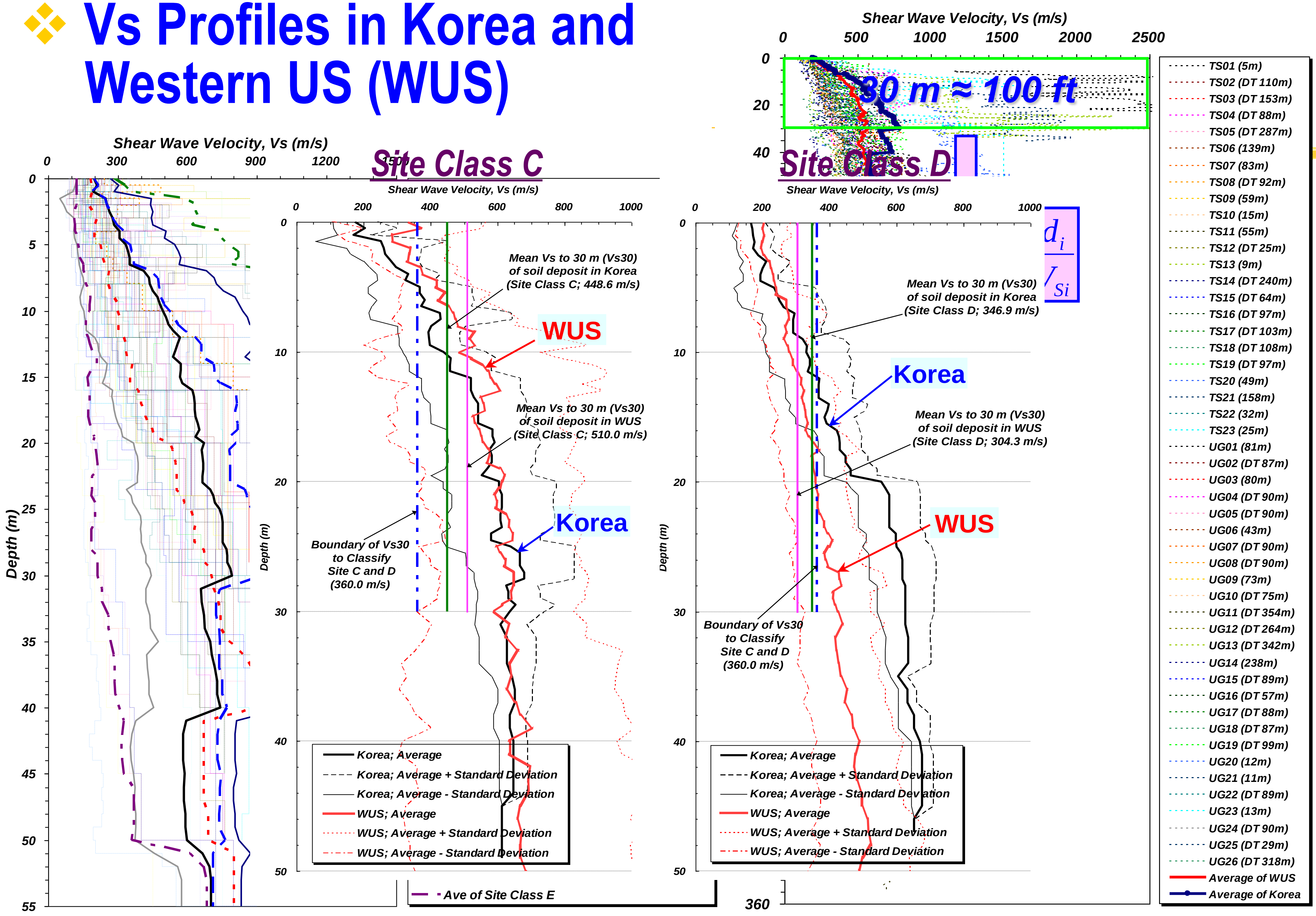


Determination of Response Spectrum for Seismic Design



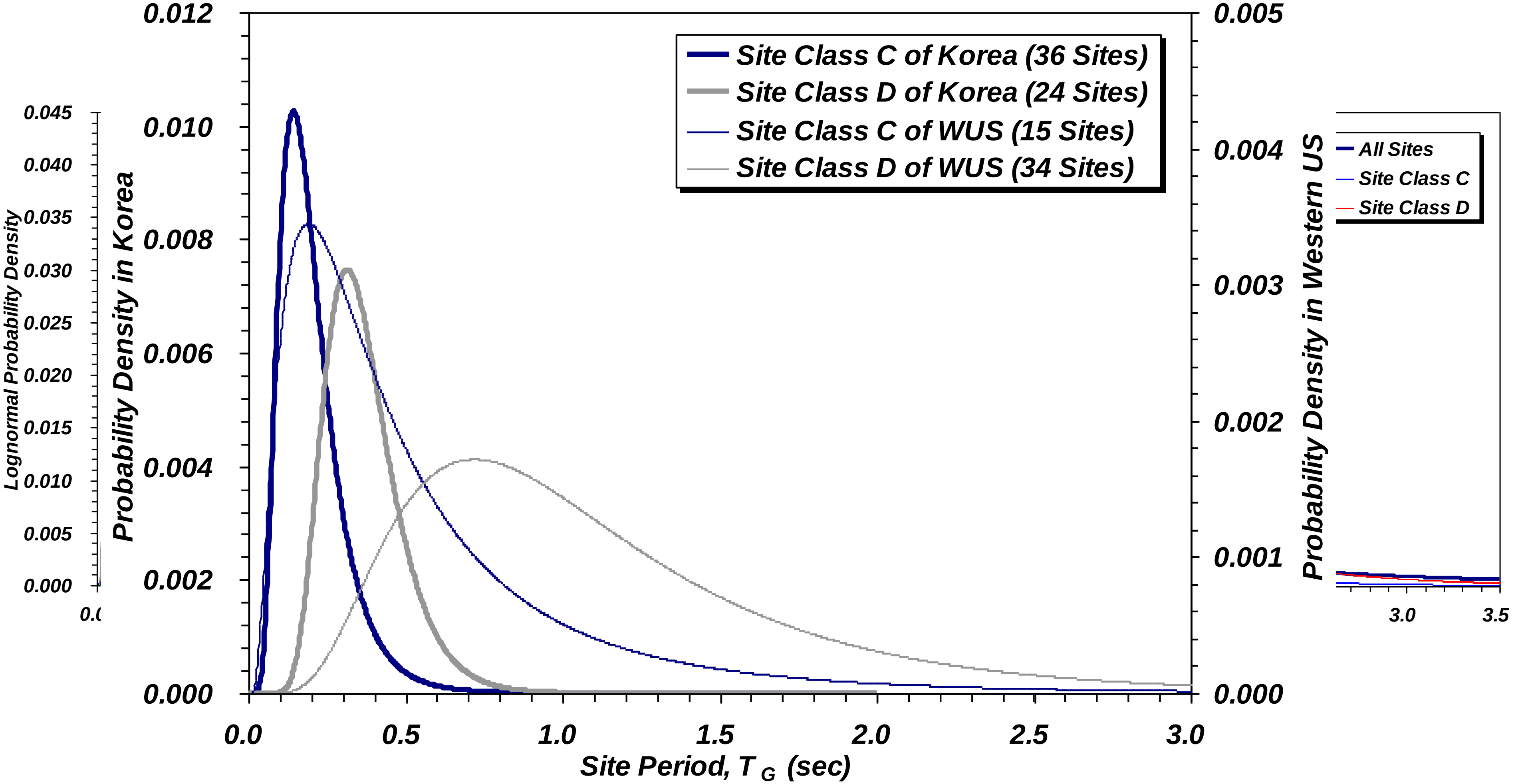
Seismic Site Response in Korea

Vs Profiles in Korea and Western US (WUS)



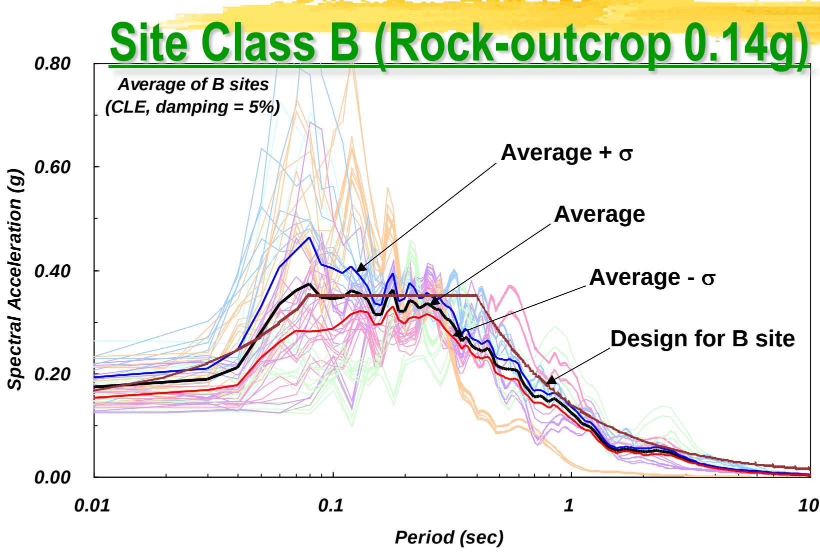
Distribution of Site Period (T_G)

$$T_G = 4\sum_{i=1}^{n}\frac{D_i}{V_{Si}}$$

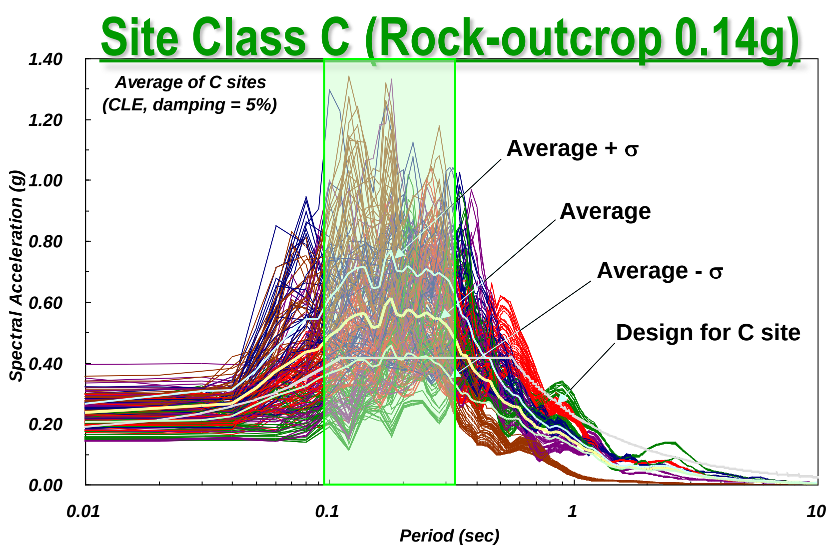


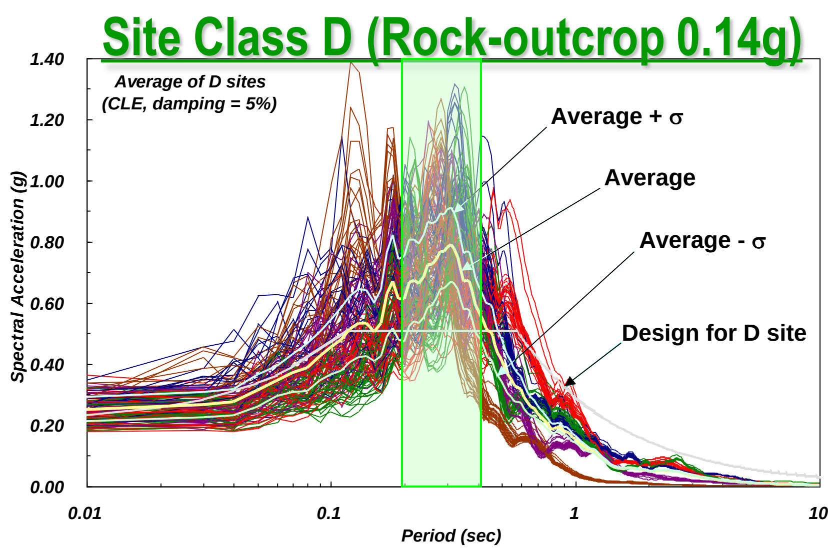
✓Somewhat different for C sites; Significantly different for D sites

Response Spectra from Analyses



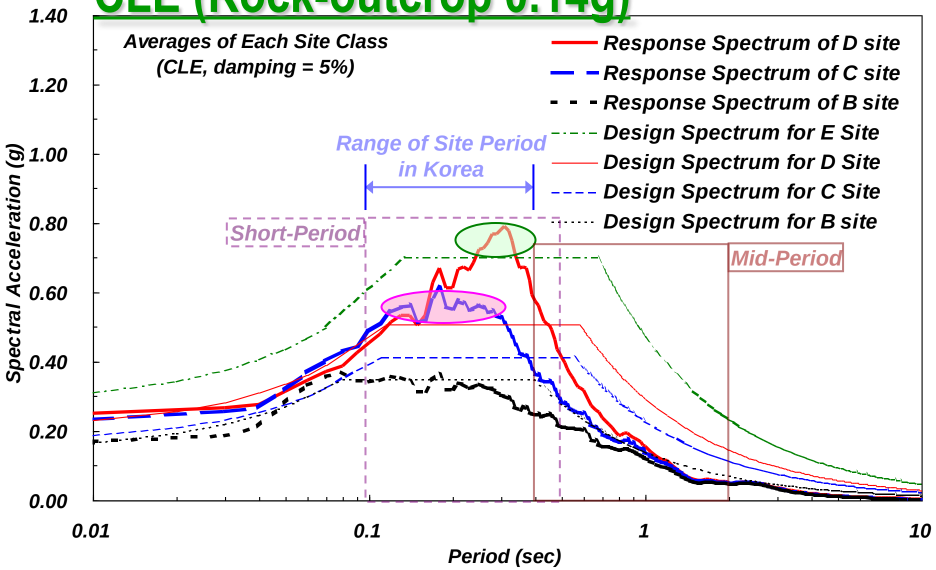
- In C and D sites, the spectral accelerations of response spectra are significantly higher than those of design spectra near resonant periods.
- The resonant periods of D sites are longer than C sites.



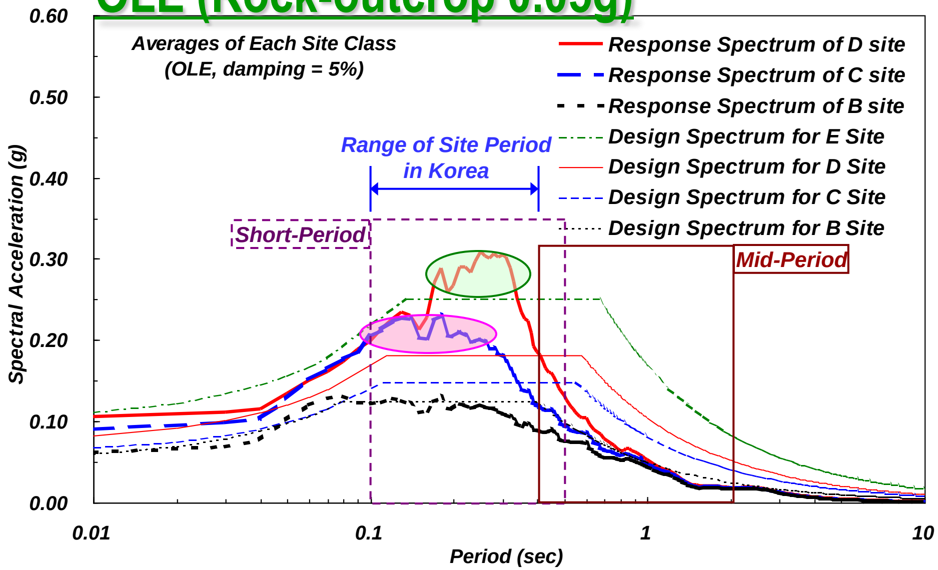


Average of Response Spectra

CLE (Rock-outcrop 0.14g)

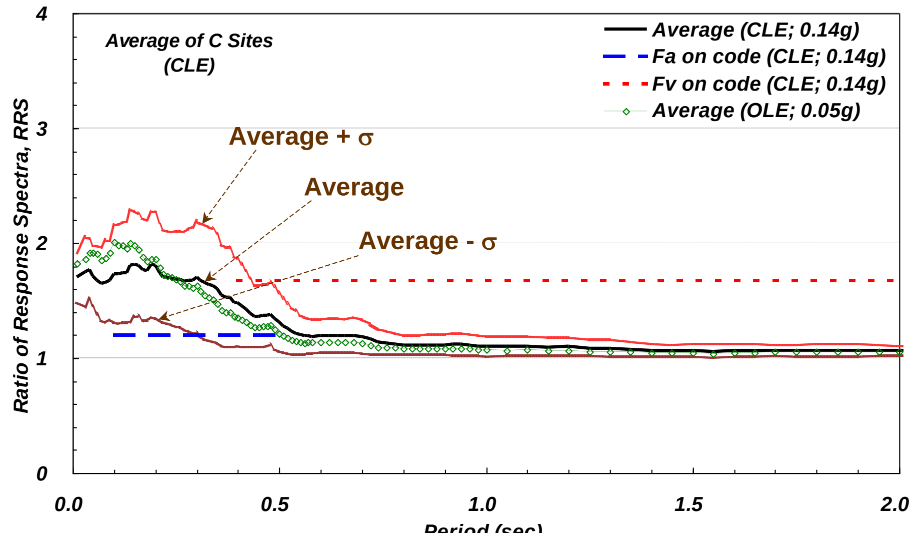


OLE (Rock-outcrop 0.05g)

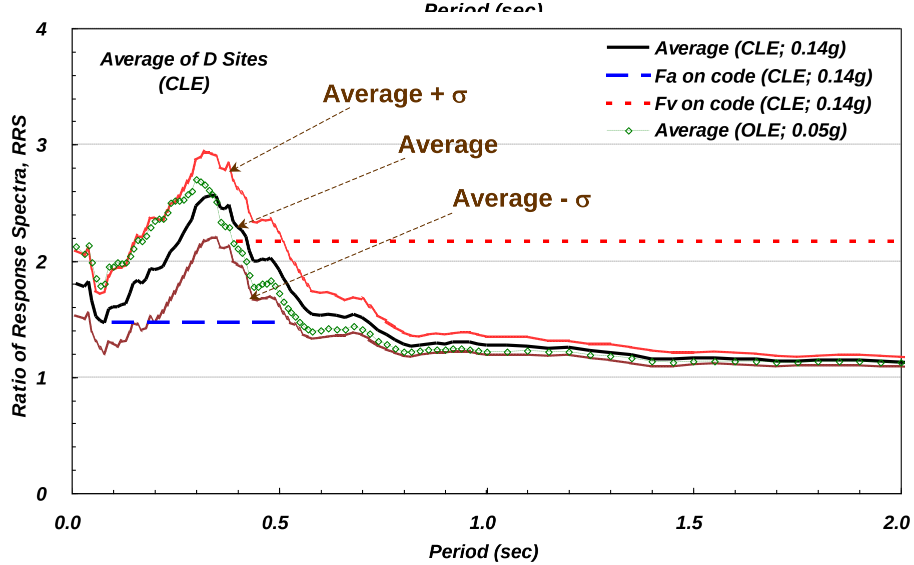


- Maximum spectral accelerations of C and D sites are higher, respectively, than those of design spectrum for site classes D and E, near resonant period.

Ratio of Response Spectra

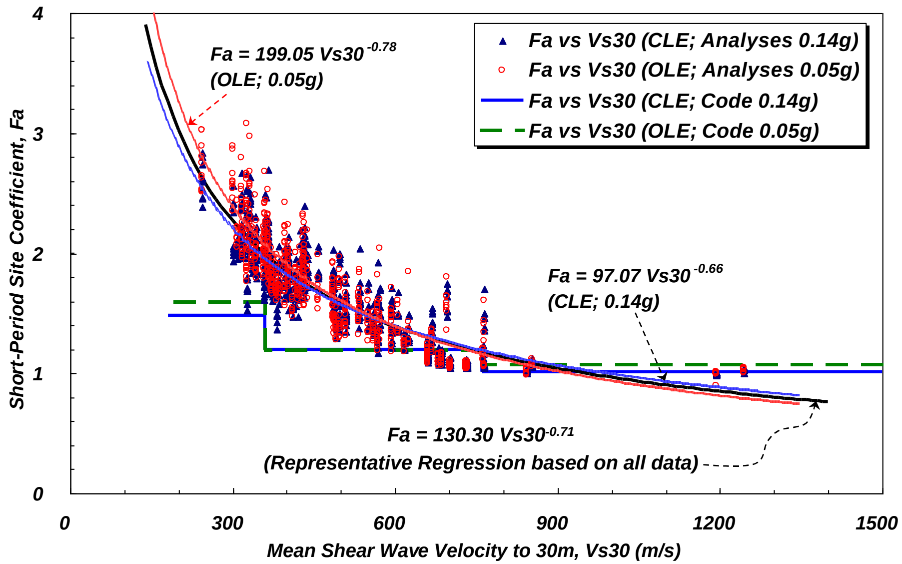


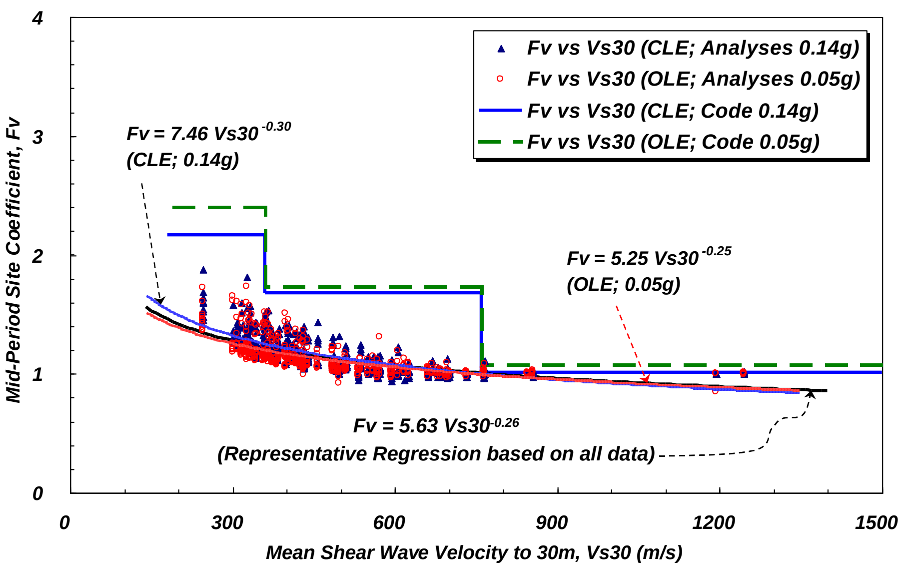
- ✓ *In site class C in Korea*
- *F_a on current code is significantly underestimated.*
- *F_v on current code is considerably overestimated.*



- ✓ *In site class D in Korea*
- *F_a on current code is underestimated.*
- *F_v on current code is considerably overestimated.*

Site Coefficients According to Vs30





- ✓ In F_a for short-periods in Korea
- F_a ranging 1.0 to 2.7 are larger than those on current code.

- ✓ Site Coefficients, F_a and F_v, show similar values, regardless of rock acceleration levels of CLE and OLE.

- ✓ In F_v for mid-periods in Korea
- F_v ranging 1.0 to 1.6 are smaller than those on current code.

Summary

- *Site characterizations in Korea were performed to evaluate the seismic site response characteristics, and the following conclusions were obtained:*

- ✓ Depth to bedrock ➔ *Korea* << *WUS*
  Soil stiffness ➔ *Korea* > *WUS*

- ✓ Site period ➔ *Korea (0.1 to 0.4 sec)* << *WUS (0.2 to 1.8 sec)*

- ✓ Spectral acceleration in response spectra from site response analyses
  ➔ *Analyses for C and D sites in Korea* > *Design code (near the site periods)*

- ✓ Site coefficients, F_a & F_v, from site response analyses
  ➔ F_a *(1.0 to 3.0) in Korea* > F_a *in Design code*
  ➔ F_v *(1.0 to 1.5) in Korea* < F_v *in Design code*


Thank You !!